



# Standard Specification for Architectural Flat Glass Clad Polycarbonate<sup>1</sup>

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## 1. Scope

1.1 This specification covers the quality requirements for cut sizes of glass clad polycarbonate (GCP) for use in buildings as security, detention, hurricane/cyclic wind-resistant, and blast and ballistic-resistant glazing applications.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 Reference to these documents shall be the latest revision unless otherwise specified by the authority applying this specification.

### 2.2 ASTM Standards:<sup>2</sup>

- C 162 Terminology of Glass and Glass Products
- C 1036 Specification for Flat Glass
- C 1048 Specification for Heat-Treated Flat Glass—Kind HS, Kind FT Coated and Uncoated Glass
- C 1172 Specification for Laminated Architectural Flat Glass
- C 1376 Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass
- C 1422 Specification for Chemically Strengthened Flat Glass
- C 1503 Specification for Silvered Flat Glass Mirror
- D 256 Test Method for Determining the Izod Pendulum Impact Resistance of Plastics
- D 543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents
- D 635 Test Method for Rate of Burning and/or Extent and

- Time of Burning of Plastics in a Horizontal Position
- D 638 Test Method for Tensile Properties of Plastics
- D 648 Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position
- D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
- D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
- D 1003 Test Method for Haze and Luminous Transmittance of Transparent Plastics
- D 1005 Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers
- D 1044 Test Method for Resistance of Transparent Plastics to Surface Abrasion
- D 3763 Test Method for High-Speed Puncture Properties of Plastics Using Load and Displacement Sensors
- E 308 Practice for Computing the Colors of Objects by Using the CIE System
- E 1886 Test Methods for Performance of Exterior Windows, Curtain Walls, Doors, and Storm Shutters Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials
- E 1996 Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Storm Shutters Impacted by Windborne Debris in Hurricanes
- F 1233 Test Method for Security Glazing Materials and Systems
- F 1642 Test Method for Glazing and Glazing Systems Subject to Airblast Loading
- F 1915 Test Methods for Glazing for Detention Facilities
- 2.3 *ANSI Standard:*
  - Z97.1 Safety Glazing Materials Used in Buildings—Safety Performance Specifications and Methods of Tests<sup>3</sup>
- 2.4 *Federal Document:*
  - CPSC 16 CFR 1201 Consumer Product Safety Commission Safety Standard for Architectural Glazing Materials<sup>4</sup>
- 2.5 *UL Standards*<sup>5</sup>
  - UL 752 Standard for Bullet Resisting Materials
  - UL 972 Standard for Burglary Resisting Glazing Materials

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

<sup>4</sup> Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098

<sup>5</sup> Available from Underwriters Laboratories (UL), Corporate Progress, 333 Pingston Rd., Northbrook, IL 60062.

### 3. Terminology

3.1 *Definitions*—Refer to the terminology in the ASTM standards referenced in 2.2, as appropriate.

3.1.1 *blemishes in flat glass*—refer to Specification C 1036, as appropriate.

3.1.2 *blemishes in polycarbonate*—refer to Appendix X1.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *adhesion chips*—glass particles or crystalline material that is permanently bonded to the surface of a lite.

3.2.2 *aliphatic polyether urethane*—a thermoplastic interlayer required to bond polycarbonate lite to polycarbonate or glass lite.

3.2.3 *asymmetrical construction*—see *non-symmetrical*.

3.2.4 *blow-in*—a separation of glass or polycarbonate and interlayer at or close to the laminate edge.

3.2.5 *boil (bubble)*—a gas pocket in the interlayer material or between the glass or polycarbonate and the interlayer.

3.2.6 *bond*—adhesion of the glass or polycarbonate ply to the interlayer.

3.2.7 *bow and warp*—a curve, bend, or other deviation from flatness.

3.2.8 *carbon specks*—flakes of carbon inherent in the manufacturing and extrusion of polycarbonate sheets.

3.2.9 *crizzle*—an imperfection in the form of a multitude of fine surface fractures.

3.2.10 *deflection temperature*—the softening temperature as determined by applying heat and load to a material.

3.2.11 *delamination*—a condition in which one or more of the lites of glass or polycarbonate loses the bond between the glass or polycarbonate lite and the interlayer.

3.2.12 *discoloration*—areas that are blushed, whitish, or yellow in appearance.

3.2.13 *distortion*—the inability to see an image clearly; the image is twisted out of natural shape.

3.2.14 *edge boil*—see *boil*.

3.2.15 *elongation*—the increase in length of a material that has been stretched.

3.2.16 *flammability rating*—the rate of burn; a CC-1 rating is based on a rate of burn less than one in./min.

3.2.17 *flexural modulus*—the stiffness/rigidity of a material as determined by bending the material at stresses less than that required to produce permanent deformation.

3.2.18 *fuse*—see *adhesion chips*.

3.2.19 *glass clad polycarbonate (GCP)*—one or more lites of flat glass bonded with an aliphatic urethane interlayer to one or more sheets of extruded polycarbonate in a pressure/temperature/vacuum laminating process.

3.2.20 *hair*—a thin filament resembling thread or animal hair.

3.2.21 *haze*—the percentage of transmitted light that, in passing through a specimen, deviates from incident beam by forward scattering.

3.2.22 *inside dirt*—foreign material trapped inside the laminate.

3.2.23 *instrumented dart*—a test evaluating the puncture properties of plastics over a range of test velocities.

3.2.24 *interlayer*—a material developed specifically for bonding glass lites to glass lites, polycarbonate to polycarbonate, or glass and polycarbonate lites together.

3.2.25 *izod milled notch*—a test evaluating the resistance of plastics to breakage by flexural shock. The notch in the izod specimen serves to concentrate the stress, minimize plastic deformation, and direct the fracture to the part of the specimen behind the notch.

3.2.26 *laminate*—see *glass clad polycarbonate*.

3.2.27 *lint*—short fibers of yarn or fabric trapped within the laminate.

3.2.28 *lite*—an assembly of glass clad polycarbonate.

3.2.29 *mismatch*—misalignment of the edges of two or more plies of glass or polycarbonate.

3.2.30 *non-symmetrical*—an assembly for which the thickness and types of glass, polycarbonate, and interlayer are not the same about the thickness center.

3.2.31 *offset*—a mismatch of the edges of two or more glass or polycarbonate plies as part of the design of the laminate.

3.2.32 *ply*—one sheet or panel of glass or polycarbonate in a laminate.

3.2.33 *PVB*—a polyvinyl butyral interlayer used to bond glass to glass.

3.2.34 *scratch*—damage on a glass or polycarbonate surface in the form of a line caused by the relative movement of an object across and in contact with the surface.

3.2.35 *scuff*—See *streak*.

3.2.36 *separation*—see *delamination*.

3.2.37 *short interlayer*—a condition of the laminate in which the interlayer does not extend to the edge.

3.2.38 *specific gravity*—the ratio of a given volume of a material to the weight of an equal volume of water at standard conditions.

3.2.39 *streak*—a noticeably visible deviation on/in the laminating unit.

3.2.40 *surfaces*—surfaces of glass and polycarbonate faces are counted from the exterior (threat) to the interior (protected). If a laminate of glass-interlayer-polycarbonate-interlayer glass is used as an example, the No. 1 surface is the surface that is to the exterior; the Nos. 2 and 3 surfaces are the next glass and polycarbonate surfaces, respectively, separated by and bonded to the interlayer material; the Nos. 4 and 5 surfaces are the following polycarbonate and glass surfaces, respectively, that are separated by and bonded to the interlayer; the No. 6 surface is the surface that is to the interior.

3.2.41 *symmetrical*—an assembly for which the thickness and types of glass, polycarbonate, and interlayers are the same about the thickness center.

3.2.42 *tabor abrasion*—a measure of the effect of a specific type of abrasion; the change in percent haze is measured for transparent materials, and weight loss is measured for opaque materials.

3.2.43 *template*—a pattern used as a guide to define the overall size and shape of a cut lite.

3.2.44 *tensile strength*—the load that causes a material to break during elongation/stretching.

3.2.45 *unlaminated area*—an area of the laminate that failed to laminate during the laminating process. This blemish is discernible due to the textured appearance of the interlayer material.

#### 4. Classification

4.1 *Kinds*—Glass clad polycarbonate furnished under this specification shall be of the following kinds, as specified:

4.1.1 *Kind GCP, Single Core (SC)*—Glass clad polycarbonate consisting of one or more lites of flat glass bonded with an aliphatic urethane interlayer to one sheet (single core) of polycarbonate in a pressure/temperature/vacuum laminating process.

4.1.2 *Kind GCP, Multiple Core (MC)*—Glass clad polycarbonate consisting of one or more lites of flat glass bonded with an aliphatic urethane interlayer to more than one sheet (multiple core) of polycarbonate in a pressure/temperature/vacuum laminating process.

4.1.3 *Kind GCP, Others (O)*—glass clad polycarbonate constructions not covered by 4.1.1 or 4.1.2.

#### 5. Ordering Information

5.1 *Procurement Information*—Purchasers should select the applicable options permitted in this section and include the following information in procurement documents:

- 5.1.1 Title, number, and date of this specification;
- 5.1.2 Kind of GCP, as referred to in this specification (see Section 4);
- 5.1.3 Edgework requirements (see 8.2);
- 5.1.4 Overall nominal thickness of the GCP, including the nominal thickness and treatment of glass plies and the nominal thicknesses of the polycarbonate and interlayer material;
- 5.1.5 Nominal length and width of the GCP;
- 5.1.6 Blueprint, drawing, template, orientation, or other information useful to the manufacturer regarding installation of the product;
- 5.1.7 Color or tint of the GCP laminate (tinted glass, interlayer, polycarbonate, or combinations);
- 5.1.8 Required minimum visible light transmittance of the laminate;
- 5.1.9 Mockup requirements (See 8.6—Flatness, Table 1 and Appendix X3.)
- 5.1.10 Security and safety standards or regulations to which the laminate must conform (see 7.1-7.8)

**TABLE 1 Maximum Allowable Overall Bow and Warp<sup>ABC</sup>**

Longest Edge Dimension, in. (mm)	Maximum Allowable Bow and Warp, in. (mm)
0 to 18 (0 to 460)	$\frac{3}{32}$ (2.4)
Over 18 to 36 (over 460 to 910)	$\frac{3}{16}$ (4.8)
Over 36 to 48 (over 910 to 1220)	$\frac{1}{4}$ (6.4)
Over 48 to 60 (over 1220 to 1520)	$\frac{5}{16}$ (7.9)
Over 60 to 96 (over 1520 to 2440)	$\frac{1}{2}$ (12.5)

<sup>A</sup> The above table is for GCP of any overall thickness having glass on both sides.

<sup>B</sup> For GCP with glass on both sides in a strip condition or for GCP with glass on one side and exposed polycarbonate on the opposing side in a nonstrip condition, the overall bow and warp is to be multiplied by 1.5. Strip condition is defined as a GCP product with a long side to short side ratio of 4 to 1 or greater.

<sup>C</sup> For GCP with glass on one side and exposed polycarbonate on the opposing side in a strip condition, the overall bow and warp is to be multiplied by 2.0.

- 5.1.11 Schedule requirements; and
- 5.1.12 All other standards to which the laminate must conform.

5.2 *Packaging Requirements*—Glass and polycarbonate packaging and protection will be standard manufacturer's practices unless otherwise specified. Consult manufacturers before specifying.

#### 6. Other Requirements

- 6.1 Annealed glass plies should conform to the requirements of Specification C 1036.
- 6.2 Heat-strengthened or fully tempered glass plies shall conform to the requirements of Specification C 1048.
- 6.3 Pyrolytic and vacuum deposition coated glass plies shall conform to the requirements of Specification C 1376.
- 6.4 Chemically strengthened glass plies shall conform to the requirements of Specification C 1422.
- 6.5 Silvered mirror glass plies shall conform to the requirements of Specification C 1503.
- 6.6 Polycarbonate sheets shall conform to the requirements of Appendix X1.
- 6.7 The aliphatic polyether urethane interlayer shall conform to the requirements of Appendix X2.
- 6.8 The polyvinyl butyral interlayer shall conform to the manufacturer's specifications.
- 6.9 Laminates specified for security glazing shall meet the applicable requirements of the security glazing standards (see 7.1).
- 6.10 Laminates specified for safety glazing shall meet the requirements of the specified safety glazing standards (see 7.2).
- 6.11 Verify compatibility of all materials in the glazing pocket including, but not limited to, primers, sealants, agents, or solvents used to clean or prepare frame materials prior to installation using testing protocol of practice B—Mechanical Stress and Reagent Exposure in Practice D 543.
- 6.12 Test protocols shall include evaluation of polycarbonates under stress. Test samples are to be  $\frac{1}{8}$  in. (3 mm) polycarbonate strips 1 in. (25 mm) wide by 12 in. (305 mm) long bent to a 10 in. (254 mm) base dimension in the strain jig.

#### 7. Test Methods

- 7.1 *Security Tests*—Test and interpret in accordance with tests required by specific jurisdictions, as applicable.
- 7.2 *Impact Test for Safety Glazing*—Test and interpret in accordance with ANSI Z97.1 or CPSC 16 CFR 1201, or both, as applicable.
- 7.3 *Test for Missile Impact and Cyclic Pressure*—Test and interpret in accordance with Test Method E 1886 and Specification E 1996.
- 7.4 *Test for Security Glazing*—Test and interpret in accordance with Test Method F 1233.
- 7.5 *Test for Glazing Subject to Airblast Loading*—Test and interpret in accordance with Test Method F 1642.
- 7.6 *Test for Detention Glazing*—Test and interpret in accordance with Test Method F 1915.
- 7.7 *Test for Bullet Resisting Glazing*—Test and interpret in accordance with Standard UL 752.
- 7.8 *Test for Burglary Resisting Glazing*—Test and interpret in accordance with Standard UL 972.

7.9 *Visual Inspection*—Place the specimen in a vertical position. The viewer shall look through the specimen, using daylight without direct sunlight, or using a background light suitable for observing the blemishes. View at 36 in. (914 mm) except where specified otherwise in Table 2.

7.10 *Transmittance*—Using Practice E 308, measure transmittance by illuminating each laminated specimen at normal incidence with the light having the spectral composition of the International Commission on Illumination (CIE), illuminate C. Measure the ratio of transmittance to incident luminous flux by calculating from the spectral distribution of illuminate C as defined by Practice E 308.

## 8. Fabrication Requirements

8.1 *Dimensional Fabrication*—All dimensional fabrication, such as cutting to overall dimensions, edgework, drilling, notching, grinding, sandblasting, and etching, on laminates incorporating heat-strengthened, chemically strengthened, or fully tempered glass must be performed prior to strengthening or tempering. In addition, custom drilling of any GCP, including speakholes and pass-through holes, may invalidate performance capabilities and is not recommended.

### 8.2 Edge:

8.2.1 Most GCP laminates incorporate heat-strengthened, chemically strengthened, or fully tempered glass. Additional edgework after strengthening or laminating compromises edge strength and is, therefore, not recommended (also see 8.1). Some mismatch can be expected with these laminates.

8.2.2 For GCP made with annealed glass, an edge shall be cut, sawed, ground, sanded to remove sharp edges only, seamed, beveled, or mitered, as specified.

### 8.3 Marking:

8.3.1 Each laminate shall bear the trademark or name of the GCP manufacturer unless otherwise specified.

8.3.2 GCP intended for safety glazing applications specified by building codes shall be marked permanently with the name or trademark of the GCP manufacturer and the designation of the applicable safety glazing standard.

8.4 *Thickness*—Since there are many possible makeups for GCP, it is essential that the specifier consult with the GCP manufacturer for the minimum and maximum thicknesses for each makeup specified. Typical thicknesses are tabulated in Table 3.

### 8.5 Mismatch, Length, and Width:

8.5.1 The maximum allowable mismatch is  $\frac{3}{16}$  in. (4.8 mm). The length and width tolerances of symmetrical laminates shall be in accordance with Table 4 when measured from edge to edge, including flares, mismatches, or offsets.

8.5.2 For non-symmetrical laminates and large or small sized laminates, contact the GCP manufacturer for length and width tolerances.

### 8.6 Flatness:

8.6.1 Because of the nature of the processes used in manufacturing heat-strengthened, rolled, tempered, or wired glass, these glasses may not be as flat as annealed or chemically strengthened transparent glass. The deviation from flatness and the resulting distortion of GCP depends on the glass type, thickness, width, length, laminating process, and other factors. The overall bow and warp of GCP, determined by measuring the greatest distance from a straight edge placed parallel to and within 1 in. (25.4 mm) of the edge of the GCP, shall not exceed the values given in Table 1.

8.6.2 Localized warp (as defined in Specification C 1048) for rectangular GCP shall not exceed  $\frac{1}{16}$  in. (1.6 mm) in any 12 in. (305 mm) span of edge.

8.7 *Blemishes*—Maximum allowable laminating process blemishes shall not be greater than those listed in Table 2. Inspection should be in accordance with Paragraph 7.10 of

**TABLE 2 Maximum Allowable Glass Clad Polycarbonate Blemishes**

Blemish <sup>A</sup>	Single Polycarbonate Core				Multiple Polycarbonate Core			
	Less than 25 ft <sup>2</sup> (2.5 m <sup>2</sup> )		25 to 50 ft <sup>2</sup> (2.5 to 4.7 m <sup>2</sup> )		Less than 25 ft <sup>2</sup> (2.5 m <sup>2</sup> )		25 to 50 ft <sup>2</sup> (2.5 to 4.7 m <sup>2</sup> )	
	Central, <sup>B</sup> in. (mm)	Outer, <sup>B</sup> in. (mm)	Central, <sup>B</sup> in. (mm)	Outer, <sup>B</sup> in. (mm)	Central, <sup>B</sup> in. (mm)	Outer, <sup>B</sup> in. (mm)	Central, <sup>B</sup> in. (mm)	Outer, <sup>B</sup> in. (mm)
Bubbles	$\frac{1}{16}$ (1.6)	$\frac{3}{32}$ (2.4)	$\frac{3}{32}$ (2.4)	$\frac{1}{8}$ (3.2)	$\frac{3}{32}$ (2.4)	$\frac{1}{8}$ (3.2)	$\frac{1}{8}$ (3.2)	$\frac{3}{16}$ (4.8)
Blow-in; edge boil	N/A	$\frac{3}{8}$ (15.9)	N/A	$\frac{3}{8}$ (15.9)	N/A	$\frac{3}{8}$ (15.9)	N/A	$\frac{3}{8}$ (15.9)
Fuse	$\frac{1}{32}$ (0.8)	$\frac{1}{16}$ (1.6)	$\frac{1}{16}$ (1.6)	$\frac{3}{32}$ (2.4)	$\frac{1}{16}$ (1.6)	$\frac{3}{32}$ (2.4)	$\frac{3}{32}$ (2.4)	$\frac{5}{32}$ (4.0)
Hair, lint (single strand)	light intensity <sup>C</sup>	medium intensity <sup>D</sup>	light intensity <sup>C</sup>	medium intensity <sup>D</sup>	medium intensity <sup>D</sup>	medium intensity <sup>D</sup>	medium intensity <sup>D</sup>	medium intensity <sup>D</sup>
Inside dirt (dirt spot)	$\frac{1}{16}$ (1.6)	$\frac{3}{32}$ (2.4)	$\frac{3}{32}$ (2.4)	$\frac{5}{32}$ (4.0)	$\frac{3}{32}$ (2.4)	$\frac{5}{32}$ (4.0)	$\frac{1}{8}$ (3.2)	$\frac{3}{16}$ (4.8)
Lint, areas of concentrated lint	light intensity <sup>C</sup>	light intensity <sup>D</sup>	light intensity <sup>C</sup>	light intensity <sup>C</sup>	light intensity <sup>C</sup>	light intensity <sup>C</sup>	light intensity <sup>C</sup>	light intensity <sup>D</sup>
Delamination, discoloration	none	none	none	none	none	none	none	none
Short interlayer; unlaminated area chip	N/A	$\frac{3}{8}$ (15.9)	N/A	$\frac{3}{8}$ (15.9)	N/A	$\frac{3}{8}$ (15.9)	N/A	$\frac{3}{8}$ (15.9)
Scuff, streak	light intensity <sup>C</sup>	medium intensity <sup>D</sup>	light intensity <sup>C</sup>	medium intensity <sup>D</sup>	light intensity <sup>C</sup>	medium intensity <sup>D</sup>	medium intensity <sup>D</sup>	medium intensity <sup>D</sup>
Scratches (white) <sup>E</sup>	light intensity <sup>C</sup>	medium intensity <sup>D</sup>	light intensity <sup>C</sup>	medium intensity <sup>D</sup>	light intensity <sup>C</sup>	medium intensity <sup>D</sup>	medium intensity <sup>D</sup>	medium intensity <sup>D</sup>
Carbon specks	$\frac{1}{16}$ (1.6)	$\frac{1}{16}$ (1.6)	$\frac{1}{16}$ (1.6)	$\frac{1}{16}$ (1.6)	$\frac{1}{16}$ (1.6)	$\frac{1}{16}$ (1.6)	$\frac{1}{16}$ (1.6)	$\frac{1}{16}$ (1.6)
Crizzle	none	none	none	none	none	none	none	none

<sup>A</sup> All imperfections noted, with the exception of carbon specks, should be separated by a minimum of 12 in. (305 mm).

<sup>B</sup> The central area is an area formed by an oval or circle whose axes or diameters, when centered, do not exceed 80 % of the overall dimension. The outer area is the area outside of the central area.

<sup>C</sup> Light intensity: barely noticeable at 36 in. (914.4 mm).

<sup>D</sup> Medium intensity: noticeable at 36 in. (914.4 mm) but not at 11 ft (3352.8 mm).

<sup>E</sup> Hairline scratches are acceptable not to exceed 4 in. (101.60 mm) in length.

**TABLE 3 Nominal Thickness**

Nominal Construction, in.	in. (mm)	Minimum Thickness, in. (mm)	Maximum Thickness, in. (mm)
7/16	0.458 (11.63)	0.426 (10.82)	0.508 (12.9)
9/16	0.576 (14.63)	0.532 (13.51)	0.638 (16.21)
11/16	0.715 (18.16)	0.658 (16.71)	0.791 (20.09)
13/16	0.794 (20.17)	0.684 (17.37)	0.824 (20.93)
15/16	0.862 (20.89)	0.79 (20.07)	0.954 (24.23)

Specification C 1172. For the quality specification for the individual glass plies, polycarbonate, and aliphatic urethane, refer to Specification C 1036, Specification C 1048 (if applicable), Specification C 1376, Appendix X1, and Appendix X2.

**TABLE 4 Size Tolerances**

Laminate Construction	in. (mm)
2 and 3 ply	± 1/8 (± 3)
4 or more ply	± 3/16 (± 4.8)

8.8 *Haze*—This value shall not exceed 2.5 %, as measured per Test Method D 1003.

## 9. Keywords

9.1 flat glass; glass clad polycarbonate; institutional glazing; laminated glass; polycarbonate; security glazing

## APPENDIXES

### (Nonmandatory Information)

#### X1. SPECIFICATION FOR EXTRUDED POLYCARBONATE SHEET USED IN TRANSPARENT COMPOSITE STRUCTURES

##### X1.1 Scope

X1.1.1 This specification covers colorless gloss smooth polycarbonate sheet material suitable for composite laminates using interlayers for adhesion. The polycarbonate sheet thickness range is from 0.060 to 0.500 in. (1.5 to 12.7 mm).

X1.1.2 *Classification*—The polycarbonate sheet shall be of the following types:

(1) *Type I*—Standard ultraviolet (UV) stabilized polycarbonate; or

(2) *Type II*—Coated mar-resistant UV stabilized polycarbonate.

##### X1.2 Physical Property Values

X1.2.1 Specimens are prepared from polycarbonate sheet materials and shall display typical property values, as specified in Table X1.1, when tested as specified by the applicable procedure.

##### X1.3 Appearance

X1.3.1 Internal dirt, contamination, and embedded particulates shall be no greater than 1/16 in. (1.6 mm) in diameter. Defects smaller in size shall not be grouped in an objectionable pattern as to impair or distort vision.

X1.3.2 Internal bubbles or voids shall not be noticeable from a distance of 36 in. (914 mm).

X1.3.3 Visually apparent blemishes, such as roll skip, die lines, and surface defects, are not allowable when viewed under the following conditions:

**TABLE X1.1 Physical Property Values<sup>A</sup>**

Property	Typical Values	Test Method
Specific gravity	1.19 to 1.21	D 792
Tensile strength	9000 psi	D 638
Elongation	80 %	D 638
Flexural modulus	340 000 psi	D 790
Impact strength Izod milled notch	16 ft lb/in. of notch	D 256
Instrumented dart	600 in. lb	D 3763
Deflection temperature under load (264 psi)	265°F	D 648
Flammability rating	CC-1	D 635
Taber abrasion <sup>B</sup> 100 cycles, CS-10F wheel 500 g	<1.5 % (change in haze)	D 1044

<sup>A</sup> Values listed in this table represent typical numbers for 1/8 in. (nominal) thickness specimens.

<sup>B</sup> For Type II sheet.

(1) Sheet shall hang vertically in front of a bank of fluorescent lights spaced 6 to 12 in. (152 to 305 mm) away;

(2) Discrepancies shall not be noticeable from a distance of 36 in. (914 mm).

X1.3.4 Thickness and light transmission of clear polycarbonate (measured as instructed in Test Method D 1003) is shown in Table X1.2.

X1.3.5 *Haze (Measured as Per Test Method D 1003)*

The maximum haze value is 2 % for all thicknesses.

X1.3.6 *Chemical Resistance*—For a specific sealant compatibility or chemical resistance, please contact the polycarbonate sheet manufacturer.

**TABLE X1.2 Thickness and Light Transmission of Clear Polycarbonate**

Nominal Gage, in. (mm) <sup>A</sup>	Minimum Thickness, in. (mm)	Maximum Thickness, in. (mm)	Light Transmission Minimum
0.060	0.054	0.066	87 %
0.093	0.084	0.102	86 %
0.118 (3.0)	0.106 (2.7)	0.130 (3.3)	86 %
0.125	0.113	0.138	85 %
0.117 (4.5)	0.159 (4.05)	0.195 (4.95)	84 %
0.220	0.198	0.242	82 %
0.236 (6.0)	0.212 (5.4)	0.260 (6.6)	82 %
0.250	0.225	0.275	81 %
0.375	0.338	0.413	78 %
0.500	0.450	0.550	75 %

<sup>A</sup> Metric is given only when an equivalent metric thickness is produced.

## X2. SPECIFICATION FOR ALIPHATIC POLYETHER URETHANE FOR USE IN FLAT GLASS CLAD POLYCARBONATE

X2.1 The following guidelines are offered as recommendations for specifying polyurethane interlayer for use in GCP composite structures:<sup>6</sup>

X2.1.1 *Type*—The recommended type of interlayer is aliphatic polyether.

X2.1.2 *Light Transmission*—The light transmission should be a minimum of 85 % when measured by Test Method D 1005 as laminated between two 1/8-in. (3.2-mm) thickness glass plies with a film of 0.050 in. (1.3 mm).

X2.1.3 *Haze*—The haze should be limited to 1 % when measured by Test Method D 1005 on a film thickness of 0.050 in. (1.3 mm).

X2.1.4 *Gage Variation*—A gage variation of  $\pm 10$  % of the nominal thickness is acceptable. This is measured every inch, and variation is not to exceed 0.002 in. (0.05 mm) per lineal inch anywhere along the sheet.

X2.1.5 *Ultimate Tensile Strength*—The ultimate tensile strength shall be 3000 psi, as a minimum, when measured by Test Method D 1005.

X2.1.6 *Ultimate Elongation*—The ultimate elongation shall be 300 %, as a minimum, when measured by Test Method D 1005.

X2.2 For a specific sealant compatibility or chemical resistance, please contact the polyurethane resin manufacturer.

<sup>6</sup> Measurements are for specimens at  $23 \pm 2^\circ\text{C}$ .

## X3. GLASS CLAD POLYCARBONATE SELECTION

X3.1 *Visual Mockups*—Viewing full-size mockups under typical site conditions and surrounding landscape is highly recommended for evaluation of reflected and optical distortion.

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