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Plastics — Polycarbonate sheets — Types, dimensions and characteristics

Plastiques — Feuilles en polycarbonate — Types, dimensions et caractéristiques

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 11963 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 11, *Products*.

Annex A forms an integral part of this International Standard.

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Plastics — Polycarbonate sheets — Types, dimensions and characteristics

1 Scope

1.1 This International Standard specifies the requirements for solid, flat extruded sheets of polycarbonate (PC) for general applications. It applies specifically to sheets made of poly-(*p*,*p*′-isopropylidenediphenyl carbonate). The sheets may be coloured or colourless, and they may be transparent, translucent or opaque. The sheets may also have a special weather-protective layer on one or both surfaces.

1.2 This International Standard applies only to thicknesses equal to or greather than 1,5 mm.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 62:1980, *Plastics — Determination of water absorption.*

ISO 75-1:1993, *Plastics — Determination of temperature of deflection under load — Part 1: General test method.*

ISO 75-2:1993, *Plastics — Determination of temperature of deflection under load — Part 2: Plastics and ebonite.*

ISO 179:1993, *Plastics — Determination of Charpy impact strength.*

ISO 291:1977, *Plastics — Standard atmospheres for conditioning and testing.*

ISO 306:1994, *Plastics — Thermoplastic materials — Determination of Vicat softening temperature (VST).*

ISO 489:1983, *Plastics — Determination of the refractive index of transparent plastics.*

ISO 527-1:1993, *Plastics — Determination of tensile properties — Part 1: General principles.*

ISO 527-2:1993, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics.*

ISO 1183:1987, *Plastics — Methods for determining the density and relative density of non-cellular plastics.*

ISO 2818:1994, *Plastics — Preparation of test specimens by machining.*

ISO 2859-0:—[1], *Sampling procedures for inspection by attributes — Part 0: Introduction to the ISO 2859 attribute sampling system.*

ISO 2859-1:1989, *Sampling procedures for inspection by attributes — Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection.*

1) To be published.

ISO 4607:1978, *Plastics — Methods of exposure to natural weathering.*

ISO 4892-1:1994, *Plastics — Methods of exposure to laboratory light sources — Part 1: General guidance.*

ISO 4892-2:1994, *Plastics — Methods of exposure to laboratory light sources — Part 2: Xenon-arc sources.*

ISO 7391-1:1987, *Plastics — Polycarbonate moulding and extrusion materials — Part 1: Designation.*

ISO 8256:1990, *Plastics — Determination of tensile-impact strength.*

ISO 10350:1993, *Plastics — Acquisition and presentation of comparable single-point data.*

ISO 13468-1:—[1], *Plastics — Determination of the total luminous transmittance of transparent materials — Part 1: Single-beam instrument.*

IEC 93:1980, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials.*

CIE 15.2:1986, *Colorimetry.*

CIE 85:1989, *Solar spectral irradiance.*

EN 2155-9:1989, *Aerospace series — Test methods for transparent materials for aircraft glazing — Part 9: Determination of haze.*

3 Composition

3.1 The following type of PC is preferred for PC sheet extrusion:

Thermoplastics ISO 7391-PC,E,61-09

(see ISO 7391-1 for explanation of designation system for PC)

3.2 The sheet may contain colorants, additives, processing aids and stabilizers (e.g. UV-absorbers) up to a total content of 5 %.

3.3 Sheets of the type specified in clause 4 may have a protective layer (on one or both surfaces) with a UV-absorber content higher than that of the substrate. The composition of the protective layer (e.g. polycarbonate and UV-absorber, or PMMA and UV-absorber, or other materials) and the application techniques (e.g. co-extrusion, coating, lamination, flow-coating, dipping) are not specified by this International Standard.

4 Requirements

4.1 Masking

The surface of the sheet as delivered shall be protected by plastics film or paper or a combination of both.

4.2 Appearance

Requirements concerning defects and optical quality shall be agreed upon between the interested parties.

4.3 Colour

The colorant(s) shall be homogeneously and uniformly distributed throughout the material, unless specified differently. For critical requirements, the degree of homogeneity shall be specified by the interested parties.

4.4 Dimensions

4.4.1 Conditions of measurement

Measurements should preferably be made under the standard conditions 23 °C ± 2 °C and (50 ± 5) % relative humidity. For measurements made under ambient conditions, due allowance shall be made for dimensional changes due to the differences in temperature and relative humidity at the place of measurement from the preferred temperature and relative humidity.

4.4.2 Length and width

The length and width of the sheets shall be agreed upon between the interested parties. The tolerances on length and width shall be as specified in table 1.

Table 1 — Tolerances on length and width

Length or width mm	Tolerance
Up to 1 000	$^{+3}_{0}$ mm
From 1 001 to 2 000	$^{+6}_{0}$ mm
From 2 001 to 3 000	$^{+9}_{0}$ mm
3 001 and over	$^{+0,3}_{0}$ %

4.4.3 Deviation of shape from rectangular

The difference Δl between the lengths of the two diagonals of the rectangular sheet shall be less than $3{,}5 \times 10^{-3} \times b$ (where b is the width, in millimetres, of the sheet, measured perpendicular to the direction of extrusion), but need not be less than 2 mm.

4.4.4 Thickness

The tolerance on the thickness of the sheets shall be as specified in table 2.

Table 2 — Tolerances on thickness

Thickness, d mm	Tolerance %
$1{,}5 \leqslant d \leqslant 5$	± 10
$5 < d$	± 5

4.5 Shrinkage

The maximum shrinkage (see 5.5.3) shall be as specified in table 3.

Table 3 — Maximum shrinkage

Thickness, d mm	Max. shrinkage %
$1{,}5 \leqslant d \leqslant 5$	10
$5 < d$	5

4.6 Basic properties

The basic mechanical, thermal and optical properties of transparent, colourless sheets shall be as specified in table 4. For other grades, the required properties shall be agreed upon between the interested parties.

4.7 Weathering behaviour

Any requirements on natural- or artificial-weathering behaviour shall be agreed upon between the interested parties, as required.

4.8 Other properties

Other properties of transparent, colourless sheets, needed for specific applications, shall be agreed upon between the interested parties. Examples of, and test methods for, such properties are presented in table 5.

For other grades, the required properties shall be agreed upon between the interested parties.

5 Test methods

5.1 General

5.1.1 Sampling

The sampling procedure shall be agreed upon between the interested parties. The procedures described in ISO 2859-0 and ISO 2859-1 are widely accepted and frequently used. Hence these are recommended for sampling.

5.1.2 Conditioning and testing of specimens

Conditioning (48 h) and testing of specimens shall be carried out at 23 °C ± 2 °C and (50 ± 5) % relative humidity, in accordance with ISO 291, except for the Vicat softening temperature and the temperature of deflection under load (see 5.5.1 and 5.5.2).

5.1.3 Preparation of specimens

Specimens shall be prepared, wherever applicable, in accordance with the procedures described in ISO 2818. When it is necessary to machine the sheet to reduce its thickness to the dimension required for a particular test method, one original surface shall be left intact.

With PC sheets coated on one side, the coated side shall remain unmachined. With PC sheets coated on both sides, two groups of specimens shall be prepared. One group shall retain one of the original coated sides and the other group the other original coated side. The two groups shall be tested separately.

5.2 Colour

Colour differences between a reference material (standard) and the specimens shall be determined using a differential colorimetric instrument, as agreed between the parties concerned: e.g. CIELAB data (CIE 15.2) may be used.

5.3 Dimensions

5.3.1 The length and width of the sheets shall be measured to the nearest 1 mm.

Table 4 — Requirements on basic properties

	Unit	Test method	Type of specimen	Required value	Subclause
Mechanical properties					
Tensile stress at yield, σ_y	MPa	ISO 527-2/1A/50 ISO 527-2/1B/50	1A 1B	⩾ 55	5.4.1
Modulus of elasticity in tension, E_t	MPa	ISO 527-2/1A/1 ISO 527-2/1B/1	1A 1B	⩾ 2 200	5.4.1
Nominal tensile strain at break, ε_{tB}	%	ISO 527-2/1A/50 ISO 527-2/1B/50	1A 1B	⩾ 60	5.4.1
Charpy impact strength (notched, notch radius 0,25 mm; method 1eA; thickness ⩾ 4 mm)	kJ/m^2	ISO 179	1	⩾ 6	5.4.2
Tensile impact strength (double-notched; method A; thickness < 4 mm)	kJ/m^2	ISO 8256	1	⩾ 150	5.4.2
Thermal properties					
Vicat softening temperature	°C	ISO 306, method B		⩾ 145	5.5.1
Temperature of deflection under load (thickness ⩾ 3 mm)	°C	ISO 75-2, method A		⩾ 130	5.5.2
Optical properties					
Light transmittance, τ_t (380 nm to 780 nm) Thickness 1,5 mm 4 mm 6 mm 12 mm	%	ISO 13468-1		 ⩾ 85 ⩾ 82 ⩾ 80 ⩾ 75	5.6

Table 5 — Typical values of other properties of transparent, colourless sheets

	Unit	Test method	Typical value
Density	g/cm^3	ISO 1183, method A	1,2
Thermal coefficient of expansion	K^{-1}	ISO 10350, table 2	65×10^{-6}
Refractive index, n_D^{20}	—	ISO 489, method A	1,59
Haze (3 mm)	%	EN 2155-9	1
Surface resistivity	Ω	IEC 93	10^{15}
Water absorption (pre-conditioning: 50 °C/24 h; immersion time in water: 24 h)	mg	ISO 62, method 1	16

5.3.2 The thickness of the sheets shall be measured to the nearest 0,05 mm, excluding the masking film or paper, and without damaging the surface. Measurements shall be made at points not less than 100 mm from the sheet edge.

5.4 Mechanical properties

5.4.1 Tensile properties shall be determined in accordance with ISO 527-1 and ISO 527-2, using specimen type 1A or 1B. The test speed for tensile stress at yield and nominal strain at break shall be 50 mm/min and for the modulus of elasticity in tension 1 mm/min.

5.4.2 When the sheet thickness is greater than or equal to 4 mm, the Charpy notched impact strength shall be determined in accordance with ISO 179, method 1eA (edgewise), using a notched bar (80 mm × 10 mm × d mm, V-notch, radius 0,25 mm), where d is equal to the sheet thickness.

If the thickness is less than 4 mm, the tensile impact strength shall be determined using a double V-notch (notch radius 1 mm) in accordance with ISO 8256 (specimen type 1, method A).

The notched impact strength shall be measured with specimens taken parallel and perpendicular to the extrusion direction.

NOTE 1 These two different tests are required because, when determining the notched impact strength to ISO 179 (Charpy), extruded PC shows a tough/brittle transition in the range of approx. 2,5 mm and 3,5 mm thickness, which gives rise to large deviations in measurements made in this range.

5.5 Thermal properties

5.5.1 The Vicat softening temperature shall be determined in accordance with ISO 306, method B, indenting the original surface. The rate of heating shall be 50 °C/h.

Prior to the test, the specimens shall be conditioned at 80 °C ± 2 °C for 16 h and allowed to cool to room temperature in a desiccator.

5.5.2 The temperature of deflection under load shall be determined in accordance with ISO 75-1 and ISO 75-2, method A. Prior to the test, the specimens shall be conditioned at 80 °C ± 2 °C for 16 h and allowed to cool to room temperature in a desiccator.

If the sheet thickness is less than 3 mm, this requirement shall not apply.

5.5.3 The change in dimensions at elevated temperature (shrinkage) shall be determined in accordance with the method described in annex A of this International Standard.

5.6 Optical properties

The light transmittance τ_t shall be determined in accordance with ISO 13468-1 by using an integrating sphere on specimens of original thickness.

5.7 Weathering behaviour

5.7.1 Natural weathering

Natural-weathering performance, when needed, shall be determined using ISO 4607.

5.7.2 Artificial-weathering tests

Artificial weathering, when required, shall be carried out in accordance with ISO 4892-1 and ISO 4892-2 with a filtered xenon lamp with a spectral intensity distribution recommended by CIE 85, at a black-standard temperature of 65 °C ± 3 °C, at (65 ± 5) % relative humidity and with a wet/dry cycle of 18 min/102 min.

The pass/fail criteria to be determined by artificial weathering shall be agreed upon between the interested parties.

NOTES

2 Because of the special photochemical degradation mechanism of PC, the result of accelerated weathering depends very much on the light source, especially in the UV range. No light of wavelength less than 300 nm may be present.

3 A very good correlation between natural and accelerated weathering, even over a long time of exposure, is given by the specified procedure.

6 Reaction to fire

Testing of reaction to fire, when needed, shall be agreed upon between the interested parties. Above all, the national laws of the countries in which the suppliers and customers are situated shall be considered.

7 Use in contact with food

If PC sheets are intended for use in food-contact applications, the special requirements shall be agreed upon between the interested parties in every case. Above all, the national laws of the countries in which the suppliers and users are situated shall be considered.

8 Retest and rejection

If any failure occurs, the material may be retested by agreement between the interested parties.

Annex A
(normative)

Determination of change in dimensions at elevated temperature (shrinkage)

A.1 Cut two specimens 150 mm square (one side parallel to the extrusion direction) from the sample sheet in areas approximately equally spaced across the width of the sample. Mark on each sample the direction of extrusion and mark with a pair of compasses a circle measuring 100 mm ± 1 mm across. Dry the specimens at 90 °C for 24 h and then allow them to cool to room temperature in a desiccator at 18 °C to 28 °C (in cases of dispute, 23 °C ± 2 °C). Measure the diameter of the circle, parallel and perpendicular to the extrusion direction, to the nearest 0,05 mm.

A.2 Place the specimens horizontally on a plane plate, and put them on a shelf in an oven at a controlled temperature of 190 °C ± 2 °C. To avoid sticking of the specimens, use a plate coated with an anti-sticking layer, e.g. polytetrafluoroethylene. The heating period, depending on the thickness of the sheet, shall be as follows:

Thickness, d mm	**Time** min
$1{,}5 \leqslant d \leqslant 5$	60
$5 < d$	75

The water contained in the sheet may produce too many bubbles — a few are allowed — and foaming of the sample may even occur during heating. If so, the test shall be repeated with an additional (pre-drying) stage, using the following conditions:

Pre-drying temperature:	90 °C
Pre-drying time:	$2 \times d^2$ hours, where d is the thickness of the specimens in millimetres.

A.3 Allow the specimens to cool to room temperature in a desiccator at 18 °C to 28 °C (in cases of dispute, 23 °C ± 2 °C) and measure the diameter of the circle, parallel and perpendicular to the extrusion direction, again to the nearest 0,05 mm.

A.4 Calculate the change in diameter (shrinkage) S for each specimen as a percentage of the initial value, using the equation:

$$S = \frac{l_0 - l}{l_0} \times 100$$

where

l_0 is the diameter after drying;

l is the diameter after heating.

Calculate the average percentage change for the two specimens parallel and perpendicular to the extrusion direction.

A.5 Report the presence of bubbles or cracks and any other changes in the appearance of the specimens.