

**Ballistic Glass & Armor Solutions**

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## Laminated Quality Specifications

### 1. SCOPE

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 that fall within the standard size limit guidelines (see GLG-100). Laminated glass used in balustrade and railing applications, where the edges of the laminate are exposed, is not included in this specification.

### 2. REFERENCES

References to these documents shall be the latest revision unless otherwise specified.

#### 2.1 ASTM STANDARDS:

- C162 Terminology of Glass and Glass Products
- C1036 Specification for Flat Glass
- C1048 Specification for Heat-Treated Flat Glass — Kind HS, Kind FT Coated & Uncoated Glass
- C1172 Specification for Laminated Architectural Flat Glass
- C1376 Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass
- F1233 Test Method for Security Glazing Materials and Systems

#### 2.2 OTHER:

- CLG-102 Laminated Glass Thickness Specification Chart
- GLG-100 Laminated Glass Size Limit Guidelines

### 3. TERMINOLOGY

Refer to ASTM standards C162, C1036, C1048 or C1172, as appropriate.

#### 3.1 Definitions of Terms Specific to This Documents

- 3.1.1 *blemish*—imperfection in the body or on the surface of the glass.
- 3.1.2 *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.
- 3.1.3 *bow*—a condition in which a lite of flat glass departs from a true plane.
- 3.1.4 *chip depth*—measured distance of a chip from the face of the glass into the thickness.
- 3.1.5 *chip length*—maximum distance parallel to the edge of the glass from one edge to the other.
- 3.1.6 *chip width*—maximum perpendicular distance from the edge of the glass to the inner edge of the chip.
- 3.1.7 *bubble*—a gas pocket in the interlayer material or between the glass and interlayer.
- 3.1.8 *coating rub*—a surface abrasion of appreciable width that has partial, or complete, removal of the coating producing a hazing appearance.
- 3.1.9 *coating scratch*—partial, or complete, removal of the coating along a thin straight or curved line.
- 3.1.10 *corrosion*—change in the color or level of reflected or transmitted light over all or part of the glass surface as a result of degradation of the coating from external sources.
- 3.1.11 *crazing*—a random conglomeration of fine lines or cracks in the coating.
- 3.1.12 *covered edge*—the peripheral area of the laminate covered by the channel or sash when installed.
- 3.1.13 *delamination*—a condition in which separation has occurred between the glass lite(s) and the interlayer.
- 3.1.14 *discoloration*—a visibly noticeable color change (from original) in the appearance of a material.
- 3.1.15 *distortion*—the inability to see an image clearly; the image is twisted out of natural shape.
- 3.1.16 *edge flake*—minor crushing at the glass edge as a result of interlayer trimming or leaning the glass on edge
- 3.1.17 *exposed edge*—the peripheral area of the laminate exposed to the environment after installation.
- 3.1.18 *fuse*—a glass particle or crystalline material that is permanently bonded to a surface of a lite.
- 3.1.19 *hair*—a slender, pigmented filament from human or animal epidermis or other thread-like filament.
- 3.1.20 *inside dirt*—foreign material trapped inside the laminate.

- 3.1.21 *interlayer*—a layer or multiple layers of material acting as an adhesive between lites of glass which add(s) additional performance to the finished product, for example, impact resistance, solar control, acoustical insulation, color, design, or combinations thereof.
- 3.1.22 *interlayer inset*— a condition of the laminate in which the interlayer does not extend to the edge. Also known as short interlayer.
- 3.1.23 *laminated glass*—an assembly consisting of two or more lites of glass, conforming to ASTM C1036 or C1048, that are bonded together by an interlayer material.
- 3.1.24 *lint*—short fibers of yarn or fabric trapped within the laminate.
- 3.1.25 *lite*—a panel or sheet of glass or a panel or sheet of laminated glass.
- 3.1.26 *mismatch*—misalignment of the edges of two lites of glass, when laminated.
- 3.1.27 *offset*—glass lites that are intentionally not aligned in a laminate.
- 3.1.28 *pinhole*—small area in which the coating is entirely or partially absent.
- 3.1.29 *rough chip*—chips that are  $> \frac{1}{2}$  the glass thickness and are angular or jagged in nature.
- 3.1.30 *rub*—abrasion of a glass surface producing a frosted appearance; also known as scuff.
- 3.1.31 *separation*—an area of the laminate that has become delaminated (see delamination).
- 3.1.32 *shell chip*—circular indentation in the glass edge as a result of breakage of a small fragment.
- 3.1.33 *shiner*—an area on a glass edge that has not been ground or polished.
- 3.1.34 *spot*—a small, opaque blemish in the coating.
- 3.1.35 *streak*—a noticeably visible directional blemish or discoloration on or in the laminated unit.
- 3.1.36 *template*—a pattern used as a guide to define the overall size and shape of a cut lite.
- 3.1.37 *unlaminated area*—an area of the laminate that failed to flow, develop acceptable optics, achieve adhesion, or combinations thereof during the laminating process. This blemish may be discernible due to a texture, haze, or other change in appearance.
- 3.1.38 *v-chip*—v-shaped imperfection in the edge of the glass lite.

#### 4. 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.

**4.1 LAMINATED PROXIMATE 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 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.

**4.3 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 laminated proximate glazing or laminated overhead glazing.

## 5. DIMENSIONAL TOLERANCES

### 5.1 THICKNESS

Thickness tolerances of standard monolithic glass and laminated glass products are specified in CLG 102. Nominal thickness tolerance computation guidelines are as follows:

- 5.1.1 *Minimum Thickness Tolerance* – Minimum thickness tolerance shall be the summation of the values for the minimum thickness of each glass lite and the minimum interlayer thickness obtained from CLG 102.
- 5.1.2 *Maximum Thickness Tolerance* – Maximum thickness tolerance shall be the summation of the values for the maximum thickness of each glass lite and the maximum interlayer thickness obtained from CLG 102.
- 5.1.3 *Measurement of Thickness* – The thickness of the laminate is to be calculated as the mean value of all measurements taken at the middle points of all its sides.

### 5.2 LENGTH AND WIDTH

Length and width tolerances of rectangular laminated glass shall be in accordance with Table 1 when measured from edge to edge, including flares, mismatch, or offset.

Table 1. Length and Width Tolerances for Rectangular Shapes of Laminated Glass

Laminate Size, A	Laminate Thickness, t	Length & Width Tolerance
Up to 40 ft <sup>2</sup>	t < 1" (25.4 mm)	± 1/16" (± 1.6 mm)
40 ft <sup>2</sup> ≤ A ≤ 60 ft <sup>2</sup>	t ≤ 1/4" (6.4 mm)	+ 5/32", -1/16" (+ 4 mm, - 1.6 mm)
	1/4" (6.4 mm) < t ≤ 1/2" (12.7 mm)	+ 1/4", -1/16" (+ 6.4 mm, - 1.6 mm)
	1/2" (12.7 mm) < t ≤ 1" (25.4 mm)	+ 1/4", -1/8" (+ 6.4 mm, - 3.2 mm)

### 5.3 SQUARENESS

The squareness of rectangular panes is expressed by the differences between its diagonals. Squareness tolerances of laminated glass shall be in accordance with Table 2 when measured corner to corner.

Table 2. Squareness Tolerances for Rectangular Shapes of Laminated Glass

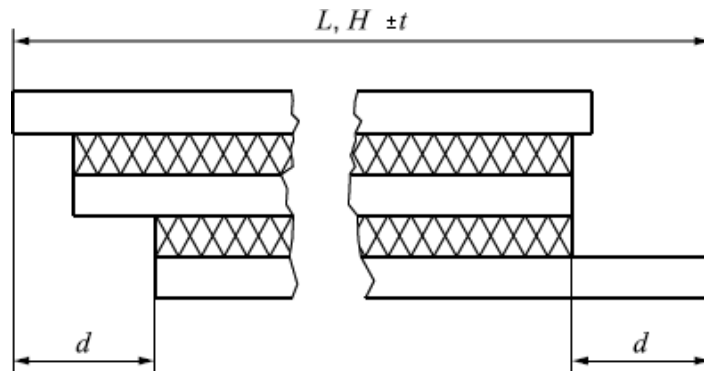
Laminate Size, A	Squareness Tolerance
Up to 40 ft <sup>2</sup>	3/32" (2.4 mm)
Over 40 ft <sup>2</sup>	5/32" (4 mm)

### 5.4 OFFSET

The maximum offset tolerances of laminated glass shall be in accordance with Table 3.

Table 3. Offset Tolerances for Rectangular Shapes of Laminated Glass

Laminate Size, A	Maximum Offset, d
Up to 40 ft <sup>2</sup>	1/16" (1.6 mm)
Over 40 ft <sup>2</sup>	1/8" (3.2 mm)



## 6. BOW TOLERANCES

### 6.1 OVERALL BOW

- 6.1.1 To measure overall bow, the glass is placed 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 or a taut string across the concave surface, parallel to and within 1 in. of the edge, and measure the maximum deviation with a taper, feeler gage or dial indicator.
- 6.1.2 The maximum permissible amount of bow is  $1/32$ " per foot length of glass plus  $1/32$ ".

## 7. EDGE FLAWS (FLAWS WITHIN $1/2$ " OF THE EDGE)

General glass quality shall conform to ASTM C1036, Type I, Class 1, Quality 3 (Q3) criteria.

### 7.1 SHELL CHIPS AND EDGE FLAKES

- 7.1.1 Shell chips are permitted within the requirements shown in Table 4, as long as there are no associated cracks, detectable without magnification, as viewed from the edge.
- 7.1.2 Edge flakes less than  $1/16$ " in thickness are permitted up to 3" in length per side.

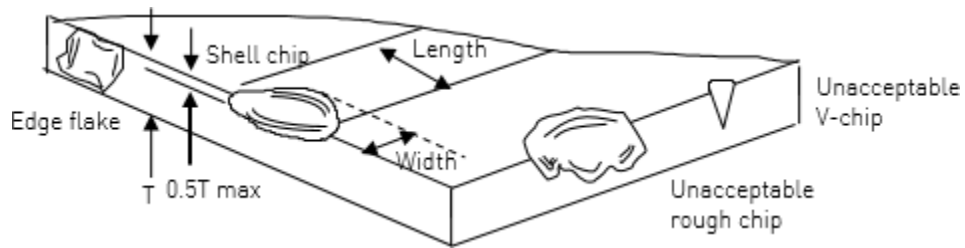


Figure 2. Acceptable and unacceptable edge flaws.

Table 4. Allowable shell chips per glass type.

Glass Type	No Limit	One Per Edge Per Glass Ply	Not Allowed
Dark Tints	Width $\leq 1/8$ " Length $< 1$ " Depth $\leq 25\%$ of glass thickness	$1/8$ " $<$ Width $\leq 1/4$ " Length $\leq 1/4$ " Depth $\leq 25\%$ of glass thickness	Width $> 1/4$ " Length $\leq 1/4$ " Depth $\leq 25\%$ of glass thickness
All Others	Width $\leq 1/8$ " Length $< 1$ " Depth $\leq 50\%$ of glass thickness	$1/8$ " $<$ Width $\leq 1/4$ " Length $\leq 1/4$ " Depth $\leq 50\%$ of glass thickness	Width $> 1/4$ " Length $\leq 1/4$ " Depth $\leq 50\%$ of glass thickness

### 7.2 V-CHIPS AND ROUGH CHIPS

No v-ships or rough chips are allowed.

### 7.3 CORNERS

- 7.3.1 Flares are not allowed.
- 7.3.2 Corners off – Up to 1/4" if edge surface is smooth and covered by frame. Sharp, jagged damage is not allowed.

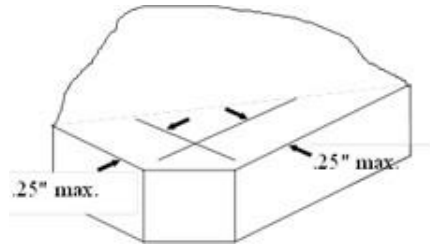


Figure 3. Max acceptable corner off.

### 7.4 INTERLAYER INSET; BLOW-IN

- 7.4.1 Up to 3/16" (4.8 mm) – unlimited length allowed along all edges.
- 7.4.2 Over 3/16" up to 1/4" (4.8 – 6.4 mm) – maximum length of either 12" or 1/3 of the total length of the edge (whichever is shorter) allowed on all edges.

### 7.5 EDGE BUBBLES

- 7.5.1 Up to 3/16" (4.8 mm) – unlimited length allowed on all edges.
- 7.5.2 Over 3/16" up to 1/4" – maximum length of either 12" or 1/3 of the total length of the edge (whichever is shorter) allowed on all edges.

## 8 VISIBLE AREA APPEARANCE

### 8.1 VISUAL INSPECTION CONDITIONS

- All visual inspections shall be made with 20/20 vision (naked eye or corrected).
- View samples in the vertical position at the distance as specified in the sections following.
- The viewer shall look at the sample at an angle of 90° (perpendicular) to the surface.

- Lighting needs to be daylight (without direct sunlight) or other uniform diffused background lighting that simulates daylight, with a minimum luminance of 1700 lux (160 foot-candles) measured at the center of the glass surface facing the light source.
- The glass is divided into two areas, each with different blemish criteria:
  - *Central Area*—an area formed by an oval or circle whose axes or diameters, when centered, do not exceed 80% of the overall

- dimension.
- o *Outer Area*—the area outside of the central area.

8.1.1 Laminated Proximate Glazing:

8.1.1.1 *Uncoated* - Inspect glazing at a distance of 39 in. (1 m). If a blemish is readily apparent under these viewing conditions, refer to Table 5 for acceptable criteria.

8.1.1.2 *Coated* - Inspect glazing at a distance of 10 ft (3 m). If a blemish is readily apparent under these viewing conditions, refer to Table 5 for acceptable criteria.

8.1.2 Laminated Overhead Glazing:

8.1.2.1 *Uncoated* - Inspect glazing at a distance of 10 ft (3 m). If a blemish is readily apparent under these viewing conditions, refer to Table 6 for acceptable criteria.'

8.1.2.2 *Coated* - Inspect glazing at a distance of 15 ft (4.6 m). If a blemish is readily apparent under these viewing conditions, refer to Table 6 for acceptable criteria.

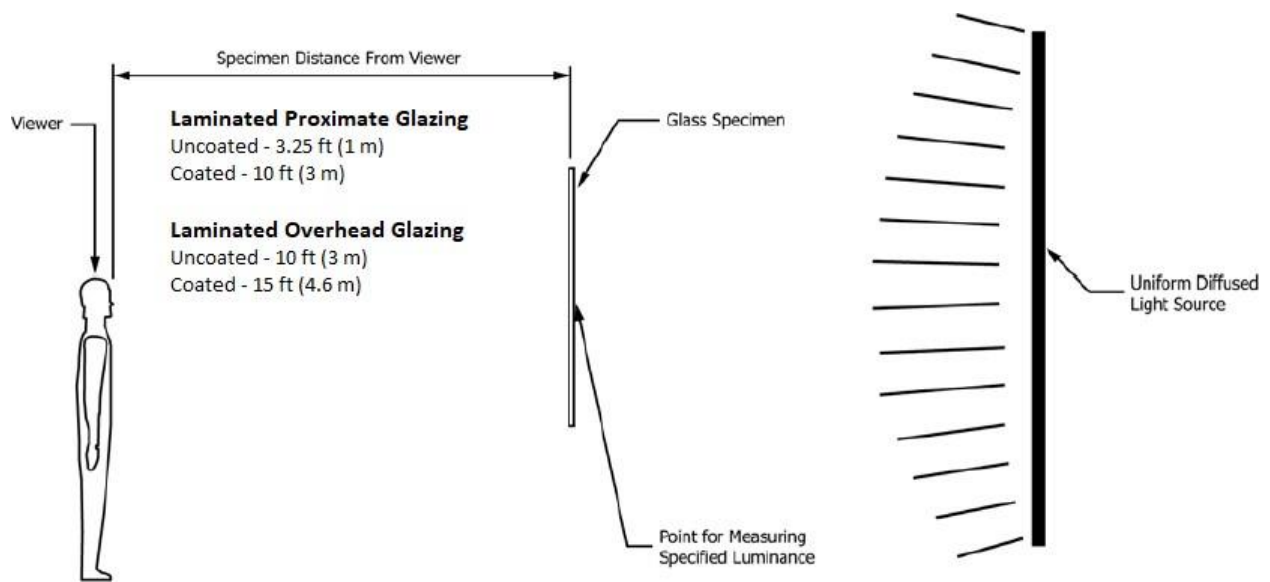


Figure 4. Viewing Conditions for Blemish Detection.



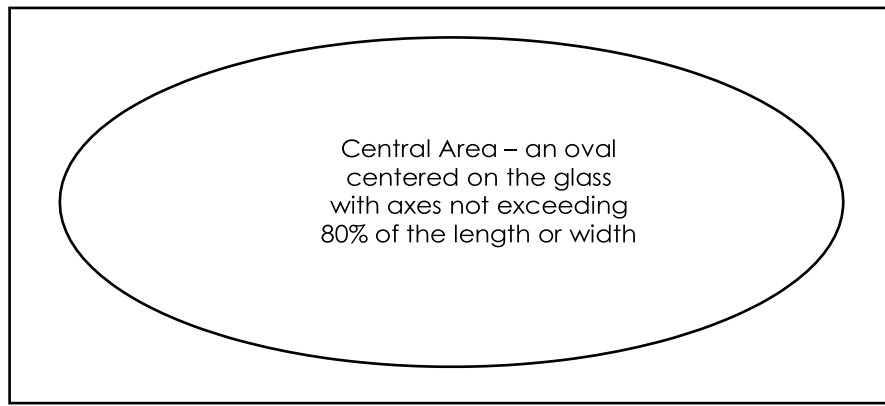


Figure 5. Glass Areas with Different Blemish Criteria.

Table 5. Maximum Allowable Blemishes for Laminated Proximate Glazing

Blemish	Up to 40 ft <sup>2</sup> (3.7 m <sup>2</sup> )		40 to 60 ft <sup>2</sup> (3.7 to 5.6 m <sup>2</sup> )	
	Central	Outer	Central	Outer
Bubbles	1/16" (1.6mm)	3/32" (2.4mm)	1/8" (3.2mm)	3/16" (4.8mm)
Fuse	1/32" (0.8mm)	1/16" (1.6mm)	1/16" (1.6mm)	3/32" (2.4mm)
Hair, lint (single strand)	light intensity & 1" (25mm) max length	medium intensity & 2" (50mm) max length	light intensity & 1" (25mm) max length	medium intensity & 2" (50mm) max length
Inside dirt (dirt spot)	1/16" (1.6mm)	3/32" (2.4mm)	3/32" (2.4mm)	5/32" (4mm)
Lint-areas of concentrat ed lint	light intensity & 1/4" (6.4mm) max diameter	medium intensity & 1/4" (6.4mm) max diameter	light intensity & 1/4" (6.4mm) max diameter	medium intensity & 1/4" (6.4mm) max diameter
Separation, discoloration	none	none	none	none
Scuff; streak; rub	light intensity & 6" (150mm) max length	medium intensity & 6" (150mm) max length	medium intensity & 6" (150mm) max length	medium intensity & 6" (150mm) max length
Scratch	none	light intensity & 3" (125mm) max length	none	light intensity & 3" (125mm) max length
Pinhole	1/16" (1.6mm)	3/32" (2.4mm)	1/16" (1.6mm)	3/32" (2.4mm)
Spot	1/16" (1.6mm)	3/32" (2.4mm)	1/16" (1.6mm)	3/32" (2.4mm)
Coating scratch	2" (50mm) max length	3" (75mm) max length	2" (50mm) max length	3" (75mm) max length
Coating rub	none allowed	length plus width not to exceed 3/4" (19mm)	none allowed	length plus width not to exceed 3/4" (19mm)
Crazing	none	none	none	none
Corrosion	none	none	none	none

light intensity—barely noticeable at 39 in (1 m)

medium intensity—noticeable at 39 in (1 m) but not at 10 ft (3 m)

NOTE—All imperfections noted must be separated by a minimum of 12 in (300 mm).

Table 6. Maximum Allowable Blemishes for Laminated Overhead Glazing

Blemish	Up to 25 ft <sup>2</sup> (2.5 m <sup>2</sup> )		25 ft <sup>2</sup> or greater (2.5 m <sup>2</sup> or greater)	
	Central	Outer	Central	Outer
Bubbles	3/32" (2.4mm)	1/8" (3.2mm)	3/16" (4.8mm)	1/4" (6.4mm)
Fuse	1/316" (1.6mm)	1/16" (1.6mm)	3/32" (2.4mm)	5/32" (4mm)
Hair, lint (single strand)	medium intensity & 2" (50mm) max length	medium intensity & 2" (50mm) max length	medium intensity & 2" (50mm) max length	medium intensity & 2" (50mm) max length
Inside dirt (dirt spot)	3/32" (2.4mm)	3/32" (2.4mm)	5/32" (4mm)	5/32" (4mm)
Lint-areas of concentra ted lint	medium intensity & 1/4" (6.4mm) max diameter	medium intensity & 1/4" (6.4mm) max diameter	medium intensity & 1/4" (6.4mm) max diameter	medium intensity & 1/4" (6.4mm) max diameter
Separation, discoloratio n	none	none	none	none
Scuff; streak; rub	medium intensity & 6" (150mm) max length	medium intensity & 6" (150mm) max length	medium intensity & 6" (150mm) max length	medium intensity & 6" (150mm) max length
Scratch	none	light intensity & 3" (125mm) max length	none	light intensity & 3" (125mm) max length
Pinhole	3/32" (2.4mm)	3/32" (2.4mm)	3/32" (2.4mm)	3/32" (2.4mm)
Spot	3/32" (2.4mm)	3/32" (2.4mm)	3/32" (2.4mm)	3/32" (2.4mm)
Coating scratch	3" (75mm) max length	3" (75mm) max length	3" (75mm) max length	3" (75mm) max length
Coating rub	length plus width not to exceed 3/4" (19mm)	length plus width not to exceed 3/4" (19mm)	length plus width not to exceed 3/4" (19mm)	length plus width not to exceed 3/4" (19mm)
Crazing	none	none	none	none
Corrosion	none	none	none	none

light intensity—barely noticeable at 39 in (1 m)

medium intensity—noticeable at 39 in (1 m) but not at 10 ft (3 m)

NOTE—All imperfections noted must be separated by a minimum of 12 in (300 mm).