Designation: C 1422 – 99

Standard Specification for Chemically Strengthened Flat Glass[1]

This standard is issued under the fixed designation C 1422; 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.

1. Scope

1.1 This specification covers the requirements for chemically strengthened glass products that originate from flat glass and are used in general building construction, transportation, and other specialty applications, such as copy machine scanners, computer disks, and flat glass screens for television monitors. Techniques such as ion implantation, dealkalization, etch-strengthening, and glaze coatings are specifically excluded.

1.2 Classification of chemically strengthened glass products is based on the laboratory measurements of surface compression and case depth and not on the modulus of rupture (MOR). This specification does not purport to address end-use performance.

1.3 *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.*

1.4 Dimensional values are stated in SI units, the standard units for this specification. Inch-pound units, given in parentheses, are for information only.

2. Referenced Documents

2.1 *ASTM Standards:*

C 162 Terminology of Glass and Glass Products[2]

C 978 Test Method for Photoelastic Determination of Residual Stress in a Transparent Glass Matrix Using a Polarizing Microscope and Optical Retardation Compensation Procedures[2]

C 1036 Specification for Flat Glass[3]

C 1279 Test Method for Nondestructive Photoelastic Measurement of Edge and Surface Stresses in Annealed, Heat-Strengthened, and Fully Tempered Flat Glass[2]

3. Terminology

3.1 Definitions—Refer to Terminology C 162, as appropriate.

3.1.1 *blemishes*—Refer to Specification C 1036 for flat glass.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *case depth*—depth of compression below the surface to the nearest zero stress plane.

3.2.2 *chemically strengthened glass*—glass which has been strengthened by ion-exchange to produce a compressive stress layer at the treated surface.

3.2.3 *ion-exchange process*—the exchange of constituent ions in the glass with externally supplied ions (generally at temperatures near the strain point of the glass). This may be accomplished by immersing glass in a molten salt bath or solution with or without electric field assistance, exposing glass to plasma, applying a paste on the glass surface, or surface crystallization with or without electric field assistance.

3.2.4 *surface compression*—an in-plane stress which tends to compact the atoms in the surface.

4. Significance and Use

4.1 Chemically strengthened glass is significantly stronger than annealed glass, depending upon the glass composition, strengthening process, level of abrasion, and the application environment. The strengthening process does not contribute significantly to optical distortion.

4.2 The chemical strengthening process can effectively strengthen glass of all sizes and shapes and can be useful in cases in which glass is too thin, small, or complex-shaped for thermal tempering.

4.3 Monolithic chemically strengthened glass is not a safety glazing product because its break pattern is similar to that of annealed glass. When safety glazing is required, chemically strengthened glass shall be laminated.

4.4 The very nature of the chemical strengthening process alters the glass surface chemistry. Therefore, the procedures for and the performance of postprocessing steps, such as laminating and coating, can be different from that of nonchemically strengthened glass.

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[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] *Annual Book of ASTM Standards*, Vol 15.02.

[3] The recommended range is from 0.5 to 1.5 mm (0.02 to 0.06 in.). Specimen thicknesses at the lower end of this range yield better results.

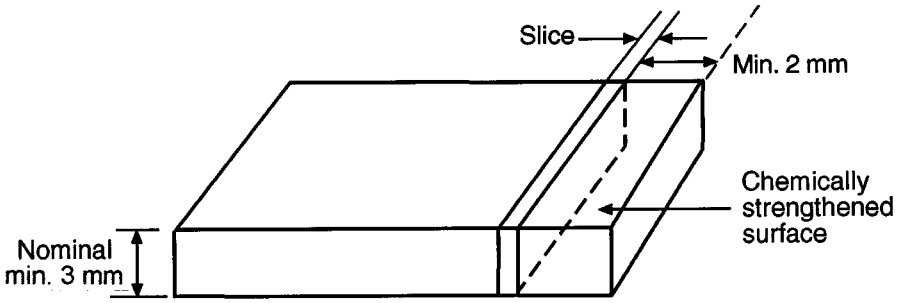

FIG. 1 Slice Location

4.5 Modulus of rupture (MOR), weight gain, and optical methods are other methods used for process control in chemical strengthening.

5. Classification

5.1 *Kinds*—Chemically strengthened glass furnished in accordance with this specification shall be classified on the basis of the surface compression levels (Level 1-5) and case depth (Levels A-F). These levels are independent of each other. Increasing levels of surface compression permit an increasing amount of flexure. Greater case depths offer more protection from strength reduction caused by abuse and abrasion. The thickness of the test specimen shall be reported with the surface compression and case depth levels. Case depth values may vary on different thicknesses of the same glass type which have been manufactured under similar chemical exchange conditions. For classification purposes, all surface compression and case depth values are to be reported on 3-mm (⅛-in.) thick witness specimens in accordance with 8.1.3.

5.1.1 *Surface Compression*:

5.1.1.1 *Level 1*—Surface compression, >7 MPa (1000 psi) ≤172 MPa (25 000 psi).

5.1.1.2 *Level 2*—Surface compression, >172 MPa (25 000 psi) ≤345 MPa (50 000 psi).

5.1.1.3 *Level 3*—Surface compression, >345 MPa (50 000 psi) ≤517 MPa (75 000 psi).

5.1.1.4 *Level 4*—Surface compression, >517 MPa (75 000 psi) ≤690 MPa (100 000 psi).

5.1.1.5 *Level 5*—Surface compression, >690 MPa (100 000 psi).

5.1.2 *Case Depth*:

5.1.2.1 *Level A*—Case depth, ≤50 µm (0.002 in.).

5.1.2.2 *Level B*—Case depth, >50 µm (0.002 in.) and ≤150 µm (0.006 in.).

5.1.2.3 *Level C*—Case depth, >150 µm (0.006 in.) and ≤250 µm (0.010 in.).

5.1.2.4 *Level D*—Case depth, >250 µm (0.010 in.) and ≤350 µm (0.014 in.).

5.1.2.5 *Level E*—Case depth, >350 µm (0.014 in.) and ≤500 µm (0.020 in.).

5.1.2.6 *Level F*—Case depth, >500 µm (0.020 in.).

6. Ordering Information

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

6.1.1 Title, number, and date of this specification.

6.1.2 Surface compression (see 5.1.1) or minimum acceptable value.

6.1.3 Case depth (see 5.1.2) or minimum acceptable value.

6.1.4 Fabrication information (see 7.1).

7. Fabrication

7.1 *Fabrication*—After the glass has been chemically strengthened, it shall only be modified as recommended by the fabricator. No modification shall be made that will affect the surface compression and case depth.

7.1.1 *Thickness*—Substrates for chemically strengthened glass shall be in accordance with the thicknesses in Specification C 1036 and as specified therein (see Section 6). All thicknesses may not be available. Consult the manufacturer or the fabricator.

8. Test Method

8.1 *Preparation of the Test Specimen*:

8.1.1 Prepare the test specimens from the same material as the test batch and anneal before chemically strengthening.

8.1.2 Protect the edges of the test specimens during the preparation process (slicing, grinding, smoothing).

8.1.3 A witness specimen plate, having minimum length and width of 25 by 12.5 mm (1 by ½ in.) and having a nominal thickness of 3 mm shall be processed. Both the large flat faces of the specimen shall have the as-fabricated condition. After the chemical strengthening process, slice a section from this specimen perpendicularly at least 2 mm (0.08 in.) away from the ends (see Fig. 1). The thickness (height) of this section between parallel faces shall not exceed 1.5 mm (0.06 in.).[3] Lightly polish the section using conventional ceramographic techniques and use the section for classification by viewing the optical retardation through its height.

8.2 *Apparatus for Measuring of the Surface Stress in a Section (Slice)*:

8.2.1 *Microscope*, used with a minimum objective time eyepiece magnification of 100×.

8.2.2 *Polarizers*, installed in mutually crossed orientation, aligned at +45° to the symmetry plane of the microscope.

8.2.3 *Means of Measuring Distances Between the Black Fringe and the Edge*, including a fine-graduated reticle or a filar micrometer eyepiece (specimen fixed to the stage) or a fine reticle (specimen supported on a micrometer stage). The measuring system must resolve 1 µm with reproducibility

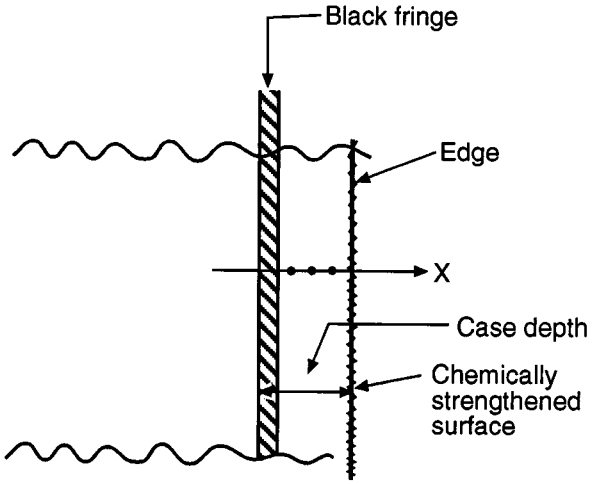

FIG. 2 Case Depth

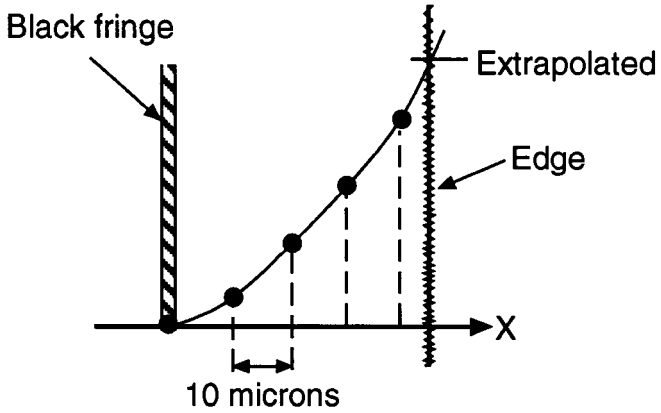

FIG. 3 Extrapolation Procedure Plotting Birefringence Versus Position

better than 5 µm. If a filar micrometer is used, it must be calibrated using a certified precision scale.

8.3 Make the measurement of case depth from the center of the dark fringes to the nearest fabrication surface using the reticle or the filar eyepiece. Compute the separation between the center of the dark fringe and the nearest surface using the known calibration and report as the case depth (see Fig. 2).

8.4 *Measurement of Surface Stress*:

8.4.1 The surface stress of the chemically strengthened witness specimen plate can be measured using polarimetry and refractometry techniques, in accordance with Test Method C 1279.

8.4.2 The edge stress of the slice removed from the witness specimen can be measured using a microscope defined in 8.2. Measure the retardation at the edge using a suitable compensator in accordance with Test Method C 978 and convert to stress in accordance with 8.5.2.

8.4.3 When visibility of the edge is inadequate, extrapolation techniques are permitted. To implement the extrapolation, measure the retardation at several points between the zero fringe and the edge, typically in 10-µm intervals (a minimum of three points is required). The profile must be then extrapolated to the edge as shown in Fig. 3.

8.5 *Calculation of Surface Stress*:

8.5.1 When surface polarimetry is used, the manufacturer's calibration is required to convert the instrument to surface stress.

8.5.2 When edge retardation is measured in accordance with 8.4.2 or in 8.4.3, calculate stress using the following:

$$S = R/tC\,(1 - v) \quad (1)$$

where:

S = stress, MPa;
R = measured retardation, nm;
t = slice thickness, mm;
v = Poisson's ratio (0.2 for most glasses); and
C = stress-optic coefficient, 10^{-12} Pa^{-1} (Brewster) units, appropriate for the parent glass.[4]

9. Keywords

9.1 case depth; chemically strengthened; flat glass; ion exchange; surface compression

[4] For a list of stress-optic coefficients, see Varshneya, A.K., *Fundamentals of Inorganic Glasses*, Academic Press, 1994, p. 481.