Designation: C 1048 – 04

Standard Specification for Heat-Treated Flat Glass—Kind HS, Kind FT Coated and Uncoated Glass[1]

This standard is issued under the fixed designation C 1048; 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 requirements for flat heat-strengthened and flat fully tempered coated and uncoated glass used in general building construction.

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

1.3 The following safety hazards caveat pertains only to the test method portion, Section 11, 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:* [3]

C 162 Terminology of Glass and Glass Products

C 346 Test Method for 45-deg Specular Gloss of Ceramic Materials

C 724 Test Methods for Acid Resistance of Ceramic Decorations on Architectural–Type Glass

C 978 Test Method for Photoelastic Determination of Residual Stress in a Transparent Glass Matrix Using a Polarizing Microscope and Optical Retardation Compensation Procedures

C 1036 Specification for Flat Glass

C 1203 Test Method for Quantitative Determination of Alkali Resistance of a Ceramic-Glass Enamel

C 1279 Test Method for Non-Destructive Photoelastic Measurement of Edge and Surface Stresses in Annealed, Heat-Strengthened, and Fully Tempered Flat Glass

2.2 *ANSI Standard:*

Z97.1 Safety Performance Specifications and Methods of Test for Safety Glazing Materials Used in Buildings[4]

2.3 *Other Documents:*

CPSC 16 CFR 1201 Safety Standard for Architectural Glazing Materials[5]

3. Terminology

3.1 *Definitions:* For definitions of terms used in this specification, refer to Terminology C 162 and Specification C 1036.

4. Classification

4.1 *Kinds*—Flat glass furnished under this specification shall be of the following kinds, as specified (see Section 6):

4.1.1 *Kind HS*—Heat-strengthened glass shall be flat glass, either transparent or patterned, in accordance with the applicable requirements of Specification C 1036 as further processed to conform with the requirements hereinafter specified for heat-strengthened glass.

4.1.2 *Kind FT*—Fully tempered glass shall be flat glass, either transparent or patterned in accordance with the applicable requirements of Specification C 1036 as further processed to conform with the requirements hereinafter specified for fully tempered glass.

4.2 *Conditions*—Glass furnished under this specification shall be of the following conditions, as specified (see Section 6):

4.2.1 *Condition A*—Uncoated surfaces.

4.2.2 *Condition B*—Spandrel glass, one surface ceramic coated.

4.2.3 *Condition C*—Other coated glass.

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[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] Reference to these documents shall be the latest issue unless otherwise specified by the authority applying this specification.

[3] 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.

[4] Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.

[5] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

4.3 *Types, Classes, Forms, Qualities, and Finishes*—these are described in Specification C 1036.

5. Intended Use

5.1 *Kind HS*—Heat-strengthened glass is generally twice as strong as annealed glass of the same thickness and configuration. When broken, the fragments are generally similar to that of annealed glass. Intended for general glazing when additional strength is desired but not requiring the strength of fully tempered glass.

NOTE 1—**Caution:** Monolithic heat-strengthened glass is not suitable for safety glazing as defined by ANSI Z97.1 or CPSC 16 CFR 1201.

5.2 *Kind FT* —Fully tempered glass is approximately four times as strong as annealed glass of the same thickness and configuration. When broken, by impact, fully tempered glass fractures into relatively small pieces meeting safety glazing requirements thereby greatly reducing the likelihood of serious cutting or piercing injuries in comparison with ordinary annealed glass. Fully tempered glass is intended for use in applications where its strength or safety characteristics may be required. For some applications, such as doors used for passage, tub and shower enclosures and fixed glass in close proximity to a walking surface, fully tempered glass is required by building codes and ordinances. It is often used for other applications where the properties of fully tempered glass are desirable such as table tops, counter tops, show case enclosures and similar applications.

6. Ordering Information

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

6.1.1 Title, number, and date of this specification.

6.1.2 Kind, condition, type, class, style, form, quality, finish, and pattern of glass as applicable (see Section 4).

6.1.3 Fabrication requirements (see 7.1).

6.1.4 Requirements for fittings and hardware (see 7.2).

6.1.5 Specific location of tong marks, when required (see 7.3).

6.1.6 Custom design or texture required (see 7.8).

6.1.7 Glass thickness (see 9.1).

6.1.8 Pattern-cut glass must be within the tolerances specified (see 9.3).

6.1.9 When surface or edge compression test is required for Kind HS or Kind FT glass (see 8.1.1).

6.1.10 When break safe characteristics are required for fully tempered (Kind FT) glass (see 8.1.2).

6.1.11 Color or tint of glass (see 8.2).

6.1.12 When either permanent or temporary identification marking is required (see Section 12).

6.1.13 Surface treatment or coatings for Condition B and Condition C glass (see 8.3 and 8.4).

6.1.14 When addition of fallout resistance capability is required for Condition A, Condition B, or Condition C glasses used as spandrels. (Normally achieved by adhering a reinforcing material to the glass surface.) (See 11.3.)

7. Fabrication

7.1 *Fabrication*—All fabrication, such as cutting to overall dimensions, edgework, drilled holes, notching, grinding, sandblasting, and etching, shall be performed before strengthening or tempering and shall be as specified (see Section 6 and 7.9). After the glass has been heat strengthened or tempered, it shall not be modified except as recommended by the fabricator; for example, some Condition C coatings. No modification shall be made that will affect its structural characteristics or integrity as specified in this specification.

7.2 *Fittings and Hardware*—Requirements for fittings and hardware shall be as specified (see Section 6) or as shown on plans or drawings. Fittings and hardware specified shall be compatible with glass fabrication limitations.

7.3 *Tong Marks*—The center of tong marks, when present, shall be located a maximum of 12.7 mm (½ in.) from one edge of the glass on thicknesses up to and including 9.5 mm (⅜ in.). On thicknesses over 9.5 mm, the center of tong marks, when present, shall be located a maximum of 19 mm (¾ in.) from one edge of the glass. Tong marks shall be located on a specific edge when specified (see Section 6). For location of tong marks on glass with special fabrication or irregular patterns, consult fabricators.

7.4 *Distortion*:

7.4.1 Thermally tempered and heat-strengthened glass is made by heating glass in a furnace to a temperature at which the glass becomes slightly plastic. Immediately after heating, the glass surfaces are rapidly cooled by quenching with air from a series of nozzles. The original flatness of the glass is slightly modified by the heat treatment, causing reflected images to be distorted. When viewing images through the glass, the distortion, in most glazing applications, is less than that of reflected images and is not as noticeable.

7.4.2 Fully tempered and heat-strengthened glass that has been made in a vertical furnace contains small surface depressions along one edge resembling dimples (tong marks) (see 7.3). Distortion will be observed in the areas surrounding the tong marks. Fully tempered and heat-strengthened glass that has been made in a horizontal furnace may contain surface distortion (for example, picture framing, heat distortion or roller wave distortion). Distortion will be detected when viewing images reflected from the glass surface.

7.4.3 Pressures, exerted around the periphery of glass by the glazing system, can also alter glass flatness thereby distorting reflected images. This is true regardless of whether or not the glass is heat treated.

7.4.4 Sealed insulating glass units also exhibit distortion regardless of glass type. Air or gas, trapped in the sealed airspace between the panes, expands or contracts with temperature and barometric changes, creating a pressure differential between the airspace and the atmosphere. The glass reacts to the pressure differential by being deflected inward or outward.

7.4.5 Regardless of glass flatness, the degree of reflected distortion perceived is largely due to the characteristics or symmetry of the object being reflected. Linear objects (such as building curtain walls and telephone poles) and moving objects

(such as cars) may appear distorted. Irregular and free-form objects such as trees and clouds will appear to have little perceived distortion.

7.4.6 Specified bow and warp limits may not adequately define, or control, the distortion that may become apparent after glazing. The factors, noted above, may have a larger influence on the perceived reflected distortion than that which is caused by bow and warp from the heat-treating process. Consultation with suppliers and the viewing of full-size mock-ups, under typical job conditions and surroundings, is highly recommended for user or architectural evaluation of the reflective distortion.

7.5 *Strain Pattern*—In heat-strengthened and fully tempered glass, a strain pattern, which is not normally visible, may become visible under certain light conditions. It is characteristic of these kinds of glasses and should not be mistaken as discoloration or nonuniform tint or color.

7.6 *Surface Particles*—The heat-treating process typically involves the transport of very hot glass on conveyor rollers. As a result of this soft glass-to-roller contact, some glass surface changes will occur. Minute glass particles (fines) from the glass cutting and edging process, typical manufacturing plant airborne debris or dust, refractory particles from the tempering oven roof, as well as external airborne dirt and grit carried into the plant by the large volumes of quench air used in the process, may adhere to one or both glass surfaces.

7.7 *Resistance to Wind Load*—The support system and the amount of glass deflection for a given set of wind-load conditions must be considered for design purposes. Consult the manufacturer to determine the appropriate thickness of heat-strengthened (Kind HS) or fully tempered (Kind FT) glass needed to satisfy the design wind load and probability of breakage design factor for the required glass.

7.8 *Special Surfaces, Types I or II*—Custom designs or textures shall be as specified (see 6.1.6) or as shown on plans or drawings.

7.9 *Fabrication Guidelines*—Heat-treated flat glass cannot be cut after tempering. Fabrication altering the stress distribution, surface or edge shape, or dimension must be performed before being heat treated. Consult suppliers for special edges or irregular patterns or, when required, on a specific type of edge. The following guidelines may be used for normal fabrication requirements.

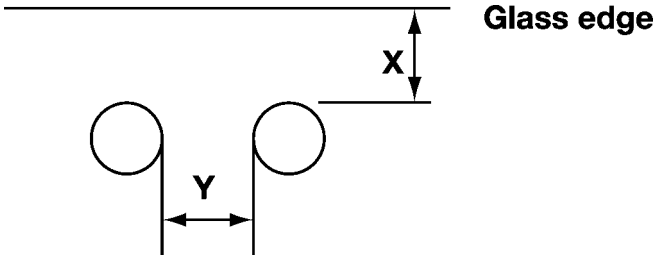
7.9.1 Heat-treated glass can be furnished with holes, notches, cutouts, and bevels.

7.9.2 *Placement of Holes*:

7.9.2.1 The minimum distance from any edge of the glass to the nearest point on the rim of a hole must be 6 mm (¼ in.) or 2 times the thickness of the glass, whichever is greater (see Fig. 1).

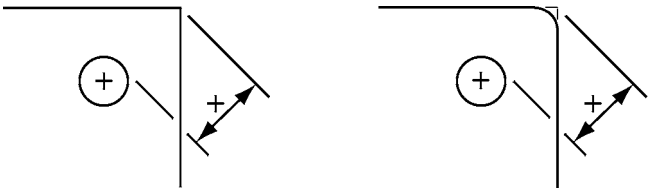
7.9.2.2 The minimum distance between the rims of adjoining holes must be 10 mm (⅜ in.) or 2 times the thickness of glass, whichever is greater (see Fig. 1).

7.9.2.3 Holes near corners must be located so that the nearest edge of the hole is a minimum of 6.5 times the thickness of the glass from the tip of the corner when the corner is 90° or more (see Fig. 2).



X = 6 mm (¼ in.) or 2t, whichever is greater
Y = 10 mm (⅜ in.) or 2t, whichever is greater
Where:
X= Minimum distance between glass edge and rim of nearest hole
Y= Minimum distance between rims of adjoining holes
t = glass thickness

FIG. 1 Placement of Holes



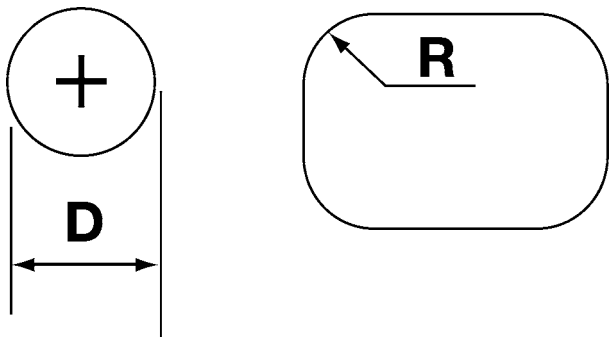
X = 6.5t
Where:
X = Minimum distance between glass corner and rim of nearest hole
t = Glass thickness.

FIG. 2 Location of Holes Near Corners

7.9.3 *Minimum Dimension of Holes*—Circular holes must have a minimum diameter of 6.4 mm (¼ in.) or the thickness of the glass, whichever is greater. In other than circular holes, any corners must have fillets, the radius of which must be equal to or greater than the thickness of the glass (see Fig. 3).

7.9.4 *Dimensional Tolerances of Holes*:

7.9.4.1 Tolerance of hole diameter shall be ±1.6 mm (1/16 in.).



D = 6 mm (1/4 in.) or 1t, whichever is greater
R≥ t
Where:
D = Minimum diameter of a hole
R = Radius
t = Glass thickness

FIG. 3 Maximum Dimension of Holes

7.9.4.2 Tolerance for dimensions of hole center from specified edges shall be ±1.6 mm (1⁄16 in.).

7.9.4.3 Tolerance for dimension between hole centers shall be ±1.6 mm (1⁄16 in.).

7.9.5 Chips and flakes at hole edges must not exceed 1.6 mm (1⁄16 in.).

7.9.6 *Notches and Cutouts*:

7.9.6.1 Notches and cutouts must have fillets, the radius of which must be equal to or greater than the thickness of the glass (see Fig. 4).

7.9.6.2 Dimensional tolerance of notches and cutouts shall be:

± 1.6 mm (1⁄16 in.) for glass thickness less than 12 mm (½ in.).

± 3 mm (⅛ in.) for glass thickness of 12 mm (½ in.) and greater.

7.9.6.3 Inner surfaces of notches and cutouts must be smooth seamed or polished.

8. Other Requirements

8.1 *Strength Requirements*:

8.1.1 *Surface and Edge Compression Requirements* (see 11.7):

8.1.1.1 *Kind HS, Heat-Strengthened Glass*—Kind HS glass with thicknesses of 6 mm (¼ in.) and less shall have a surface compression between 24 to 52 Mpa (3500 and 7500 psi). Surface compression testing, when required (see 6.1.9), shall be done in accordance with 11.7.

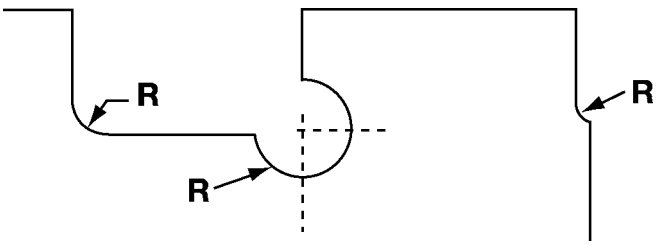
NOTE 2—Heat strengthening of glass thicker than 6 mm (¼ in.) within narrow limits of surface compression is difficult. Consult manufacturer.

8.1.1.2 *Kind FT, Fully Tempered Glass*—Kind FT glass shall have either a minimum surface compression of 69 MPa (10 000 psi) or an edge compression of not less than 67 MPa (9700 psi) or meet ANSI Z97.1 or CPSC Standard 16 CFR1201 in accordance with 11.8. Surface compression or edge compression testing, when required (see 6.1.9), shall be done in accordance with 11.7.

8.1.2 *Break Test Requirement for Kind FT Glass*—When specified (see Section 6), the break requirements of Kind FT glass shall be tested and interpreted in accordance with 11.8.

8.2 *Color or Tint*—The color or tint for each kind, type, class, style, finish, or pattern shall be as specified in 6.1.11 and as follows:

8.2.1 *Tint*—Heat-absorbing glass and light-reducing glass are available in a variety of tints. These types of glass vary in tint between different manufacturers and from melt to melt so some variation in tint may occur.



R ≥ t
t = thickness of glass
R = radius
See paragraph 7.9.6.

FIG. 4 Notch and Cutout Fillets

8.2.2 *Color or Tint Samples*—The request and particular purpose of any color or tint sample shall be stated in the invitation for bid. Tint samples must be heat strengthened or fully tempered, as required, for the matching of tints as the heat-strengthened or fully tempered glasses may exhibit slight changes from the tint of annealed glass. Viewing of the color or tint samples should be performed with the glass in the eventual glazed position.

8.3 *Condition B*—Ceramic-coated spandrel glass, shall be Kind HS heat-strengthened or Kind FT fully tempered glass having a ceramic coating of a specified color which has been fused onto and made an integral part of the surface of the glass (see 6.1.13).

8.3.1 *Appearance*—When viewed in accordance with 11.9, scattered pinholes, screen marks, and small opaque particles in the ceramic coating are permissible.

8.4 *Condition C*—Other coated glass shall be Kind HS heat-strengthened or Kind FT fully tempered glass with a specified special coating designed to modify one or more environmental characteristic such as solar and visible light transmission reflection and absorption or surface emissivity or both (see Specification C 1376).

9. Dimension Requirements

9.1 *Thickness*—Substrates for heat-strengthened and fully tempered glass shall be in accordance with the thickness requirements of Specification C 1036 and as specified therein (see Section 6). Available sizes and thicknesses of HS and FT glass are subject to the processing limitations of each furnace. All thicknesses are not available in all conditions, types, and classes. Consult manufacturers or fabricators.

9.2 *Tolerance, Length, and Width for Rectangular Shapes for Conditions A, B, and C Glass*—See requirements in Table 1.

9.3 *Pattern-Cut*—Unless otherwise specified (see Section 6), dimensional tolerances for pattern-cut glass must be specified (see 6.1.8). Consult the manufacturer or fabricator for tolerances.

9.4 *Flatness*—Because of the nature of the processes used in manufacturing tempered and heat-strengthened glasses, these glasses are not as flat as annealed glass. The deviation for flatness depends on thickness, width, length, and other factors. Usually greater thicknesses yield flatter products (see 11.6).

9.4.1 *Localized Warp*—Localized warp for rectangular glass shall not exceed 1.6 mm (1⁄16 in.) over any 300-mm (12-in.)

TABLE 1 Tolerance, Length and Width Requirements (8.2)

Glass thickness mm (in.)	Finished Size Tolerance Length and Width, plus or minus mm, (in.)
3.0 (⅛)	1.6 (1⁄16)
4.0 (5⁄32)	1.6 (1⁄16)
5.0 (3⁄16)	1.6 (1⁄16)
6.0 (¼)	1.6 (1⁄16)
8.0 (5⁄16)	2.0 (5⁄64)
10.0 (⅜)	2.4 (3⁄32)
12.0 (½)	3.2 (⅛)
16.0 (⅝)	4.0 (5⁄32)
19.0 (¾)	4.8 (3⁄16)

TABLE 2 Overall Bow and Warp, Maximum

	Edge Dimension, cm (in.)											
	0–50 (0–20)	>50–90 (>20–35)	>90–120 (>35–47)	>120–150 (>47–59)	>150–180 (>59–71)	>180–210 (>71–83)	>210–240 (>83–94)	>240–270 (>94–106)	>270–300 (>106–118)	>300–330 (>118–130)	>330–370 (>130–146)	>370–400 (>146–158)
Glass Thickness, mm (in.)	Maximum Bow and Warp, mm (in.)											
3 (⅛)	3.0 (0.12)	4.0 (0.16)	5.0 (0.20)	7.0 (0.28)	9.0 (0.35)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)	19.0 (0.75)	...	...	...
3 (⅛) Alternate Method[A]	2.0 (0.08)	2.0 (0.08)	2.0 (0.08)	3.0 (0.12)	5.0 (0.20)	6.0 (0.24)	7.0 (0.28)	8.0 (0.31)	10.0 (0.39)	...	...	...
4 (5⁄32)	3.0 (0.12)	4.0 (0.16)	5.0 (0.20)	7.0 (0.28)	9.0 (0.35)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)	19.0 (0.75)	...	...	...
5 (3⁄16)	3.0 (0.12)	4.0 (0.16)	5.0 (0.20)	7.0 (0.28)	9.0 (0.35)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)	19.0 (0.75)	...	...	...
6 (¼)	2.0 (0.08)	3.0 (0.12)	4.0 (0.16)	5.0 (0.20)	7.0 (0.28)	9.0 (0.35)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)	19.0 (0.75)	21.0 (0.83)	24.0 (0.94)
8 (5⁄16)	2.0 (0.08)	2.0(0.08)	3.0 (0.12)	4.0 (0.16)	5.0 (0.20)	6.0 (0.24)	8.0 (0.31)	10.0 (0.39)	13.0 (0.51)	15.0 (0.59)	18.0 (0.71)	20.0 (0.79)
10 (⅜)	2.0 (0.08)	2.0 (0.08)	2.0 (0.08)	4.0 (0.16)	5.0 (0.20)	6.0 (0.24)	7.0 (0.28)	9.0 (0.35)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)	19.0 (0.75)
12–22 (1⁄12 –7⁄8)	1.0 (0.04)	2.0 (0.08)	2.0 (0.08)	2.0 (0.08)	4.0 (0.16)	5.0 (0.20)	5.0 (0.20)	7.0 (0.28)	10.0 (0.39)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)

[A] Values apply to 3 mm (⅛ in.) thickness only when the alternative checking procedure in 11.6 is used.

span. Localized warp for strips shall not exceed 2.4 mm (3⁄32 in.) over any 300-mm (12-in.) span.

9.4.2 *Tong Kink*—Any localized kink centered at any tong location shall not exceed 1.6 mm (1⁄16 in.) in a 50-mm (2-in.) span.

9.4.3 *Overall Bow and Warpage Tolerances*—Overall bow and warpage tolerances shall not exceed the deviations shown in Table 2 when measured in accordance with 11.6.

10. Glass Quality and Finish

10.1 Glass qualities in this specification shall be in accordance with the applicable requirements for qualities q[3], q[4], q[5], and q[6], given in Specification C 1036 and as specified in Section 6.

11. Test Methods

11.1 *Expansion Fit Test for Ceramic Coating—Condition B, Ceramic-Coated Spandrel Glass*:

11.1.1 *Test Specimens*—Prepare and test in accordance with Test Method C 978.

11.1.2 *Test Results*:

11.1.2.1 The expansion match between the glass and ceramic enamel influences significantly the strength characteristics of spandrel glass. Proper match is essential to ensure that significant reduction in strength does not result due to the ceramic enamel coating.

11.1.2.2 When coated, cured, and well-annealed glass strips are tested in accordance with Test Method C 978, the stress measured in the glass at the ceramic-glass interface shall be a maximum of 1.52 MPa (220 psi) tension or compression.

11.2 *Durability Tests of Ceramic Coating*:

11.2.1 *Test Specimens*:

11.2.1.1 Specimens for durability tests shall have a representative thickness of ceramic coating of the same type and color as provided in specimens in 11.1.1. Specimens shall be fired in a normal manner with a production lot.

11.2.1.2 Specimens for tests in 11.2.2 and 11.2.4 may be of any convenient size.

11.2.2 *Test for Porosity*—Use either Test Method A or B.

11.2.2.1 *Test Method A—Gloss Test*:

(1) Procedure—With a glossmeter[6] conforming to Test Method C 346, check the gloss value. The glossmeter must be calibrated such that the gloss value reading with black glass (black Carrara or any similar product with polished surfaces) has a value of 54.5 (see Test Method C 346 for detailed discussion).

(2) Test Results—Penetration of water through porous ceramic can cause separation of the ceramic enamel from the base glass in freezing weather; ceramic with adequate gloss has been found to prohibit water entry, thus preventing such failure. When tested, the gloss value shall not be less than 35 at the time of manufacture.

11.2.2.2 *Test Method B—India Ink Test*:

(1) Procedure—Lightly scrape an approximate 25- by 75-mm (1- by 3-in.) area of the ceramic enamel coating with ten passes of a single-edge razor blade oriented toward the ten and four o'clock position at an angle of 45° to the surface of the specimen. Draw a line with India ink along the 75-mm (3-in.) dimension. After the ink has been on the specimen for 15 min, apply a fine abrasive paste over the line and scrub with an assay brush until the paste is removed from the line area. View the scrubbed area under a diffused light source with the unaided eye to determine if any residue remains in the ceramic enamel coating.

(2) Test Results—Residual deposits of ink indicate a porosity of the ceramic enamel coating that will allow water moisture penetration that may result in a discoloration of the ceramic enamel coating or a separation of the ceramic enamel coating and the glass substrate in freezing weather or both.

11.2.3 *Alkali Resistance Test*—Specimens for evaluation of resistance to alkali shall be prepared and tested in accordance with Test Method C 1203. The measured weight loss shall not exceed 0.0028 g/cm^2.

11.2.4 *Acid-Resistance Test*—Specimens for evaluation of resistance to acid shall be tested in accordance with Test

[6] A glossmeter manufactured by Photovolt Corp., Hunter Associates Laboratory, Gardner Instrument Co., or others using a 45° search unit have been found suitable for this purpose.

Method C 724. The acid resistance of the test specimen shall be five or better to be considered acceptable, and no visible stain shall be observed when the undecorated side of the sample is viewed over an opaque background.

11.3 *Fallout Resistance Test for an Assembly of Glass and Adhered Reinforcing Material*—Applies to Condition A, Condition B, or Condition C glasses when used as spandrels. (NOTE—Fallout resistance capability is optional and is intended to provide temporary retention of broken spandrels.) (See 6.1.14).

11.3.1 *Frequency of Tests*—Unless otherwise specified, the test for fallout resistance shall be performed with specimens taken from the initial production lot and thereafter only when changes are made in the assembly.

11.3.2 *Specimen Size*—Size of specimens shall be 863 by 1930 mm (34 by 76 in.) with a tolerance of ±1.6 mm (1⁄16 in.) on each dimension.

11.3.3 *Test Procedure*—Test for 100 cycles and repeat with no time delay between cycles. Perform each cycle in sequence as follows:

11.3.3.1 Hold for 1 h at – 29°C (–20°F) and ambient humidity.

11.3.3.2 During the next 3 h, increase temperature from – 29 to 82°C (–20°F to 180°F) with relative humidity at 95 to 100 % when above 5°C (41°F).

11.3.3.3 Then hold for 1 h at 82°C (180°F), 95 to 100 % relative humidity.

11.3.3.4 During the next 3 h, decrease temperature from 82 to – 29°C (180 to – 20°F) and ambient humidity.

11.3.4 *Sample Stabilization*—After completion of the test procedure of 11.3.3.4, the sample shall be allowed to rest for at least four h at temperatures between 20 and 30°C (68 and 86°F).

11.3.5 *Test Apparatus*—Each specimen shall be mounted in a test frame as specified in ANSI Z97.1 or CPSC 16 CFR 1201 as modified to conduct pressure test of 11.3.7.

11.3.6 *Fracturing Glass*—While the specimen is in the test frame, break the specimen using a spring-loaded prick punch at the midpoint of either vertical edge and 25 mm (1 in.) inboard of the edge. Cracks and fissures that may develop are permissible.

11.3.7 *Wind Load*—Subject each specimen after breakage to ten cycles of positive and negative pressure at 200 Pa (4 psf) to simulate the action of wind load against a building. Each positive and negative pressure shall be of 5-min duration.

11.3.8 *Interpretation of Tests*—Although cracks and fissures that may have developed are permissible, no opening shall occur through which a 76.2-mm (3-in.) diameter sphere may be freely passed, nor shall there be single or multiple areas with a cumulative total area of more than 58 cm^2 (9 $in.^2$) in which an attached film or other reinforcing material is detached from the glass.

11.4 *Wave, Ream, Strings, and Lines, Condition A and Condition C Glass, Type I*—Place sample in a vertical position at a distance of approximately 1 m (36 in.) from a brick wall or similar background showing essentially straight lines. Look through the sample at a distance of approximately 1 m from the sample using daylight without direct sunlight or with background light suitable for observing each type of imperfection. View the sample at an angle to the surface of not less than the vision interference angle in the table for the applicable glass in Specification C 1036. The line of vision shall be perpendicular to the wall. Determine acceptability in accordance with the applicable table of blemishes in Specification C 1036.

11.5 *Scratches, Rubs, Stones, and Gaseous Inclusions*:

11.5.1 *Condition A and Condition C Glass, Type I*—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 Specification C 1036 Tables 2, 3, and 4 for evaluation criteria.

11.5.2 *Condition B, Ceramic Coated*—Spandrel glass shall be viewed by light reflected from the viewed surface. Place the spandrel glass sample against an opaque backup material in a vertical position. View the sample from a distance of approximately 1 m (36 in.) for initial blemish detection. Refer to Specification C 1036 Tables 2, 3, and 4 for evaluation criteria.

11.6 *Localized Warp and Overall Bow and Warp*—Place sample glass in a freestanding vertical position, resting on blocks at the quarter points. With the glass in this position, place a straightedge across the concave surface, parallel to and within 25.4 mm (1 in.) of the edge, and measure the maximum deviation with a taper, or feeler gage, dial indicator or fine scale ruler. When the above procedure is impractical for larger sizes of 3-mm (⅛-in.) thickness, place the glass on a flat surface, concave side down, and use a taper, feeler gage, dial indicator, or fine scale ruler, reading in 0.02-mm (0.001-in.) increments, to determine overall bow and warp. Overall bow and warp values shown on the second line of Table 2 apply to 3mm (⅛ in.) when the alternative (horizontal) procedure is used.

11.7 *Surface and Edge Compression, Kinds HS and FT*—Examine specimens by the polariscopic or light refraction methods for surface or edge compression. When the range of the apparatus permits examination for edge compression only, obtain the averaged value for all midpoints of every edge. Accomplish this examination for Condition B spandrel glass by removing the ceramic coating with hydrofluoric acid or abrasive cloth. Index oil and a glass-slide cover plate may be necessary to eliminate the diffusing effect of the abraded surface and expose compression color bands.

11.7.1 *Surface Compression, Kinds HS and FT (see 8.1)*—Surface compression to be measured by light refraction methods such as GASP, DSR, or similar methods per Test Method C 1279. Two surface compression measurements shall be made in each of five locations, oriented in two directions at 90° to each other, for a total of ten readings on each specimen to be tested. Average the ten readings to determine the stress level of the test sample. The five locations to be examined are shown in Fig. 5.

11.8 *Break Test, Kind FT, Fully Tempered Glass*—Test and interpret in accordance with ANSI Z97.1 or CPSC 16 CFR 1201 as applicable (see 8.1.2).

11.9 *Coating Criteria, Condition B, Ceramic Coated*—Spandrel glass shall be viewed by light reflected from the

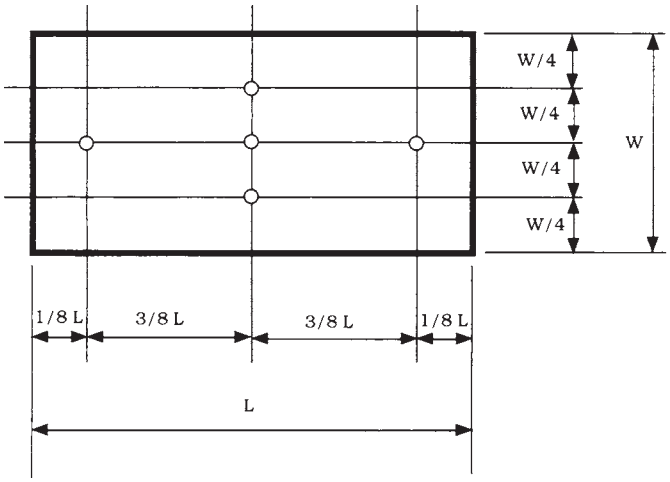


FIG. 5 Five Locations Examined

viewed surface. Place the spandrel glass sample against an opaque backup material and in a vertical position. View the sample from a distance of approximately 3 m (10 ft). Determine acceptability in accordance with 8.3.1.

11.10 *Coating Criteria Condition C*—See Specification C 1376.

12. Product Marking

12.1 The identification marking, when required, shall include the manufacturer's name or trademark, the glass thickness, and the designation of heat strengthened or fully tempered, as applicable for Kind FT glass. The identification marking shall be either permanent or temporary, as specified. Heat–treated glass intended for use in vision areas (such as doors and windows) shall be permanently marked.

12.1.1 *Permanent Identification Marking*—Permanent identification marking shall be accomplished by sandblasting, etching, or fired-on ceramic decal or silk-screened imprint methods that do not introduce stresses. The marking shall be located at a corner of the glass where it shall be fully visible and legible when the glass is installed.

12.1.2 *Temporary Identification Marking*—Temporary identification marking shall consist of a label that is attached to the glass and can be removed after installation of the glass.

13. Keywords

13.1 edge compression; flat glass; heat-strengthened glass; heat-treated glass; surface compression; tempered glass