

BS EN 16153:2013+A1:2015



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Light transmitting flat multiwall polycarbonate (PC) sheets for internal and external use in roofs, walls and ceilings — Requirements and test methods

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National foreword

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

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English Version

Light transmitting flat multiwall polycarbonate (PC) sheets for
internal and external use in roofs, walls and ceilings -
Requirements and test methods

Plaques d'éclairage multiparois et planes en
polycarbonate (PC) pour usage intérieur ou extérieur dans
les toitures, bardages et plafonds - Exigences et méthodes
d'essai

Lichtdurchlässige, flache Stegmehrfachplatten aus
Polycarbonat (PC) für Innen- und Außenanwendungen an
Dächern, Wänden und Decken - Anforderungen und
Prüfverfahren

This European Standard was approved by CEN on 5 February 2013 and includes Amendment 1 approved by CEN on 24 November 2014.

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Foreword

This document (EN 16153:2013+A1:2015) has been prepared by Technical Committee CEN/TC 128 “Roof covering products for discontinuous laying and products for wall cladding”, the secretariat of which is held by NBN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2015, and conflicting national standards shall be withdrawn at the latest by December 2016.

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

This document includes Amendment 1, approved by CEN on 2014-11-24.

This document supersedes EN 16153:2013.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A1** **A1**.

A1 This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of the EU Construction Products Regulation 305/2011.

For relationship with the EU Regulation 305/2011, see informative Annex ZA, which is an integral part of this document. **A1**

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This document describes the requirements for light transmitting flat multiwall PC sheets for internal and external use in walls, roofs and ceilings.

It is applicable to the sheets for the delivery only. Reference should be made to national regulations and manufacturer's literature for requirements concerning the design, storage and fundamental guidance for installation of sheets, including all safety aspects.

The standards and guideline addressing light transmitting flat multiwall PC sheets for building applications are the following:

- EN 1873, *Prefabricated accessories for roofing — Individual roof lights of plastics — Product specification and test methods* (harmonised standard)
- EN 14963, *Roof coverings — Continuous rooflights of plastics with or without upstands — Classification, requirements and test methods* (harmonised standard)
- EOTA ETA-Guideline 010, *Self supporting translucent roof kits*

The multiwall PC sheets that satisfy the requirements of this document are suitable for use as components in accordance with EN 1873, EN 14963 or EOTA ETA-Guideline 010.

1 Scope

This European Standard specifies the requirements for light transmitting flat multiwall polycarbonate (PC) sheets for internal and external use in walls, roofs and ceilings.

This European Standard applies to light transmitting flat extruded multiwall PC sheets with or without functional layers (e.g. coating, co-extruded layer) made from PC-based or other materials, without filling materials.

It also specifies the test methods needed for the evaluation of conformity and marking of the sheets.

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.

EN 410:2011, *Glass in building — Determination of luminous and solar characteristics of glazing*

EN 673, *Glass in building — Determination of thermal transmittance (U value) — Calculation method*

EN 674, *Glass in building — Determination of thermal transmittance (U value) — Guarded hot plate method*

EN 1990:2002, *Eurocode — Basis of structural design*

EN 1873:2005, *Prefabricated accessories for roofing — Individual roof lights of plastics — Product specification and test methods*

EN 1995-1-1, *Eurocode 5: Design of timber structures — Part 1-1: General — Common rules and rules for buildings*

EN 13501-1, *Fire classification of construction products and building elements — Part 1: Classification using data from reaction to fire tests*

EN 13501-2, *Fire classification of construction products and building elements — Part 2: Classification using data from fire resistance tests, excluding ventilation services*

EN 13501-5, *Fire classification of construction products and building elements — Part 5: Classification using data from external fire exposure to roofs tests*

EN 13823, *Reaction to fire tests for building products — Building products excluding floorings exposed to the thermal attack by a single burning item*

EN 14500:2008, *Blinds and shutters — Thermal and visual comfort — Test and calculation methods*

EN 14963:2006, *Roof coverings — Continuous rooflights of plastics with or without upstands — Classification, requirements and test methods*

EN ISO 178, *Plastics — Determination of flexural properties (ISO 178)*

EN ISO 291, *Plastics — Standard atmospheres for conditioning and testing (ISO 291)*

EN ISO 472:2013, *Plastics — Vocabulary (ISO 472:2013)*

EN ISO 717-1, *Acoustics — Rating of sound insulation in buildings and of building elements — Part 1: Airborne sound insulation (ISO 717-1)*

EN ISO 899-2, *Plastics — Determination of creep behaviour — Part 2: Flexural creep by three-point loading (ISO 899-2)*

EN ISO 1043-1:2011, *Plastics — Symbols and abbreviated terms — Part 1: Basic polymers and their special characteristics (ISO 1043-1:2011)*

EN ISO 1716, *Reaction to fire tests for products — Determination of the gross heat of combustion (calorific value) (ISO 1716)*

EN ISO 4892-2:2006, *Plastics — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps (ISO 4892-2:2006)*

EN ISO 6603-1, *Plastics — Determination of puncture impact behaviour of rigid plastics — Part 1: Non-instrumented impact testing (ISO 6603-1)*

EN ISO 10077-2, *Thermal performance of windows, doors and shutters — Calculation of thermal transmittance — Part 2: Numerical method for frames (ISO 10077-2)*

EN ISO 10140-1:2010, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 1: Application rules for specific products (ISO 10140-1:2010)*

EN ISO 10140-2, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 2: Measurement of airborne sound insulation (ISO 10140-2)*

EN ISO 10140-4, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 4: Measurement procedures and requirements (ISO 10140-4)*

EN ISO 10140-5, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 5: Requirements for test facilities and equipment (ISO 10140-5)*

EN ISO 11664-1, *Colorimetry — Part 1: CIE standard colorimetric observers (ISO 11664-1)*

EN ISO 11664-2, *Colorimetry — Part 2: CIE standard illuminants (ISO 11664-2)*

EN ISO 11925-2, *Reaction to fire tests — Ignitability of products subjected to direct impingement of flame — Part 2: Single-flame source test (ISO 11925-2)*

EN ISO 12572, *Hygrothermal performance of building materials and products — Determination of water vapour transmission properties (ISO 12572)*

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

EOTA ETA-Guideline 010, *Self Supporting Translucent roof Kits*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 472:2013, EN ISO 1043-1:2011 and the following apply.

3.1.1

PC sheet

extruded sheet substantially made of polycarbonate polymer to which are added those additives to facilitate the manufacture of sheet conforming to the requirements of this standard and customer requirements

Note 1 to entry: Additives can be e.g. lubricants, processing aids, UV absorbers, colorants, functional layers or flame retardants.

Note 2 to entry: There is a distinction between a coloured sheet containing colorants and an uncoloured sheet having a coloured functional layer or paint on the external surfaces.

3.1.2

multiwall PC sheet

flat PC sheet with two parallel outside walls, internal parallel or non-parallel walls generally connected by vertical or non-vertical ribs or other internal features

3.1.3

multiwall PC sheet with symmetrical in-plane cross-section

multiwall PC sheet having, perpendicularly to the extrusion direction, symmetrical geometrical shape and material distribution relatively to a median plane

Note 1 to entry: Examples of typical sheets with symmetrical in-plane cross-section are given in Figure 1.

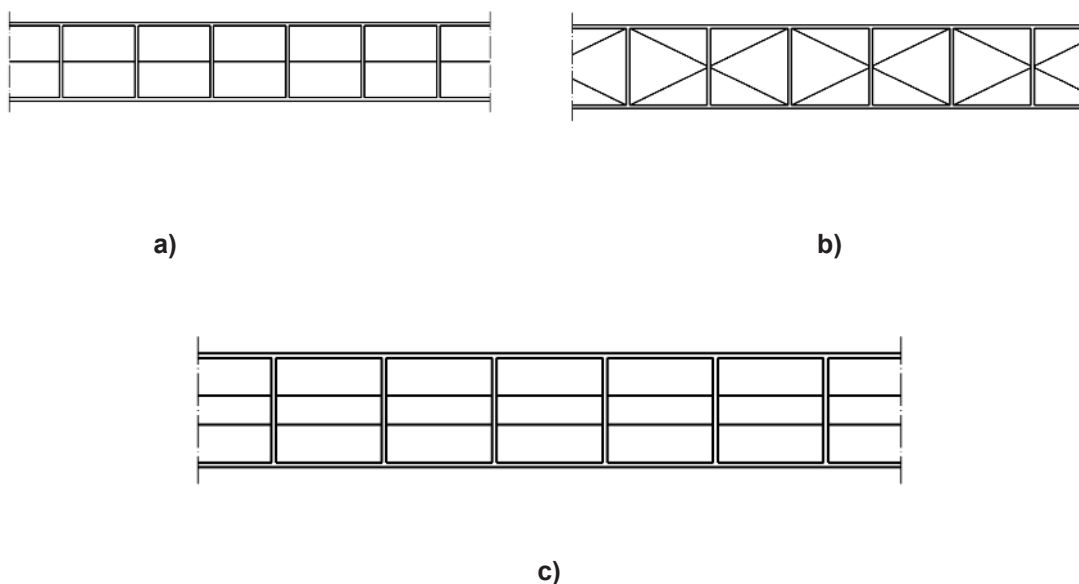


Figure 1 — Typical sheets with symmetrical in-plane cross-section

3.1.4

multiwall PC sheet with symmetrical in-plane mirror

multiwall PC sheet having perpendicularly to the extrusion direction, symmetrical geometrical shape and material distribution relatively to a plane-mirror located parallel to one of both outer surfaces and lateral movement

Note 1 to entry: An example of typical sheets with symmetrical in-plane mirror is given in Figure 2.

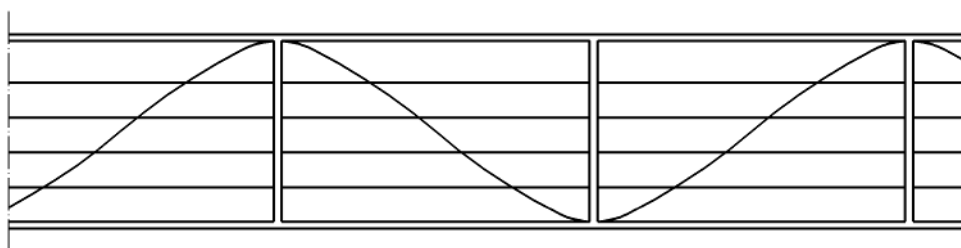


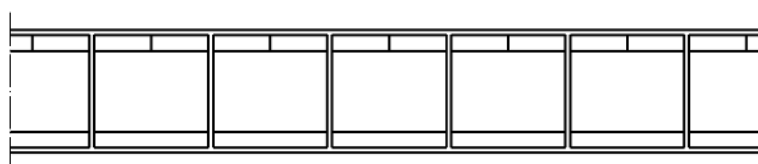
Figure 2 — Typical sheet with symmetrical in-plane mirror

3.1.5

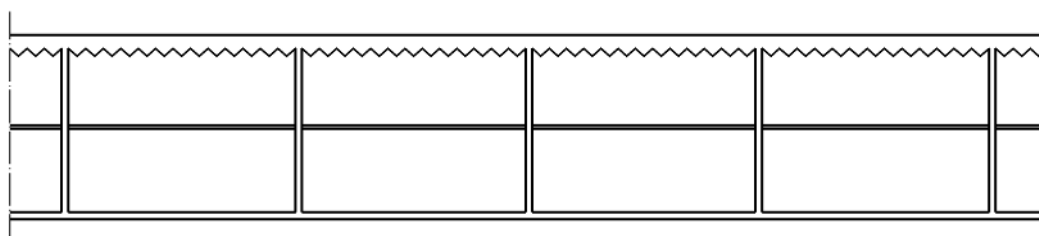
multiwall PC sheet with unsymmetrical geometry

multiwall PC sheet which does not comply with the definitions given in 3.1.3 and 3.1.4

Note 1 to entry: Examples of typical sheets with unsymmetrical geometry are given in Figure 3.



a)



b)

Figure 3 — Typical sheets with unsymmetrical geometry

3.1.6

indirect test

IT

test performed by the manufacturer, different from that specified for that particular characteristic, having verified its correlation with the specified test

3.1.7

sheet length

dimension of a sheet in the extrusion direction, parallel to the cells

Note 1 to entry: It is expressed in millimetres (mm).

3.1.8

sheet width

W_s

dimension of a sheet perpendicular to the extrusion direction

Note 1 to entry: It is expressed in millimetres (mm).

3.1.9

x-direction

extrusion direction corresponding to the length of a sheet

3.1.10

y-direction

direction perpendicular to the x-direction of a sheet in the sheet plane

3.1.11

overall sheet thickness

h

total thickness of a sheet

Note 1 to entry: It is expressed in millimetres (mm).

3.1.12

width

b

width of a test specimen in x-direction testing or length of a test specimen in y-direction testing

Note 1 to entry: It is expressed in millimetres (mm).

Note 2 to entry: For the purposes of bending tests in 5.6.

3.1.13

span

L

initial distance between lines of contact between the test specimen and the test specimen supports

Note 1 to entry: It is expressed in millimetres (mm).

Note 2 to entry: For the purposes of bending tests in 5.6.3 and 5.6.4.

3.1.14

cross-head span

L_c

distance between the cross-head loading points

Note 1 to entry: It is expressed in millimetres (mm).

Note 2 to entry: For the purposes of the four-point bending test in 5.6.4.2.

3.1.15

cell size

w_c

dimension of the smallest geometric unit of a sheet, perpendicular to the extrusion direction, which is repeated across the sheet structure

Note 1 to entry: It is expressed in millimetres (mm).

Note 2 to entry: Examples of typical cells geometry are given in Figure 4.

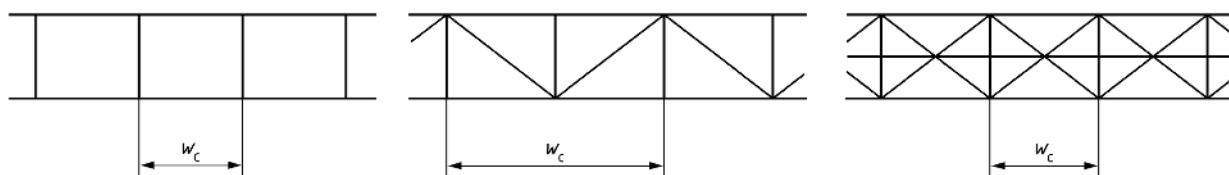


Figure 4 — Typical cell geometry

3.2 Symbols

For the purposes of this document, the symbols and the relevant subclauses are given in Table 1.

Table 1 — Symbols

Symbols	Term/definition	Relevant subclause
a_1	Out of squareness of a sheet	5.1.11
a_2	Out of squareness of a sheet	5.1.11
b	Either width of a test specimen in x-direction testing or length of a test specimen in y-direction testing	5.6.3 and 5.6.4
c	Lateral curvature of a sheet	5.1.12
B_x	Bending stiffness in x-direction	5.6.3
B_y	Bending stiffness in y-direction	5.6.3
d_1	Flatness across the sheet width	5.1.10
d_2	Flatness across the sheet width	5.1.10
F	Applied force	5.6.4
F_b	Maximum applied force corresponding to buckling	5.6.4
F_x	Applied force for test in x-direction	5.6.3
F_y	Applied force for test in y-direction	5.6.3
g	Total solar energy transmittance	4.4; 5.2
h	Overall sheet thickness	Whole document
h_e	External heat transfer coefficient	5.2.1
h_i	Internal heat transfer coefficient	5.2.1
L	Span	5.6
L_c	Cross-head span	5.6.4.2
L_{sp}	Length of a test specimen	5.1
L_x	Span for test in x-direction	5.6.3.3
L_y	Span for test in y-direction	5.6.3.3
M_b	Buckling moment	5.6.4
m	Mass of a test specimen	5.1.5; 5.1.6
o_s	Overhang	5.6.4.2; 5.6.4.3

Symbols	Term/definition	Relevant subclause
$\langle A_1 \rangle R_w(C; C_{tr}) \langle A_1 \rangle$	Sound reduction index	4.8; 5.7
R_1	Radius of the supports	5.6.4.2; 5.6.4.3
r	Flexural strain rate	5.6.3; 5.6.4.2; 5.6.4.3
S_y	Shear stiffness in y-direction	5.6.3.3
$\langle A_1 \rangle s_x \langle A_1 \rangle$	Deflection at mid-span	5.6.3.3
s	Deflection	5.6.4.2
s_{y1}	Deflection at mid-span Ly1	5.6.3.3
s_{y2}	Deflection at mid-span Ly2	5.6.3.3
U	Thermal transmittance	4.9
W_s	Sheet width	5.1
W_{sp}	Width of a test specimen	5.1
w_c	cell size	5.6.4.2; 5.6.4.3
YI	Yellowness index	4.6, 5.4
α	Linear thermal expansion	4.12
α_{e1}	Solar direct absorptance of the outer face	5.2.1.3
α_{e2}	Solar direct absorptance of the inner face	5.2.1.3
α_{pe}	Solar direct absorptance of one of both outside walls	5.2.1.3
δ	Water vapour permeability	4.10
ΔY	Variation of yellowness index	4.6, 5.4
λ	Thermal conductance between two virtual walls	5.2.1
ρ_a	Mass per unit area	5.1.5
ρ_d	Mass per unit area of a test specimen	5.1.6
ρ_e	Solar direct reflectance	5.2.1
ρ_{pe}	Solar direct reflectance of one of both outside walls	5.2.1
τ_e	Solar direct transmittance	4.3; 5.2.1
$\tau_{e,n-h}$	Normal-hemispherical solar transmittance (see 4.3, NOTE 1).	4.3
τ_{pe}	Solar direct transmittance of one of both outside walls	4.3; 5.2.1
τ_v	Light transmittance	4.3
$\tau_{v,n-h}$	Normal-hemispherical light transmittance (see 4.3, NOTE 1).	4.3

4 Requirements

4.1 Visual appearance

The sheets shall have regular and smooth surfaces. There shall be no scratches, marks or other defects larger than 4 mm² each anywhere on the sheet surface.

There shall be no obvious bubbles, inclusions, cracks, depressions or other defects anywhere in the sheet that could adversely affect the performance of the sheet in its intended application.

The edges of the sheet shall be straight and cut cleanly.

The colour distribution shall be visually uniform, unless otherwise specified.

For specific uses, further requirements concerning the visual aspects of the sheets might be considered.

4.2 Dimensions and mass per unit area and their tolerances

The dimensional tolerances and mass per unit area shall be assessed when subject to regulatory requirement.

When tested in accordance with the test methods specified in 5.1.1 to 5.1.12, the dimensional tolerances and mass per unit area of the sheets shall conform to the requirements given in Table 2.

The test methods given in Table 2 are used for initial type testing, and are the reference test methods. Any other indirect test method may be chosen provided that it is sufficiently accurate to ensure that the dimensions of the products meet the requirements of Table 2 and as far as a correlation is demonstrated with the concerned reference test method.

Table 2 — Requirements for dimensions and mass per unit area and their tolerances

Characteristic	Test method	Requirement
Overall sheet thickness	5.1.4	The nominal overall sheet thickness of the sheet shall be declared in millimetres. The overall sheet thickness at any point shall not vary by more than $\pm 0,5$ mm of this value.
Mass per unit area	5.1.5	The nominal mass per unit area of the sheet shall be declared in grams per square metre. The mass per unit area of a sheet shall be not less than 95 % of the declared nominal mass per unit area.
Variation of mass per unit area	5.1.6	The mass per unit area of each cut section across the width of the sheet shall not vary by more than ± 6 % from the calculated mean mass per unit area of the cut sections.
Sheet length	5.1.7	The sheet length shall be within the interval from: - 0 mm to +12 mm of the declared sheet length for sheet length up to 3 000 mm; - 0 % to +0,40 % of the declared sheet length for sheet length greater than 3 000 mm.
Sheet width	5.1.7	The sheet width shall be within the interval from – 2 mm to + 6 mm of the declared sheet width.
Deviation from rectangular shape (only for rectangular sheets)	5.1.8	The difference between the lengths of the two diagonals of the sheet shall be less than 0,5 % of the width of the sheet.
Wall and internal feature thickness	5.1.9	When required, the nominal wall and internal feature thicknesses and the tolerances shall be declared.
Sheet flatness	5.1.10	The deviation from flat across the width of the sheet shall be ≤ 5 mm per meter of width. The deviation from flat along the length of the sheet shall be ≤ 5 mm/linear metre.
Out of square	5.1.11	The deviation of squareness of the sheet shall be < 5 mm per meter of width.
Lateral curvature	5.1.12	The maximum distance between the straight edge and the side(s) of the sheet shall be < 5 mm/m.

4.3 Spectral characteristics

The spectral characteristics of multiwall PC sheets shall be assessed when subject to regulatory requirement.

The spectral characteristics of a multiwall PC sheet include the luminous and solar characteristics, $\overline{A}_V$ and the reflection and transmission characteristics $\overline{A}_T$.

The multiwall PC sheets are defined by their geometry, colour and mass per unit area. A change of one of these physical characteristics affects the spectral characteristics of a multiwall PC sheet.

The spectral characteristics shall be measured according to EN 14500 considering the samples cut from multiwall PC sheets as thick translucent samples (see EN 14500:2008, 6.3.2).

NOTE 1 The normal-hemispherical light transmittance, $\tau_{v,n-h}$, and the normal-hemispherical solar transmittance, $\tau_{e,n-h}$, as designated in EN 14500 correspond respectively to the light transmittance, τ_v , and the solar direct transmittance, τ_e , as designated in EN 410.

The test samples shall be of sufficient size to cover its structural aspects.

Test samples shall be clean and dry, unless otherwise specified. The storage and the cleaning procedures stated by the manufacturer shall be followed.

The spectral characteristics, i.e. the light transmittance, τ_v , and the solar direct transmittance, τ_e , shall be declared and subsequent measurements shall be within ± 5 absolute value (or units) of the declared values.

[A1] For a declared value of the light transmittance equal to 60 %, the actual light transmittance of a sheet may be included between 55 % and 65 %. **[A1]**

NOTE 2 The normal-hemispherical light transmittance, $\tau_{v,n-h}$, corresponds to the total luminous transmittance, τ_{D65} , as stated in EN 1873 and ETA-Guideline 010.

For unsymmetrical in-plan cross-section multiwall PC sheets, in the case where both sides of the sheets may be considered as an external surface, the reflectance measurements shall be carried out on each external face. In that case, the superscript “ ‘ ” shall be used to indicate for the reflectance factor of the opposite external face of the multiwall PC sheet from the first one.

4.4 Total solar energy transmittance

The total solar energy transmittance, g , as defined in EN 410 shall be determined either by calculation according to 5.2.1 or by measurement according to 5.2.2.

The calculation method is applicable only to multiwall PC sheets with symmetrical in-plane cross-section (see 3.1.3) or symmetrical in-plane mirror (see 3.1.4).

Where the calculation method is not applicable, then the total solar energy transmittance shall be measured.

4.5 Impact resistance

4.5.1 Small hard body impact resistance

The small hard body impact resistance shall be assessed when subject to regulatory requirement.

The small hard body impact resistance shall be evaluated by determining the impact behaviour according to 5.5.

Failure occurs when a crack or a break appears on the test specimen. White discolorations are not considered as cracks.

When ten test specimens taken from three sheets are submitted to the test, no failure shall occur.

4.5.2 Large soft body impact resistance

The resistance to large soft body impact depends very heavily on the method of installation and the roof system into which the light transmitting sheet is incorporated, rather than a property of the sheet itself.

The large soft body impact resistance of the same product is likely to be different when the same product is used in different roofing systems and/or installed with different methods of installation, and therefore cannot be declared for a particular product.

In the absence of an appropriate European test method for sheets, the manufacturer may declare the method of installation for each application, which shall consider the large soft body impact resistance. The

manufacturer shall assess the large soft body impact resistance separately in accordance with ETAG 010, EN 1873, EN 14963 or individual national safety requirements for each such application. The test report shall record the test method and the manufacturer's instructions for the installation.

NOTE At the date of publication of this document, the following national safety requirements have been identified: DS 1133:1987 [2] and ACR[M]001:2005 [1].

The user should not assume that the large soft body impact resistance for any one application shall apply to any other application or method of installation.

4.6 Durability

4.6.1 General

The durability shall be assessed when subject to regulatory requirement.

The durability of the sheets shall be demonstrated by testing after artificial ageing the variation of the yellowness index and the light transmittance with the same level of radiant exposure in the total daylight and declaring the results according to 4.6.2.

4.6.2 Classification according to the radiant exposure

The exposure to artificial ageing shall be carried out in accordance with 5.3 using one of the classes given in Table 3.

Table 3 — Artificial ageing classification

Class	Radiant exposure in the total daylight range (300 nm to 2 500 nm) GJ/m ²	Uncoloured sheets		Coloured sheets	
		Variation of yellowness index ΔYI absolute value (or unit)	Variation of light transmittance $\Delta \tau_v$ %	Variation of yellowness index ΔYI absolute value (or unit)	Variation of light transmittance $\Delta \tau_v$ %
ΔA	18	≤ 10	≤ 5	≤ 10	≤ 5
ΔD	18	Not applicable	Not applicable	≤ 20 ^a	≤ 10 ^a
ΔE	10	≤ 10	≤ 10	≤ 10	≤ 10
ΔF	10	Not applicable	Not applicable	≤ 20 ^b	≤ 10 ^b

^a A coloured sheet made from the same PC polymer as an uncoloured sheet classified ΔA and having the same UV protection shall be classified ΔD without further testing.

^b A coloured sheet made from the same PC polymer as an uncoloured sheet classified ΔE and having the same UV protection shall be classified ΔF without further testing.

In the case of an exposure to a radiant exposure greater than 18 GJ/m², the actual value may be declared by the manufacturer to allow the customer to determine the suitability of the sheets to exposure in areas where the conditions are particularly severe.

EXAMPLE An uncoloured sheet, with the following characteristics:

— $YI = 2$ before ageing and $YI \leq 12$ after ageing: $\Delta YI \leq 10$

— $\tau_v = 80$ % before ageing and $\tau_v \geq 75$ % after ageing: $\Delta \tau_v \leq 5$ %

is classified ΔA .

4.6.3 Variations of yellowness index and light transmittance after artificial ageing

To evaluate the durability, the variations of the yellowness index and light transmittance after artificial ageing shall be assessed when subject to regulatory requirement.

The variation of the yellowness index shall be determined in accordance with 5.4.

The variation of the light transmittance shall be determined in accordance with 5.2.

Either the separated UV-protected wall of a sheet or a thin UV-protected solid sheet shall be tested to assess the durability. The test specimen shall fulfil the following requirements:

- a) the thickness of test specimen shall be less than 1,5 mm, and
- b) the test specimen shall be representative of the lowest level of UV-protection provided by the concentration of UV absorbers and the layer thickness.

The sheets shall be classified into one of the four classes given in Table 3.

The variations of the yellowness index and of light transmittance shall be declared.

The yellowing behaviour of sheets is dependent on the performance of the UV-protected layer. Therefore, the correlation between levels of yellowing index and radiant exposure in the total daylight for its UV protection system shall be demonstrated.

These results shall be valid also for increased layer thicknesses or/and higher UV-absorber concentrations of a given UV-protection system. Different UV-protecting systems (e.g. containing different UV-absorbers) require testing on each system separately.

4.6.4 Variation of deformation behaviour

If the characteristics of a sheet conform to Table 3 for a declared class, the variation of the mechanical properties (deformation and breaking behaviour) after the corresponding exposure given in Table 3 is assumed to be less than 10 %.

Therefore, the sheet is in conformance with:

- a) the requirements of class Cu 1, as given in EN 14963:2006, Table 2, and EN 1873:2005, Table 2;
- b) the requirements of class Ku 1, as given in EN 14963:2006, Table 3, and EN 1873:2005, Table 3.

4.7 Deformation behaviour

The deformation behaviour shall be assessed when subject to regulatory requirement.

The deformation behaviour of the sheets shall be determined in accordance with 5.6.

The bending stiffness, B_x and B_y , the shear stiffness, S_y , and the buckling moment, M_b , shall be declared.

These values may be used for determining the behaviour of the sheets and for comparison of the results of full scale tests performed with other sheets.

4.8 Airborne sound insulation

The method(s) of installation shall consider the airborne sound insulation.

The sound reduction index, R_w (C;C_{tr}), of the multiwall sheets shall be assessed when subject to regulatory requirement.

The sound reduction index, R_w ($C;C_{tr}$), shall be measured in accordance with 5.7 and declared.

4.9 Thermal transmittance

The thermal transmittance, U value, shall be assessed when subject to regulatory requirement.

The thermal transmittance, U value, shall be either calculated in accordance with EN ISO 10077-2, using the definitions of EN 673, or measured according to EN 674, considering an horizontal and/or vertical thermal flow crossing normal to the faces of the multiwall sheets.

4.10 Water vapour permeability

The water vapour permeability, δ , shall be assessed when subject to regulatory requirement.

The standard value of the water vapour permeability, δ , of PC sheets is $3,8 \times 10^{-5}$ mg/m h · Pa and it shall be declared. When a better performance is sought for declaration, the water vapour permeability of the material used for the sheet shall be determined according to EN ISO 12572.

4.11 Water/air tightness

The water/air tightness shall be assessed when subject to regulatory requirement.

PC sheets are deemed to satisfy the water/air tightness requirement without the need for testing provided that there are no defects in the sheets. The absence of defects (e.g. holes) shall be evaluated by examination of visual appearance according to 4.1.

4.12 Linear thermal expansion

The linear thermal expansion, α , shall be assessed when subject to regulatory requirement.

The value of the coefficient of linear thermal expansion, α , of the PC material is 65×10^{-6} K⁻¹. When a higher performance is sought for declaration, the thermal expansion coefficient of the material used for the sheet shall be determined according to ISO 11359-2.

For practical purposes, the coefficient of linear thermal expansion is valid for temperatures in the range -20 °C to 70 °C.

4.13 Reaction to fire

The reaction to fire shall be assessed when subject to regulatory requirement.

The reaction to fire performance of the sheets shall be determined in accordance with 5.8 and declared by the manufacturer according to EN 13501-1.

4.14 External fire performance

External fire performance shall be assessed when subject to regulatory requirements.

The product shall be tested using the test method(s) as referred to and classified in accordance with EN 13501-5. The products to be tested shall be installed, in addition to the general provisions given in the relevant test method, in a manner representative of their intended end use.

4.15 Resistance to fire

Resistance to fire shall be assessed when subject to regulatory requirements.

The product shall be tested using the test method(s) as referred to and classified in accordance with EN 13501-2.

In general, the product cannot be classified. "No performance determined" (NPD) should therefore be used.

Where required by a particular test method, and in addition to any specific requirements in that test method, the product shall be mounted and fixed for testing in a manner representative of its intended end use.

4.16 Net heat of combustion

The value of the net heat of combustion for PC polymer is 29,8 MJ/kg. When a better performance is sought for declaration, the net heat of combustion of the material used for the sheet shall be determined according to EN ISO 1716.

4.17 Presence of functional layers

The manufacturer shall declare the presence and function of layers (coating, co-extruded layer, etc.), if relevant.

The side(s) of the sheet with the functional layer(s) shall be indicated.

NOTE The functional layer (UV protected layer) is typically on the exposed face of the sheet.

4.18 Dangerous substances

National regulations on dangerous substances may require verification and declaration on release, and sometimes content, when construction products covered by this standard are placed on those markets.

In the absence of European harmonised test methods, verification and declaration on release/content should be done taking into account national provisions in the place of use.

NOTE An informative database covering European and national provisions on dangerous substances is available at the Construction web site on EUROPA accessed through: <http://ec.europa.eu/enterprise/construction/cpd-ds/>.

4.19 Resistance to fixings

The principles of fixing of the sheets shall be declared.

The method(s) of installation shall consider resistance to wind loads, snow loads and resistance to large soft body impact which may be assessed separately, e.g. in accordance with the requirements given in EN 14963, EN 1873, ETAG 010, or individual safety national requirements.

4.20 Temporary protective coverings

For shipping and handling, the surfaces of the sheets, as delivered, may be protected by suitable materials, e.g. a polyethylene film, which is removable without causing surface contamination or damage.

5 Test and calculation methods

5.1 Dimensional tolerances and mass per unit area

5.1.1 General

The measurements shall be carried out at an ambient temperature of $(20 \pm 5) ^\circ\text{C}$. In case of dispute, the measurements shall be made using standard atmosphere 23/50, Class 2, according to EN ISO 291. For measurements made under ambient conditions, due allowance shall be made for dimensional changes due to the differences in temperature and relative humidity between test locations.

All tolerances shall apply to the declared values.

5.1.2 Apparatus

5.1.2.1 Micrometer, capable of measuring to an accuracy of 0,01 mm, with hemispherical anvils of 5 mm in diameter.

5.1.2.2 Measuring quick-test gauges, capable of measuring to an accuracy of 0,01 mm, with hemispherical anvils of 1,5 mm.

5.1.2.3 Calliper gauges, capable of measuring to an accuracy of 0,01 mm.

5.1.2.4 Measuring tape, capable of measuring the full length of the test specimen to an accuracy of 1,0 mm.

5.1.2.5 Short metal ruler, capable of measuring to an accuracy of 0,5 mm.

5.1.2.6 Metal straight edge, 1 metre long, the straightness of which is accurate to 0,5 mm.

5.1.2.7 Balance, with an accuracy of 0,1 g.

5.1.3 Sampling

The samples shall be complete sheets, as delivered.

5.1.4 Overall sheet thickness

The overall sheet thickness shall be measured to the nearest 0,05 mm, excluding the masking film and without damaging the surface, at intervals of approximately 200 mm across the extrusion width, beginning at the central point of the edge cell and measuring at the central point of each cell.

All the measured values shall fulfil the tolerances given for overall sheet thickness in Table 2.

5.1.5 Mass per unit area

The mass per unit area shall be determined as follows:

- cut a test specimen in the width of the sheet with a length L_{sp} of at least 100 mm;
- weigh the test specimen to the nearest gram;
- calculate the mass per unit area, ρ_a , in grams per square metre, using Formula (1):

$$\rho_a = \frac{m}{W_s \times L_{sp}} \quad (1)$$

where

- m is the mass, in grams, of the test specimen;
- W_s is the width, in millimetres, of the test specimen;
- L_{sp} is the length, in millimetres, of the test specimen.

Record the value of ρ_a to the nearest 10 g/m².

All the calculated values shall fulfil the tolerances given in Table 2.

5.1.6 Variation of the mass per unit area

The variation of the mass per unit area shall be determined as follows:

- cut a specimen in the full width of the sheet with a length L_{sp} mm of at least 80 mm;
- cut off 50 mm on each side of the specimen and divide the remaining part into at least five equally-sized test specimens across the width; when the sheet width is less than 1 000 mm, take an appropriate number of test specimens;
- weigh each test specimen, to the nearest 1 g;
- calculate the mass per unit area of each test specimen, ρ_d , in grams per square metre, using Formula (2):

$$\rho_d = \frac{m}{W_{sp} \times L_{sp}} \quad (2)$$

where

- m is the mass, in grams, of the test specimen;
- W_{sp} is the width, in millimetres, of the test specimen;
- L_{sp} is the length, in millimetres, of the test specimen, in the extrusion direction.

Record the values of ρ_d to the nearest 10 g/m² for each test specimen, calculate the mean of the five recorded values and compare the obtained values.

All the measured values shall fulfil the tolerances given in Table 2.

5.1.7 Sheet length and sheet width

The total length of the sheet shall be measured along both edges, to the nearest millimetre. Record the values so obtained.

The results shall be expressed as follows: the average of the two values, expressed in millimetres, to the nearest millimetre.

5.1.8 Deviation from rectangular shape (only for rectangular sheets)

The test specimen shall be a whole sheet.

The lengths of the two diagonals of the test specimen shall be measured, to the nearest millimetre. Calculate the difference between the two measured values and record it.

All the measured values shall fulfil the tolerances given in Table 2.