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Standard Specification for Laminated Architectural Flat Glass¹

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^{ε1} NOTE—Editorial changes were made throughout in March 2011.

1. Scope

1.1 This specification covers the quality requirements of flat laminated glass consisting of two or more lites of glass bonded with an interlayer material for use in building glazing.

1.2 Depending on the number, thickness and treatment of lites, and the number and thickness of interlayers, the glass shall be laminated for applications including but not limited to safety security, detention, hurricane/cyclic-wind resistant, blast resistant, bullet resistant and sound reduction glazing applications. Laminated glass used in furniture applications is not included in this specification.

1.3 Optical distortion and the evaluation thereof are not currently within the scope of the standard. Mockups are recommended as a method to evaluate glass. (See [Appendix X1](#).)

1.4 The dimensional values, except thickness designations, stated in inch-pound units are to be regarded as the standard. The values in parentheses are for information only.

1.5 The following safety hazards caveat pertains only to the test method portion, Section 7, of this specification. *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*:²

¹ This specification is under the jurisdiction of ASTM Committee C14 on Glass and Glass Products and is the direct responsibility of Subcommittee C14.08 on Flat Glass.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

C162 Terminology of Glass and Glass Products

C1036 Specification for Flat Glass

C1048 Specification for Heat-Strengthened and Fully Tempered Flat Glass

C1376 Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass

C1422 Specification for Chemically Strengthened Flat Glass

C1503 Specification for Silvered Flat Glass Mirror

E308 Practice for Computing the Colors of Objects by Using the CIE System

E1886 Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials

E1996 Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes

F1233 Test Method for Security Glazing Materials And Systems

F1642 Test Method for Glazing and Glazing Systems Subject to Airblast Loadings

F1915 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 Tests³

2.4 *Federal Document*:⁴

CPSC 16CFR1201 Consumer Product Safety Commission Safety Standard for Architectural Glazing Materials

2.5 *National Institute of Justice (NIJ) Standard*:⁵

NIJ 0108.1 Ballistic Resistant Protective Materials

2.6 *UL Standards*:⁶

UL 752 Standard for Bullet Resisting Materials

UL 972 Standard for Burglary Resisting Glazing Materials

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

⁴ Available from U.S. Consumer Product Safety Commission (CPSC), 4330 East West Hwy., Bethesda, MD 20814, <http://www.cpsc.gov>.

⁵ Available from National Institute of Justice (NIJ), 810 7th St., NW, Washington, DC 20531, <http://www.ojp.usdoj.gov/nij>.

⁶ Available from Underwriters Laboratories (UL), 333 Pfingsten Rd., Northbrook, IL 60062-2096, <http://www.ul.com>.

3. Terminology

3.1 Definitions:

3.1.1 Refer to Terminology **C162**, Specifications **C1036** or **C1048**, as appropriate.

3.1.2 *blemishes in flat glass*—Refer to Specifications **C1036** or **C1048**, as appropriate.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *adhesion chips*—See *fuse*.

3.2.2 *blow-in*—a separation of glass and interlayer at or close to the laminate edge caused by penetration of the autoclaving medium into the edge during manufacturing.

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

3.2.4 *covered edge*—the peripheral area of the laminate covered by the channel or sash when installed.

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

3.2.6 *discoloration*—a visibly noticeable color change (from original) in the appearance of a material.

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

3.2.8 *edge boil*—See *boil (bubble)*.

3.2.9 *exposed edge*—the peripheral area of the laminate exposed to the environment after installation.

3.2.10 *fuse*—a glass particle or crystalline material that is permanently bonded to a surface of a lite.

3.2.11 *hair*—a slender, pigmented filament from human or animal epidermis or other thread-like filament.

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

3.2.13 *interlayer*—a layer or multiple layers of material acting as an adhesive between lites of glass which adds additional performance to the finished product, for example, impact resistance, solar control, acoustical insulation.

3.2.14 *laminated glass*—an assembly consisting of two or more lites of glass, conforming to Specification **C1036** or **C1048** that are bonded together by interlayer material.

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

3.2.16 *lite or light*—a panel or sheet of glass or a panel or sheet of laminated glass.

3.2.17 *mismatch*—misalignment of the edges of two lites of glass, when laminated.

3.2.18 *nonsymmetrical*—a term used to describe the construction of a laminate comprised of different glass types or thickness, or both.

3.2.19 *offset*—glass lites that are intentionally not aligned in a laminate.

3.2.20 *rub*—abrasion of a glass surface producing a frosted appearance. Also known as a scuff.

3.2.21 *separation*—an area of the laminate that has become delaminated (see *delamination*).

3.2.22 *shiner*—an area on a glass edge that has not been ground or polished.

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

3.2.24 *streak*—a noticeably visible directional blemish or discoloration on or in the laminated unit.

3.2.25 *symmetrical*—a term used to describe the construction of a laminate comprised of only one glass type and thickness.

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

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

4. Classification

4.1 *Type*—Laminated flat glass furnished under this specification shall be of the following types, as specified:

4.1.1 *Type I - Laminated Glass*—an assembly consisting of two or more lites of glass, conforming to Specification **C1036** or **C1048** that are bonded together by interlayer material.

4.1.2 *Type II - Laminated Safety Glass*—as defined in ANSI Z97.1 or CPSC 16CFR1201 or both. Two or more lites of flat glass, bonded by interlayer material. In the case of breakage, the interlayer serves to retain the glass fragments, limit the size of the opening and reduce the risk of cutting or piercing injuries.

4.2 *Application*—the following terms are designed to guide the user to the appropriate inspection charts and requirements. The glazing can usually, but not always be viewed in transmittance and reflectance.

4.2.1 *Laminated Vertical Glazing*—Glazing used in an installation in which the lower edge of the glazing is a maximum of 6 ft (1.8 m) above the walking surface. The glazing is usually vertical, however may also be sloping in or out from the vertical plane. The glazing can be approached within 10 ft (3 m) or less (if distance is greater than 10 ft (3 m) see *Laminated Overhead Glazing*). Interior decorative glazing will be judged according to laminated vertical glazing criteria.

4.2.2 *Laminated Overhead Glazing*—Glazing used in an installation in which the lower edge of the glass is more than 6 ft (1.8 m) above a walking floor level or cannot be approached within 10 ft (3 m). The glazing is usually sloping from the vertical plane, however may also be vertical. Sloped glazing is considered any glazing that slopes more than 15° from the vertical in any direction.

4.2.3 *Laminated Spandrel Glazing*—Glazing used in an installation in which the glazing is only viewed in reflection from the building's exterior. The glazing is usually installed vertically, however, may be at a slope to the vertical plane. Laminated spandrel glazing shall be inspected using the criteria of vertical or overhead laminated glazing. (See section 4.2.1 or 4.2.2) based upon installation as vertical or overhead glazing.

5. Ordering Information

5.1 Purchasers should select the preferred options permitted in this specification and include the following information in procurement documents:

- 5.1.1 Title, number, and date of this specification.
- 5.1.2 Type of laminated flat glass as referred to in this specification (see Section 4).
- 5.1.3 Edgework requirements (see 8.2).
- 5.1.4 Thickness requirements:
 - 5.1.4.1 Thickness designation of each individual lite of glass to be used in the laminate,
 - 5.1.4.2 Interlayer type and thickness designation, and
 - 5.1.4.3 Overall nominal thickness of the laminate.
- 5.1.5 Nominal length and width of the laminate.
 - 5.1.5.1 Blueprint, drawing, template, configuration specification, or other forms of information which detail overall size, configuration, and orientation.
- 5.1.6 Types of each individual lite of glass to be used in the laminate.
 - 5.1.6.1 Color, tint, coating, decorative effect and strength of each individual lite of glass.
- 5.1.7 Color, tint and decorative effect of the interlayer.
- 5.1.8 The luminous transmittance of the laminate (see 7.11).
- 5.1.9 Safety standards or regulations to which the laminate must conform.
- 5.1.10 All other standards to which the laminate must conform.

5.2 *Packaging Requirements*—Glass packaging and protection will be standard manufacturer practice unless otherwise specified. Consult manufacturer before specifying.

6. Other Requirements

- 6.1 Annealed glass lites shall conform to the requirements of Specification **C1036** for the incorporated glass type.
- 6.2 Chemically strengthened glass lites shall conform to the requirements of Specification **C1422**.
- 6.3 Heat strengthened or fully tempered glass lites shall conform to the requirements of Specification **C1048**.
- 6.4 Mirror glass lites shall conform to the requirements of Specification **C1503**.
- 6.5 Pyrolytic and vacuum deposition coated glass lites shall conform to the requirements of Specification **C1376**.
- 6.6 Solar and Optical property shall be as specified.
- 6.7 Solar Heat Gain Coefficient shall be as specified.
- 6.8 Spandrel glass lites shall conform to the requirements of Specification **C1048** for the incorporated glass type.
- 6.9 Visible reflection shall be as specified.
- 6.10 Visible transmittance shall be as specified.
- 6.11 U-factor shall be as specified.

7. Test Methods

7.1 *Impact Test for Safety Glazing*—Test and interpret in accordance with ANSI Z97.1 or CPSC 16CFR1201, or both, as applicable.

7.2 *Test for Missile Impact and Cyclic Pressure*—Test and interpret in accordance with Test Method **E1886** and Specification **E1996**.

7.3 *Test for Security Glazing*—Test and interpret in accordance with Test Method **F1233**.

7.4 *Test for Glazing Subject to Airblast Loading*—Test and interpret in accordance with Test Method **F1642**.

7.5 *Test for Detention Glazing*—Test and interpret in accordance with Test Method **F1915**.

7.6 *Test for Bullet Resisting Glazing*—Test and interpret in accordance with specified standards such as Test Method **F1233**, NIJ 0108.1, and Standard UL 752.

7.7 *Test for Burglary Resisting Glazing*—Test and interpret in accordance with specified standards such as, but not limited to: Test Method **F1233**, NIJ 0108.1, and UL 972.

7.8 *Overall Bow/Warp*—Place sample glass in a free-standing vertical position, with the longest edge resting on blocks at the quarter points. With the laminate in this position, place a straightedge across the concave surface, parallel to and within 1 in. (25.4 mm) of the edge, and measure the maximum deviation with a taper or feeler gage. A dial indicator may also be used.

7.9 *Size*—Measure length and width from edge to edge, including flares, mismatch, or offset (see 8.5).

7.10 *Visual Inspection*—All visual inspections shall be made with 20/20 vision (normal or corrected eye). The viewer shall look at the sample at an angle of 90° (perpendicular) to the surface using the following lighting unless otherwise specified: daylight (without direct sunlight) or other uniform diffused background lighting that simulates daylight, with a minimum luminance of 160 fc (1700 lx) measured at the surface of the glass facing the light source.

7.10.1 *Laminated Vertical Glazing*—Inspect glazing in the vertical position at a distance of 39 in. (1 m). If a blemish is readily apparent under these viewing conditions, refer to **Table 1** for acceptable criteria.

7.10.2 *Laminated Overhead Glazing*—Inspect glazing in the vertical position at a distance of 10 ft (3 m). If a blemish is readily apparent under these viewing conditions, refer to **Table 2** for acceptable criteria.

7.11 *Transmittance*—Using Practice **E308**, measure transmittance by illuminating each laminated specimen at normal incidence with light having the spectral composition of International Commission on Illumination (CIE) illuminant *C*. Measure the ratio of transmittance to incident luminous flux by calculating from the spectral distribution of illuminant *C* as defined by Practice **E308**.

8. Fabrication Requirements

8.1 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 shall be performed prior to strengthening or tempering. After the glass