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## Standard Specification for Flat Glass<sup>1</sup>

This standard is issued under the fixed designation C1036; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

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<sup>e1</sup> NOTE—Editorial changes were made in February 2012.

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### 1. Scope

1.1 This specification covers the requirements for annealed, monolithic flat soda-lime glass supplied as cut sizes or stock sheets.

1.2 This specification is applicable for laboratory and field evaluation only to the extent that such evaluation can be carried out in accordance with the test method(s) prescribed herein.

1.3 This specification covers the quality requirements of flat, transparent, clear, and tinted glass. This glass is intended to be used primarily for architectural glazing products including: coated glass, insulating glass units, laminated glass, mirrors, spandrel glass, or similar uses.

NOTE 1—Reflective distortion is not addressed in this specification.

1.4 This specification covers the quality requirements of patterned or wired glasses intended to be used primarily for decorative and general glazing applications.

1.5 The values given in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *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 *ASTM Standards:*<sup>2</sup>

**C162 Terminology of Glass and Glass Products**

2.2 *NFRC Standard:*<sup>3</sup>

**NFRC 300 Test Method for Determining the Solar Optical Properties of Glazing Materials and Systems**

### 3. Terminology

3.1 *Definitions*—For additional definitions of terms, refer to Terminology **C162**.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *associated distortion, n*—alteration of viewed images caused by variations in glass flatness or inhomogeneous portions within the glass.

3.2.2 *bevel, n*—angled surface at the edge of a lite of glass.

3.2.3 *blemish, n*—imperfection in the body or on the surface of the glass; for the purpose of this specification, blemishes are divided into two categories:

3.2.3.1 *linear blemish, n*—scratches, rubs, digs, and other similar imperfections, which may be straight or curved in nature. If curved, the length of such a blemish is to be measured from end to end along the curve.

3.2.3.2 *point blemish, n*—crush, knots, dirt, stones, gaseous inclusions, and other similar imperfections.

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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> National Fenestration Rating Council, 84884 Georgia Ave., Suite 320, Silver Spring, MD 20910.

3.2.4 *bow*, *n*—a condition in which a lite of flat glass departs from a true plane.

3.2.5 *chip depth*, *n*—measured distance of a chip from the face of the glass into the thickness.

3.2.6 *chip length*, *n*—maximum distance parallel to the edge of the glass from one edge of a chip to the other.

3.2.7 *chip width*, *n*—maximum perpendicular distance from the edge of the glass to the inner edge of the chip.

3.2.8 *clear glass*, *n*—glass formulated to have transmittance in the visible spectrum greater than 82 % (reference to NFRC 300 measurement method) at a standard thickness of 6 mm (1/4 in.) with lack of color as compared to tinted glass of the same thickness.

3.2.9 *crush*, *n*—lightly pitted condition with a dull gray appearance.

3.2.10 *cut size*, *n*—glass ordered cut to its final intended size.

3.2.11 *dig*, *n*—~~deep, short scratch:~~ a deep scratch in the glass surface.

3.2.12 *dirt*, *n*—small particle of foreign matter embedded in the surface of flat glass.

3.2.13 *fire crack*, *n*—small, sometimes microscopic fissure in the edge of wired or patterned glass.

3.2.14 *flare*, *n*—protrusion on the glass edge or corner of an otherwise rectangular surface.

3.2.15 *gaseous inclusion*, *n*—round or elongated bubble in the glass.

3.2.16 *knot*, *n*—inhomogeneity in the form of a vitreous lump.

3.2.17 *line*, *n*—fine cords or string, usually on the surface of flat glass.

3.2.18 *low iron glass*, *n*—glass formulated to have transmittance in the visible spectrum higher than that of clear glass of the same thickness.

3.2.19 *patterned glass*, *n*—rolled flat glass having a pattern on one or both surfaces.

3.2.20 *ream*, *n*—linear distortion as a result of non-homogeneous layers of flat glass.

3.2.21 *rub*, *n*—abrasion of a glass surface producing a frosted appearance.

3.2.22 *scratch*, *n*—damage on an abrasion of a glass surface in the form of a line caused by the movement of an object across and in contact with the glass surface: curved line, a straight line, or both.

3.2.23 *shell chip*, *n*—circular indentation in the glass edge as a result of breakage of a small fragment out of an otherwise regular surface: fragment.

3.2.24 *stock sheets*, *n*—glass ordered in sizes intended to be cut to create final or cut size (that is, uncuts, intermediates, jumbos, and lehr ends).

3.2.25 *stone*, *n*—crystalline inclusion in glass.

3.2.26 *string*, *n*—straight or curled line, usually resulting from slow solution of a large grain of sand or foreign material.

3.2.27 *tinted glass*, *n*—glass formulated to have a uniform color throughout the glass, with the purpose of reducing glare (visible transmittance), solar heat gain, or visible/ultraviolet (UV) transmittance.

3.2.28 *v-chip*, *n*—v-shaped imperfection in the edge of the glass lite.

3.2.29 *vision interference angle*, *n*—viewing angle at which distortion in transmission first appears (see Fig. 1); Fig. 2).

3.2.30 *wired glass*, *n*—flat glass with a layer of wire mesh embedded in the glass.

~~3.2.28 *bow*, *n*—a condition in which a lite of flat glass departs from a true plane.—~~

~~3.2.29 *clear glass*, *n*—glass formulated to have high transmittance in the visible spectrum greater than 82 % (reference to NFRC 300 measurement method) at a standard thickness of 6 mm (1/4 in.) with high clarity and lack of color as compared to tinted glass of the same thickness. This includes glass with ultra high transmittance for additional clarity. Edge color of clear glass can vary so the glass manufacturer should be consulted regarding an application where edge color is an aesthetic consideration.~~

#### 4. Classification and Intended Use

NOTE 2—When referencing this specification, the user shall indicate the title and date of the specification, and the type, class, quality (including cut-size or stock sheets), size, and thickness of the glass.

4.1 *Types, Classes, Forms, Qualities, and Finishes*—Glass shall be of the following types, classes, forms, qualities, and finishes, as specified:

4.1.1 *Type 1—Transparent Flat Glass: Class 1—Clear, or Class 2—Tinted:*

4.1.1.1 *Class 1—Clear:*

Quality	Typical Use
Quality-Q1 (cut-size or stock sheets)	Production of high-quality mirrors.
Quality-Q2 (cut-size or stock sheets)	Production of general use mirrors and other applications.
Quality-Q3 (cut-size or stock sheets)	Production of architectural glass products including coated, heat treated, laminated, and other select glass products.
Quality-Q4 (cut-size or stock sheets)	General glazing applications.

**TABLE 1 Type I, Class 1 and 2 Quality and Use**

Quality	Typical Use
Quality-Q1 (cut-size or stock sheets) <sup>A</sup>	Production of high-quality mirrors.
Quality-Q2 (cut-size or stock sheets)	Production of general use mirrors and other applications.
Quality-Q3 (cut-size or stock sheets)	Production of architectural glass products including coated, heat treated, laminated, and other select glass products.
Quality-Q4 (cut-size or stock sheets)	General glazing applications.

<sup>A</sup> For Class 2 Tinted, there is no Quality Q1 available

4.1.1.2 *Class 2—Tinted:*

Quality	Typical Use
Quality-Q1	Not available.
Quality-Q2 (cut-size or stock sheets)	Production of general use mirrors and other applications.
Quality-Q3 (cut-size or stock sheets)	Production of architectural glass products including coated, heat treated, laminated, and other select glass products.
Quality-Q4 (cut-size or stock sheets)	General glazing applications.

4.1.2 *Type II—Patterned and Wired Flat Glass:—Glass Class 1—Clear, or Class 2—Tinted:*

4.1.2.1 *Class 1—Clear*

**TABLE 2 Type II, Class 1 and 2 Quality and Use**

Quality	Typical Use
Quality-Q5	Applications in which design and aesthetic characteristics are major considerations.
Quality-Q6	Applications in which functional characteristics are a consideration and blemishes are not a major concern.
Form	Description
Form 1	Wired glass, polished both sides
Form 2	Wired glass, patterned surfaces
Form 3	Patterned glass
Finish	Description
Finish 1 (F1)	Patterned one side
Finish 2 (F2)	Patterned both sides
Mesh	Description
Mesh 1 (M1)	Diamond
Mesh 2 (M2)	Square

TABLE 2 Continued

Quality	Typical Use
Mesh 3 (M3)	Parallel strand
Mesh 4 (M4)	Special
Pattern	Description
Pattern 1 (P1)	Linear
Pattern 2 (P2)	Geometric
Pattern 3 (P3)	Random
Pattern 4 (P4)	Special

4.1.2.2 Class 2—Tinted:

Quality	Typical Use
Quality-Q5	Applications in which design and aesthetic characteristics are major considerations.
Quality-Q6	Applications in which functional characteristics are a consideration and blemishes are not a major concern.
Form	Description
Form 1	Wired glass, polished both sides
Form 2	Wired glass, patterned surfaces
Form 3	Patterned glass
Finish	Description
Finish 1 (F1)	Patterned one side
Finish 2 (F2)	Patterned both sides
Mesh	Description
Mesh 1 (M1)	Diamond
Mesh 2 (M2)	Square
Mesh 3 (M3)	Parallel strand
Mesh 4 (M4)	Special
Pattern	Description
Pattern 1 (P1)	Linear
Pattern 2 (P2)	Geometric
Pattern 3 (P3)	Random
Pattern 4 (P4)	Special

5. Requirements

5.1 Requirements for Type 1 (Transparent Flat Glass):

5.1.1 Edge Requirements—Edges of glass shall be supplied as specified:

NOTE 3—Glass edges are typically supplied as factory cut. Optional edge work can be specified as seamed, ground, polished, beveled, mitered, or other, as arranged with the manufacturer. See manufacturer’s literature for more information.

5.1.1.1 Shell Chips—Shell chips are permitted within the requirements shown in Table 13, as long as there are no associated cracks, detectable without magnification, as viewed from the edge.

5.1.1.2 V-Chips—Visible V-chips are not permitted. (See 6.1.1 for viewing criteria.)

5.1.2 Dimensional Tolerances—Tolerances for length, width, squareness, and thickness for rectangular shapes shall be in accordance with Table 24. Nonrectangular shapes shall use the same thickness tolerances in Table 24. For linear straight line dimensions of nonrectangular shapes, the length and width requirements in Table 24 shall be used. For curvilinear dimensions of nonrectangular shapes, tolerances shall be as agreed upon by the involved parties.

5.1.3 Blemishes—Allowable blemishes are addressed in Section 6 and in Tables 3-5-57.

NOTE 4—In addition to the point blemishes allowed in accordance with Table 5, rejectable point blemishes are allowed in Stock Sheets up to the limits shown in Table 6.

5.1.4 Uniformity—For glass with a thickness of 6 mm (¼ in.) or less, the glass shall not vary in thickness more than 0.1 mm (0.004 in.) over a 100 mm (4 in.) length.

5.1.5 *Distortion*—Reams, strings, lines, and other allowable distortion (in transmission) are addressed in Section 6 and [Table 68](#).

5.1.6 *Squareness*—The squareness requirements for cut glass are shown in [6.1.4](#) and [Table 24](#).

5.2 *Requirements for Type II (Patterned and Wired Flat Glass):*

5.2.1 *Wired (Forms 1 and 2):*

5.2.1.1 *Form 1 (Polished Both Sides)*—Glass may contain waviness that does not interfere with vision normal to the surface.

5.2.1.2 *Form 1 & 2 (Patterned One or Both Sides)*—Glass shall not contain visible fire cracks.

5.2.1.3 *Dimensional Tolerances*—Tolerance for length, width, and thickness shall be in accordance with [Table 79](#).

5.2.1.4 *Wire and Mesh*—Diameter of wires shall be from 0.43 to 0.64 mm (0.017 to 0.025 in.). Discoloration and slight distortion of wire are permissible. Wired glass may contain numerous gaseous inclusions along the wire.

(1) *Mesh M1*, diamond shall be welded. Opening in the mesh shall not exceed 32 mm (1¼ in.) between wire intersections measured across diagonal corners of the diamond.

(2) *Mesh M2*, square shall be welded. Opening in the mesh shall not exceed 16 mm (5⁄8 in.) between wire intersections measured along a side of the square.

(3) *Mesh M3*, parallel strand, spacing shall be as specified.

(4) *Mesh M4*, as specified.

5.2.2 *Patterned (Form 3):*

5.2.2.1 *Dimensional Tolerances—Finishes F1 and F2, Patterns P1, P2, P3, and P4*—Tolerances for Patterns P1 and P2 for length, width, and thickness shall be in accordance with [Table 810](#). Check with the manufacturer for thickness and dimensional tolerances on random Pattern P3 and special Pattern P4.

5.2.2.2 *Blemishes*—Allowable blemishes are addressed in Section 6 and in [Table 911](#).

5.2.2.3 *Patterned glass* shall not contain visible fire cracks.

5.2.2.4 *Surface Pattern:*

(1) *Quality Q5*—Surface pattern shall be clear, sharp, defined, and free of obvious disfiguration that affects the appearance of the pattern.

(2) *Quality Q6*—Surface pattern shall be free of large areas of blemishes. Scattered areas of non-uniform surface and scattered surface blemishes are permissible.

NOTE 5—Patterned glass can vary slightly in both configuration and color from run to run. Glass edge requirements stated in this standard do not apply to Type II glass.

## 6. Test Methods

6.1 *Test Methods for Type I Glass (Transparent Flat Glass):*

6.1.1 *Viewing Conditions for Blemish Detection*—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 be positioned perpendicular to the glass surface ((~~Fig. Fig. 2~~)-1) 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 1700 lux (160 foot-candles) measured at the center of the glass surface.

6.1.1.1 *Blemish Detection for Point Blemish (Knots, Dirt, Stones, Crush, Gaseous Inclusions, and Other Similar Blemishes)*—Samples shall be viewed from a distance of approximately 1 m (39 in.). If blemishes are detected, refer to [Tables 35 and 46](#) for evaluation criteria.

6.1.1.2 *Point Blemish Measurement*—Point blemish size shall be determined by measuring the maximum length and maximum perpendicular width of the blemish and calculating the average of the two dimensions. The allowable blemish sizes listed in [Table 35](#) include associated distortion for Q1 and Q2, but do not include associated distortion for Q3 and Q4.

6.1.1.3 *Detection for Linear Blemishes (Scratches, Rubs, Digs, and Other Similar Blemishes)*—Samples shall be viewed at the detection distance of 3.3 m (~~132~~(130 in.)). The inspection shall then progress sequentially to each of the shorter distances for other applicable blemish intensities listed in [Table 4012](#). Any blemishes detected from these distances shall be compared with the length and separation criteria for allowable blemishes given in [Table 57](#).

6.1.1.4 *Blemish Distribution*—Separation between blemishes shall be determined by measuring the distance between the two closest points of the blemishes. For blemish size ranges with different separation distance criteria, the minimum separation distance is determined by the minimum separation distance required for the larger of the two blemishes. Blemishes in size ranges that are allowed without separation distance criteria shall not be compared with those that have separation criteria.

6.1.2 *Ream, Strings, Lines, and Distortion*—(See ~~Fig. 1~~)-[Fig. 2](#).) Place sample, with the direction of the draw oriented vertically, at a distance of approximately 4.5 m (15 ft) from a zebra board with a measured illumination of 215 lux (20 foot-candles) minimum with 25-mm (1-in.) black-and-white diagonal stripes. Start with the glass sample parallel with the zebra board (identified as 0°) and perpendicular with the viewer's line of sight. Rotate the specimen clockwise from zero until it reaches the angle at which the distortion appears and report that angle as the vision interference angle. Refer to [Table 68](#) for evaluation criteria. If the direction of draw cannot be determined, then the sample shall also be viewed turning the sample 90° and evaluated as stated above. The lower of the two interference angles measured shall be used to compare to the evaluation criteria in [Table 68](#).

6.1.3 *Dimensional Measurements*—To measure the length and width of cut size and stock sheets of flat glass, measure the perpendicular distance from edge to edge, including flares and bevels. Measurements, including length, width, and thickness, shall meet the tolerance requirements of Table 4.

6.1.4 *Squareness Measurement*—After measuring the length and width for compliance with dimensional tolerance, measure the length of both diagonals (corner to corner). The difference in length between the two diagonals (D1–D2) shall not exceed the limits set forth in Table 24.

6.1.5 *Solar/Optical Properties*—If specified, the reflectance and transmittance of glass are to be determined in accordance with NFRC 300.

6.2 *Test Methods for Type II Glass (Wired or Patterned Glass):*

6.2.1 *Associated Distortion and Blemish Appraisal*—Because of the variety of uses of patterned and wired glass, specific inspection guidelines are beyond the scope of this specification. Check with the manufacturer for more information.

6.2.2 *Dimensional Measurements*—To measure the length and width of cut size and stock sheets of flat glass, measure the perpendicular distance from edge to edge, including flares and bevels. Measurements taken at any point—Measurements, including length, width, and thickness shall meet the tolerance requirements of Table 79 or Table 810, or both.

6.2.3 *Point Blemish Measurement*—Point blemish size shall be determined by measuring the maximum length and maximum perpendicular width of the blemish and calculating the average of the two dimensions. The allowable blemish sizes listed in Table 911 do not include associated distortion. Glass shall be viewed at distance of 1.5 m (59 in.) normal to the glass surface with the light source approximating diffused daylight at 3 m (118 in.) behind the glass (see Fig. 2). Fig. 1).

6.2.4 *Solar/Optical Properties*—For patterned and wired glass, consult with the manufacturer when the solar and optical properties are required.

6.2.5 *Measuring the Thickness of Patterned Glass*—The thickness of patterned glass shall be determined by measuring high point to high point to the precision and accuracy in Table 810, using a measuring device with 19-mm (3/4-in.) diameter or greater contact surfaces. As an alternate method, the thickness may be measured using two bars with flat and parallel surfaces 75 mm (3 in.) long or greater × 6 mm (0.25 in.) wide or greater × 6 mm (0.25 in.) thick or greater.

7. Package Marking

7.1 Each package of glass shall be identified by the manufacturer and include the manufacturer’s name or trademark, nominal thickness, glass description, date of manufacture or date of final packaging, and place of manufacture.

8. Keywords

8.1 architectural glass; clear glass; flat glass; glazing; low iron glass; patterned glass; tinted glass; transparent glass; wired glass

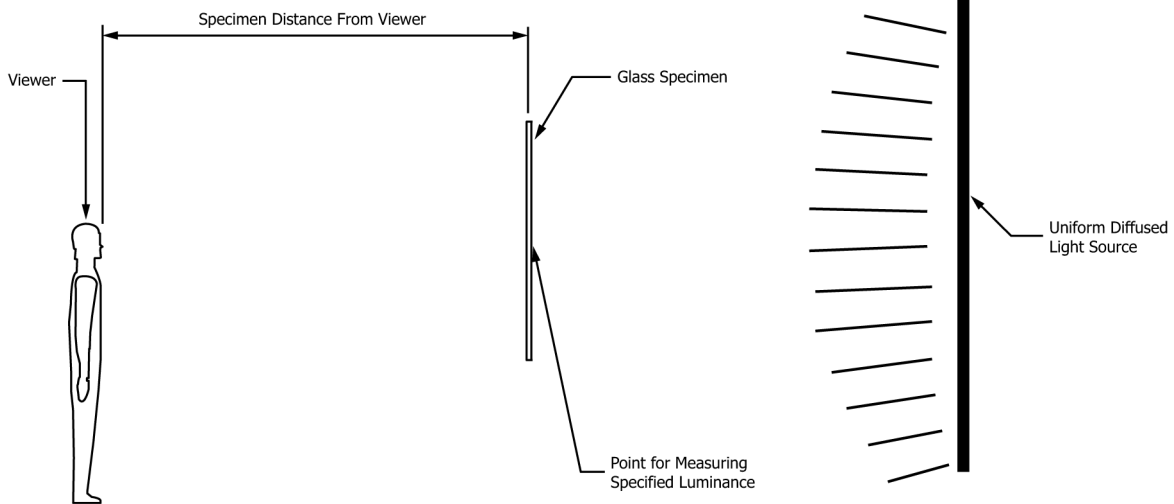


FIG. 1 Vision Interference Angle Procedure Viewing Conditions for Blemish Detection