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~~Designation:C 1048–97b~~ Designation: C1048 – 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 C1048; 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]

C162 Terminology of Glass and Glass Products

C346 Test Method for 45-deg Specular Gloss of Ceramic Materials

C724 Test ~~Methods~~Method for Acid Resistance of Ceramic Decorations on Architectural~~–~~-Type Glass

C978 Test Method for Photoelastic Determination of Residual Stress in a Transparent Glass Matrix Using a Polarizing Microscope and Optical Retardation Compensation Procedures

C1036 Specification for Flat Glass

C1203 Test Method for Quantitative Determination of Alkali Resistance of a Ceramic-Glass Enamel

C1279 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~~Consumer Product Safety Commission Standard on Architectural Glazing Materials~~ Safety Standard for Architectural Glazing Materials[5]

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## 3. Terminology

3.1 *Definitions:* For definitions of terms used in this specification, refer to Terminology ~~C 162~~C162 and Specification ~~C 1036~~C1036.

## 4. Classification

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

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

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Current edition approved Jan. 1, 2004. Published March 2004. Originally approved in 1985. Last previous edition approved in 1997 as C1048 – 97b. DOI: 10.1520/C1048-04.

[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* ~~, Vol 15.02.~~volume information, refer to the standard's Document Summary page on the ASTM website.

~~[4] Annual Book of ASTM Standards, Vol 02.05.~~

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

~~[5] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.~~

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

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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~~C1036 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~~C1036 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.

4.3 ~~*Types, Classes, Styles, Forms, Qualities, and Finishes*—Glass substrate shall be of the following types, classes, styles, forms, qualities, and finishes, as specified (see Section 6):~~

~~4.3.1*Type I—Transparent Glass, Flat:*~~

~~4.3.1.1*Class 1—Clear:*~~

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~~Quality~~

~~q[3]—Glazing select~~
~~q[4]—Glazing A~~
~~q[5]—Glazing B~~
~~q[6]—Greenhouse~~

~~4.3.1.2*Class 2—Tinted Heat-Absorbing and Light-Reducing*:~~

~~Quality~~

~~q[3]—Glazing select~~
~~q[4]—Glazing A~~
~~q[5]—Glazing B~~
~~Style A—Higher light transmittance~~
~~Style B—Lower light transmittance~~

~~4.3.1.3*Class 3—Tinted Light-Reducing*:~~

~~Quality~~

~~q[3]—Glazing select~~
~~q[4]—Glazing A~~
~~q[5]—Glazing B~~

~~4.3.2*Type II—Patterned Glass, Flat*:~~

~~Class~~

~~1—Clear~~
~~2—Tinted heat-absorbing and light-reducing~~
~~Style A—Higher light transmittance~~
~~Style B—Lower light transmittance~~
~~3—Tinted Light Reducing~~

~~Forms (Classes 1, 2, and 3)~~

~~3—Patterned~~

~~Quality~~

~~q[7]—Decorative~~
~~q[8]—Glazing~~

~~Finish~~

~~f[1]-Patterned one side~~
~~f[2]-Patterned both sides~~

~~Pattern (Forms 2 and 3)~~

~~p[1]—Linear~~
~~p[2]—Geometric~~
~~p[3]—Random~~
~~p[4]—Special~~

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Types, Classes, Forms, Qualities, and Finishes—these are described in Specification C1036.

## 5. Intended Use

5.1 *Kind ~~HS, Types I and H~~HS*—Heat-strengthened glass is generally twice as strong as annealed glass of the same thickness and configuration. When broken, the fragments are generally ~~somewhat larger than for fully tempered~~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:** ~~H~~Monolithic heat-strengthened glass ~~may~~is not ~~be~~ suitable for safety glazing as defined by ANSI Z97.1 or CPSC 16 CFR 1201.

5.2 ~~*Kind FT, Types I and II*—Fully tempered glass is up to five times as strong as annealed glass of the same thickness and configuration. When broken, it breaks into innumerable small fragments of more or less cubical shape. Intended for general glazing and safety glazing such as sliding doors, storm doors, building entrances, bath and shower enclosures, counter tops, showcases, interior partitions, and other uses where the superior strength characteristics and safety properties of fully tempered glass are required.~~ 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 ~~data~~date of this specification.

~~6.1.2Kind,~~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 ~~7.7~~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 ~~impact is~~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).
~~6.1.12Luminous transmittance, Class 3 glasses (see 8.4).~~
~~6.1.13When either permanent or temporary identification marking is required (see Section~~
6.1.12 When either permanent or temporary identification marking is required (see Section 12).
~~6.1.14~~
6.1.13 Surface treatment or coatings for Condition B and Condition C glass (see ~~8.5~~ 8.3 and ~~8.6~~8.4).
~~6.1.15~~
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 Requirements~~ 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 ~~7.8~~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 ~~slight~~ surface ~~waves. This waviness~~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 ~~reflective~~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 ~~reflective~~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

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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.

~~7.7~~

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.

~~7.8~~

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.

7.8~~9~~.1 Heat-treated glass can be furnished with holes, notches, cutouts, and bevels.

~~7.8.2~~7.9.2 *Placement of Holes*:

7.8~~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 ~~1.5~~2 times the thickness of the glass, whichever is greater (see Fig. 1).

~~7.8.2.2The minimum distance between the rims of adjoining holes in glass less than 5 mm (3⁄16 in.) thick must be at least 12 mm (½ in.) or ½ the larger hole diameter, whichever is greater (see~~

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).

~~7.8.2.2.1The minimum distance between the rims of adjoining holes in 5 mm (3⁄16 in.) or thicker glass must be at least 10 mm (⅜ in.) or two times the glass thickness times the larger hole diameter, whichever is greater (see Fig. 1).~~

~~7.8.2.3Holes near corners must be located so that the nearest edge of the hole is at least 6.5 times the thickness of the glass from the tip of the corner when the corner is 90° or more (see~~

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).

~~7.8.3~~

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).

~~7.8.4~~

7.9.4 *Dimensional Tolerances of Holes*:

7.8~~9~~.4.1 Tolerance of hole diameter shall be ±1.6 mm (1⁄16 in.).

7.8~~9~~.4.2 Tolerance for dimensions of hole center from specified edges shall be ±1.6 mm (1⁄16 in.).

7.8~~9~~.4.3 Tolerance for dimension between hole centers shall be ±1.6 mm (1⁄16 in.).

7.8~~9~~.5 Chips and flakes at hole edges must not exceed 1.6 mm (1⁄16 in.).

~~7.8.6~~

7.9.6 *Notches and Cutouts*:

7.8~~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).

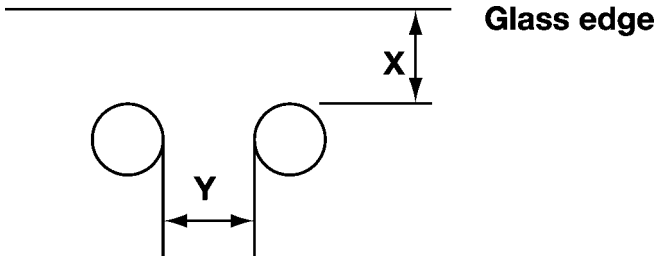


**FIG. 1—s Placeme~~7.8.2.~~nt of Holes**

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

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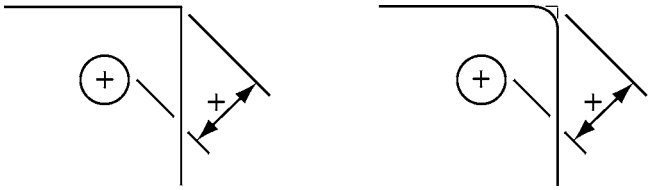

FIG. 2 Location of Hole 1—s Near Corne7.8.2.3.rs

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

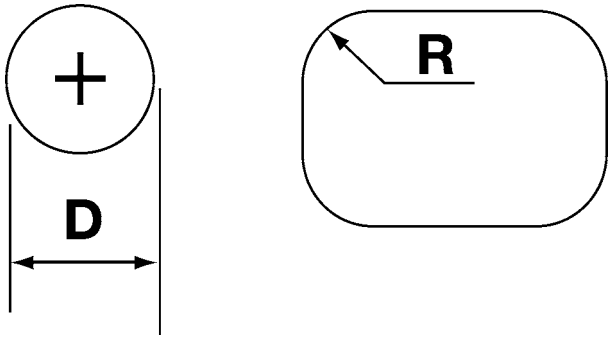


FIG.8. 3. Maximum Dimension of Holes

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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

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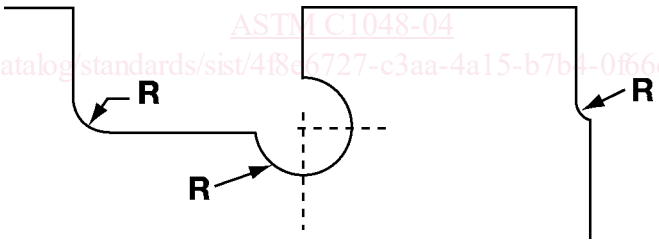


FIG. 4 Note 1—See paragrapch7.8.6. and Cutout Fillets

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

7.89.6.2 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.

7.89.6.3 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.