Designation: C 1377 – 97

Standard Test Method for
Calibration of Surface/Stress Measuring Devices[1]

This standard is issued under the fixed designation C 1377; 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 test method covers calibration or verification of calibration or both, of surface-stress measuring devices used to measure stress in annealed and heat-strengthened or tempered glass, using polariscopic or refractometry based principles.

1.2 This test method is nondestructive.

1.3 This test method uses transmitted light, and therefore, is applicable to light-transmitting glasses.

1.4 This test method is not applicable to chemically tempered glass.

1.5 Using the procedure described, surface stresses can be measured only on the "tin" side of float glass.

1.6 *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:*

C 158 Test Methods for Strength of Glass by Flexurermination of Modulus of Rupture[2]

C 162 Terminology of Glass and Glass Products[2]

C 770 Test Method for Measurements of Glass Stress—Optical Coefficient[2]

C 1048 Specification for Heat-Treated Flat Glass—Kind HS, Kind FT Coated and Uncoated Glass[2]

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*—For terminology used in this test method, refer to Terminology C 162.

4. Summary of Test Method

4.1 In this test method, a test bar is subjected to bending using deadweights or calibrated load-cells to introduce surface stresses that can be calculated from the specimen geometry and forces applied. At a point in which the stresses are calculated, those same stresses also are measured using the instrument to be calibrated or verified. Since both the specimen dimension and the applied forces can be established accurately using traceable (primary) standards, the method permits a fully traceable calibration of the stress-measuring instrument.

5. Significance and Use

5.1 The strength and performance of heat-strengthened and fully tempered glass is greatly affected by the surface and edge stress induced during the heat-treating process.

5.2 The edge and surface stress levels are specified in Specification C 1048, in the Engineering Standards Manual of GANA[3], and in foreign specifications.

5.3 Surface stresses can be measured nondestructively using methods, such as Test Method C 1279. The calibration of surface measuring devices used in those procedures and periodic verification of calibration are needed. This test method offers a convenient way to accomplish this task.

6. Principle of Operation

6.1 The instrument to be calibrated is placed on the surface of the calibration specimen. Stresses at a point where the instrument is placed are calculated using expressions shown in Section 9. To increase the precision of measurement, several levels of stress are produced by applying forces incrementally. Measurement of stress using the instrument to be calibrated is repeated for each stress level and these measurements are used to calibrate the instrument.

7. Test Specimens and Loading Schemes

Two loading geometries can be practiced: cantilever and four-point bending.

7.1 *Cantilever-Beam Specimen (Fig. 1)*—the dimensions of the specimen used for cantilever loading should be selected within limits shown below:

Thickness (t): 6 mm (0.22 in.) minimum
Width (w): $8t \leq w \leq 12t$
Length (L): $6w$ minimum
Distance to the point of measurement (L_o): $4w$
Clamped length: $1.5w$

7.1.1 A heat-strengthened or tempered specimen, with polished edges is preferred, but annealed specimens can be used if the range of stress is less than 24.13 MPa (3500 psi).
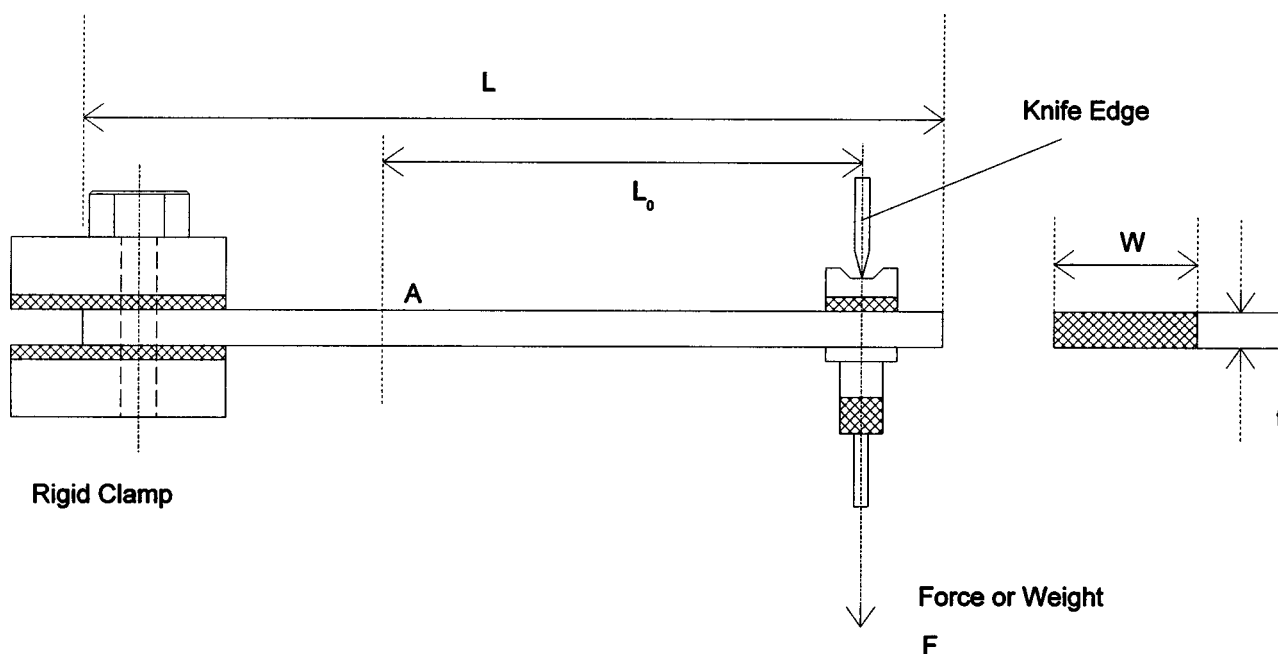

FIG. 1 Cantilever Beam Loading

7.2 *Four-Point Bending Specimen (Fig. 2)*—The four-point bending specimen should be preferred since it has uniform stress in the central loading zone. The dimensions of the specimen should be selected within the following limits:

Thickness (t): minimum 2 mm (0.079 in.)
Width (w): $8t \leq w \leq 12t$ (see Note 1)
Length L_o: minimum $4w$
Gage length L_c section: $3w$
Minimum overall length L: $12w$
Edges: Polished, no chips in the gage section, bevel less than $0.1t$.

NOTE 1—When the thickness t is less than 6 mm, and width of the beam exceeds $12t$, instead of the beam bending, plate bending equations should be used to calculate surface stress, or suitable corrections are required in the equations in 9.1. Barata[4] and Ashwell[5] show the correction procedures.

7.3 *Application of Forces*—Forces required must be calculated to eliminate possible breakage. Stresses must be estimated first using the equations in 9.1. A tempered specimen may be subjected to stress levels up to 10 000 psi (69 MPa). Using annealed specimens, the stress should remain at a safe level, typically below 3500 psi (24 MPa).

7.3.1 *Cantilever Specimen*—The specimen must be clamped securely using wood, plastic, or rubber-lined metal clamping surfaces, with rounded edges, as shown in Fig. 3. The forces can be applied using a calibrated testing machine or dead weights, by means of knife edges, to insure exact positioning of the line-of-loading B-B. The pad used for load application can be secured from slipping using high-friction materials. To eliminate possible twisting action, the knife edge should be narrow, or a steel ball used to center the point of application of force.

7.3.2 *Four-Point Bending Specimen*—In the case of four-point bending, the force must be applied equally at two points,

and two articulated knives or roller supports are required to ascertain accurately the length L_0 and L_c. Particular precautions are required to insure that the end supports do not introduce a twist in the specimen, as a result of nonparallel support surfaces or nonflatness of the specimen itself. Fig. 2 illustrates the setup for application of forces to obtain tension and compression on the upper face. Test Methods C 158 provides a description of support design.

8. Procedure

8.1 When calibrating a surface polarimeter, apply forces in five equal increments, using a testing machine or dead weight. When calibrating a critical angle measuring instrument, at least ten increments are needed, and a tempered specimen must be used.

8.2 For each incremental loading, including zero, obtain the instrument reading. Repeat the reading at least three times, and average the readings. When calibrating a surface polarimeter, measure the fringe tilt θ. When calibrating a differential refractometer, measure the differential angle using a micrometer reticle, and read the distance between the borders of illuminated zones at mutually perpendicular polarization in accordance with instrument manual.

8.3 Prepare a table of results, and plot these data, with applied stress as the ordinant (x axis) and tan θ (using surface polarimeter) or angular distance between emerging light beams (using refractometer) versus applied stress (see Fig. 4).

9. Calculation

9.1 For each force increment, calculate the stress at Point A where measurements are obtained using the following formula:

$$\text{Stress}_{(psi)} = \text{FORCE}_{(lbs)} \times \frac{6\,L_{o(in.)}}{w_{in.}\,t_{in.}^2} \qquad (1)$$

or

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[4] Barata, F. I., "When Is a Beam a Plate?," *American Ceramic Society Communications,* May 1981.

[5] Ashwell, D. G., "The Anticlastic Curvature of Rectangular Beams and Plates," *Journal of Aeronautics,* Vol 54, 1950, pp. 708-715.