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Standard Specification for Chemically Strengthened Flat Glass[1]

This standard is issued under the fixed designation C1422/C1422M; 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 PC screens, notebooks, tablets, smart phones, and E-readers, as well 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 (depth of compression) compression and case depth and not on the modulus of rupture (MOR). This specification does not purport to address end-use performance.

1.3 A test method for the measurement of case depth and surface compression is included in Section 8.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C162 Terminology of Glass and Glass Products

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

C1279 Test Method for Non-Destructive Photoelastic Measurement of Edge and Surface Stresses in Annealed, Heat-Strengthened, and Fully Tempered Flat Glass

F218 Test Method for Measuring Optical Retardation and Analyzing Stress in Glass

2.2 *ANSI Standard:*[3]

Z97.1–2009 Safety Glazing Materials Used in Buildings-Safety Performance, Specifications and Methods of Tests

2.3 *Federal Document:*[4]

CPSC 16CFR 1201 Consumer Product Safety Commission Safety Standard for Architectural Glazing Materials

3. Terminology

3.1 *Definitions:*

3.1.1 Refer to Terminology C162, as appropriate.

3.1.2 *blemishes*—Refer to Specification C1036 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.

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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] 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.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from U.S. Consumer Product Safety Commission (CPSC), 4330 East West Hwy., Bethesda, MD 20814, http://www.cpsc.gov.

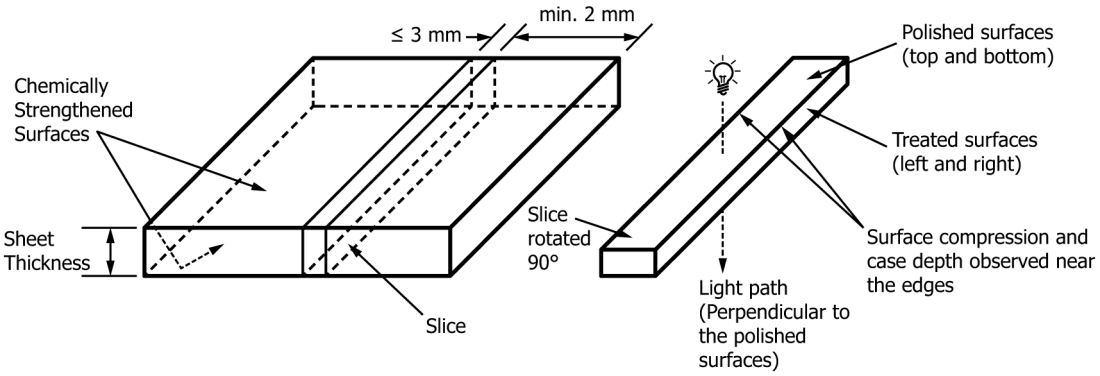

Fig. 1 Slice Location Fig. 1a Finished Slice

FIG. 1 Slice Location

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 *depth of compression (DOC)*-—see *case depth.*

3.2.4 *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~~ field, ultrasonic or other assistance, exposing glass to plasma, applying a paste on the glass surface, or contacting glass with molten salts in a furnace.

3.2.5 *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 in accordance with CPSC 16CFR 1201 Cat. I or Cat. II or ANSI Z97.1–2009.

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.

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 1-7) and case depth (Levels A-F). ~~These levels~~ Surface compression and case depth 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~~ [reported, along with the sheet~~⅛ in.] thick witness specimens~~thickness of the witness specimen in accordance with 8.1.3. See Fig. 1and Fig. 1a.

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] ≤862 MPa [125 000 psi].

5.1.1.6 *Level 6*—Surface compression, >862 MPa [125 000 psi] ≤1034 MPa [150 000 psi].
5.1.1.7 *Level 7*—Surface compression, >1034 MPa [150 000 psi].
5.1.2 *Case Depth:*
5.1.2.1 *Level ~~A~~ A1*—Case depth, ~~≤50~~≤25 µm ~~[0.002~~[0.001 in.].
5.1.2.2 *Level A2*—Case depth, >25 µm and ≤ 50 µm [0.002 in.]
5.1.2.3 *Level B*—Case depth, >50 µm [0.002 in.] and ≤150 µm [0.006 in.].
5.1.2.4 *Level C*—Case depth, >150 µm [0.006 in.] and ≤250 µm [0.010 in.].
5.1.2.5 *Level D*—Case depth, >250 µm [0.010 in.] and ≤350 µm [0.014 in.].
5.1.2.6 *Level E*—Case depth, >350 µm [0.014 in.] and ≤500 µm [0.020 in.].
5.1.2.7 *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 Glass thickness.
6.1.3 Surface compression (see 5.1.1) or minimum acceptable value.
6.1.4 Case depth (see 5.1.2) or minimum acceptable value.
6.1.5 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 C1036 ~~and~~or 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~~ at ½ in.] ~~and having a nominal thickness of 3 mm [0.12 in.]~~ a minimum of six times the sheet thickness 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~~ slice thickness shall not exceed ~~4~~3 mm, which allows for grinding and polishing loss.[5] The recommended range of slice thickness is from 0.10 to 3.00 mm (0.04 to 0.12 in). Slice thicknesses at the lower end of this range yield more accurate results. Lightly polish the ~~section~~ slice on its non-chemically strengthened surfaces using conventional ceramographic techniques and ~~use the section~~ examine it for classification by viewing the optical retardation through ~~its height.~~the slice thickness.

8.2 *Apparatus for Measuring of the Surface Stress and Case Depth in a Section ~~(Slice):~~ (Slice) Using a Polarizing Microscope:*
8.2.1 *Microscope,* used with a minimum objective times eyepiece magnification of 25x. Case depths < 50 microns shall use a minimum magnification of ~~50x.~~50×. The optimum magnification shall be selected based on the case depth.
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).~~ reticle, an eyepiece reticle, or stage micrometer of appropriate resolution. The measuring system must resolve 1 µm or 2 % of the case depth, whichever is greater. ~~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).~~*Measurement of Case Depth:*
8.3.1 Using white light, identify the black fringe representing the transition from mid-plane tension to surface compression. Make the measurement of case depth from the center of that black fringe to the nearest fabrication surface using the reticle or micrometer. 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 and Fig. 2a).

8.4 *Measurement of Surface Stress:*

[5] The recommended range is from 0.15 to 3.00 mm [0.005 to 0.12 in.]. Specimen thicknesses at the lower end of this range yield better results.