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Standard Specification for Flat Glass¹

This standard is issued under the fixed designation C 1036; 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 reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

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

1. Scope

1.1 This specification covers the quality requirements for cut sizes of flat, transparent, clear glass having glossy, apparently plane and smooth surfaces for glazing, mirrors, and general architectural or similar uses.

1.2 This specification covers the quality requirements for cut sizes of flat transparent tinted heat-absorbing or light-reducing glass, or both, having glossy, apparently plane and smooth surfaces. The glass is intended to be used primarily for building construction to control the transmission of light, heat, or solar radiation, or combination thereof.

1.3 This specification covers the quality requirements for cut sizes of patterned and wired glasses for decorative and general glazing applications.

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

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

2. Referenced Documents

2.1 ASTM Standards:

C 162 Terminology of Glass and Glass Products³

E 308 Test Method for Computing the Colors of Objects by Using the CIE System⁴

E 903 Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres⁵

¹ This specification is under the jurisdiction of ASTM Committee C-14 on Glass and Glass Products and is the direct responsibility of Subcommittee C14.08 on Flat Glass.

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² Latest issue, unless otherwise specified by the agency applying Specification C 1036.

³ *Annual Book of ASTM Standards*, Vol 15.02.

⁴ *Annual Book of ASTM Standards*, Vol 06.01.

⁵ *Annual Book of ASTM Standards*, Vol 12.02.

3. Terminology

3.1 *Definitions*—For additional definitions of terms, refer to Terminology C 162.

3.1.1 *blemishes in flat glass*:

NOTE 1—These definitions do not apply to in-service damage.

3.1.1.1 *crush*—a lightly pitted area resulting in a dull gray or white appearance over the region.

3.1.1.2 *digs*—deep, short scratches.

3.1.1.3 *dirt*—a small particle of foreign matter imbedded in the glass surface.

3.1.1.4 *gaseous inclusions*—round or elongated bubbles in the glass.

3.1.1.5 *knot*—a transparent area of incompletely assimilated glass.

3.1.1.6 *lines*—fine cords or strings, usually on the surface of sheet glass.

3.1.1.7 *open gaseous inclusions*—bubbles at the surface of glass that are open, leaving a cavity in the surface.

3.1.1.8 *process surface blemishes*—slight surface blemishes that originated in the process that can be small particles of foreign materials on either surface or surface irregularities.

3.1.1.9 *ream*—inclusions within the glass or layers or strings of glass that are not homogeneous with the main body of the glass.

3.1.1.10 *rub*—abrasion of the glass surfaces producing a frosted appearance. A rub differs from a scratch in having appreciable width.

3.1.1.11 *scratch*—any marking or tearing of the surface produced in manufacturing or handling, appearing as though it were done by a sharp or rough instrument.

3.1.1.12 *smoke*—streaked areas appearing as slight discoloration.

3.1.1.13 *stone*—any crystalline inclusion imbedded in the glass.

3.1.1.14 *string*—transparent line appearing as though a thread of glass had been incorporated into the sheet.

3.1.1.15 *wave*—blemishes resulting from irregularities of the surfaces of glass, making objects viewed at varying angles appear wavy or bent.

3.1.2 *vision interference angle*—the acute angle included

between the plane of the glass and the vertical plane perpendicular to the wall, such plane including the observer when the glass is examined in accordance with 7.1.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *heat-absorbing glass*—glass for absorbing appreciable portions of radiant energy, especially solar energy.

3.2.2 *illuminant C*—as defined in Test Method E 308, an approximate representation of average daylight. Standard illuminant C (CIE 1931) (Commission Internationale de l'Éclairage) is a gas-filled lamp of color temperature 2848 K used in conjunction with a liquid filter (Davis-Gibson filter) for converting color temperature 2856 to 6670 K.

3.2.3 *light-reducing glass*—glass which is formulated to reduce the transmission of light.

3.2.4 *light transmittance*—that fraction of the incident light of a given wavelength which is not reflected or absorbed but passes through a substance.

3.2.5 *patterned glass*—rolled flat glass having a pattern on one or both surfaces.

3.2.6 *shading coefficient*—for any fenestration, the ratio of the rate of total solar heat gain through that type of fenestration to the total solar heat gain that would be admitted through a standard single pane of 3-mm (0.12-in.) thick clear glass in the same situation, the standard pane having a total solar transmittance value of 0.87.

3.2.7 *wired glass*—rolled glass having a layer of meshed or standard wire completely imbedded in the sheet.

4. Classification and Intended Use

4.1 *Types, Classes, Styles, Forms, Qualities, and Finishes*—Glass shall be of the following types, classes, styles, forms, qualities, and finishes, as specified (see Section 5):

4.1.1 *Type I—Transparent Glass, Flat:*

4.1.1.1 *Class 1—Clear:*

- q¹—Mirror select Quality
- q²—Mirror
- q³—Glazing select
- q⁴—Glazing A
- q⁵—Glazing B
- q⁶—Greenhouse

4.1.1.2 *Class 2—Tinted, Heat-Absorbing and Light-Reducing:*

- q³—Glazing select Quality
- q⁴—Glazing A
- q⁵—Glazing B
- Style A—Higher light transmittance
- Style B—Lower light transmittance

4.1.1.3 *Class 3—Tinted, Light-Reducing:*

- q³—Glazing select Quality
- q⁴—Glazing A
- q⁵—Glazing B

4.1.2 *Type II—Patterned and Wired Glass, Flat:*

- Class
- 1—Clear
- 2—Tinted, heat-absorbing and light-reducing (A and B applies to Class 2 only)
 - Style A—Higher light transmittance
 - Style B—Lower light transmittance
- 3—Tinted, light reducing

- Form (Classes 1, 2, and 3)
 - 1—Wired, polished both sides
 - 2—Patterned and wired
 - 3—Patterned
- Quality
 - q⁷—Decorative
 - q⁸—Glazing
- Finish
 - f¹—Patterned one side
 - f²—Patterned both sides
- Mesh (Forms 1 and 2)
 - m¹—Diamond
 - m²—Square
 - m³—Parallel strand
 - m⁴—Special
- Pattern (Forms 2 and 3)
 - p¹—Linear
 - p²—Geometric
 - p³—Random
 - p⁴—Special

4.2 *Intended Use of Transparent Flat Glass:*

4.2.1 *Mirror Select Quality*, q¹—Intended to be coated for premium mirrors.

4.2.2 *Mirror Quality*, q²—Intended to be coated for general use mirrors.

4.2.3 *Glazing Select Quality*, q³—Intended for architectural fenestrations or other applications where distant objects are viewed through the glass by the observer.

4.2.4 *Glazing A Quality*, q⁴—Intended for selected glazing applications such as appliances or show cases where the observer views near objects through the glass.

4.2.5 *Glazing B Quality*, q⁵—Intended for general glazing applications that have lesser aesthetic demands than a q³ or q⁴ quality grade.

4.2.6 *Greenhouse Quality*, q⁶—Intended for greenhouses or other applications where restrictions on aesthetic conditions are not required.

4.3 *Intended Use of Patterned and Wired Flat Glasses:*

4.3.1 *Decorative Quality*, q⁷—Intended for use where design and aesthetic characteristics are major considerations.

4.3.2 *Glazing Quality*, q⁸—Intended for general glazing where functional or aesthetic characteristics are a consideration and where surface blemishes are not a major concern.

4.3.3 *Wired Glass*—Intended for skylights and general glazing where fire retardation or glass retention in the frame are a consideration.

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, class, quality, style, and form, as requested (see 4.1),
- 5.1.3 Edges (see 6.1),
- 5.1.4 Length and width of cut size (see 6.3, 6.8.1.1, and 6.8.2.1), and
- 5.1.5 Glass thickness (see 6.3, 6.8.1.1, and 6.8.2.1).
- 5.1.6 *Samples*—If for any particular purpose samples with bids are necessary, they should be specifically asked for in the invitation for bids and the particular purpose to be served by the bid sample should be definitely stated.

5.2 Additional information to be specified for tinted, heat-absorbing or light-reducing flat glass, or both:

- 5.2.1 *Heat-Absorbing Glass*—Style and tint.
- 5.2.2 *Light-Reducing Glass*—Transmittance and tint.
- 5.2.3 *Availability*—Heat-absorbing glass is available in a variety of styles and tints, but within limitations. Combinations of all styles and tints are not possible. It is advisable that before referencing glass to this specification, the authority applying this specification should consult with suppliers.

5.3 Additional information to be specified for patterned or wired glass, or both.

- 5.3.1 For patterned glass, pattern description, whether one or both sides.
- 5.3.2 For wired glass, surface finish, wire mesh, and pattern description, if any.
- 5.3.3 *Samples*—If for any particular purpose samples with bids are necessary, such as wired glass that may contain numerous gaseous inclusions along the wire, they should be specifically asked for in the invitation for bids and the particular purpose to be served by the bid sample should be definitely stated.

6. Requirements

6.1 *Edge*—An edge shall be cut, ground, sanded to remove sharp edges only, seamed, ground and polished, beveled, or mitered, as specified.

6.2 *Marking*—Each package of glass shall bear a label, affixed by the manufacturer, giving the manufacturer’s name or trademark, the quality of glass, nominal thickness, and place of manufacture.

6.3 *Dimensional Tolerances for Type I (Transparent Glass, Flat)*—Tolerances for length, width, and thickness shall be in accordance with Table 1.

6.4 *Blemishes for Type I (Transparent Glass, Flat)*—Blemishes shall be not greater than those listed in Table 2, Table 3, and Table 4.

6.5 *Quality q⁶ (Greenhouse)*—Glass may contain visual blemishes that are suitable for greenhouse glazing.

6.6 *Additional Requirements for Type I, Class 2 (Tinted, Heat-Absorbing and Light-Reducing Flat Glass)*:

6.6.1 *Transmittance, Styles A and B*—The illuminant C (daylight) and solar transmittance shall be in accordance with Table 5.

6.6.2 *Blemishes for Type I, Class 2 (Tinted, Heat-Absorbing and Light-Reducing Flat Glass)*—The type and number of blemishes shall be not greater than those specified in Table 3 and Table 4.

6.6.3 *Tint*—The tint of each class, style, and quality shall be as specified. Note that the color of tinted heat-absorbing glass is a major consideration for either design and aesthetic reasons or for color matching requirements. Tinted heat-absorbing glass should be viewed as installed for color comparison. Colors may vary considerably among different manufacturers and from run to run.

6.7 *Additional Requirements for Type I, Class 3 (Tinted, Light-Reducing, Flat Glass)*:

6.7.1 *Luminous Transmittance*—Light-reducing glass may be produced in a wide range of luminous transmittance values. The transmittance shall be as specified.

6.7.2 *Blemishes for Type I, Class 3 (Tinted, Light-Reducing, Flat Glass)*—The type and number of blemishes shall be as specified in Table 3 and Table 4.

6.7.3 *Color*—The color of tinted glass is a major consideration for either design and aesthetic reasons or color matching requirements. Tinted glass should be viewed as installed for color comparison. Colors may vary considerably among different manufacturers and from run to run.

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

6.8.1 *Wired (Forms 1 and 2)*:

TABLE 1 Dimensional Tolerance for Rectangular Shapes of Type 1 Transparent, Flat Glass

Designation, mm	Thickness Traditional Designation	Nominal Decimal, in.	Tolerance				Length and Width for Cut Sizes, plus or minus, mm (in.)	Generally Available in the Following Qualities
			Thickness Range,		min	max		
			mm	in.				
1.0	micro-slide	0.04	0.79	1.24	0.031	0.049	1.6 (1/16)	q ⁴ , q ⁵
1.5	photo	0.06	1.27	1.78	0.050	0.070	1.6 (1/16)	q ⁴ , q ⁵
2.0	picture	0.08	1.80	2.13	0.071	0.084	1.6 (1/16)	q ⁴ , q ⁵
2.5	single	0.09	2.16	2.57	0.085	0.101	1.6 (1/16)	q ¹ , q ² , q ⁴ , q ⁵
2.7	lami	0.11	2.59	2.90	0.102	0.114	1.6 (1/16)	q ⁴ , q ⁵
3.0	double-1/8 in.	0.12	2.92	3.40	0.115	0.134	1.6 (1/16)	q ¹ , q ² , q ³ , q ⁴ , q ⁵ , q ⁶
4.0	5/32 in.	0.16	3.78	4.19	0.149	0.165	1.6 (1/16)	q ³ , q ⁴ , q ⁵
5.0	3/16 in.	0.19	4.57	5.05	0.180	0.199	1.6 (1/16)	q ¹ , q ² , q ³ , q ⁴ , q ⁵
5.5	7/32 in.	0.21	5.08	5.54	0.200	0.218	1.6 (1/16)	q ³ , q ⁴ , q ⁵
6.0	1/4 in.	0.23	5.56	6.20	0.219	0.244	1.6 (1/16)	q ¹ , q ² , q ³
8.0	5/16 in.	0.32	7.42	8.43	0.292	0.332	2.0 (5/64)	q ³
10.0	3/8 in.	0.39	9.02	10.31	0.355	0.406	2.4 (3/32)	q ³
12.0	1/2 in.	0.49	11.91	13.49	0.469	0.531	3.2 (1/8)	q ³
16.0	5/8 in.	0.63	15.09	16.66	0.595	0.656	4.0 (5/32)	q ³
19.0	3/4 in.	0.75	18.26	19.84	0.719	0.781	4.8 (3/16)	q ³
22.0	7/8 in.	0.87	21.44	23.01	0.844	0.906	5.6 (7/32)	q ³
25.0	1 in.	1.00	24.61	26.19	0.969	1.031	6.4 (1/4)	q ³
32.0	1 1/4 in.	1.23	28.58	34.93	1.125	1.375	7.9 (5/16)	q ³

TABLE 2 Glass Qualities q¹ and q², Maximum Allowable Blemishes for Thicknesses 6.0 mm (1/4 in.) or Less^A

Blemishes	q ¹ , Mirror Select Quality				q ² , Mirror Quality	
	Up to 2.5 m ² (25 ft ²)		Over 2.5 m ² (25 ft ²)		Central ^B	Outer ^B
	Central ^B	Outer ^B	Central ^B	Outer ^B		
Gaseous inclusions, maximum size ^C	0.8 mm (1/32 in.) ^{D,E}	1.2 mm (3/64 in.) ^{D,E}	1.2 mm (3/64 in.) ^{D,E}	1.6 mm (1/16 in.) ^{D,E}	6.4 mm (1/4 in.) ^{E,F}	6.4 mm (1/4 in.) ^{E,F}
Open or translucent gaseous inclusions, maximum size ^C	none	0.4 mm (1/64 in.) ^{D,E}	0.4 mm (1/64 in.) ^{D,E}	0.8 mm (1/32 in.) ^{D,E}	6.4 mm (1/4 in.) ^{E,F}	6.4 mm (1/4 in.) ^{E,F}
Knots, dirt, and stones, maximum size ^C	none	0.4 mm (1/64 in.) ^{D,E}	0.4 mm (1/64 in.) ^{D,E}	0.8 mm (1/32 in.) ^{D,E}	0.8 mm (1/32 in.) ^{E,F}	0.8 mm (1/32 in.) ^{E,F}
Scratches and rubs (intensity, maximum length)	faint, <150 mm (<6 in.) ^G	light, <150 mm (<6 in.) ^G	faint ^G	light ^G	light, <150 mm (<6 in.) ^G	medium, <150 mm (<6 in.) ^G
Crush (intensity, maximum length)	none	none	faint, <12.7 mm (<1/2 in.) ^{F,G}	faint, <19.0 mm (<3/4 in.) ^{F,G}	light, <0.4 mm (<1/64 in.) ^{F,G}	medium, <0.8 mm (<1/32 in.) ^{F,G}
Digs, maximum length	none	none	0.4 mm (1/64 in.) ^F	0.8 mm (1/32 in.) ^F	6.4 mm (1/4 in.) ^F	6.4 mm (1/4 in.) ^F
Ream, strings, lines and other linear distortion (maximum angle or intensity)	30° ^H or light ^I		30° ^H or light ^I		45° ^H or medium ^I	
Wave (intensity)	medium ^J	medium ^J	medium ^J	medium ^J	medium ^J	medium ^J
Process surface blemishes (intensity)	faint ^K	light ^K	faint ^K	light ^K	light ^K	medium ^K

^A Glass greater than 6.0 mm (1/4 in.) in thickness may contain proportionally more and larger blemishes.

^B The central area is considered to form an oval or circle centered on the lite whose axes or diameters do not exceed 80 % of the overall dimension. The remaining area is considered the outer area.

^C Gaseous inclusions, knots, dirt, and stones may be round or elongated. For elongated blemishes of this type(s) the maximum size specified shall be determined by adding the length and width of the blemish and dividing by two, for example (L + W)/2.

^D Separated by at least 305 mm (12 in.).

^E For blemishes of a smaller size or of less intensity, the minimum separation shall be proportionately less. The larger of the two blemishes shall govern the separation. Blemishes not specifically mentioned shall be compared to the blemish they most closely resemble.

^F Separated by at least 610 mm (24 in.).

^G Intensity (scratches, rubs, and crush)—When looking through the glass and perpendicular to it using daylight without direct sunlight or with background light suitable for observing each type of blemish, the blemishes shall not be detectable at distances greater than the following, except for heavy intensity (see 7.3):

Intensity	Distance
Faint	203 mm (8 in.)
Light	914 mm (36 in.)
Medium	3.3 m (132 in.)
Heavy	detected at distances greater than 3.3 m (132 in.)

^H Vision interference angle (see 3.1.1 and 7.1).

^I Intensity (ream, strings, lines, and other linear distortion)—When evaluated using the shadowgraph, the intensities of these blemishes are defined as having a shadowgraph readout at distances greater than or equal to the following (see 7.2):

Intensity	Minimum Distance, mm (in.)
Light	76 (3)
Medium	51 (2)
Heavy	25 (1)

^J Intensity (wave)—When evaluated using the shadowgraph, the intensities of wave are defined as having shadowgraph readouts at distances greater than or equal to the following (see 7.2):

Intensity	Minimum Distance, mm (in.)
Medium	254 (10)
Heavy	152 (6)

^K Intensity (process surface blemishes)—When viewed in normal reflected light, the blemishes are classified as follows: faint—visible only to the trained eye; light—just noticeable; medium—visible as a slight grayish haze; and heavy—readily visible as a cloudy surface.

6.8.1.1 *Thickness and Dimensional Tolerances*—The allowable tolerances for rectangular shapes shall be ±1.6 mm (±1/16 in.) for each 3.2 mm (1/8 in.) of nominal thickness. Thickness, and tolerance on thickness, shall be in accordance with Table 6.

6.8.1.2 *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 is permissible.

(a) Mesh m¹, diamond, shall be welded. Openings in the mesh shall not exceed 31.8 mm (1 1/4 in.) between wire intersection measured across diagonal corners of the diamond.

(b) Mesh m², square, shall be welded. Openings in the mesh shall not exceed 15.9 mm (5/8 in.) between wire intersections measured along a side of the square.

(c) Mesh m³, parallel strand, spacing shall be as specified.

6.8.1.3 *Wired Glass (Polished or Patterned)*:

(a) *Form 1 (Polished Both Sides)*—Glass may contain

waviness that does not interfere with vision normal to the surface.

(b) *Form 2 (Patterned One or Both Sides)*—Glass shall not contain fire cracks, exposed wire, or stones that can cause spontaneous breakage in annealed glass.

6.8.2 *Patterned (Form 3)*:

6.8.2.1 *Thickness and Dimensional Tolerances*—Finishes f¹ and f², patterns p¹, p², and p³. Tolerances for length, width, and thickness shall be in accordance with Table 7.

6.8.2.2 *Glass*—Patterned glass shall not contain fire cracks and stones that can cause spontaneous breakage in annealed glass.

6.8.2.3 *Surface Pattern*:

NOTE 2—Patterned glass can vary slightly in both configuration and color from run to run.

TABLE 3 Glass Quality q³, Maximum Allowable Blemishes for Thicknesses 6.0 mm (¼ in.) or Less^A

Blemishes	q ³ , Glazing Select Quality					
	Up to 2.5 m ² (25 ft ²)		2.5 to 7.0 m ² (25 to 75 ft ²)		Over 7.0 m ² (75 ft ²)	
	Central ^B	Outer ^B	Central ^B	Outer ^B	Central ^B	Outer ^B
Gaseous inclusions, maximum size ^C	1.6 mm (⅙ in.) ^{D,E}	2.4 mm (⅜ in.) ^{D,E}	3.2 mm (⅙ in.) ^{D,E}	4.8 mm (⅜ in.) ^{D,E}	6.4 mm (¼ in.) ^{D,E}	6.4 mm (¼ in.) ^{D,E}
Open or translucent gaseous inclusions, maximum size ^C	1.2 mm (⅜ in.) ^{D,E}	1.6 mm (⅙ in.) ^{D,E}	1.2 mm (⅜ in.) ^{D,E}	1.6 mm (⅙ in.) ^{D,E}	6.4 mm (¼ in.) ^{D,E}	6.4 mm (¼ in.) ^{D,E}
Knots, dirt, and stones, maximum size ^C	0.4 mm (⅙ in.) ^D	0.8 mm (⅓ in.) ^D	1.6 mm (⅙ in.) ^D	1.6 mm (⅙ in.) ^D	3.2 mm (⅙ in.) ^D	3.2 mm (⅙ in.) ^D
Scratches and rubs (intensity)	medium ^F	medium ^F	medium ^F	heavy ^F	heavy ^F	heavy ^F
Crush (intensity, maximum length)	medium ^F <1.6 mm (<⅙ in.) ^G	medium ^F <2.4 mm (<⅜ in.) ^G	medium ^F <3.2 mm (<⅙ in.) ^G	heavy ^F <4.8 mm (<⅜ in.) ^G	heavy ^F <6.4 mm (<¼ in.) ^G	heavy <6.4 mm (<¼ in.) ^G
Digs, maximum length	1.6 mm (⅙ in.) ^G	2.4 mm (⅜ in.) ^G	3.2 mm (⅙ in.) ^D	4.8 mm (⅜ in.) ^D	6.4 mm (¼ in.) ^D	6.4 mm (¼ in.) ^D
Ream, strings, lines, and other linear distortion (maximum angle or intensity)	45° ^H or medium ^I		90° ^H or heavy		90° ^H or heavy	
Wave (intensity)	medium ^J	medium ^J	medium ^J	heavy ^J	heavy ^J	heavy ^J
Process surface blemishes (intensity)	medium ^K	medium ^K	medium ^K	heavy ^K	heavy ^K	heavy ^K

^A Glass greater than 6.0 mm (¼ in.) in thickness may contain proportionally more and larger blemishes.

^B The central area is considered to form an oval or circle centered on the lite whose axes or diameters do not exceed 80 % of the overall dimension. The remaining area is considered the outer area.

^C Gaseous inclusions, knots, dirt, and stones may be round or elongated. For elongated blemishes of this type(s) the maximum size specified shall be determined by adding the length and width of the blemish and dividing by two, for example (L + W)/2.

^D Separated by at least 305 mm (12 in.).

^E For blemishes of a smaller size or of less intensity, the minimum separation shall be proportionately less. The larger of the two blemishes shall govern the separation. Blemishes not specifically mentioned shall be compared to the blemish they most closely resemble.

^F Intensity (scratches, rubs, and crush)—When looking through the glass and perpendicular to it using daylight without direct sunlight or with background light suitable for observing each type of blemish, the blemishes shall not be detectable at distances greater than the following, except for heavy intensity (see 7.3):

Intensity	Distance
Faint	203 mm (8 in.)
Light	914 mm (36 in.)
Medium	3.3 m (132 in.)
Heavy	detected at distances greater than 3.3 m (132 in.)

^G Separated by at least 610 mm (24 in.).

^H Vision interference angle (see 4.1 and 7.1).

^I Intensity (ream, strings, lines, and other linear distortion)—When evaluated using the shadowgraph, the intensities of these blemishes are defined as having a shadowgraph readout at distances greater than or equal to the following (see 7.2):

Intensity	Minimum Distance, mm (in.)
Light	76 (3)
Medium	51 (2)
Heavy	25 (1)

^J Intensity (wave)—When evaluated using the shadowgraph, the intensities of wave are defined as having shadowgraph readouts at distances greater than or equal to the following (see 7.2):

Intensity	Minimum Distance, mm (in.)
Medium	254 (10)
Heavy	152 (6)

^K Intensity (process surface blemishes)—When viewed in normal reflected light, the blemishes are classified as follows: faint—visible only to the trained eye; light—just noticeable; medium—visible as a slight grayish haze; and heavy—readily visible as a cloudy surface.

(a) *Quality q⁷ (Decorative)*—Surface pattern shall be clear, sharp, and defined and free of disfiguration that affects the appearance of the pattern. The smooth sides shall be free of open gaseous inclusions greater than 2.4 mm (⅜ in.) or equivalent elliptical open inclusions up to 15.9 mm (⅝ in.) long with no more than three of the maximum size in each 4.64 m² (50 ft²) of each cut sheet.

(b) *Quality q⁸ (Glazing)*—Surface pattern shall be free of large areas of blemishes. Scattered areas of nonuniform surface and scattered surface blemishes are permissible. The smooth side shall be free of imbedded foreign materials and shall be free of open gaseous inclusions greater than 3.2 mm (⅙ in.) or equivalent elliptical open inclusions up to 19 mm (¾ in.) long with no more than three of the maximum size in each 4.64 m² (50 ft²) of each cut sheet.

7. Test Methods

7.1 *Ream, Strings, and Distortion (Test Method A)*—Place specimen in a vertical position at a distance of approximately 914 mm (36 in.) from a brick wall or similar background showing straight lines. The viewer shall look through the sample at a distance of 914 mm from the sample using daylight without direct sunlight or with background light suitable for observing each type of blemish. View the sample at an angle to the surface of not less than vision interference angle in Table 2, Table 3, and Table 4, for the applicable glass. The line of vision shall be perpendicular to the wall.

7.2 *Ream, Strings, Lines, and Wave (Test Method B, Shadowgraph)*—Focus a light projector with a 500-W lamp, or equivalent, and an objective lens with an approximate 51-mm

TABLE 4 Glass Qualities q⁴, q⁵, and q⁶, Maximum Allowable Blemishes for Thicknesses 6.0 mm (¼ in.) or Less^A

Blemishes	q ⁴ Glazing A		q ⁵ Glazing B		q ⁶ Greenhouse
	Central ^B	Outer ^B	Central ^B	Outer ^B	Total
Gaseous inclusions, maximum size ^C	6.4 mm (¼ in.) ^{DE}	12.7 mm (½ in.) ^{DE}	12.7 mm (½ in.) ^{DE}	19.0 mm (¾ in.) ^{DE}	>19.0 mm (>¾ in.) ^{DE}
Open or translucent gaseous inclusions, maximum size ^C	6.4 mm (¼ in.) ^{EF}	6.4 mm (¼ in.) ^{EF}	6.4 mm (¼ in.) ^{EF}	6.4 mm (¼ in.) ^{EF}	≥6.4 mm (≥¼ in.) ^{EF}
Knots, dirt, and stones, maximum size ^C	0.8 mm (⅓ in.) ^{EF}	1.6 mm (⅓ in.) ^{EF}	1.6 mm (⅓ in.) ^{EF}	3.2 mm (⅓ in.) ^{EF}	≥3.2 mm (≥⅓ in.) ^{EF}
Scratches and rubs (intensity)	light ^G	light ^G	medium ^G	medium ^G	≥medium ^G
Crush (intensity, maximum length)	light ^G <6.4 mm (<¼ in.) ^E	light ^G <12.7 mm (<½ in.) ^E	medium ^G <12.7 mm (<½ in.) ^E	medium ^G <19.0 mm (<¾ in.) ^E	≥medium ^G ≥19.0 mm (≥¾ in.)
Digs, maximum length	6.4 mm (¼ in.) ^E	12.7 mm (½ in.) ^E	12.7 mm (½ in.) ^E	19.0 mm (¾ in.) ^E	>19.0 mm (>¾ in.) ^E
Ream, strings, lines, and other linear distortion (maximum angle or intensity)		30° ^H or light ^I		90° ^H or heavy ^I	90° ^H or heavy ^I
Wave (intensity)	medium ^J	medium ^J	heavy ^J	heavy ^J	heavy ^J
Process surface blemishes (intensity)	medium ^K	medium ^K	heavy ^K	heavy ^K	heavy ^K

^A Glass greater than 6.0 mm (¼ in.) in thickness may contain proportionally more and larger blemishes.

^B The central area is considered to form an oval or circle centered on the lite whose axes or diameters do not exceed 50 % of the overall dimension. The remaining area is considered the outer area.

^C Gaseous inclusions, knots, dirt, and stones may be round or elongated. For elongated blemishes of this type(s) the maximum size specified shall be determined by adding the length and width of the blemish and dividing by two, for example (L + W)/2.

^D Separated by at least 305 mm (12 in.)

^E For blemishes of a smaller size or of less intensity, the minimum separation shall be proportionately less. The larger of the two blemishes shall govern the separation. Blemishes not specifically mentioned shall be compared to the blemish they most closely resemble.

^F Separated by at least 610 mm (24 in.)

^G *Intensity (scratches, rubs, and crush)*—When looking through the glass and perpendicular to it using daylight without direct sunlight or with background light suitable for observing each type of blemish, the blemishes shall not be detectable at distances greater than the following, except for heavy intensity (see 7.3):

Intensity	Distance
Faint	203 mm (8 in.)
Light	914 mm (36 in.)
Medium	3.3 m (132 in.)
Heavy	detected at distances greater than 3.3 m (132 in.)

^H Vision interference angle (see 4.1 and 7.1).

^I *Intensity (ream, strings, lines and other linear distortion)*—When evaluated using the shadowgraph, the intensities of these blemishes are defined as having a shadowgraph readout at distances greater than or equal to the following (see 7.2):

Intensity	Minimum Distance, mm (in.)
Light	76 (3)
Medium	51 (2)
Heavy	25 (1)

^J *Intensity (wave)*—When evaluated using the shadowgraph, the intensities of wave are defined as having shadowgraph readouts at distances greater than or equal to the following (see 7.2):

Intensity	Minimum Distance, mm (in.)
Medium	254 (10)
Heavy	152 (6)

^K *Intensity (process surface blemishes)*—When viewed in normal reflected light, the blemishes are classified as follows: faint—visible to the trained eye; light—just noticeable; medium—visible as a slight grayish haze; and heavy—readily visible as a cloudy surface.

(2-in.) aperture and an approximate 305-mm (12-in.) focal length on a flat white projection screen positioned 8 m (25 ft) from the light source in a dark room. Place the glass in a vertical position parallel to the screen between the light and the screen. Move the glass slowly toward the screen with a circulating motion in the plane perpendicular to the light beam. The shadowgraph readout is the distance at which the distortion just blends with the general shadow of the glass on the screen.

7.3 Scratches, Rubs, Stones, and Gaseous Inclusions—Place samples in a vertical position approximately 1 m (36 in.) from the viewer’s position for initial blemish detection. The viewer shall look through the sample using daylight without direct sunlight or with background light suitable for observing each type of blemish. Refer to Table 2, Table 3, and Table 4 for evaluation criteria.

7.4 Cut Sizes—Measure length and width from edge to edge including flares.

7.5 Additional Procedures for Type I, Class 2 (Tinted, Heat-Absorbing or Light-Reducing Flat Glass, or Both):

7.5.1 Transmittance:

7.5.1.1 Specimens—Select two specimens, one each from two samples.

7.5.1.2 Color or Tint—Place the specimen in a vertical position in an area illuminated either by daylight (without direct sunlight) or a background light suitable for observing blemishes. View the glass at an angle of 90° perpendicular to the surface from a distance of 1 m.

7.5.1.3 Luminous Transmittance—Using Practice E 308, measure transmittance by illuminating each specimen at normal incidence with light having the spectral composition of ICI illuminant C. Measure the ratio of transmittance to incident luminous flux by calculation from the spectral distribution of illuminant C as defined by Practice E 308.

7.5.1.4 Solar Transmittance—Use Test Method E 903. Calculate transmittance for solar energy from the measured

TABLE 5 Transmittance Values for Style A and Style B Heat-Absorbing Glass

Thickness, mm (in.)	ICI Illuminant C Transmittance	Solar Transmittance, total max, % ^A
	Style A, min, % ^A	
2.5 (0.090)	83	74
3.0 (0.118)	80	67
5.0 (0.197)	75	56
6.0 (0.236)	70	52
8.0 (0.315)	65	45
10.0 (0.394)	60	39
12.0 (0.472)	50	36
	Style B, max, % ^A	
2.5 (0.090)	83	74
3.0 (0.118)	80	67
5.0 (0.197)	75	56
6.0 (0.236)	70	52
8.0 (0.315)	65	45
10.0 (0.394)	60	39
12.0 (0.472)	50	36

^A Straight line interpolation may be used for intermediate thickness, as an approximation.

TABLE 6 Thickness and Tolerance for Wired Glass

Thickness Designation, mm (in.)	Tolerance, Thickness, mm (in.)	
	max	min
5.6 (7/32) ^A	6.4 (0.250)	5.1 (0.203)
6.4 (1/4)	7.6 (0.297)	6.4 (0.250)
9.5 (3/8)	9.9 (0.391)	8.3 (0.328)

^A Never approved by Underwriter's Laboratories for fire resistance.

spectral transmittance of the glass using the values for spectral distribution of solar energy received at sea level by a surface perpendicular to the sun's rays through an air mass of 1.5.

7.6 Additional Procedure for Type II (Patterned and Wired Flat Glass):

7.6.1 *Transmittance Samples for Classes 2 and 3*—For specimens with patterned surfaces, grind and polish surfaces to a smooth finish.

TABLE 7 Thickness and Tolerance for Patterned Glass Patterns p¹ to p³

Thickness Designation, mm (in.)	Tolerance, Thickness, mm (in.)		Cut Size Tolerance, Length and Width, plus or minus, mm (in.)
	max	min	
2.5 (SS)	2.8 (0.110)	2.2 (0.085)	1.6 (1/16)
3.0 (DS)	3.4 (0.134)	2.8 (0.110)	1.6 (1/16)
3.2 (InI)	4.4 (0.172)	2.8 (0.110)	1.6 (1/16)
4.0 (5/32)	4.4 (0.172)	3.6 (0.142)	1.6 (1/16)
4.8 (3/16)	5.6 (0.219)	4.4 (0.172)	1.6 (1/16)
5.6 (7/32)	6.8 (0.266)	5.2 (0.203)	2.4 (3/32)
6.4 (1/4)	7.6 (0.297)	6.0 (0.234)	3.2 (1/8)
7.9 (5/16)	9.1 (0.359)	7.1 (0.281)	4.0 (5/32)
9.5 (In#)	10.7 (0.422)	8.7 (0.344)	4.8 (3/16)

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