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

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

Plaques d’éclairement planes multiparois en polycarbonate (PC) pour toitures, bardages et plafonds intérieurs et extérieurs — Exigences et méthodes d’essai

ICS:

Descriptors:
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Foreword

This document (TC 128 WI 00128xxx) 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 document is a working document.
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 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 (harmonized standard)
- EN 14963, Roof coverings — Continuous rooflights of plastics with or without upstands — Classification, requirements and test methods (harmonized standard)
- EOTA ETA-Guideline 010, Self supporting translucent roof kits

The multiwall PC sheets that satisfy the requirements of this document are presumed to satisfy these of 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.

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

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 410, 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 1990:2002, Eurocode — Basis of structural design
EN 13501-1, Fire classification of construction products and building elements — Part 1: Classification using test 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 test data from external fire exposure to roof 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, Roof coverings — Continuous rooflights of plastics with or without upstands — Classification, requirements and test methods


EN ISO 9001, Quality management systems — Requirements (ISO 9001:2000)


EN ISO 11925-2, Reaction to fire tests — Ignitability of building 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 12572:2001)

ISO 11359-2, Plastics — Thermomechanical analysis (TMA) — Part 2: Determination of coefficient of linear expansion and glass transition temperature for plastics
ISO 10526, standard illuminants for colorimetry
ISO/CIE 10527, CIE standard colorimetric observers
EOTA ETA-Guideline 010, Self supporting translucent roof kits

3 Terms and definitions

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

3.1 PC sheet
sheet substantially made of polycarbonate resin to which are added those additives such as lubricants, processing aids, UV absorbers, colorants, functional layers or flame retardants that are needed to facilitate the manufacture of sheet conforming to the requirements of this standard and customer requirements

3.2 multiwall PC sheet
flat extruded 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

3.3 multiwall PC sheet with symmetrical in-plan cross-section
multiwall PC sheet having, perpendicularly to the extrusion direction, symmetrical geometrical shape and material distribution relatively to a line drawn equally distant from the outer surfaces of the sheet

3.4 multiwall PC sheet with unsymmetrical in-plan cross-section
multiwall PC sheet having, perpendicularly to the extrusion direction, unsymmetrical geometrical shape and/or material distribution relatively to a line drawn equally distant from the outer surfaces of the sheet

NOTE See Annex A for typical cross-sections of multiwall PC sheet with symmetrical or unsymmetrical in-plan cross-section.

3.5 indirect test (IT)
test performed by the manufacturer, different from that specified for that particular characteristic, having verified its correlation with the specified test

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

3.7 sheet width
dimension of a sheet perpendicular to the extrusion direction

4 Symbols and abbreviations

4.1 Symbols

4.2 Abbreviations

FPC factory production control
5 Requirements

5.1 Protective coverings

Unless otherwise agreed upon between the manufacturer and the customer, the surfaces of the sheets, as delivered, shall be protected by suitable materials, e.g. a polyethylene film, which is readily removable without causing surface contamination or damage.

5.2 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 sheets that could adversely affect the performance of the sheets in its intended application.

The edges of the sheet shall be straight and free from swarf.

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

For specific uses, further requirements concerning the visual aspects of the sheets can be agreed upon between the manufacturer and the customer.

5.3 Dimensional tolerances and mass per unit area

The dimensional tolerances and mass per unit area shall be assessed when subject to regulatory requirement. When measured in accordance with the test methods as specified in 6.1.1 to 6.1.3 and Table 1, the dimensional tolerances and mass per unit area of the sheets shall conform to the requirements given in Table 1.

The test methods given in Table 1 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 1 and as far as a correlation is demonstrated with the concerned reference test method.
Table 1 — Dimensional tolerances and mass per unit area requirements

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Test method</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall sheet thickness</td>
<td>6.1.4</td>
<td>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 ± 0.5 mm of this value.</td>
</tr>
<tr>
<td>Mass per unit area</td>
<td>6.1.5</td>
<td>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.</td>
</tr>
<tr>
<td>Variation of mass per unit area</td>
<td>6.1.6</td>
<td>The mass per unit area of each cut section of the sheet shall not vary by more than ± 6 % from the calculated mean mass per unit area of the cut sections.</td>
</tr>
</tbody>
</table>
| Sheet length                                | 6.1.7       | 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                                 | 6.1.7       | 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) | 6.1.8       | 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         | 6.1.9       | When required, the nominal wall and internal feature thicknesses and the tolerances shall be declared.                                                                                                         |
| Sheet flatness                              | 6.1.10      | 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                               | 6.1.11      | The deviation of squareness of the sheet shall be < 5 mm per meter of width.                                                                                                                                    |
| Lateral curvature                           | 6.1.12      | The maximum distance between the straight edge and the side(s) of the sheet shall be < 5 mm/m.                                                                                                                 |

5.4 Spectral characteristics

5.4.1 General

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, and the reflexion and transmission characteristics.

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 given in 5.4.2 shall be measured according to EN 14500 considering the samples cut from multiwall PC sheets as thick translucent samples (see 6.3.2, EN 14500).

The test samples shall be of sufficient size to prevent the possibility of light leakage at the edges of the entrance port of the measuring equipment and 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 normal-hemispherical light transmittance, $\tau_{v,n-h}$, and the normal-hemispherical solar transmittance, $\tau_{e,n-h}$, based on the mean values shall be declared and the mean values of subsequent measurements shall be within $\pm 10\%$ of the declared values.

5.4.2 Notation used
[from EN 14500:2008]

5.4.2.1 General

For the purpose of this European Standard, the optical factors $\tau$ (transmittance) and $\rho$ (reflectance) are labelled with subscripts which indicate:

- the visual or solar properties;
- the angle of the incident and the transmitted or reflected radiation.

5.4.2.2 Visual and solar properties

According to the respective spectrum, the following subscripts are used:

- "e" solar (energetic) characteristics, given for the global solar irradiance, (wavelengths $\lambda$ from 300 nm to 2 500 nm), according to EN 410,
- "v" visual characteristics, given for the standard illuminant D65 weighted with the sensitivity of the human eye (wavelengths $\lambda$ from 380 nm to 780 nm), according to EN 410.

5.4.2.3 Geometry of the radiation

The following subscripts are used to indicate the geometry of the incident radiation and the angle of the transmitted or reflected radiation:

- "n" for normal, near-normal incidence, when the angle of incidence, $\theta$, is $0^\circ \leq \theta \leq 8^\circ$,
- "h" for hemispherical (collected in the half space behind the sample plane).

5.4.2.4 Optical factors

The optical factors to be determined are designated as follows:

- $\tau_{v,n-n}$: normal-normal light transmittance;
- $\tau_{e,n-n}$: normal-normal solar transmittance;
- $\tau_{v,n-h}$: normal-hemispherical light transmittance;
- $\tau_{e,n-h}$: normal-hemispherical solar transmittance;
- $\rho_{v,n-h}$: normal-hemispherical light reflectance;
- $\rho_{e,n-h}$: normal-hemispherical solar reflectance.
NOTE 1  The normal-hemispherical light transmittance, $\tau_{v,n-h}$, and the normal-hemispherical solar transmittance, $\tau_{e,n-h}$, are corresponding respectively to the light transmittance, $\tau_{v}$, and the direct radiant transmittance, $\tau_{e}$, as stated in EN 14963.

NOTE 2  The normal-hemispherical light transmittance, $\tau_{v,n-h}$, is corresponding to the total luminous transmittance, $\tau_{D65}$, 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.

### 5.5  Total solar energy transmittance

The total solar energy transmittance, $g$, is given by the Equation (1):

$$ g = \tau_{e,n-h} + q_i \tag{1} $$

NOTE  From EN 410:1998, 4.4.1.

where

- $\tau_{e,n-h}$ is the normal-hemispherical solar transmittance;
- $q_i$ is the secondary internal heat transfer factor.

The total solar energy transmittance, $g$, shall be determined by calculation according to 6.2. But the calculation method is applicable only to multiwall PC sheets with symmetrical in-plan cross-section and where the secondary internal heat transfer factor is less than 8 %. Where the calculation method is not applicable, then the total solar energy transmittance shall be measured.

The total solar energy transmittance of multiwall PC sheets, $g$, may be determined by direct measurement if the following conditions are satisfied:

- the size of the equipment used for measuring the solar factors shall be adapted to avoid troubles due to the thermal and radiation losses on the edges of the sample;
- the conditions on the external surfaces of the sample shall be:
  - air-velocity on the external surface of the sample : 4 m/s;
  - minimum irradiance level: 500 W/m² on the external surface of the sample for near-normal incidence;
  - internal heat transfer coefficient: $8 \pm 1$ W/(m²K);
  - external heat transfer coefficient: $(23 \pm 3)$ W/(m²K);
  - external temperature: $(25 \pm 2)$ °C.

By lack of a relevant solar sensor system, the total solar energy transmittance of multiwall PC sheets shall be calculated by the method described in 6.2 taking care of the limits given on that method itself.

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 optical properties as the solar factor.
5.6 Impact resistance

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

The impact resistance shall be evaluated by determining the impact behaviour according to 6.5.

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

5.7 Durability

5.7.1 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 global irradiance level and declaring the results according to 5.6.3.

5.7.2 Artificial ageing performance

Artificial ageing shall be carried out in accordance with 6.3 using one of the classes given in Table 2.

<table>
<thead>
<tr>
<th>Class</th>
<th>Global irradiance (300 nm to 3 000 nm) GJ/m²</th>
<th>Uncoloured sheets</th>
<th>Coloured sheets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ΔYI absolute value (or unit)</td>
<td>Δτv,n-h %</td>
</tr>
<tr>
<td>ΔA</td>
<td>18</td>
<td>≤ 10 ≤ 5</td>
<td>≤ 10 ≤ 5</td>
</tr>
<tr>
<td>ΔD</td>
<td>18</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>ΔE</td>
<td>10</td>
<td>≤ 10 ≤ 10</td>
<td>≤ 10 ≤ 10</td>
</tr>
<tr>
<td>ΔF</td>
<td>10</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

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

NOTE In the case of an exposure to a global irradiance 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 ≤ 12 after ageing: ΔYI ≤ 10
- τv,n-h = 80 % before ageing and τv,n-h ≥ 75 % after ageing: Δτv,n-h ≤ 5

is classified ΔA.
5.7.3 Variations of yellowness index and light transmittance after artificial ageing

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

The yellowness index of the UV-protected layer of an uncoloured sheet shall be measured in accordance with 6.4.

The light transmittance shall be measured in accordance with 6.2.

The sheets shall be classified into one of the four classes given in Table 2.

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

The yellowing behaviour of sheets is depending on the performance of the UV-protected layer. Therefore, the correlation between yellowing index and global irradiance levels for his 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.

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

— the thickness of test specimen shall be less than 1.5 mm;
— the test specimen shall be representative of the base resin;
— the test specimen shall be representative of the lowest level of UV-protection provided by the concentration of UV absorbers and the layer thickness.

5.7.4 Variation of deformation behaviour

If the characteristics of a sheet conform to Table 2 for a declared class, the variation of the mechanical properties (deformation and the breaking behaviour) after artificial ageing is assumed to be less than 10 %, therefore the sheet is in conformance with the requirements of classes Cu 1 and Ku 1 as given in EN 14963 and EN 1873.

5.8 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 6.6.

The bending stiffness, shear stiffness and buckling moment shall be declared.

5.9 Airborne sound insulation

The sound reduction index of the multiwall sheets shall be assessed when subject to regulatory requirement.

The sound reduction index shall be measured in accordance with 6.7 and declared.

5.10 Thermal transmittance

The thermal transmittance, $U$ value, shall be assessed when subject to regulatory requirement.
The thermal transmittance shall be calculated in accordance with EN ISO 10077-2, using the definitions of EN 673, considering a thermal flow crossing normal to the faces of the multiwall sheets.

5.11 Water vapour permeability

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

The standard value of the water vapour permeability coefficient of PC sheets is $3.8 \times 10^{-5}$ mg/m·h·Pa and it shall be declared. When a higher performance is sought for declaration, the water vapour permeability coefficient of the material used for the sheet shall be determined according to EN ISO 12572.

5.12 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 shall be evaluated by examination of visual appearance according to 5.2.

5.13 Linear thermal expansion

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

The value of the coefficient of linear thermal expansion of the PC material is $65 \times 10^{-6}$ 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 EN ISO 11359-2.

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

5.14 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 6.8 and declared by the manufacturer according to EN 13501-1.

5.15 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.

5.16 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.

NOTE In general, the product should be classified EI 0.

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.
5.17 Presence of functional layers

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

The functional side of the sheet shall be indicated.

5.18 Release of dangerous substances

Materials used in products shall not release any dangerous substances in excess of the maximum permitted levels specified in a relevant European Standard for the material or permitted in the national regulations of the member state of destination.

NOTE See ZA.1 and ZA.3 of Annex ZA.

5.19 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 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.

6 Test and calculation methods

6.1 Dimensional tolerances and mass per unit area

6.1.1 General

The measurements shall be carried out at an ambient temperature of \((20 \pm 5) \, ^\circ C\). 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.

6.1.2 Apparatus

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

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

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

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

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

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

6.1.2.7 Balance, with an accuracy of 0,1 g.
6.1.3 Samples

The samples shall be complete sheets, as delivered.

6.1.4 Overall sheet thickness

The overall thickness of the sheet 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 5.3.

6.1.5 Mass per unit area

The mass per unit area shall be determined as follows:

— cut a test piece in the width of the sheet with a length \( L \) of at least 100 mm.

— weigh the test piece to the nearest gram.

— calculate the mass per unit area, \( \rho_a \), in kilograms per square metre, using the following Equation (2):

\[
\rho_a = \frac{m}{W \times L} \times 10^3
\]  

(2)

where

\( m \) is the mass, in grams, of the test piece;

\( W \) is the width, in millimetres, of the sheet;

\( L \) is the length, in millimetres, of the test piece.

Record the value of \( \rho_a \) to the nearest 0,01 kg/m².

All the measured values shall fulfil the tolerances given in 5.3.

6.1.6 Variation of the mass per unit area

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

— cut a test piece in the full width of the sheet with a length \( L \) mm of at least 80 mm.

— cut off 50 mm on each side of the test piece and divide the rest into at least 5 equally sized test specimens across the width. Where 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, \( \rho_d \), in kilograms per square metre, using Equation (3):

\[
\rho_d = \frac{m}{W \times L} \times 10^3
\]  

(3)

where
is the mass, in grams, of the specimen;

\( W \) is the width, in millimetres, of each test specimen;

\( L \) is the length, in millimetres, of each test specimen in the extrusion direction.

Record the values of \( \rho_d \) to the nearest 0,01 kg/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 5.3.

6.1.7 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 mm, to the nearest millimetre.

6.1.8 Deviation from rectangular shape (only for rectangular sheets)

The lengths of the two diagonals of the sheet 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 5.3.

6.1.9 Wall and internal feature thickness

The thickness of the walls and the internal features shall be measured to the nearest 0,01 mm, without damaging the surface, at a minimum of three equally spaced intervals of the extrusion width, beginning at the central point of the edge cell. Calculate the mean value and record it.

All the measured values shall fulfil the tolerances declared by the manufacturer.

6.1.10 Flatness of a sheet surface

6.1.10.1 Test specimens

The length of the specimen shall be at least two times the width of the sheet. If the sheet is shorter, then it shall be the specimen.

6.1.10.2 Flatness across the width of the sheet

Place the sheet with its edges in contact with a flat surface.

Measure with a small rule to the nearest 0,5 mm the maximum distance between the flat surface and the adjacent sheet surface. See Figure 1.

Record the maximum value measured for each end of the sheet.

6.1.10.3 Flatness along the length of the sheet

Place the sheet with its ends in contact with a flat surface.

Measure with a small rule, to the nearest 0,5 mm, the maximum distance between the flat surface and the adjacent sheet surface. See Figure 1.
Record the maximum value measured for each edge of the sheet.

or

Place the sheet on a flat surface.

Place a straight edge along the centre line of the sheet in the extrusion direction.

Measure with a small rule, to the nearest 0.5 mm, the maximum distance between the straight edge and the adjacent sheet surface.

Record the maximum value measured at the sheet centre line and adjacent to each edge of the sheet.

![Figure 1 — Determination of the flatness](image)

### 6.1.11 Out of square

Place the sheet in a rectangular frame and push its end against the end of the frame keeping the side in contact with the side of the frame.

Measure the maximum distance, to an accuracy of 0.5 mm, between the end of the sheet and the square end of the rectangular frame. See Figure 2.

Measure and record the maximum value for each end.

Or

Place one sheet on a flat surface

Place a second sheet on top of the first, with its top surface down, and corners aligned at one edge.

Measure to an accuracy of 1.0 mm the distance between the corners of the two sheets at the opposite edge.

Repeat at the other end of the sheets.

The sheets are out of square by half of that measured distance.
6.1.12 Lateral curvature

Place a long straight edge on or alongside the side of the sheet to be measured, and aligned with the ends of the sheet edge.

Measure with a small rule, to the nearest 0.5 mm, the maximum distance between the straight edge and the edge of the sheet. See Figure 3.

Record the maximum value measured for each edge of the sheet.

6.2 Total solar energy transmittance (calculation method)

6.2.1 Limits of the model

The calculation method shall be applied with multiwall PC sheets including symmetrical optical aspects only and that are, for example, without strong optical effect from coextruded layers on the external faces (i.e. without infra-red protective layer).
The calculation method consists to calculate the total solar energy transmittance, \( g \), considering the multiwall PC sheets like a virtual double insulating glazing.

6.2.2 Theory

A double insulating glazing corresponds to two parallel walls which are similar optical and physical properties. It may be defined for both walls with the virtual optical factors as follows:

- \( \tau_{pe,n-h} \): solar direct transmittance of one of both outside walls;
- \( \rho_{pe,n-h} \): normal-hemispherical solar reflectance of one of both outside walls;
- \( \alpha_{pe,n-h} \): normal-hemispherical solar absorbance of one of both outside walls

The relationship between these virtual optical factors is given by Equation (4):

\[
\tau_{pe,n-h} + \rho_{pe,n-h} + \alpha_{pe,n-h} = 1
\]  

(4)

The relationships between the multiwall PC sheet and its model are given by Equations (5) and (6):

\[
\tau_{e,n-h} = \frac{\tau_{pe,n-h}^2}{1 - \rho_{pe,n-h}}
\]  

(5)

\[
\rho_{e,n-h} = \rho_{pe,n-h} \frac{1 + \tau_{pe,n-h}^2}{1 - \rho_{pe,n-h}^2}
\]  

(6)

and the normal-hemispherical solar reflectance, \( \rho_{pe,n-h} \), and the solar direct transmittance, \( \tau_{pe,n-h} \), are given by Equation (7) and (8) respectively:

\[
\rho_{pe,n-h} = \frac{\rho_{e,n-h}}{1 + \tau_{e,n-h}}
\]  

(7)

\[
\tau_{pe,n-h} = \left[ \tau_{e,n-h} \left( 1 - \rho_{pe,n-h}^2 \right) \right]^{0.5}
\]  

(8)

The value of the external heat transfer coefficient called \( h_{ext} \), is equal to 23 W/(m²K) and the \( 1/h_{ext} \) is round off to 0.04 (m²K)/W.

The value of the internal heat transfer coefficient called \( h_{int} \), is equal to 8 W/(m²K) and the \( 1/h_{int} \) is round off to 0.13 (m²K)/W.

The thermal transmittance called \( U \) (for calculation, see 5.10) may be expressed by Equation (9):

\[
R = \frac{1}{U} = \frac{1}{h_{int}} - \frac{1}{h_{ext}}
\]  

(9)

where

\( R \) is the thermal conductance between both virtual walls.
6.2.3 Calculation

As regards the calculation of secondary internal heat transfer factor, $q_i$, for a double glazing according to EN 410, it can be extract from the subclause 4.4.6.3 Equation (10):

$$q_i = \frac{\alpha_{e1} + \alpha_{e2} + \alpha_{e2}R}{h_{ext} + \frac{1}{h_{int}} + R}$$

where

$$\alpha_{e1} = \alpha_{pe,n-h} \left(1 + \tau_{pe,n-h} \frac{\rho_{pe,n-h}}{1 - \rho_{pe,n-h}} \right)$$

$$\alpha_{e2} = \alpha_{pe,n-h} \frac{\tau_{pe,n-h}}{1 - \rho_{pe,n-h}}$$

and the total solar energy transmittance is obtained from Equations (1) and (10):

$$g = \tau_{e,n-h} + \frac{\alpha_{e1} + \alpha_{e2} + \alpha_{e2}R}{h_{ext} + \frac{1}{h_{int}} + R}$$

and from Equation (9) and Equation (13):

$$g = \tau_{e,n-h} + \left[ \frac{\alpha_{e1} + \alpha_{e2}}{h_{ext}} + \alpha_{e2} \left( \frac{1}{U} - \frac{1}{h_{int}} - \frac{1}{h_{ext}} \right) \right] U$$

$$g = \tau_{e,n-h} + \left[ \frac{\alpha_{e1}}{h_{ext}} + \alpha_{e2} \left( \frac{1}{U} - \frac{1}{h_{int}} \right) \right] U$$

6.2.4 Test report

Test results of the calculation method should be expressed according to Table 3.

<table>
<thead>
<tr>
<th>Multiwall PC sheet</th>
<th>Results from the calculation method</th>
<th>Optical factors (5.4.2.4)</th>
<th>Thermal transmittance (5.10)</th>
<th>Secondary internal heat transfer factor</th>
<th>Total solar energy transmittance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>$\rho_{pe,n-h}$</td>
<td>$\tau_{pe,n-h}$</td>
<td>$\alpha_{e1}$</td>
<td>$\alpha_{e2}$</td>
<td>$h^a$</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>mm</td>
</tr>
<tr>
<td></td>
<td>Eq.(7)</td>
<td>Eq.(8)</td>
<td>Eq.(11)</td>
<td>Eq.(12)</td>
<td></td>
</tr>
</tbody>
</table>

$^a$ $h$: overall sheet thickness.
6.3 Artificial ageing test method

Artificial ageing shall be carried out according to EN ISO 4892-2:2006, Method A, cycle No 1.

The UV range is corresponding to 300 nm to 400 nm.

According to Table 1 of EN ISO 4892-1:2000 the UV radiant exposure, corresponding to the 300 nm to 400 nm range, is representing 6.8 % of the global irradiance, expressed in GJ/m².

The duration of testing shall be determined so as to fulfil one of the levels of global irradiance given in Table 4.

With an irradiance of 60 W/m², the test durations corresponding to the four levels of global irradiance are given in Table 4.

<table>
<thead>
<tr>
<th>Global irradiance level (300 nm to 3 000 nm) GJ/m²</th>
<th>Irradiance (300 nm to 400 nm) GJ/m²</th>
<th>Test duration 60 W/m² (300 nm to 400 nm) h</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>1,224</td>
<td>5 666</td>
</tr>
<tr>
<td>10</td>
<td>0,68</td>
<td>3 148</td>
</tr>
</tbody>
</table>

The dimensions of the exposed test pieces shall be sufficient to allow carrying out the light transmission test and the subsequent specific tests.

6.4 Yellowness index

6.4.1 Apparatus

Spectrocolorimeter with integrating sphere (hemispherical illumination and viewing the transmitting portion at an angle perpendicular to the test specimen surface or illumination perpendicular to the specimen surface and viewing the transmitted portion with an integrating sphere).

6.4.2 Test specimens

The same test specimens as used for the change in the light transmission shall be used.

6.4.3 Procedure

Calibrate and operate the spectrocolorimeter and other instruments in accordance with instructions supplied by their manufacturer.

Obtain spectral transmittance data illuminant D65 relative to air in the wave length range of 380 nm to 780 nm.

6.4.4 Expression of results

Calculate the tristimulus values, X, Y and Z, for CIE standard illuminant D 65 as given by ISO 10526 and CIE standard colorimetric observer 2° as given by ISO/CIE 10527 by numerical integration from recorded spectral data or by automatic integration during spectrocolorimeter operation.

Calculate the magnitude and sign of the yellowness from the following equation:

\[ \text{Yellowness} = \frac{Z}{X + Y + Z} \]
Calculate the magnitude and direction of change of the yellowness from the following equation:

\[ \Delta Y = Y - Y_0 \]

Where

- \( Y \) is the yellowness index of a test specimen exposed to ageing;
- \( Y_0 \) is the yellowness index of a test specimen unexposed to ageing;
- \( \Delta Y \) is the change of the yellowness index after ageing.

6.5 Impact resistance

The impact resistance shall be determined according to the method given EN ISO 6603-1, by using the test arrangement shown in Figure 4, on 10 test specimens taken from the three sheets samples from separated production batches.

The test specimens shall be conditioned at (23 ± 4) °C for a minimum of 24 h.

The test specimens shall include at least 5 ribs.

The dimensions of the test specimens shall be at least 300 mm x 300 mm.

The test conditions shall be as follows:

- height of fall: (1 000 ± 5) mm;
- falling mass (solid steel ball): 250 g ± 1 %;
- test temperature: (23 ± 4) °C

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

When 10 test specimens taken from three sheets are submitted to the impact resistance test, no failure shall occur.
6.6 Deformation behaviour

6.6.1 General

As the multiwall PC sheets have different flexural properties in the extrusion direction (x-direction) and transverse direction (y-direction), the flexural properties shall be determined separately in both directions. Also, unlike a solid sheet where the shear deformation is negligible relatively to the bending deformation, multiwall PC sheets have, in many cases, shear flexibility in the transverse direction, which can not be neglected. In order to determine separately the bending stiffness and the shear stiffness, two tests with two different spans shall be performed in the y-direction.

The buckling behaviour in the y-direction is a major characteristic of the multiwall PC sheets. Depending on the cross-section geometry of the multiwall PC sheets (e.g. so-called X-, K- or M-structures – see Figure 8), the loads causing buckling of the multiwall PC sheets in the compressed skin of cross-sections can be lower than these for solid sheets, despite of a higher stiffness.

For multiwall PC sheets having symmetrical in-plan cross-sections, the shear stiffness, the bending stiffness and the buckling moment shall be determined by testing the specimens with the UV-protected layer (outer skin) under compression only.
For multiwall PC sheets having unsymmetrical in-plan cross-sections, the shear stiffness, the bending stiffness and the buckling moment shall be determined by testing both the specimens with the exposed face (with UV-protected layer) (outer skin) under compression and the specimens with the unexposed face (inner skin) under compression.

NOTE The data determined in this subclause relates to the multiwall PC sheet properties. However, it does not allow to assess directly the ability of a full size sheet to withstand external loads such as wind or snow loads.

6.6.2 Terms, definitions and symbols

6.6.2.1 Terms and definitions

For the purpose of this subclause, the following terms and definitions apply.

6.6.2.1.1 \(x\)-direction
extrusion direction corresponding to the length of a sheet

6.6.2.1.2 \(y\)-direction
direction perpendicular to the \(x\)-direction of a sheet in the sheet plane

6.6.2.1.3 overall sheet thickness
\(h\) sheet total thickness, in millimetres

6.6.2.1.4 width
\(b\) either width of a specimen in \(x\)-direction testing or length of a specimen in \(y\)-direction testing, in millimetres (mm)

6.6.2.1.5 span
\(L\) initial distance, in millimetres, between lines of contact between the test specimen and supports

6.6.2.1.6 bending stiffness in \(x\)-direction
\(B_x\) resistance to bending per metre width, in newtons square metres per metre, analogue to \(\frac{EI}{b}\) in the plate theory,

6.6.2.1.7 bending stiffness in \(y\)-direction
\(B_y\) resistance to bending per metre length, in newtons square metres per metre, analogue to \(\frac{EI}{b}\) in the plate theory
6.6.2.1.8
shear stiffness in y-direction
\( S_y \)
resistance to the shear deformation per metre length, in newtons per metre, analogue to \( \frac{GA}{b} \) in the plate theory

6.6.2.1.9
buckling moment
\( M_b \)
bending moment in y-direction, in newtons metres per metre, when a sheet buckles

6.6.2.1.10
cross-head span length
\( W \)
distance between the cross-head loading points, in millimetres

NOTE See Figure 7.

6.6.2.2 Symbols

\( h \) overall sheet thickness
\( b \) width
\( F \) applied force
\( F_x \) applied force for test in x-direction
\( F_y \) applied force for test in y-direction
\( L \) span
\( L_x \) span for test in x-direction
\( L_{y1} \) span for test in y-direction
\( L_{y2} \) span for test in y-direction
\( B_x \) bending stiffness in x-direction
\( B_y \) bending stiffness in y-direction
\( S_y \) shear stiffness in y-direction
\( M_b \) buckling moment
\( W \) cross-head span length

6.6.3 Sampling

The test specimens for testing in x-direction and y-direction shall be cut uniformly distributed from at least three sheet samples from separated production batches.

Figure 5 shows a typical distribution of the test specimens when they can be taken from the middle (x-direction and y-direction) of the sheet sample.
Figure 6 shows a typical distribution of the test specimens when they cannot be taken from the middle (x-direction and y-direction) of the sheet sample.

In any cases, the test pieces shall not be taken within 100 mm of the edge of the samples.

The dimensions of the test specimens to be used for the determination of the creep behaviour and buckling behaviour are specified in the relevant subclauses 6.6.4.2, 6.6.5.2 and 6.6.6.2.

Dimensions in millimetres

Key
X  x-direction
Y  y-direction
A  test specimens cut in x-direction for the determination of the creep behaviour
B  test specimens cut in y-direction for the determination of the creep behaviour
C  test specimens cut in y-direction for the determination of the buckling behaviour

Figure 5 — Typical distribution of test specimens in a sheet sample
6.6.4 Determination of the creep behaviour

6.6.4.1 General

The creep behaviour of the multiwall PC sheets shall be determined in \( x \)-direction by using the span, \( L_x \), and in \( y \)-direction by using two different spans (\( L_{y1} \) and \( L_{y2} \)) according to the method specified in EN ISO 899-2 (flexural creep by three-point-loading) using standard atmosphere 23/50, Class 2 according to EN ISO 291, with the test conditions specified in 6.6.4.2. The values of the deflection, \( s_x \), \( s_{y1} \) and \( s_{y2} \) shall be measured after 6 min load duration.

The bending stiffness in \( x \)-direction, \( B_x \), bending stiffness in \( y \)-direction, \( B_y \), and shear stiffness in \( y \)-direction, \( S_y \), of the multiwall PC sheets shall be calculated by using equations given in 6.6.4.3.
6.6.4.2 Test conditions

The spans and the applied forces to be used for the three-point-loading tests are given in Table 5.

Table 5 — Spans and test loads

<table>
<thead>
<tr>
<th>Overall sheet thickness, $h$ mm</th>
<th>x-direction</th>
<th>Test direction</th>
<th>y-direction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Span, $L_x$</td>
<td>Applied force, $F_x$</td>
<td>Span, $L_{y1}$</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>6</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>8</td>
<td>160</td>
<td>120</td>
<td>160</td>
</tr>
<tr>
<td>10</td>
<td>200</td>
<td>175</td>
<td>200</td>
</tr>
<tr>
<td>12</td>
<td>240</td>
<td>175</td>
<td>200</td>
</tr>
<tr>
<td>16</td>
<td>320</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>20</td>
<td>400</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>25</td>
<td>500</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>32</td>
<td>640</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>40</td>
<td>800</td>
<td>200</td>
<td>500</td>
</tr>
</tbody>
</table>

If the overall sheet thickness is not given in Table 5, the spans and applied forces to be used shall be determined as follows:

a) the span $L_x$ (x-direction) shall be $20h$.

b) the span $L_{y1}$ (y-direction) shall be $10h$ to $12.5h$.

c) the span $L_{y2}$ (y-direction) shall be $20h$.

d) the applied forces to be used for the three-point-loading tests shall be determined first by a short-term flexural test according to EN ISO 178. At least, three tests shall be performed for each configuration.

The vertical cross-head speed, $\nu$, expressed in millimetres per minute, shall be calculated from Equation (16):

$$\nu = 0.0017 \frac{L^2}{h}$$

where

$L$ is the span $L_x$ or the span $L_{y2}$;  
$h$ is the overall sheet thickness.

For the creep-bending tests; the applied force, respectively $F_x$ and $F_y$ shall be equal to 30 % of the mean value of the maximum load determined in the short-term tests. For $y$-direction, the applied force shall be defined according to the short term tests with a span of $20h$.

The width of the test specimens, $b$, shall be at least 80 mm.
For testing in x-direction, the width of the test specimens shall include at least four main ribs (or channels).

The length of the test specimens shall be at least $1,1L_x$, $1,1L_{y1}$ or $1,1L_{y2}$, as applicable.

After testing in y-direction by using the span, $L_{y1}$ (for the determination of the deflection $s_{y1}$), the test specimen shall be allowed to relax for at least one hour and then be retested by using the span, $L_{y2}$ (for the determination of the deflection $s_{y2}$).

### 6.6.4.3 Calculation

Calculate the bending stiffness, $B_x$, expressed in newtons square metres per metre (Nm²/m), in x-direction using Equation (17):

$$B_x = \frac{F_x \cdot L_x^3}{48 \cdot s_x \cdot b}$$  \hspace{1cm} (17)

where

- $F_x$ is the applied force for test in x-direction;
- $L_x$ is the span for test in x-direction;
- $s_x$ is the deflection, at mid-span at time 0,6 min;
- $b$ is the width of the test specimen.

**NOTE** In three-point bending test the influence of the transverse force is neglected.

Calculate the bending stiffness, $B_y$, expressed in newtons square metres per metre (Nm²/m), in y-direction using Equation (18):

$$B_y = \frac{F_y \cdot (L_{y1}^3 - L_{y1} \cdot L_{y2}^2)}{48b \cdot (s_{y1} - s_{y2} \cdot \frac{L_{y1}}{L_{y2}})}$$  \hspace{1cm} (18)

where

- $F_y$ is the applied force for test in y-direction;
- $L_{y1}$ is the span for test in y-direction (used for the first test);
- $L_{y2}$ is the span for test in y-direction (used for the second test);
- $s_{y1}$ is the deflection, at mid-span $L_{y1}$ at time 6 min;
- $s_{y2}$ is the deflection, at mid-span $L_{y2}$ at time 6 min;
- $b$ is the thickness of the test specimen.

Calculate the shear stiffness, $S_y$, expressed in newtons per metre (N/m), in y-direction using Equation (19):
where

\[ S_y = \frac{F_y \cdot (L_{y1} - \frac{L_{y1}^3}{L_{y2}^2})}{4b \cdot (s_{y1} - s_{y2} \frac{L_{y1}^3}{L_{y2}^3})} \] (19)

\[ F_y \] is the applied force for test in y-direction;

\[ L_{y1} \] is the span for test in y-direction (used for the first test);

\[ L_{y2} \] is the span for test in y-direction (used for the second test);

\[ s_{y1} \] is the deflection, at mid-span \( L_{y1} \) at time 6 min;

\[ s_{y2} \] is the deflection, at mid-span \( L_{y2} \) at time 6 min;

\[ b \] is the width of the test specimen.

### 6.6.5 Determination of the buckling behaviour

#### 6.6.5.1 Principle

The buckling characteristics of multiwall PC sheets, in y-direction, shall be determined either by a four-point-bending test or by a six-point-bending test. If the buckling occurs under the loading points in the four-point-bending test, then the six-point-bending test shall be performed.

#### 6.6.5.2 Four-point-bending test

##### 6.6.5.2.1 General

The four-bending test shall be carried out according to the arrangement given in Figure 7 using standard atmosphere 23/50, Class 2 according to EN ISO 291, with the test conditions specified in 6.6.5.2.2.

The buckling moment, in y-direction, \( M_{b} \), of the multiwall PC sheets shall be calculated by using Equation (21) given in 6.6.5.2.3.
6.6.5.2.2 Test conditions

The width, \( b \), of test specimens shall be preferably 100 mm, with a minimum value of 80 mm.
The span, $L$, is depending on the mean cell size of the multiwall PC sheet. It shall be at least 40$s$ ($s$ is the mean cell size of the sheet, as shown in Figure 7) and at least 40$h$ ($h$: overall sheet thickness), whichever is the greater. However, for practical reason, the value of the span, $L$, shall not exceed 1 000 mm.

The two loading points of the cross-head shall be at a distance, $W$, apart, as follows:

$$L/4 < W < L/3$$

The loading points shall be designed as it is shown in Figure 7c), where the applied force is distributed across three vertical ribs (cells, channels) of the sheet.

The overhang of the multiwall PC sheet, $e$, shown in Figure 7b), shall be 3$s$.

The radius, $r$, of the supports shall be as follows:

$$r = (5 \pm 0.2)\ mm.$$  

The test speed, $\nu$, expressed in millimetres per minute, shall be calculated by using Equation (20):

$$\nu = 0.0017 \frac{(L - W)(L + 2W)}{h}$$  

(20)

where

$L$ is the span in the four-point-bending test;

$W$ is the cross-head span length;

$h$ is the overall sheet thickness.

A typical curve of applied force, $F$, versus deflection $\delta$ is shown in Figure 9. The maximum force, $F_b$, is corresponding to the buckling failure of the multiwall PC sheet.

The test results shall be declared valid only if buckling takes place between the two loading points of the cross-head. If buckling occurs under the loading points, the test shall be declared invalid and the buckling behaviour shall be characterized by the six-point-bending test, as specified in 6.6.5.3.

![Figure 9 — Typical curve of applied force versus deflection](image)

### 6.6.5.2.3 Calculation

Calculate the buckling moment, $M_b$, in $y$-direction, expressed in newtons metres per metre, using Equation (21):

$$M_b = \frac{F_b L}{2}$$
\[ M_b = \frac{F_b(L - W)}{4b} \]  

(21)

where

- \( F_b \) is the maximum force corresponding to the buckling of the sheet;
- \( L \) is the span;
- \( W \) is the cross-head span length;
- \( b \) is the width of the test specimen.

### 6.6.5.3 Six-point-bending test

#### 6.6.5.3.1 General

The six-bending test shall be carried out according to the arrangement given in Figure 10 using standard atmosphere 23/50, Class 2 according to EN ISO 291, with the test conditions specified in 6.6.5.3.2.

The buckling moment, in \( y \)-direction, \( M_b \), of the multiwall PC sheets shall be calculated by using the equation given in 6.6.5.3.3.

#### 6.6.5.3.2 Test conditions

The width, \( b \), of the specimen shall be at least 80 mm.

The transmission of the loads (\( F/4 \)) shall cover at least three ribs. The centre of the test specimen shall be central between two ribs (Figure 10d)).

The span, \( L \), is depending on the distance of the ribs of the sheets. The span, \( L \), shall be at least 28 as (as is the distance between two ribs, see Figure 10d)) or 20\( h \) (\( h \): overall sheet thickness).

The span, \( L \), shall additionally be chosen that way that the buckling occurs in the free section in the centre between load transmissions.

The radius, \( r \), of the supports shall be as follows:

\[ r = (5 \pm 0.2) \text{ mm}. \]

The load, \( F \), shall be increased in such manner that the deformation rate is equivalent to approx. 1 % extreme fibre elongation per minute.

Therefore, it shall be taken into account, that the test speed, \( v \), of the test machine is a mean value of the displacements of the loading points.

The test speed, \( v \), expressed in millimetres per minute, shall be calculated by using Equation (22):

\[ v = 0.0014 \frac{L^2}{h} \]  

(22)

where

- \( L \) is the span in the six-point-bending test;
- \( h \) is the overall sheet thickness.
The applied force, $F_b$, at buckling shall be determined.

![Diagram of six-point-bending test rig]

**Figure 10 — Six-point-bending test rig**

**6.6.5.3.3 Calculation**

Calculate the buckling moment, $M_b$, in y-direction, expressed in newtons metres per metre, using Equation (23):

$$M_b = \frac{F_b \cdot L}{8b}$$

(23)

where

- $F_b$ is the maximum force corresponding to the buckling of the sheet;
- $L$ is the span;

**Key**

1. test specimen
2. applied force
3. loading point
4. support
6.6.6 Test report

The bending and buckling properties shall be determined based on 10 test specimens.

They shall be evaluated statistically according to EN 1990, Annex D, assuming a log-normal distribution. For the statistical evaluation, the 5% fractile for unknown coefficient of variation \( V_x \) shall be determined with a confidence level of 75%. The 5% fractile corresponds to the characteristic value of the respective properties.

The test report shall include the following information:

a) a reference to this European Standard;
b) all information necessary for the identification of the sheet tested;
c) name, trade mark or other means for the identification of the manufacturer;
d) the bending stiffness in x-direction, \( B_{x,k} \), and the coefficient of variation, \( V_x \);
e) the bending stiffness in y-direction, \( B_{y,k} \), and the coefficient of variation, \( V_x \);
f) the shear stiffness in y-direction, \( S_{y,k} \), and the coefficient of variation, \( V_x \);
g) the buckling moment, \( M_{b,k} \), and the coefficient of variation, \( V_x \);
h) the overall sheet thickness, \( h \), (with a required accuracy: ± 0,05 mm) of the test specimens;
i) the thicknesses of the walls and ribs (with a required accuracy: ± 0,01 mm), the distance between two ribs (with a required accuracy: ± 0,1 mm), the angle between ribs and walls of the test specimens;
j) the mass per unit area (with a required accuracy: ± 1 g) of the test specimens.

6.6.7 Magnification and reduction factors

6.6.7.1 General

The magnification and reduction factors take into account the influence of load duration (\( C_t, K_t \)), the influence of the temperature (\( C_\theta, K_\theta \)) and the ageing and environmental influences (\( C_u, K_u \)). These values apply to multiwall sheets with UV-protected layers under normal natural ageing conditions.

The magnification factors \( C_i \) cover the deformation behaviour. The reduction factors \( K_i \) cover the breaking behaviour. These material factors are not safety coefficients but describe the changes in the behaviour over the period of use, or the effect of the load. The limit states of serviceability and the ultimate limit states of multiwall sheets are both deformation-induced. The reduction factors \( K_i \) are indicative.

6.6.7.2 Load duration

The reference time is 6 minutes. The load duration is chosen according to EN 1995-1-1. Additionally a value for a load duration ≤ 6 min is given. This value may be used e.g. for wind loads (gust of wind).

The magnification and reduction factors for the load duration are given in Table 6.
Table 6 — Magnification and reduction factors for load duration

<table>
<thead>
<tr>
<th>Load duration</th>
<th>Magnification factor</th>
<th>Reduction factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very short (less than 6 minutes)</td>
<td>$C_{tw} = 1,0$</td>
<td>$K_{tw} = 1,0$</td>
</tr>
<tr>
<td>Short (less than 1 week)</td>
<td>$C_{tk} = 1,1$</td>
<td>$K_{tk} = 1,2$</td>
</tr>
<tr>
<td>Medium (1 week to 6 months)</td>
<td>$C_{ts} = 1,2$</td>
<td>$K_{ts} = 1,3$</td>
</tr>
<tr>
<td>Permanent (more than 10 years)</td>
<td>$C_{tg} = 1,5$</td>
<td>$K_{tg} \leq 1,6$</td>
</tr>
</tbody>
</table>

6.6.7.3 Ageing and environmental influences

$C_u \leq 1,1; K_u = 1,1$.

NOTE Ageing (especially UV-radiation) usually causes an increase of the stiffness of the multiwall PC sheets.

6.6.7.4 Influence of temperature

The magnification and reduction factors for the influence of the temperature are given in Table 7.

Table 7 — Magnification and reduction factors for influence of the temperature

<table>
<thead>
<tr>
<th>Temperature up to °C</th>
<th>$C_{\theta}$</th>
<th>$K_{\theta}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>1,0</td>
<td>1,05</td>
</tr>
<tr>
<td>50</td>
<td>1,10</td>
<td>1,15</td>
</tr>
<tr>
<td>80</td>
<td>1,25</td>
<td>1,40</td>
</tr>
</tbody>
</table>

NOTE Interim values may be linearly interpolated.

6.6.7.5 Conversion factors

Using the magnification and reduction factors as given in 6.6.7.2 to 6.6.7.4, the conversion factors $\eta$ according to EN 1990 may be determined (see also ETAG 010).

In case of deformation-induced serviceability or ultimate limit states, $\eta_c$ is given by Equation (24):

$$\eta_c = \frac{1}{C_i \cdot C_{tu} \cdot C_{\theta}}$$  \hspace{1cm} (24)

If the material strength is decisive (for multiwall sheets usually not), $\eta_k$ is given by Equation (25):

$$\eta_k = \frac{1}{K_i \cdot K_{tu} \cdot K_{\theta}}$$  \hspace{1cm} (25)

6.6.7.6 Marginal deformation

For the mounting in curved roof systems the multiwall PC sheets can be bent at ambient temperature. The bending radius shall be minimum 150$t$ ($t$: overall sheet thickness).

NOTE This corresponds to an extreme fibre elongation of 0,33 %.
6.7 Airborne sound insulation

The sound reduction index of the sheet shall be determined in accordance with EN ISO 140-3. For the evaluation of the results, see EN ISO 717-1.

6.8 Reaction to fire

6.8.1 Principle

The product shall be tested in accordance with EN ISO 11925-2 and EN 13823, and classified in accordance with EN 13501-1.

6.8.2 Ignitability test (EN ISO 11925-2)

Specimens shall be tested in accordance with EN ISO 11925-2.

The flame shall be applied to the surface of the test piece.

All multiwall PC sheets, including roof, ceiling and horizontal wall types, shall be tested vertically in the test rig with air channels in a vertical direction.

The channels shall be closed by tapes (e.g. adhesive aluminium tapes) on top and bottom to prevent air flow through in the channels (chimney effect).

6.8.3 Single burning item test (EN 13823) – Specimens, mounting and fixing of specimens

6.8.3.1 General

All multiwall PC sheets, including roof, ceiling and horizontal wall types, shall be tested vertically in the test rig with air channels in a vertical direction.

For multiwall PC sheets for external use in roof and wall applications, the internal face and/or the external face shall be tested, depending on the end use conditions and the regulatory requirements in the Member State of use.

For multiwall PC sheets for internal end use applications, where both faces of the sheets may be exposed to the internal fire, the following shall apply:

— multiwall PC sheets with symmetrical in-plan cross-section shall be tested on one side only;
— multiwall PC sheets with unsymmetrical in-plan cross-section shall be tested at both sides.

6.8.3.2 Test specimens

The corner specimen consists of two wings, designated the short and long wings.

The specimens shall have the following dimensions:

a) short wing: (495 ± 5) mm x (1 500 ± 5) mm,
b) long wing: (1 000 ± 5) mm x (1 500 ± 5) mm.

The long wing shall be tested without joint.
6.8.3.3 Mounting of test specimens

Specimens shall be mounted and fixed as described in EN 13823 with the configuration shown in Figure 11 to 13.

The wing shall be mounted in a right-angled frame made of steel shown in Figures 12 and 13. In addition, a backing frame shown in Figures 12 and 13 are put behind each wing and is held in place mechanically at minimum three points by pressure. This setting secures specimens in vertical position during testing.

The test assembly shall be positioned immediately behind the drip trays of the test unit. A spacer frame and a 12 mm thick calcium silicate backing board shall be positioned behind each wing of the test assembly to give a maximum air gap between the rear surface of the specimen and the backing board.

Where there is a range of thicknesses/mass per unit area of product, two or more thicknesses/mass per unit area of sample shall be tested, and the lowest of the results shall be declared for all thicknesses/mass per unit areas between the two extremes tested.

The same procedure shall be applied for a range of mass per unit area.

If a range of colour is proposed, three different colours (a clear light one, an intermediate one and an opaque dark one) shall be chosen for each SBI test. If the same classification (e.g. class B, C, etc.) is kept so it is possible to extend to various colours with lowest additional classifications for smoke and flaming droplets. Otherwise, it is necessary to test two additional specimens with the colour which gives the lowest result. The classification shall be given by the mean of the three specimens with the colour specified before.
Figure 11 — View of the assembly – Steel-based frame and specimens
Key
A multiwall PC sheet
X extrusion direction
1 counter-support (thickness: 4 mm)
2 steel angle (thickness: 4 mm)
3 bindings
For sections A-A, B-B, C-C and D-D, see Figure 13.

Figure 12 — Steel-based frame for fixing of specimens
Key
A multiwall PC sheet
1 counter-support (thickness: 4 mm)
2 steel angle (thickness: 4 mm)

Figure 13 — Sections of the steel-based frame
7 Evaluation of conformity

7.1 General

The compliance of light transmitting flat multiwall PC sheets with the requirements of this document and with the stated values (including classes) shall be demonstrated by:

- initial type testing,
- factory production control by the manufacturer, including product assessment.

For the purposes of testing, products may be grouped in families, where it is considered that test results, for one or more characteristics, from any one product with a family are applicable to all products within that family.

7.2 Initial type testing

Initial type testing (ITT) shall be performed to show conformity with this document. Tests previously performed in accordance with the provisions of this document (same product, same characteristic(s), test method, sampling procedure, system of attestation of conformity, etc.) may be taken into account.

The characteristics subjected to ITT are listed in Table 8.

Whenever a change occurs in the product design, the raw material or supplier of the components, or the production process (subject to the definition of a family), which would change significantly one or more of the characteristics, the type tests shall be repeated for the appropriate characteristic(s).

When it is not specified in the relevant sub clause, at least three samples shall be used for each test to be taken from separated production batches, or from different time periods of one production. All products tested shall be representative of the manufacturer's normal production.

Where raw materials are used whose characteristics have already been determined, by the raw material manufacturer, on the basis of conformity with this or other product standards, these characteristics need not be reassessed provided that the raw materials’ performance or method of assessment remain the same, that the characteristics of the raw material are suitable for the intended end use of the finished product, and insofar as the manufacturing process does not have a detrimental affect on the determined characteristics.
**Table 8 — Initial type testing of sheets**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Requirement clause</th>
<th>Assessment method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual appearance</td>
<td>5.2</td>
<td>–</td>
</tr>
<tr>
<td>Dimensional tolerances and mass per unit area (^a)</td>
<td>5.3</td>
<td>6.1</td>
</tr>
<tr>
<td>Spectral characteristics (^a)</td>
<td>5.4</td>
<td>EN 14500</td>
</tr>
<tr>
<td>Total solar energy transmittance (^a)</td>
<td>5.5</td>
<td>6.2</td>
</tr>
<tr>
<td>Impact resistance (^a)</td>
<td>5.6</td>
<td>6.5</td>
</tr>
<tr>
<td>Durability:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>variation of yellowness index after ageing (^a)</td>
<td>5.7.3</td>
<td>6.4</td>
</tr>
<tr>
<td>variation of light transmittance after ageing (^a)</td>
<td>5.7.3</td>
<td>6.2</td>
</tr>
<tr>
<td>Deformation behaviour (^a)</td>
<td>5.8</td>
<td>6.6</td>
</tr>
<tr>
<td>Airborne sound insulation (^a)</td>
<td>5.9</td>
<td>6.7</td>
</tr>
<tr>
<td>Thermal transmittance (^a)</td>
<td>5.10</td>
<td>EN ISO 10077-2</td>
</tr>
<tr>
<td>Water vapour permeability (^a)</td>
<td>5.11</td>
<td>EN ISO 12572</td>
</tr>
<tr>
<td>Water/air tightness (^a)</td>
<td>5.12</td>
<td>–</td>
</tr>
<tr>
<td>Linear thermal expansion (^a)</td>
<td>5.13</td>
<td>EN ISO 11359-2</td>
</tr>
<tr>
<td>Reaction to fire (^a)</td>
<td>5.14</td>
<td>6.8</td>
</tr>
<tr>
<td>External fire performance (^a)</td>
<td>5.15</td>
<td>EN 13501-5</td>
</tr>
<tr>
<td>Resistance to fire (^a)</td>
<td>5.16</td>
<td>EN 13501-2</td>
</tr>
<tr>
<td>Presence of functional layers (^b)</td>
<td>5.17</td>
<td>–</td>
</tr>
<tr>
<td>Resistance to fixings (^b)</td>
<td>5.19</td>
<td>–</td>
</tr>
</tbody>
</table>

\(^a\) Only where subjected to regulation

\(^b\) If relevant.

When a sheet requires a new ITT as a result of an enforced raw material change by the supplier, and that change affects the raw material composition or grade, the sheet manufacturer may, at his own risk, benefit from a presumption of conformity to the existing ITT for defined characteristic(s). These shall be durability – variation of yellowness index and light transmission, because these are the subject of long term testing procedures. The presumption of conformity shall be subject to the following:

i) the raw material supplier’s written confirmation that the new composition or grade is no less durable than the previous grade or composition (only if this information is available),

or

if the new material is considered less durable, the manufacturer shall estimate the new durability based upon relevant information from the material supplier (only if this information is available),

ii) the new ITT is commenced at the earliest practical time,

iii) if the new ITT indicates a reduced performance than that declared by the manufacturer, the manufacturer shall have suitable traceability procedures and advise the purchaser accordingly,

iv) the presumption of conformity shall cease when the period of time has elapsed that would permit the test to provide comparable results with the ITT.
7.3 **Factory production control (FPC)**

7.3.1 **General**

The manufacturer shall establish, document and maintain an FPC system to ensure that the products placed on the market conform with the stated performance characteristics. The FPC system shall consist of procedures, regular inspections and tests and/or assessments and the use of the results to control raw and other incoming materials or components, equipment, the production process and the product.

All the elements, requirements and provisions adopted by the manufacturer shall be documented in a systematic manner in the form of written policies and procedures. This production control system documentation shall ensure a common understanding of conformity evaluation and enable the achievement of the required component characteristics and the effective operation of the production control system to be checked.

Factory production control therefore brings together operational techniques and all measures allowing maintenance and control of the conformity of the component with its technical specifications. Its implementation may be achieved by controls and tests on measuring equipment, raw materials and constituents, processes, machines and manufacturing equipment and finished components, including material properties in components, and by making use of the results thus obtained.

7.3.2 **General requirements**

The FPC system shall fulfil the requirements as described in the following clauses of EN ISO 9001:2000, where applicable:

- 4.2 except 4.2.1 a),
- 5.1 e), 5.5.1, 5.5.2,
- Clause 6,
- 7.1 except 7.1 a), 7.2.3 c), 7.4, 7.5, 7.6,
- 8.2.3, 8.2.4, 8.3, 8.5.2.

The FPC system may be part of a quality management system, e.g. in accordance with EN ISO 9001:2000.

7.3.3 **FPC requirements for all manufacturers**

7.3.3.1 **Product specific requirements**

The FPC system shall:

- address this document; and
- ensure that the products placed on the market conform with the stated performance characteristics.

The results of inspections, tests or assessments requiring action shall be recorded, as shall any action taken. The action to be taken when control values or criteria are not met shall be recorded and retained for the period specified in the manufacturer’s FPC procedures.

7.3.3.2 **Raw materials and components**

The specifications of all incoming raw materials and components shall be documented, and the inspection scheme for ensuring their conformity shall be in accordance with Table 9.
Table 9 — Inspection scheme for raw materials and components

<table>
<thead>
<tr>
<th>Material/component</th>
<th>Control</th>
<th>Method</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material and component</td>
<td>Conformity of supplier's declaration with manufacturer's requirement a</td>
<td>Document examination</td>
<td>Each delivery</td>
</tr>
</tbody>
</table>

a This also applies where the manufacturer of the sheets is also the producer of the raw materials.

7.3.3.3 Product testing and evaluation

The manufacturer shall establish procedures to ensure that the stated values of all of the characteristics are maintained. The characteristics, and the means of control, shall be as given in Table 10.
Table 10 — Characteristics and minimum sampling frequencies for FPC testing

<table>
<thead>
<tr>
<th>Characteristic a</th>
<th>Requirement clause</th>
<th>Factory production control b</th>
<th>Minimum frequency of testing c</th>
<th>Compliance criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual appearance</td>
<td>5.2</td>
<td>Visual inspection</td>
<td>As defined in 5.2</td>
<td></td>
</tr>
<tr>
<td>Water/air tightness</td>
<td>5.12</td>
<td>Visual inspection</td>
<td>No holes</td>
<td></td>
</tr>
<tr>
<td>Dimensional tolerances and mass per unit area</td>
<td>5.3</td>
<td>Measurement according to 6.1</td>
<td>Once per 8 hours</td>
<td>Within the tolerances as defined in Table 1</td>
</tr>
<tr>
<td>Spectral characteristics</td>
<td>5.4</td>
<td>Raw material and process control</td>
<td>See Table 9 for raw material and continuous process control</td>
<td>Within manufacturer’s specification</td>
</tr>
<tr>
<td>Total solar energy transmittance</td>
<td>5.4</td>
<td>Raw material and process control</td>
<td>See Table 9 for raw material and continuous process control</td>
<td>Within manufacturer’s specification</td>
</tr>
<tr>
<td>Impact resistance</td>
<td>5.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durability (after ageing):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– variation of yellowness index</td>
<td>5.7.3</td>
<td>Raw material and process control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– variation of light transmittance</td>
<td>5.7.4</td>
<td>Raw material and process control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deformation behaviour</td>
<td>5.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airborne sound insulation</td>
<td>5.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal transmittance</td>
<td>5.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water vapour permeability</td>
<td>5.11</td>
<td>d</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear thermal expansion</td>
<td>5.13</td>
<td>e</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reaction to fire</td>
<td>5.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External fire performance</td>
<td>5.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistance to fire</td>
<td>5.16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of functional layers f</td>
<td>5.17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistance to fixing</td>
<td>5.19</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a FPC is performed only if the characteristic is being declared.
b Indirect methods of measurement (e.g. process control) are allowed provided that they give the same degree of confidence as if the specified minimum sampling frequency had been followed.
c Hourly frequencies relate to production time.
d No control necessary if using the reference value given in 5.11.
e No control necessary if using the reference value given in 5.13.
f Not necessary for any uncoated product.
g Raw material control is required only where raw material is purchased with protective coating already applied.

8 Marking and labelling

Sheets complying with this European Standard shall be durably marked with the name or trade mark of the manufacturer, and a means of traceability to documentation showing the classes according to this document.
When the sheets are protected by a coating/treatment on one side only, this side shall be identified.

The following information shall be clearly indicated on the delivery note, invoice or supplier' declaration, supplied with the delivery of light transmitting multiwall PC sheets:

a) name, trade mark or other means of identification of the manufacturer;
b) reference to this European Standard;
c) identification of the sheet;
d) type of material;
e) identification symbol of any third party, if relevant;
f) nominal overall sheet thickness (see 5.3);
g) nominal mass per unit area (see 5.3);
h) normal-hemispherical light transmittance, and the normal-hemispherical solar transmittance (see 5.4.1);
i) total solar energy transmittance (see 5.5);
j) impact resistance (see 5.6), if relevant;
k) class for the durability (see 5.7.2, Table 2);
l) variation of the yellowness index after thermal ageing (see 5.7.2, Table 2);
m) variation of the light transmittance after artificial ageing (see 5.7.2, Table 2);
n) bending stiffness, shear stiffness and buckling moment (see 5.8);
o) airborne sound insulation (see 5.9), if relevant;
p) thermal transmittance (see 5.10);
q) water vapour permeability (see 5.11), if relevant;
r) linear thermal expansion (see 5.13), if relevant;
s) class for the reaction to fire (see 5.14);
t) class for the external fire performance (see 5.15), if relevant;
u) class for the resistance to fire (see 5.16), if relevant;
v) presence of functional layers (see 5.17), if relevant.

NOTE Where ZA.3 covers the same requirements as this clause, the requirements of this clause are met.
Annex A
(informative)

Typical cross-sections of multiwall PC sheets

a) Sheet with symmetrical rectangular in-plan cross-section

b) Sheet with symmetrical in-plan cross-section with diagonal inner structures

c) Sheet with unsymmetrical rectangular in-plan cross-section

d) Sheet with unsymmetrical in-plan cross-section with diagonal inner structures
e) Sheet with unsymmetrical in-plan cross-section

f) Sheet with unsymmetrical in-plan cross-section with diagonal inner structure

Figure A.1 — Typical in-plan cross-sections of sheets
Annex ZA
(informative)

Clauses of this European Standard addressing the provisions of the EU Construction Products Directive

ZA.1 Scope and relevant characteristics

This European Standard has been prepared under Mandate M/121 "Internal and external wall and ceiling finishes" and Mandate M/122 "Roof coverings, rooflights, roof windows and ancillary products" given to CEN by the European Commission and the European Free Trade Association.

The clauses of this European Standard, shown in this annex, meet the requirements of the Mandates M121 and M122 given under the EU Construction Products Directive (89/106/EEC).

Compliance with these clauses confers a presumption of fitness of the construction products covered by this annex for their intended uses indicated herein; reference shall be made to the information accompanying the CE marking.

WARNING — Other requirements and other EU Directives, not affecting the fitness for intended uses, can be applicable to the construction products falling within the scope of this European Standard.

NOTE 1 In addition to any specific clauses relating to dangerous substances contained in this standard, there may be other requirements applicable to the products falling within its scope (e.g. transposed European legislation and national laws, regulations and administrative provisions). In order to meet the provisions of the EU Construction Products Directive, these requirements need also to be complied with, when and where they apply.

NOTE 2 An informative database of European and national provisions on dangerous substances is available at the Construction web site on EUROPA (accessed through http://ec.europa.eu/enterprise/construction/internal/dangsub/dangmain_en.htm

This annex establishes the conditions for the CE marking of Light transmitting flat multiwall polycarbonate sheets for internal and external roofs, wall and ceilings intended for the uses indicated in Tables ZA.1.1 and ZA.1.2 and shows the relevant clauses applicable.

The scope of this annex is defined by Tables ZA.1.1 to ZA.1.2 and is the same as Clause 1 of this standard.
Table ZA.1.1 — Relevant clauses for light transmitting flat multiwall polycarbonate sheets intended for roof coverings for buildings

<table>
<thead>
<tr>
<th>Products:</th>
<th>Light transmitting flat multiwall polycarbonate sheets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intended use:</td>
<td>Roof covering for buildings</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Essential characteristics</th>
<th>Requirements clauses in this standard</th>
<th>Levels and/or classes</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical resistance</td>
<td>5.8</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>External fire performance</td>
<td>5.15</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistance to fire</td>
<td>5.16</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reaction to fire</td>
<td>5.13</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water/air permeability</td>
<td>5.12</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensional tolerances</td>
<td>5.3</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water vapour permeability</td>
<td>5.11</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Release of dangerous substances</td>
<td>5.18</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact resistance</td>
<td>5.6</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct airborne sound insulation</td>
<td>5.9</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Thermal properties</td>
<td>5.10</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Durability – variation of yellowness index and light transmittance</td>
<td>5.7.3</td>
<td>–</td>
<td>Class $\Delta A$, $\Delta D$, $\Delta E$ or $\Delta F$ according to Table 2</td>
</tr>
<tr>
<td>Durability – variation of deformation behaviour</td>
<td>5.7.4</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>
Table ZA.1.2 — Relevant clauses for light transmitting flat multiwall polycarbonate sheets intended for internal and external wall and ceiling finishes

<table>
<thead>
<tr>
<th>Essential characteristics</th>
<th>Requirement clauses in this standard</th>
<th>Levels and/or classes</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaction to fire</td>
<td>5.14</td>
<td></td>
<td>Classified in accordance with EN 13501-1</td>
</tr>
<tr>
<td>Release of dangerous substances</td>
<td>5.18</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Water vapour permeability</td>
<td>5.11</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Water/air permeability</td>
<td>5.12</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Shatter properties – Impact resistance</td>
<td>5.6</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Flexural/tensile strength</td>
<td>?</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Resistance to fixings</td>
<td>5.19</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Direct airborne sound insulation</td>
<td>5.9</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Thermal properties</td>
<td>5.10</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Durability – variation of yellowness index and light transmission</td>
<td>5.7.3</td>
<td>–</td>
<td>Class $\Delta A$, $\Delta D$, $\Delta E$ or $\Delta F$ according to Table 2</td>
</tr>
<tr>
<td>Durability – variation of deformation behaviour</td>
<td>5.7.4</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>

The requirement on a certain characteristic is not applicable in those Member States (MSs) where there are no regulatory requirements on that characteristic for the intended use of the product. In this case, manufacturers placing their products on the market of these MSs are not obliged to determine nor declare the performance of their products with regard to this characteristic and the option “No performance determined” (NPD) in the information accompanying the CE marking (see ZA.3) may be used. The NPD option may not be used, however, where the characteristic is subject to a threshold level.

ZA.2 Procedures for the attestation of conformity of light transmitting flat multiwall polycarbonate sheets

ZA.2.1 Systems of attestation of conformity

The systems of attestation of conformity of light transmitting flat multiwall polycarbonate sheets indicated in Tables ZA.1.1 and ZA.1.2, respectively in accordance with:

- the Decision of the Commission 98/436/EC of 1998-06-22 (published the 10.07.98 under L194) amended by the Decision 01/596/EC (published the 2.08.01 under L209) as given in Annex III of the mandate for "Roof coverings, roof lights, roof windows and ancillary products",

- the Decision of the Commission 98/437/EC of 1998-06-30 (published the 10.07.98 under L194) amended by the Decision 01/596/EC (published the 2.08.01 under L209) as given in Annex III of the mandate for "Internal and external wall and ceiling finishes",

are shown in Table ZA.2 for the indicated intended uses and relevant levels or classes.
Table ZA.2 — Systems of attestation of conformity

<table>
<thead>
<tr>
<th>Products</th>
<th>Intended uses</th>
<th>Level(s) or class(es)</th>
<th>Attestation of conformity systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>As roofing coverings subject to reaction to fire regulations</td>
<td>A1*, A2*, B* and C* (A1, A2, B, C)**, D and E F</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Light transmitting flat multiwall polycarbonate sheets</td>
<td>As roof coverings subject to external fire performance regulations</td>
<td>See EN 13501-5  F_{roof}</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>As roof coverings subject to regulations on dangerous substances</td>
<td>–</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>As roof coverings for all other uses</td>
<td>–</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>As external finishes in ceilings subject to reaction to fire regulations</td>
<td>A1*, A2*, B* and C* (A1, A2, B, C)**, D and E F</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>As internal or external finishes in walls or ceilings, as relevant, subject to regulations on dangerous substances</td>
<td>–</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Products/materials for which a clearly identifiable stage in the production process results in an improvement of the reaction to fire classification (e.g. an addition of fire retardants or a limiting of organic material). Fire retardant products are under conformity system 1.

** Products for which there is no clearly identifiable stage in the production process results in an improvement of the reaction to fire classification (e.g. an addition of fire retardant or limiting of organic material).


The attestation of conformity of the light transmitting flat multiwall polycarbonate sheets in Tables ZA.1.1 and ZA.1.2 shall be in accordance with the evaluation of conformity procedures indicated in Tables ZA.3.1 to ZA.3.3 resulting from application of the clauses of this standard indicated therein.
### Table ZA.3.1 — Assignment of evaluation of conformity tasks for light transmitting flat multiwall polycarbonate sheets under system 1

<table>
<thead>
<tr>
<th>Tasks under the responsibility of the manufacturer</th>
<th>Content of the task</th>
<th>Evaluation of conformity clauses to apply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factory production control (FPC)</td>
<td>Parameters related to all characteristics of Table ZA.1.1 and/or ZA.1.2 relevant for the intended end use</td>
<td>7.3</td>
</tr>
<tr>
<td>Initial type testing by a notified test laboratory</td>
<td>Release of dangerous substance (only for internal or external wall finishes) and external fire performance, if relevant.</td>
<td>7.2</td>
</tr>
<tr>
<td>Initial type testing by the manufacturer</td>
<td>All characteristics of Table ZA.1.1 and/or ZA.1.2 relevant for the intended use except fire and dangerous substances</td>
<td>7.2</td>
</tr>
<tr>
<td>Initial type testing</td>
<td>Reaction to fire (Classes A1*, A2*, B*, C*)</td>
<td>7.2</td>
</tr>
<tr>
<td>Initial inspection of factory and of FPC</td>
<td>Parameters related to all characteristics of Table ZA.1.1 and/or ZA.1.2 relevant for the intended use, in particular reaction to fire and external fire performance</td>
<td>7.3</td>
</tr>
<tr>
<td>Continuous surveillance, assessment and approval of FPC</td>
<td>Parameters related to all characteristics of Table ZA.1.1 and/or ZA.1.2 relevant for the intended use, in particular reaction to fire and external fire performance</td>
<td>7.3</td>
</tr>
</tbody>
</table>

* See footnote to Table ZA.2.

### Table ZA.3.2 — Assignment of evaluation of conformity tasks for light transmitting flat multiwall polycarbonate sheets under system 3

<table>
<thead>
<tr>
<th>Tasks under the responsibility of the manufacturer</th>
<th>Content of the task</th>
<th>Evaluation of conformity clauses to apply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factory production control (FPC)</td>
<td>Parameters related to all characteristics of Table ZA.1.1 and/or ZA.1.2 relevant for the intended end use</td>
<td>7.3</td>
</tr>
<tr>
<td>Initial type testing by the manufacturer</td>
<td>All characteristics of Table ZA.1.1 and/or ZA.1.2 relevant for the intended use except fire and dangerous substances</td>
<td>7.2</td>
</tr>
<tr>
<td>Initial type testing by a notified test laboratory</td>
<td>Reaction to fire (Classes A1**, A2**, B**, C**, D and E), external fire performance and release of dangerous substances (only for internal or external wall finishes), if relevant</td>
<td>7.2</td>
</tr>
</tbody>
</table>

** See footnote to Table ZA.2.
Table ZA.3.3 — Assignment of evaluation of conformity tasks for light transmitting flat multiwall polycarbonate sheets under system 4

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Content of the task</th>
<th>Evaluation of conformity clauses to apply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tasks under the responsibility of the manufacturer</td>
<td>Parameters related to all characteristics of Table ZA.1.1 and/or ZA.1.2 relevant for the intended end use</td>
<td>7.3</td>
</tr>
<tr>
<td>Factory production control (FPC)</td>
<td>All relevant characteristics of Table ZA.1.1 and/or ZA.1.2, relevant for the intended end use, namely mechanical resistance, water vapour permeability, water/air permeability, dimensional tolerances and durability.</td>
<td>7.2</td>
</tr>
<tr>
<td>Initial type testing by the manufacturer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ZA.2.2 EC Certificate and Declaration of conformity**

*(In case of products with system 1):* When compliance with the conditions of this annex is achieved, the certification body shall draw up a certificate of conformity (EC Certificate of conformity), which entitles the manufacturer to affix the CE marking. The certificate shall include:

— name, address and identification number of the certification body,

— name and address of the manufacturer, or his authorised representative established in the EEA, and place of production,

  NOTE 1 The manufacturer may also be the person responsible for placing the product onto the EEA market, if he takes responsibility for CE marking.

— description of the product (type, identification, use, ...),

— provisions to which the product conforms (i.e. Annex ZA of this EN),

— particular conditions applicable to the use of the product (e.g. provisions for use under certain conditions),

— the number of the certificate,

— conditions of validity of the certificate, where applicable,

— name of, and position held by, the person empowered to sign the certificate.

In addition, the manufacturer shall draw up and retain a declaration of conformity (EC Declaration of conformity) including the following:

— name and address of the manufacturer, or his authorised representative established in the EEA,

— name and address of the certification body,

— description of the product (type, identification, use, ...), and a copy of the information accompanying the CE marking,

  NOTE 2 Where some of the information required for the Declaration is already given in the CE marking information, it does not need to be repeated.
— provisions to which the product conforms (i.e. Annex ZA of this EN), and a reference to the ITT report(s) and factory production control records (if appropriate),

— particular conditions applicable to the use of the product (e.g. provisions for use under certain conditions),

— number of the accompanying EC Certificate of conformity,

— name of, and position held by, the person empowered to sign the declaration on behalf of the manufacturer or of his authorised representative.

(In case of products under system 3 or 4): When compliance with the conditions of this annex is achieved, the manufacturer or his agent established in the EEA shall draw up and retain a declaration of conformity (EC Declaration of conformity), which entitles the manufacturer to affix the CE marking. This declaration shall include:

— name and address of the manufacturer, or his authorised representative established in the EEA, and place of production,

NOTE 3 The manufacturer may also be the person responsible for placing the product onto the EEA market, if he takes responsibility for CE marking.

— description of the product (type, identification, use,...), and a copy of the information accompanying the CE marking,

NOTE 4 Where some of the information required for the Declaration is already given in the CE marking information, it does not need to be repeated.

— provisions to which the product conforms (i.e. Annex ZA of this EN), and a reference to the ITT report(s) and factory production control records (if appropriate),

— particular conditions applicable to the use of the product, (e.g. provisions for use under certain conditions),

— name and address of the notified laboratory(ies) (only for products under system 3),

— name of, and position held by, the person empowered to sign the declaration on behalf of the manufacturer or his authorised representative.

The above mentioned declaration and certificate shall be presented in the language or languages accepted in the Member State in which the product is to be used.

ZA.3 CE marking and labelling

The manufacturer or his authorised representative established within the EEA is responsible for the affixing of the CE marking. The CE marking symbol to affix shall be in accordance with Directive 93/68/EEC and shall be shown on the product and accompanying commercial documents (e.g. a delivery note) and may also be shown on the label or packaging.

The CE marking symbol shall appear on the product and be accompanied by sufficient information to identify the manufacturer and enable the manufacturer to identify all relevant properties of the product and traceability of manufacture.

The following information about the product and its essential characteristics shall accompany the CE marking symbol on the accompanying commercial documents, and some or all of the information may be given on the label, packaging or products:

— the name or identification mark and registered address of the manufacturer,
— the number of this European Standard,
— the last two digits of the year in which the marking is affixed,
— the same reference number as on the product so linking the commercial document to the product,
— description of the product (material, profile identification, light transmission, thickness and/or mass per square metre, stiffness factor, glass content of glass-reinforced sheets),
— intended use(s) of the product,
— mechanical resistance (impact class I₀ or I₁ and bending stiffness), external fire performance (including the test method(s) applied and, where relevant, appropriate test parameters (e.g. pitch)) and reaction to fire, water vapour permeability (where different from the values given in Table 3), flexural tensile strength (flexural strength and modulus or tensile strength and Young’s modulus) if applicable, resistance to fixings (may be by reference to a document held by the manufacturer) and durability (may include more than one exposure classification).

The “No performance determined” (NPD) option may not be used where the characteristic is subject to a threshold level. Class F or Class F_roof are the equivalent to NPD for reaction to fire and external fire performance respectively. Otherwise, the NPD option may be used when and where the characteristic, for a given intended use, is not subject to regulatory requirements in the Member State of destination.

Figure ZA.1 gives an example of the information to be given on the commercial documents.

Where a product may be used both for wall finishing and roofing, the information on relevant characteristics may be combined into a single CE marking (as Figure ZA.1 shows).
In addition to any specific information relating to dangerous substances shown above, the product should also be accompanied, when and where required and in the appropriate form, by documentation listing any other legislation on dangerous substances for which compliance is claimed, together with any information required by that legislation.

NOTE 1  European legislation without national derogations need not be mentioned.

NOTE 2  Affixing the CE marking symbol means, if a product is subject to more than one directive, that it complies with all applicable directives.