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INTERNATIONAL STANDARD

Printed electronics –
Part 201: Materials – Substrates

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PRINTED ELECTRONICS –

Part 201: Materials – Substrates

FOREWORD

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International Standard IEC 62899-201 has been prepared by IEC technical committee 119: Printed electronics.

The text of this standard is based on the following documents:

FDIS	Report on voting
119/87/FDIS	119/100A/RVD

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

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

A list of all parts in the IEC 62899 series, published under the general title *Printed electronics*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website 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- withdrawn,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.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

The IEC 62899-20x series relates mainly to evaluation methods for materials of printed electronics. The series also includes storage methods, packaging and marking, and transportation conditions.

The IEC 62899-20x series is divided into parts for each material. Each part is prepared as a generic specification containing fundamental information for the area of printed electronics.

The IEC 62899-20x series consists of the following parts:

Part 201: Materials – Substrates

Part 202: Materials – Conductive ink

Part 203: Materials – Semiconductor ink[1]

(Subsequent parts will be prepared for other materials.)

Furthermore, sectional specifications, blank detail specifications, and detail specifications for each material will follow these parts.

This part of IEC 62899 is prepared for substrate used in printed electronics and contains the test conditions, the evaluation methods and the storage conditions.

[1] Under consideration.

PRINTED ELECTRONICS –

Part 201: Materials – Substrates

1 Scope

This part of IEC 62899 defines the terms and specifies the evaluation method for substrates used in the printing process to form electronic components/devices. This international standard is also applied to the substrates which make surface treatment in order to improve their performance.

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 60050 (all parts), *International Electrotechnical Vocabulary* (available at www.electropedia.org)

IEC 60093:1980, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials*

IEC 60216-1:2013, *Electrical insulating materials – Thermal endurance properties – Part 1: Ageing procedures and evaluation of test results*

IEC 60216-2, *Electrical insulating materials – Thermal endurance properties – Part 2: Determination of thermal endurance properties of electrical insulating materials – Choice of test criteria*

IEC 60216-3, *Electrical insulating materials – Thermal endurance properties – Part 3: Instructions for calculating thermal endurance characteristics*

IEC 60216-4-1, *Electrical insulating materials – Thermal endurance properties – Part 4-1:* Ageing *ovens – Single-chamber ovens*

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

IEC 60216-6, *Electrical insulating materials – Thermal endurance properties – Part 6: Determination of thermal endurance indices (TI and RTE) of an insulating material using the fixed time frame method*

IEC 60243-1:2013, *Electric strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

IEC 60674-2:1988, *Specification for plastic films for electrical purposes – Part 2: Methods of* test
IEC 60674-2:1988/AMD1:2001

IEC 60674-3-1:1998, *Plastic films for electrical purposes – Part 3: Specifications for individual materials – Sheet 1: Biaxially oriented polypropylene (PP) films for capacitors*
IEC 60674-3-1/AMD1:2011

IEC 60695-11-10, *Fire hazard testing – Part11-10: Test flames – 50W horizontal and vertical flame test methods*

IEC 60721-3-1, *Classification of environmental conditions – Part 3 Classification of groups of environmental parameters and their severities – Section 1: Storage*

IEC 60721-3-2, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 2: Transportation*

IEC 61189-2:2006, *Test methods for electrical materials, printed boards and other interconnection structures and assemblies – Part 2: Test methods for materials for interconnection structures*

IEC 61189-3:2007, *Test methods for electrical materials, printed boards and other interconnection structures and assemblies – Part 3: Test methods for interconnection structures (printed boards)*

ISO 5-2, *Photography and graphic technology – Density measurements – Part 2: Geometric conditions for transmittance density*

ISO 5-3, *Photography and graphic technology – Density measurements – Part 3: Spectral conditions*

ISO 62, *Plastics – Determination of water absorption*

ISO 175:2010, *Plastics – Methods of test for the determination of the effects of immersion in liquid chemicals*

ISO 291, *Plastics – Standard atmospheres for conditioning and testing*

ISO 472, *Plastics – Vocabulary*

ISO 489:1999, *Plastics – Determination of refractive index*

ISO 527-1:2012, *Plastics – Determination of tensile properties – Part 1: General principles*

ISO 527-2, *Plastics – Determination of tensile properties – Part 2: Test conditions for moulding and extrusion plastics*

ISO 527-4, *Plastics – Determination of tensile properties – Part 4: Test conditions for isotropic and orthotropic fibre-reinforced plastic composites*

ISO 527-5, *Plastics – Determination of tensile properties – Part 5: Test conditions for unidirectional fibre-reinforced plastic composites*

ISO 868, *Plastics and ebonite – Determination of indentation hardness by means of a durometer (Shore hardness)*

ISO 2039-1, *Plastics – Determination of hardness – Part 1: Ball indentation method*

ISO 2039-2, *Plastics – Determination of hardness – Part 2: Rockwell hardness*

ISO 2578:1993, *Plastics – Determination of time-temperature limits after prolonged exposure to heat*

ISO 3274, *Geometrical Product Specifications (GPS) – Surface texture: Profile method – Nominal characteristics of contact (stylus) instruments*

ISO 3664, *Graphic technology and photography – Viewing conditions*

ISO 4287, *Geometrical Product Specifications (GPS) – Surface texture: Profile method – Terms, definitions and surface texture parameters*

ISO 4288:1996, *Geometrical Product Specifications (GPS) – Surface texture: Profile method – Rules and procedures for the assessment of surface texture*

ISO 6383-1, *Plastics – Film and sheeting – Determination of tear resistance – Part 1: Trouser tear method*

ISO 6383-2, *Plastics – Film and sheeting – Determination of tear resistance – Part 2: Elmendorf method*

ISO 6507-1, *Metallic materials – Vickers hardness test – Part 1: Test method*

ISO 7991, *Glass – Determination of coefficient of mean linear thermal expansion*

ISO 9773:1998, *Plastics – Determination of burning behaviour of thin flexible vertical specimens in contact with a small-flame ignition source*
ISO 9773:1998/AMD1:2003

ISO 11359-2:1999, *Plastics – Thermomechanical analysis (TMA) – Part 2: Determination of coefficient of linear thermal expansion and glass transition temperature*

ISO 11664-4, *Colorimetry – Part 4: CIE 1976 $L^*a^*b^*$ Colour space*

ISO 13468-1:1996, *Plastics – Determination of the total luminous transmittance of transparent materials – Part 1: Single beam instrument*

ISO 13468-2:1999, *Plastics – Determination of the total luminous transmittance of transparent materials – Part 2: Double-beam instrument*

ISO 13565-2:1996, *Geometrical Product Specification (GPS) – Surface texture: Profile method; Surfaces having stratified functional properties – Part 2: Height characterization using the linear material ratio curve*

ISO 13655, *Graphic technology – Spectral measurement and colorimetric computation for graphic arts images*

ISO 14782, *Plastics – Determination of haze for transparent materials*

ISO 15105-1, *Plastics – Film and sheeting – Determination of gas-transmission rate – Part 1: Differential-pressure methods*

ISO 15105-2:2003, *Plastics – Film and sheeting – Determination of gas-transmission rate – Part 2: Equal-pressure method*

ISO 15106-1, *Plastics – Film and sheeting – Determination of water vapour transmission rate – Part 1: Humidity detection sensor method*

ISO 15106-2, *Plastics – Film and sheeting – Determination of water vapour transmission rate – Part 2: Infrared detection sensor method*

ISO 15106-3, *Plastics – Film and sheeting – Determination of water vapour transmission rate – Part 3: Electrolytic detection sensor method*

ISO 15106-4, *Plastics – Film and sheeting – Determination of water vapour transmission rate – Part 4: Gas-chromatographic detection sensor method*

ISO 15184, *Paints and varnishes – Determination of film hardness by pencil test*

ISO 15512, *Plastics – Determination of water content*

ISO 15989, *Plastics – Film and sheeting – Measurement of water-contact angle of corona-treated films*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050, IEC 60695-11-10, ISO 472, ISO 4287, as well as the following apply.

3.1
bow and twist
distortion in the dimensions of a plastic object which occurs after moulding or processing

Note 1 to entry: See Figure 1 for an example of bow and Figure 2 for an example of twist.

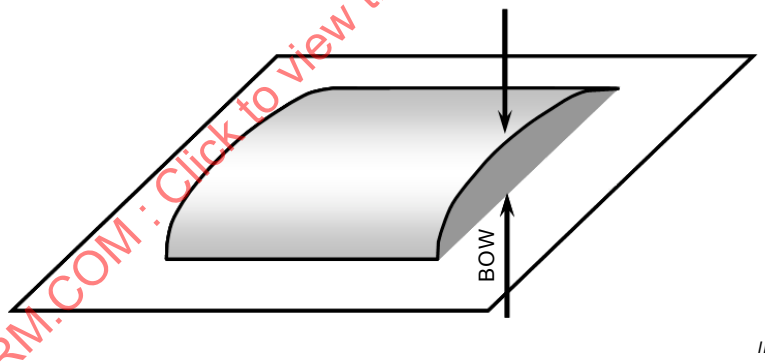

Figure 1 – Example of bow

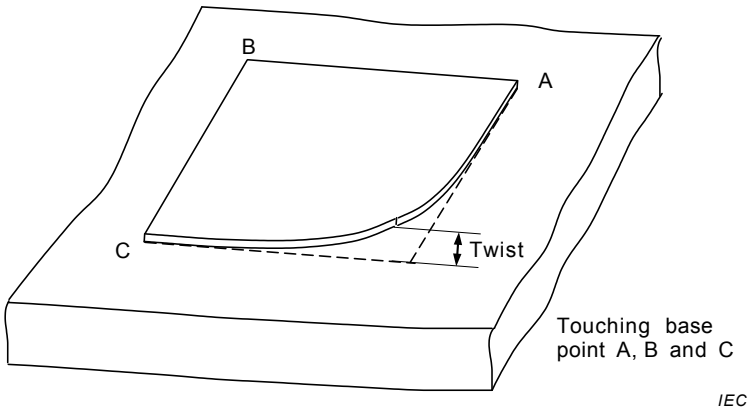

Figure 2 – Example of twist

3.2
roughness
surface property of a substrate which indicates a high-frequency component of irregular elements in the profile curve

Note 1 to entry: Roughness is obtained as a roughness curve by subtracting noise and micro-waviness (see 3.3) from the profile curve measured with a profile filter and phase compensation filter.

3.3
micro-waviness
surface property of a substrate which indicates a low-frequency component of irregular elements in the profile curve

Note 1 to entry: Micro-waviness is obtained from the average line (from the deviation curve) of the measured profile curve.

3.4
foreign substance on surface
substance which is located on the surface of the substrate and can be removed easily by washing off with water, alcohols, cleaning agents, etc., or ultrasonic cleaning

3.5
foreign inclusion
substance which is completely embedded in the substrate or partially exposed on the surface of the substrate, and cannot be removed by cleaning

3.6
edge condition
state of the edges of the substrate which indicates the presence of distortion, waviness, scratches, fracture, burrs, or foreign substances

3.7
minimum bending radius
smallest limit bending radius for which permanent structural change does not occur

3.8
tear strength
force required to rip test specimens apart

Note 1 to entry: The unit of tear strength is newton (N).

3.9
tear propagation resistance
tear strength (see 3.8) divided by thickness

Note 1 to entry: The unit of tear propagation resistance is newton/millimetre (N/mm).

3.10
gas transmission
ease of gas which passes through a unit area of a substrate per unit time under specified temperature and humidity conditions

3.11
water vapour transmission
amount of water vapour which passes through a unit area of a substrate per unit time under specified temperature and humidity conditions

Note 1 to entry: Water vapour transmission is generally expressed as the mass of water vapour which passes through an area of 1 m^2 in 24 h ($g/m^2 \cdot d$).

3.12
oxygen gas transmission
amount of oxygen which passes through a unit area of substrate per unit time and unit partial pressure between both sides of the substrate under specified temperature and humidity conditions

3.13
electric strength
quotient of the maximum voltage applied without breakdown, by the distance between conducting parts under prescribed test conditions

[SOURCE: IEC 60050-212:2010, 212-11-37]

3.14
temperature index
numerical value corresponding to the temperature, in degrees Celsius, derived from the thermal endurance relationship at a given time (normally 20 000 h)

[SOURCE: ISO 2578:1993, 3.1, modified – “numerical value” is used instead of “number”.]

3.15
relative temperature index
temperature index (see 3.14) of a test material, obtained at the time which corresponds to the known temperature index of a reference material when both materials are subjected to the same ageing and diagnostic procedures in a comparative test

[SOURCE: ISO 2578:1993, 3.2, modified – the reference to “temperature index” has been added.]

3.16
chip
<glass substrates> place from which a small piece of glass has been removed from the glass surface

3.17
crack
<glass substrates> lines on the surface of the central or edge of glass where it has broken but not split into separate parts

3.18
scratch
<glass substrates> shallow grooves on a glass surface which are made during handling

Note 1 to entry: A scratch may be accompanied by a crack.

4 Materials, structures and dimensions

4.1 Base materials

Base materials are used in the printing process to form electronic components/devices that are polymer, glass and other materials such as ceramics, metal, paper, etc.

4.2 Structures of substrates

The substrate shall have a monolithic structure of one of the materials specified in 4.1, a composite structure of several of those materials, or a reinforced composite structure strengthened with fibres or particles. The surface of the substrate may be treated to enhance the wettability, adhesive property, gas transmission, smoothness, and electric insulation.

4.3 Dimensions of substrates

4.3.1 Outline

Substrates made of the material(s) specified in 4.1 and with a structure specified in 4.2 shall be supplied in the form of (rigid or flexible) sheets or rolls.

The preferred area dimensions (width and length) of the substrate are shown below. The preferred thickness is specified in 4.3.4. The dimensions of the substrate shall be agreed between user and supplier, and described in the product specifications.

4.3.2 Sheet dimensions

The recommended standard area dimensions (width and length) of a sheet are shown below. The tolerance of width and length is ±1 mm.

370 mm × 470 mm, 550 mm × 650 mm, 680 mm × 880 mm, and 1 100 mm × 1 300 mm

4.3.3 Width and length (roll supply)

4.3.3.1 Polymer substrates

Preferred substrate widths are 800 mm and 1 600 mm with a tolerance of ±1 mm. The test method for substrate width shall be as specified in IEC 60674-2:1988, Clause 5.

The substrate winding length on a roll shall be as agreed between user and supplier.

The inner diameter of a roll winding core shall be 7,62 cm (3 inches) or 15,24 cm (6 inches). The core shape shall be cylindrical. The core material may be any material which can be used in a level 100 clean room.

The winding condition on a roll shall be evaluated by referring to IEC 60674-2:1988, Clause 6. The sum of the curvature and sag shall be 10 mm or less.

The roll winding misalignment of the roll (the difference between the roll width and the maximum substrate width) shall comply with Table 1.

Table 1 – Winding misalignment of the roll

Dimensions in millimetres

Substrate width	Winding misalignment
less than 150	0,5 or less
150 to less than 300	1,0 or less
300 or more	2,0 or less

4.3.3.2 Glass substrates

Preferred substrate widths are 300 mm, 600 mm, 800 mm and 1 600 mm with a tolerance of ±5 mm. Substrate winding length on a roll shall be as agreed between user and supplier.

The inner diameter of the roll winding core, core material, roll winding condition and roll winding misalignment should be as specified in the stipulations regarding the polymer substrate.

4.3.3.3 Other materials

Under consideration.

4.3.4 Substrate thickness

4.3.4.1 Polymer substrates

Substrate nominal thickness shall be selected from 5 μm, 7,5 μm, 10 μm, 12,5 μm, 20 μm, 25 μm, 30 μm, 38 μm, 50 μm, 75 μm, 100 μm, 125 μm, 150 μm, 188 μm, 200 μm or 250 μm. The tolerance of the nominal thickness shall be ±10%.

4.3.4.2 Glass substrates

Substrate nominal thickness should be selected from 5 μm, 10 μm, 20 μm, 30 μm, 40 μm, 50 μm, 70 μm, 100 μm, 125 μm, 150 μm, 200 μm, 250 μm, 300 μm, 400 μm, 500 μm, 600 μm, 700 μm, 800 μm or 1 000 μm. The tolerance of the nominal thickness should be ±10 %.

4.3.4.3 Other materials

Under consideration.

5 General descriptions of evaluation tests

5.1 Sampling

Under consideration.

5.2 Preparation of test specimens

The substrate shall be in its original form, or cut into the appropriate size for testing.

Care should be taken not to touch the test specimens with fingers, etc. The specimens shall not be cleaned unless otherwise specified.

5.3 Atmospheric conditions for evaluation test

The temperature and humidity conditions for evaluation tests shall be at a temperature of 23 °C ± 1 °C and relative humidity of (50 ± 5) % according to ISO 291 unless otherwise specified.

5.4 Conditioning

5.4.1 Polymer substrates

Polymer substrates need conditioning. Unless otherwise specified, the test specimens to be evaluated shall be stored at a temperature of 23 °C ± 1 °C and relative humidity of (50 ± 5) % for 48 h or more.

5.4.2 Glass substrates

Since glass substrates have no hygroscopicity, conditioning is generally not necessary.

5.4.3 Other materials

Under consideration.

6 Characteristics and evaluation method of polymer substrates

6.1 Surface properties

6.1.1 Surface defects

6.1.1.1 General characteristics

The surface of a substrate shall not have the following defects. However, since the maximum permissible size of defects depends on the purpose, the defect condition shall be agreed upon between user and supplier.

– Pinholes, hollows, blisters, pimples, fish-eyes, speckles, cracks, fractures, wrinkles, detachment and creep

6.1.1.2 Detection method

The surface defects of a substrate shall be detected with normal or corrected vision (6/6 or better), with a microscope, or with a surface inspection machine such as a stylus-based profilometer, or WLI (white light interferometry).

6.1.1.3 Report of the results

The report shall include the following items. For defect(s) not exceeding the permissible size, items b) through f) may be omitted:

a) type of defects;

b) length of each defect;

c) width of each defect;

d) depth or height of each defect;

e) number of defects;

f) position of each defect.

6.1.2 Flatness

6.1.2.1 Bow and twist

6.1.2.1.1 Test method

Bow and twist are expressed as the bow ratio and twist ratio according to IEC 61189-3:2007, 9.4 (test 3M04).

The permissible bow ratio and twist ratio shall be agreed upon between user and supplier as required. This agreement should consider the actual use on products as well as the manufacturing process.

6.1.2.1.2 Report of the results

The report shall include the bow ratio and twist ratio.

6.1.2.2 Surface roughness

6.1.2.2.1 Procedure of measurement and calculation

Surface roughness is expressed as the arithmetic mean roughness (Ra). However, unevenness (extrusions) which exceeds the level difference (Rk) at the core shall be treated as protrusions.

Ra shall be obtained as follows.

Measurement shall be made using a contact (stylus) instrument specified in ISO 3274 and a roughness parameter shall be calculated according to ISO 4288:1996, 7.2. From the profile curve obtained, stylus strain and noise are removed with a profile filter and the form deviation curve (waviness curve) is extracted. The cut-off value (wavelength) of the phase compensation filter used to distinguish the waviness curve shall be the wavelength at an amplitude transmission rate of 50 %. The high-frequency component (short-wavelength component) curve obtained is treated as a surface roughness curve, from which the arithmetic mean roughness (Ra) is calculated.

For protrusions, Rk shall be obtained according to ISO 13565-2:1996, Clause 4; unevenness exceeding this value is treated as protrusions, and the number of protrusions per unit area is calculated.

6.1.2.2.2 Report of the results

The report shall include the following items:

a) measuring instruments;
b) sampling method and place, and specimen size;
c) result of Ra measurement;
d) number of protrusions.

6.1.2.3 Micro-waviness

6.1.2.3.1 Procedure of measurement and calculation

Micro-waviness is expressed as the arithmetic mean waviness (Wa). Wa is obtained as follows.

Measurement shall be made using a stylus (contact) instrument specified in ISO 3274 and a roughness parameter shall be calculated according to ISO 4288:1996, 7.2. From the profile curve obtained, stylus strain and noise are removed with a profile filter and the roughness curve is extracted. The cut-off value (wavelength) of the phase compensation filter used to distinguish the roughness curve shall be the wavelength at an amplitude transmission rate of 50 %. The low-frequency component (long-wavelength component) curve obtained is treated as a form deviation curve (waviness curve), from which the arithmetic mean waviness (Wa) is calculated.

6.1.2.3.2 Report of the results

The report shall include the following items:

a) measuring instruments;
b) sampling method and place, and specimen size;
c) result of Wa measurement.

6.1.3 Surface condition

6.1.3.1 Contact angle

6.1.3.1.1 Test method

The contact angle shall be measured as specified in ISO 15989, using water or some other solvent which does not affect the substrate.

6.1.3.1.2 Report of the results

The report shall include the following items:

a) sampling method and place;

b) substrate and water or other solvent;

c) test conditions (temperature and humidity);

d) mean contact angle.

6.1.3.2 Foreign substances on the surface

6.1.3.2.1 Principle

Regarding foreign substances on the surface of the substrate, those which are equal to or greater than the specified size (maximum diameter) agreed between user and supplier shall be detected.

6.1.3.2.2 Inspection method

Foreign substances shall be detected with normal or corrected vision (6/6 or better), with a microscope, edge light, or with a surface inspection machine. There shall be no foreign substances which are equal to or greater than the specified size (maximum diameter) agreed between user and supplier.

6.1.3.2.3 Report of the results

The report shall include the following items:

a) detection method;

b) inspection method (100 % or sampling), sampling method and place, and specimen size;

c) no foreign substances which are equal to or greater than a certain size (maximum diameter).

6.1.3.3 Foreign inclusions

6.1.3.3.1 Principle

For foreign substances and voids which are included in the substrate, those which are equal to or greater than the specified size (maximum diameter) agreed between user and supplier shall be detected.

6.1.3.3.2 Inspection method

Foreign substances shall be detected with normal or corrected vision (6/6 or better), with a microscope, or with a surface inspection machine.

Since the permissible state of inclusion of foreign substances depends on the purpose, the allowable size shall be agreed between user and supplier.

Regarding the inclusion of foreign substances which cause unevenness on the surface, the allowable height shall be agreed between user and supplier.

6.1.3.3.3 Report of the results

The report shall include the following items:

a) detection method;

b) inspection method (100 % or sampling), sampling method and place, and specimen size;

c) no foreign substances which are equal to or greater than a certain size (maximum diameter).

6.1.4 Edge condition

6.1.4.1 General characteristics

To evaluate the condition of the edge of the substrate, specific cracks, scratches, unevenness, and foreign substances shall be detected as mutually agreed upon between user and supplier.

6.1.4.2 Inspection method

Edge conditions shall be inspected with the normal or corrected vision (6/6 or better), with a microscope, or with a surface inspection machine. Adhesive tape is used to detect foreign substances. There shall be no foreign substances on the tape.

6.1.4.3 Report of the results

The report shall include the following items:

a) detection method;

b) inspection method (100 % or sampling), sampling method and plane, and specimen size;

c) specific cracks, scratches, unevenness, and foreign substances.

6.2 Mechanical properties

6.2.1 Elongation at break

6.2.1.1 Outline

Rupture elongation is expressed as the tensile strain at break or nominal tensile strain at break, to which ISO 527-1 and the following shall be applied.

6.2.1.2 Test speeds

Test speeds shall be selected from ISO 527-1:2012, Table 1, as agreed between user and supplier and described in the product specifications.

6.2.1.3 Test specimens

For the size and preparation of test specimens, appropriate standards shall be selected from ISO 527-2, ISO 527-4, or ISO 527-5 according to the material of the substrate, and shall be described in the product specifications.

6.2.1.4 Report of the results

The report shall include the following items:

a) testing machine;

b) test speed (mm/min);

c) specimen size (mm);

d) test environment (temperature and humidity);

e) tensile strain at break or nominal tensile strain at break (dimensionless ratio or %).

6.2.2 Tensile strength

6.2.2.1 Outline

Tensile strength is expressed as the stress at which the specimen breaks, to which ISO 527-1 and the following shall be applied.

6.2.2.2 Test speeds

Test speeds shall be selected from ISO 527-1:2012, Table 1, as agreed between user and supplier and described in the product specifications.

6.2.2.3 Test specimens

For the size and preparation of test specimens, appropriate standards shall be selected from ISO 527-2, ISO 527-4, or ISO 527-5 according to the material of the substrate, and shall be described in the product specifications.

6.2.2.4 Report of the results

The report shall include the following items:

a) testing machine;
b) test speed (mm/min);
c) specimen size (mm);
d) test environment (temperature and humidity);
e) tensile strength (MPa).

6.2.3 Tensile modulus

6.2.3.1 Test method

ISO 527-1 and the following shall be applied to tensile modulus.

6.2.3.2 Recommended test speeds

A test method is selected from ISO 527-2012, Table 1, as agreed between user and supplier and described in the product specifications.

6.2.3.3 Test specimens

For the size and preparation of test specimens, appropriate standards shall be selected from ISO 527-2, ISO 527-4, ISO 527-5 according to the material of the substrate, and shall be described in the product specifications.

6.2.3.4 Report of the results

The report shall include the following items:

a) testing machine;
b) test speed (mm/min);
c) specimen size (mm);
d) test environment (temperature and humidity);
e) tensile modulus (MPa).

6.2.4 Minimum bending radius

6.2.4.1 Principle

When the substrate is bent beyond the minimum bending radius, permanent structural changes (creases or cracks) occur on the substrate at a certain radius.

Subclause 6.2.4 defines the method for obtaining the minimum bending radius below which no permanent structural changes occur on the substrate. One test method uses a flex resistance

tester and the other a fracture resistance tester. An appropriate test method shall be selected according to the material of the substrate, and shall be described in the product specifications.

6.2.4.2 Measurement equipment

6.2.4.2.1 General

The measurement equipment shall be a flex resistance tester (also known as a U-shaped flex tester) or a fracture resistance tester (also known as a two-sided fracture tester).

6.2.4.2.2 Flex resistance tester

A flex resistance tester has the structure shown in Figure 3 near the part where the specimen is attached, and shall satisfy the following requirements:

– The two flat plates are parallel. The distance d between the flat plates can be adjusted and measured.
– Each flat plate has a mechanism to hold the side of the specimen so that no part of the specimen protrudes when it is bent in a U shape.

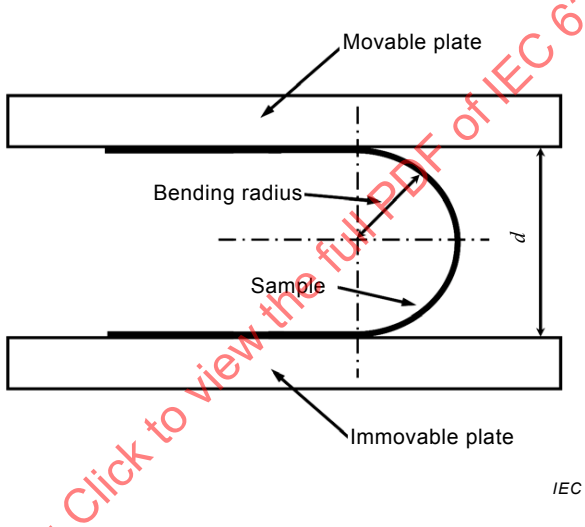

Figure 3 – Structure of the flex resistance tester near the part where the specimen is attached

6.2.4.2.3 MIT instrument

The MIT instrument which is described in the ISO 5626 is used. This instrument has the structure shown in Figure 4.

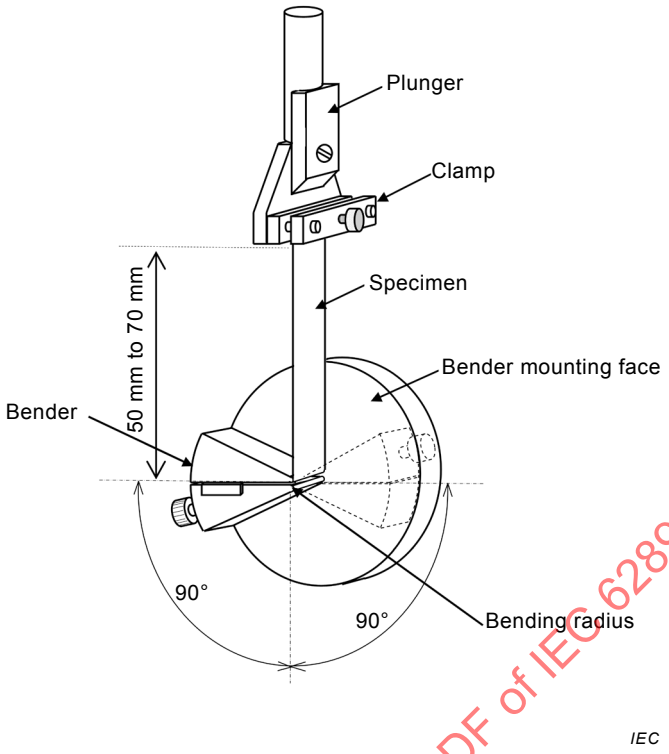

Figure 4 – Structure of the MIT instrument

The MIT instrument has a movable part which holds the specimen and bends it by 180° (90° on both sides of the vertical direction), a bending part for applying constant curvature to the specimen, and a mechanism for applying constant tension to the specimen. This instrument shall satisfy the following requirements.

– It can apply the tension specified in the product specifications to the specimen, and measure and display the tension.

– It can conduct tests at radiuses of curvature greater than that specified in the product specifications.

– It has a power unit that applies rotational motion at the speed specified in the product specifications to the bending device.

6.2.4.3 Test specimens

The specimen shall be in its original form, and of the size specified in the product specifications.

6.2.4.4 Measurement procedure

6.2.4.4.1 Flex resistance test

As shown in Figure 3, the specimen is bent in a U shape and fixed to both parallel plates. The distance d between the parallel plates shall be sufficiently larger than twice the minimum bending radius of the specimen. Then d shall be set to four times the minimum bending radius and kept for the time specified in the product specifications. When the test is completed, increase d, detach the specimen, and perform the inspection after testing.

The test shall be repeated with d reduced each time until permanent structural change is detected according to 6.2.4.4.2.

6.2.4.4.2 MIT instrument

The tension applied to the specimen, bending speed, and hold time shall be according to the product specifications.

Fix the plunger with locking screws and apply to the plunger the force equal to the tension applied to the specimen. Accurately attach the specimen to the clamp connected to the plunger and the bender so that it is kept flat and does not touch the mounting face of the bender. The specimen shall be attached to the clamp and the bender without rotating the bender or causing deflection to the specimen. Loosen the locking screws on the plunger to apply tension to the specimen. If the reading of the indicator changes, adjust the tension to the specified level.

Rotate the bender 90º from the vertical direction at the specified bending speed and keep it for the specified time. Then rotate the bender back to the original position and rotate it 90º in the opposite direction. When the test is completed, detach the specimen, and perform the inspection after testing.

Repeat the test by gradually reducing the radius of the curvature at the bender from approximately twice the minimum bending radius of the specimen specified in the product specifications to the level specified in the product specifications.

The test shall be repeated by reducing the bending radius from twice the minimum bending radius to the one specified in the product specification, until permanent structural change is detected according to 6.2.4.4.2.

6.2.4.4.3 Inspection after test

To evaluate whether permanent structural changes occurred or not (creases or cracks), the specimen shall be inspected with normal or corrected vision (6/6 or better), with a microscope, or with a surface inspection machine.

6.2.4.5 Expression of the results

The minimum bending radius at which no permanent structural change occurs to the specimen is the minimum bending radius.

6.2.4.6 Report of the results

The report shall include the following items:

a) test method (flex resistance tester or MIT instrument);
b) type and thickness of the specimens;
c) number of specimens;
d) conditioning (temperature, humidity, and kept time);
e) test environment (temperature and humidity);
f) minimum bending radius.

6.2.5 Tear strength and tear propagation resistance

6.2.5.1 Test method

Tear strength shall be measured and calculated using the trouser tear method specified in ISO 6383-1 or the Elmendorf tear method specified in ISO 6383-2. Either method can be used to measure tear strength. An appropriate test method depends on the stiffness and deformation (extent) of the material to be tested. The test method shall be as specified in IEC 60674-3-1, or the test method as agreed between user and supplier.

As the tear properties change according to the thickness, tear speed, and measuring atmosphere, if a data comparison is required, these conditions shall be accurately controlled.

6.2.5.2 Test specimens

When comparing tear strength between different materials, adjust the specimen so that the difference in thickness is no more than 10 %. In addition, since the dependency on tear speed might greatly differ between materials, care shall be taken when comparing the results.

6.2.5.3 Expression of the results

The tear property obtained is the tear propagation resistance in newton per millimetre (N/mm), which is calculated by dividing the force required to tear the specimen (tear strength) in newton (N) by the thickness of the specimen.

6.2.5.4 Report of the results

The report shall include the following items:

a) thickness of the specimen;
b) tear speed;
c) measuring atmosphere;
d) tear propagation resistance (tear strength may be accompanied).

6.2.6 Edge strength

Under consideration.

6.2.7 Hardness

6.2.7.1 Test method

Hardness shall be measured as pencil hardness according to ISO 15184. If required, Shore hardness (see ISO 868) or ball indentation hardness (see ISO 2039-1 and ISO 2039-2) can be used.

6.2.7.2 Report of the results

The report shall include the following items:

a) test method;
b) thickness of the specimen;
c) temperature and humidity during the test;
d) brand of the pencil used (for pencil hardness), durometer type (for Shore hardness), or Rockwell hardness scale (for ball indentation hardness);
e) test result;
f) difference from the specified test method (if applicable).

6.3 Chemical properties

6.3.1 Resistance to chemicals

6.3.1.1 Test method

ISO 175 and the following shall apply to the resistance to chemicals.

6.3.1.2 Selection of test conditions

The properties of the specimen soaked in the liquid such as mass, size, and colour are selected from ISO 175 as agreed between user and supplier, and described in the product specification.

The liquid used for the test shall be an acid solution, an alkaline solution, or an organic solvent, which should preferably be selected from Table A.1 (reagents) and Table A.2 (various liquid products) in ISO 175:2010. However, depending on the target material and the process used, other liquids may be used as agreed between user and supplier.

6.3.1.3 Test specimens

The size and preparation of test specimens shall follow ISO 175 and be described in the product specification.

6.3.1.4 Report of the results

The report shall include the following items:

a) test method;
b) test conditions;
c) test specimen;
d) test environment (temperature and humidity);
e) resistance to chemicals.

6.3.2 Halide contents

6.3.2.1 Test method

Mass fraction (10^{-6}) shall be obtained using the method in IEC 61189-2:2006, 8.12 (test 2C12).

6.3.2.2 Report of the results

The report shall include the following items:

a) test method;
b) test conditions;
c) test specimen;
d) test environment (temperature and humidity);
e) mass fraction (10^{-6}).

6.3.3 Volatile content

6.3.3.1 Test method

The test method shall be the mass reduction in a high-temperature oven as specified in IEC 61189-2:2006, 8.4 (test 2C04).

For materials which are not specified in IEC 61189-2:2006, 8.4 (test 2C04), the oven shall follow the instruction of the material manufacture.

6.3.3.2 Report of the results

The report shall include the following items:

a) test method;

b) test conditions;

c) test specimen;

d) test environment (temperature and humidity);

e) mass fraction (10^{-6}).

6.3.4 Gas transmission

6.3.4.1 Water vapour transmission

6.3.4.1.1 Test method

Water vapour transmission shall be measured using the humidity detection sensor method specified in ISO 15106-1, infrared sensor method specified in ISO 15106-2, gas chromatographic method specified in ISO 15106-4, or electrolytic sensor method specified in ISO 15106-3. However, as agreed upon between user and supplier, another method may be used. The test method selected shall be described in the product specification.

6.3.4.1.2 Report of the results

The report shall include the following items:

a) test method;

b) test conditions;

c) test specimen;

d) test environment (temperature and humidity);

e) mass of water vapour which passes through an area of 1 m^2 in 24 h (g/m^2 d).

6.3.4.2 Oxygen gas transmission

6.3.4.2.1 Test method

Oxygen gas transmission shall be measured using the differential pressure method (pressure sensor method) specified in ISO 15105-1 or isopiestic method (electrolytic sensor method or gas chromatographic method) specified in ISO 15105-2. However, as agreed upon between user and supplier, another method may be used. The test method selected shall be described in the product specification.

The gas transmission and gas transmission coefficient (gas permeability) can be obtained as test results. The properties used for the evaluation shall be described in the product specification as agreed between user and supplier.

6.3.4.2.2 Test specimens

Since both sides of the specimen may have different properties, a method for distinguishing each side shall be determined and the side which is exposed to the test gas shall be recorded.

6.3.4.2.3 Report of the results

The report shall include the following items:

a) test method;

b) test conditions;

c) test specimen (method for distinguishing sides and the side exposed to the test gas);

d) test environment (temperature and humidity);

e) gas transmission and gas transmission coefficient (gas permeability).

6.3.5 Moisture absorption

6.3.5.1 Test method

The test is conducted using the D method (exposing the specimen to a relative humidity of 50 % and measuring the amount of water absorption) specified in ISO 62.

The change in the amount of water in the substrate before and after moisture absorption is obtained according to the method for determining water content specified in ISO 15512.

6.3.5.2 Report of the results

The report shall include the following items:

a) test method;
b) test environment (temperature and humidity);
c) test conditions (exposure time);
d) test specimen (area size and thickness);
e) water absorption coefficient (mass fraction in percentage: %).

6.4 Electrical properties

6.4.1 Measurement at ambient temperature

6.4.1.1 Volume resistance and surface resistance

6.4.1.1.1 Outline

Volume resistance is expressed in Ohm centimetre (Ω cm). Surface resistance is expressed in Ohm (Ω).

6.4.1.1.2 Test method

Volume resistance and surface resistance shall be measured as specified in IEC 60093.

6.4.1.1.3 Measurement equipment

Measurement equipment shall be as specified in IEC 60093. The dimensions of the measuring electrode described in IEC 60093:1980, Clause 6, are: d_1 = 50 mm, d_2 = 60 mm, and d_3 = 80 mm (see Figure 5). However, the other electrode dimensions of d_1 = 50 mm, d_2 = 70 mm, d_3 = 80 mm, may be used.

6.4.1.1.4 Applied voltage

Applied voltage shall be selected from the voltage listed in IEC 60093:1980, Clause 4.

6.4.1.1.5 Test specimens

The shape, dimensions and preparation of the test specimen shall be as specified in IEC 60093:1980, Clause 6.

6.4.1.1.6 Calculation of the results

Volume resistivity shall be calculated in accordance with IEC 60093:1980, 11.1, from the measurement results. Surface resistivity is calculated in accordance with IEC 60093:1980, 11.2, from the measurement results.

6.4.1.1.7 Report of the results

The report shall include:

a) volume resistance and/or surface resistance;

b) shape and dimensions of the specimen: length × width or diameter (mm), and thickness (μm);

c) treatment and conditioning for the specimen (application of cleaning and method, conditioning atmosphere, etc.);

d) test atmosphere (temperature and relative humidity);

e) electrode dimensions (d_1, d_2 and d_3) and material;

f) applied voltage (V).

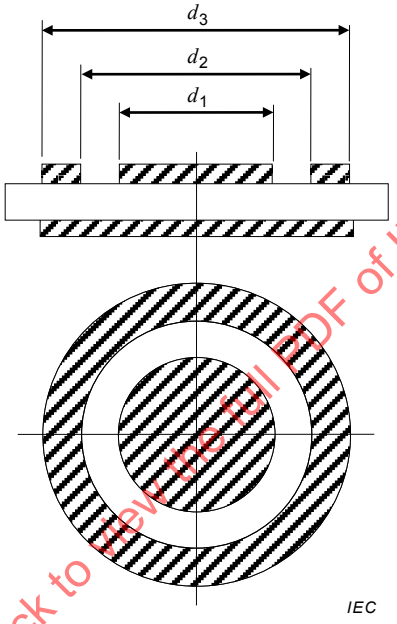

Figure 5 – Example of a measuring electrode

6.4.1.2 Electrical strength

6.4.1.2.1 Outline

Breakdown voltage is measured in the direction perpendicular to the surface of the substrate. Electric strength is the quotient of the breakdown voltage by the distance between the electrodes under specified test conditions.

6.4.1.2.2 Test method

Breakdown voltage shall be measured by the test method as specified in IEC 60243-1 with the following details:

a) the specimen shall be as specified in 5.2;

b) the specimen shall be conditioned as specified in 5.3;

c) the temperature and humidity of the test shall be as specified in 5.3;

d) the surrounding medium should be air. If the specimens have high breakdown values, they may be tested in insulating liquid as agreed between user and supplier;

e) the electrodes are unequal electrodes;

f) the frequency of the applied voltage is selected between 48 Hz and 62 Hz;

g) the test voltage is increased according to IEC 60243-1:2013, 10.1 (short time test), with a rising rate of 500 V/s.

6.4.1.2.3 Report of the results

The report shall include:

a) measured electric strength in kV/mm (minimum, maximum and median), preferably in conjunction with breakdown mode and location;

b) dimensions of the specimen (length × width or diameter (mm), and thickness (μm));

c) treatment and conditioning for the specimen (application of cleaning and method, conditioning atmosphere, etc.);

d) test atmosphere (surrounding medium: air or insulation liquid, temperature and relative humidity);

e) electrode dimensions (d_1, d_2 and d_3) and material;

f) mode of increasing voltage.

6.4.1.3 Relative permittivity

Under consideration.

6.4.1.4 Dissipation factor

Under consideration.

6.4.2 Measurement at high temperature

6.4.2.1 Surface resistance

Under consideration.

6.4.2.2 Volume resistance

Under consideration.

6.5 Thermal properties

6.5.1 Glass transition temperature

6.5.1.1 Test method

Glass transition temperature shall be measured using the DSC method specified in IEC 61189-2:2006, 9.10 (test 2M10), or the TMA method specified in IEC 61189-2:2006, 9.11 (test 2M11).

6.5.1.2 Report of the results

The report shall include:

a) measurement method;

b) rate of temperature rise;

c) glass transition temperature.

6.5.2 Coefficient of linear thermal expansion

6.5.2.1 Test method

The coefficient of linear thermal expansion shall be measured using the method as specified in ISO 11359-2 or an equivalent method.

6.5.2.2 Measurement conditions

Measurement conditions such as the measuring of the temperature range, heating rate, surrounding atmosphere, gas flow rate, are dependent on the specimen characteristics, and shall be specified in the product specification.

6.5.2.3 Conditioning atmosphere

According to ISO 11359-2:1999, 6.2, the conditioning atmosphere shall be as specified in ISO 291. However, if a modification of the condition is required to the characteristics of the material, the conditioning atmosphere may be determined by agreement between user and supplier.

6.5.2.4 Report of the results

The report shall include the following items:

a) coefficient of linear thermal expansion;
b) conditioning atmosphere;
c) measuring temperature range;
d) heating rate;
e) surrounding atmosphere;
f) gas flow rate, etc.

6.5.3 Dimensional stability

6.5.3.1 Dimensional stability (heating)

6.5.3.1.1 Test method

Dimensional stability (heating) shall be measured using the method specified in IEC 61189-2:2006, 12.1 (test 2X02) or the method agreed between user and supplier.

6.5.3.1.2 Test conditions

Test conditions shall be as specified in IEC 61189-2:2006, 12.1 (test 2X02). Processing temperature and time may be modified as agreed between user and supplier.

6.5.3.1.3 Report of the results

The report shall include:

a) results of the dimensional stability;
b) specimen dimensions;
c) processing temperature and processing time.

6.5.3.2 Dimensional stability (humidity)

Under consideration.

6.5.4 Relative temperature index (RTI)

6.5.4.1 Test method

The relative temperature index (RTI) shall be determined by the procedures as specified in IEC 60216-5 and IEC 60216-3, using the data obtained by the method defined in IEC 60216-1. If there is agreement between user and supplier, the method specified in IEC 60216-6 shall be used.

NOTE The method specified in IEC 60216-2 is called the "temperature fixed method", and the method specified in IEC 60216-6 is called the "time fixed sampling method". There is almost no difference between the results obtained by each measuring method.

According to the recommendation described in IEC 60216-2, the property to determine RTI shall be specified in the product specification. Tensile strength and/or electric strength should be selected to determine RTI. Unless otherwise specified, the evaluation method of the selected property (properties) shall be the respective method specified in this document. If special conditioning is necessary, the product specification shall specify the conditions.

The reference material shall be selected according to ISO 2578:1993, 4.4.

6.5.4.2 Test apparatus

The ageing oven shall be as specified in IEC 60216-1:2013, 5.6, or it shall be able to hold the exposure temperature within the tolerance as specified in the product specification. Unless otherwise specified, the oven type as specified in IEC 60216-4-1 shall be used.

6.5.4.3 Test conditions

According to the requirements specified in IEC 60216-1:2013, 5.5, the exposure temperatures shall be selected as appropriate to the specimen and shall be specified in the product specification.

The exposure temperatures should be four or more. The lowest temperature shall be selected so that time to end-point will be more than 5 000 h. The highest temperature shall be selected so that time to end-point will be less than 500 h.

The atmospheric conditions during exposure shall be according to IEC 60216-1:2013, 5.7.2. However, if special atmospheric conditions are required depending on the characteristics of the specimen, the atmospheric conditions shall be as specified in the product specification.

The method of determining the end-point shall be according to IEC 60216-1:2013, 5.2.

If the product specification so specifies, the evaluation shall be made before reaching the end-point or at the time the end-point is reached.

6.5.4.4 Test specimens

Specimen preparation shall be as specified in the product specification.

6.5.4.5 Conditioning atmosphere

The conditioning atmosphere shall be as specified in the product specification.

6.5.4.6 Test conditions

The test conditions shall follow the product specifications.

Atmospheric conditions during ageing shall be as specified in the product specification.

6.5.4.7 Calculation and expression of RTI

The relative temperature index shall be calculated using the formula TIr + (T_A – T_B) from the temperatures obtained by extending the degradation function of the material to be evaluated (regression line) and the degradation function of the reference material for the time required in practice (20 000 h, 60 000 h, 100 000 h, etc.) (with T_A indicating the temperature of the material to be evaluated and T_B indicating the temperature of the reference material), and from the temperature index (TIr) of the reference material.

The relative temperature index shall be obtained using the temperatures (T_A for the specimen and T_B for the reference material) which are obtained by extrapolating the practical time (20 000 h, 60 000 h, 100 000 h) to the degradation function (regression line) of the specimen and the reference material, and temperature index of the reference material (TIr) as expressed by the formula TIr + (T_A – T_B).

6.5.4.8 Report of the results

The report shall include:

a) relative temperature index (RTI);

b) extrapolated temperatures;

c) property(ies) for determining the relative temperature index.

6.6 Optical properties

6.6.1 Method of testing the colour of the substrates

6.6.1.1 Outline

Subclauses 6.6.1.2 through 6.6.1.5 shall apply to transparent or nearly transparent materials.

6.6.1.2 Luminous transmittance

6.6.1.2.1 Measuring method

Luminous transmittance is expressed as total luminous transmittance, and shall be measured using the single-beam method as specified in ISO 13468-1, or the double-beam method as specified in ISO 13468-2, with the following details. If agreed upon between user and supplier (supplier and purchaser), another method which is recognized as equivalent may be used.

6.6.1.2.2 Measuring equipment

Measuring equipment shall be as specified in ISO 13468-1:1996, Clause 4, or ISO 13468-2:1999, Clause 4, as appropriate. Measuring equipment according to ISO 13655 and/or ISO 5-2 may be used.

6.6.1.2.3 Wavelength or wavelength range used in the test

Luminous transmittance shall be measured either at a particular wavelength or at a wavelength range, as agreed between user and supplier considering factors such as the material characteristics and application.

6.6.1.2.4 Report of the results

The report shall include the following items:

a) measuring method;

b) measuring wavelength;

c) specimen thickness;

d) luminous transmittance.

6.6.1.3 Chromaticity

6.6.1.3.1 Outline

According to ISO 11664-4, chromaticity is presented as the CIE (1976) $L^*a^*b^*$ colour space.

6.6.1.3.2 Measuring method

The measuring method shall be the reflected light method or the transmitted light method, depending on the application and the purpose.

If the reflected light method is used, a reflecting diffuser shall be placed on both the surface to be measured and the other surface, with the specimen in between.

The product specification shall specify the measuring method.

The reflecting diffuser shall be a perfect reflecting diffuser or a reference diffuser used for calibrating measuring equipment.

6.6.1.3.3 Measuring equipment and auxiliaries

The measuring equipment and light source shall be in accordance with at least one of the following: ISO 5-2, ISO 5-3, ISO 3664 or ISO 13655, and shall be specified in the product specification.

NOTE There is a measuring instrument which conforms to ISO 14981.

6.6.1.3.4 Expression of the results

The results shall be presented as the numerical values of each of the $L^*a^*b^*$ coordinate axes, or shall be plotted in the $L^*a^*b^*$ colour space. If agreed between user and supplier, the results may be presented instead by the numerical value of a specific coordinate axis or the numerical values of two specific coordinate axes of the $L^*a^*b^*$ colour space. In this case, the coordinate axis or axes concerned shall be clearly stated.

6.6.1.3.5 Report of the results

The report shall include the following items:

a) measuring instrument and light source;

b) measurement method (reflected light or transmitted light);

c) chromaticity (numerical values of each of the $L^*a^*b^*$ coordinate axes, plotted in the $L^*a^*b^*$ colour space, or the numerical value of a specific coordinate axis or numerical values of two specific coordinate axes of the $L^*a^*b^*$ colour space).

6.6.1.4 Uniformity of colour

6.6.1.4.1 Principle

Colour differences are obtained at 10 points on the specimen, and their average is evaluated by the difference between the standard chromaticity and standard deviation.

6.6.1.4.2 Measuring equipment

According to 6.6.1.3.

6.6.1.4.3 Illuminant

According to 6.6.1.3.

6.6.1.4.4 Measuring method

According to 6.6.1.3, chromaticity shall be measured at 10 points on a single specimen using the same instrument and under the same conditions. Five or more pairs of points are selected so that all 10 points are chosen. From the colour difference between each pair of points, the

mean colour difference, the difference between the reference chromaticity and the mean, and the standard deviation are calculated.

6.6.1.4.5 Calculation of colour difference

Colour difference is calculated using the colour difference formula based on the numerical values of each of the $L^*a^*b^*$ coordinate axes, or using the colour difference formula based on lightness, chroma, and hue.

The colour difference based on the $L^*a^*b^*$ colour system is calculated according to the following formula:

$$\Delta E^*_{ab} = \left[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2 \right]^{1/2}$$

where:

ΔE^*_{ab} is the colour difference based on the $L^*a^*b^*$ colour system;

ΔL^*, Δa^*, Δb^* are the difference in L^* and the difference in the colour coordinates a^* and b^* of the chromaticity between a pair of points obtained in 6.6.1.3.

The colour difference based on the luminosity, chroma, and hue is calculated according to the following formula:

$$\Delta E^*_{ab} = \left[(\Delta L^*)^2 + (\Delta C^*_{ab})^2 + (\Delta H^*_{ab})^2 \right]^{1/2}$$

where:

ΔE^*_{ab} is the colour difference based on the $L^*a^*b^*$ colour system;

ΔL^* is the difference in luminosity L^* of the chromaticity between a pair of points obtained in 6.6.1.3;

ΔC^*_{ab} is the difference in ab chroma of the chromaticity between a pair of points obtained in 6.6.1.3;

ΔH^*_{ab} is the difference in ab hue of the chromaticity between a pair of points obtained in 6.6.1.3.

The colour difference formula in CIE DE2000 (see CIE Publication No. 142) may also be used for calculating colour difference.

6.6.1.4.6 Report of the results

The report shall include the following items:

a) measuring instruments;

b) measurement method (reflected light or transmitted light);

c) standard chromaticity;

d) difference between the standard chromaticity and the mean, and standard deviation.

6.6.1.5 Spectrophotometric characteristics

6.6.1.5.1 Outline

Spectrophotometric characteristics are indicated as changes in the energy of the transmitted light or the reflected light against the wavelength of light. For example, they are represented in a chart with wavelength plotted on the horizontal axis and relative energy value at each wavelength on the vertical axis.

6.6.1.5.2 Measuring equipment

Spectrophotometric characteristics shall be measured using an instrument which conforms to one or more of the following: ISO 5-2, ISO 5-3, ISO 3664, or ISO 13655. A similar measuring instrument may be used. It is also possible to measure the total luminous flux using an integrating sphere, in which case, the measuring instrument specified in ISO 13468-1 or ISO 13468-2 or a similar instrument shall be used.

6.6.1.5.3 Measuring method

Transmitted light or reflected light may be used for measurement. The details of the measuring method shall be described in the product specifications.

6.6.1.5.4 Report of the results

The report shall include the following items:

a) measuring instruments;

b) measurement method (reflected light or transmitted light);

c) chart plotting the changes in the energy of the transmitted light and the reflected light against the wavelength (with the wavelength on the horizontal axis and relative energy at each wavelength on the vertical axis). The vertical axis may be used as an index which represents the distribution of light energy at different wavelengths. The vertical axis shall be labeled with the index used.

6.6.2 Refractive index

6.6.2.1 Measuring method

The refractive index shall be measured using method A (for measuring the refractive index using a refractometer) specified in ISO 489 or some other method.

6.6.2.2 Contacting liquid

A contacting liquid with a refractive index higher than that of the measured object and with a substrate which does not swell or dissolve as listed in ISO 489:1999, Table 1, shall be used.

6.6.2.3 Conditioning

Conditioning shall be performed at a temperature of 23 °C ± 2 °C and a relative humidity of (50 ± 10) % for 88 h or longer.

6.6.2.4 Report of the results

The report shall include the following items:

a) refractometer used, and the type of light source and wavelength;

b) refractive index;

c) dispersion (if applicable).

6.6.3 Retardation

Under consideration.

6.6.4 Luminous reflectance

6.6.4.1 Principle

Luminous reflectance is measured relative to a perfect white diffuser or the reference diffuser used for calibrating the measuring instrument.

NOTE Theoretically, measurement on a translucent plate which absorbs little light in the visible region results in the sum of the total luminous transmittance and the total luminous reflectance being almost 100 %. If such an ideal state is attained, the reflectance can be obtained by subtracting luminous transmittance from 100 % in 6.6.1.2. Subclause 6.6.4 specifies a method for measuring reflectance independently.

6.6.4.2 Measuring equipment

Luminous reflectance shall be measured using an equipment which conforms to one or more of the following: ISO 5-3, ISO 3664, and ISO 13655.

6.6.4.3 Illuminant

The illuminant shall be specified in the product specifications.

6.6.4.4 Measuring method

The measuring method shall be specified in the product specifications.

6.6.4.5 Report of the results

The report shall include the following items:

a) measuring instrument and light source;
b) reflectance.

6.6.5 Haze

6.6.5.1 Measuring method

Haze is measured using the method specified in ISO 14782. A similar method may be used as agreed between user and supplier.

6.6.5.2 Report of the results

The report shall include the following items:

a) thickness of the specimen;
b) type of light source;
c) haze.

6.7 Flammability

6.7.1 Outline

Flammability is evaluated in the vertical burning test. The vertical burning test is defined by method B specified in IEC 60695-11-10 or as follows. An evaluation method which has been confirmed to be equivalent may be used.

6.7.2 Test method

In principle, method B specified in IEC 60695-11-10 shall be used. However, if it cannot hold the specimen vertically and/or the specimen is off the flame due to insufficient thickness, deformation, or contraction, or the specimen bursts into flame up to the clamp, the vertical burning test for easily bent materials specified in ISO 9773 or a method which has been confirmed to be equivalent may be used to evaluate the specimen.

6.7.3 Report of the results

The report shall include the following items:

a) thickness of the specimen;