Designation: E671 − 98 (Reapproved 2022)

Standard Specification for Maximum Permissible Thermal Residual Stress in Annealed Glass Laboratory Apparatus[1]

This standard is issued under the fixed designation E671; 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 a limit for thermal residual stress in reusable annealed glass laboratory apparatus as determined by prescribed photoelastic measurement procedures.

1.2 In broad classification, the laboratory glassware items covered by this specification, but not limited to, are:

- beakers
- bottles, aspirator
- bottles, dropping
- bottles, gas washing
- bottles, infusion
- bottles, milk test
- bottles, reagent
- bottles, weighing
- bulbs, absorption
- bulbs, leveling
- bulbs, sampling
- burets
- condensers
- crystallizing dishes
- culture dishes
- custom apparatus
- cylinders, graduated and plain
- desiccators
- extraction tubes
- flasks
- fritted ware
- funnels
- generators, Kipp
- grinder, tissue
- Imhoff cones
- impingers
- jars, battery
- jars, bell
- jars, chromatography
- jars, cylindrical
- joints, ball and socket or standard taper
- manometers
- percolators
- pycnometers
- stopcocks
- tubes, centrifuge
- tubes, chromatography
- tubes, color comparison (turbidity)
- tubes, combustion (ignition)
- tubes, connecting and adapter
- tubes, digestion
- tubes, drying
- tubes, fermentation
- tubes, thistle (spray traps)
- vapor traps
- viscometers
- watch glasses

1.3 This specification recognizes that photoelastic measurements are proportional to the difference of the principal stresses. The limit imposed represents a safety factor to cover a situation in which one of the principal stresses may be larger than the apparent stress.

1.4 This specification applies only to annealed glassware that is intended for sale as such. It excludes glassware that has been thermally tempered, ion-exchanged, or laminated with glass layers of differing expansion. The intent of this specification is to limit the residual stresses for safe consumer use in annealed glass, as it leaves the manufacturer.

1.5 Stresses introduced by thermal expansion differences within the glassware are covered by this specification. Graded and glass-to-metal seals are excluded.

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E1157 Specification for Sampling and Testing of Reusable Laboratory Glassware

E1273 Specification for Color Coding of Reusable Laboratory Pipets

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

3. Stress Limit

3.1 The stress as measured by the procedure in Section 4 and calculated by Eq 2 shall not exceed 5.2 MPa (750 psi), except for combustion, centrifuge, and chromatography tubes, for which a limit of 4.5 MPa (650 psi) applies. Ware exceeding these limits shall be rejected or reannealed to meet the specification.

4. Measurement Procedure

4.1 Using a Friedel (Senarmont) polarimeter as described in Test Method F218, place the glass article to be measured in the viewing field in air. Examine every part of the article with a definable light path (glass dimension) by rotating the analyzer to compensate for local stress birefringence. Document those zones showing the higher values for the retardation or thickness ratios by recording analyzer angle, glass thickness (light path), and position in ware.

[1] This specification is under the jurisdiction of ASTM Committee E41 on Laboratory Apparatus and is the direct responsibility of Subcommittee E41.01 on Laboratory Ware and Supplies.

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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.

4.2 In some orientations, such as sighting perpendicular to the axis of a thin-walled cylinder, two glass paths must be included in the measurement. If by rotating the cylinder, the retardation appears to be relatively constant, the measurement is straightforward and the two walls define the light path. If the retardation is variable, the scheme shown in Fig. 1 is recommended. If an adjacent region is found with low or constant retardation, or both, measure this retardation at normal incidence. Then use the recommended (slant) path shown which includes one wall of the adjacent region and one wall of the region in question. The retardation that applies in this case is the slant path reading algebraically corrected by one half of the normal incidence reading taken in the adjacent zone (Note 1). If an adjacent region meeting these criteria cannot be found, simply record the maximum retardation detected through both walls of the variable region at normal incidence.

NOTE 1—If large angles (>10°) from normal are chosen or necessary, the increased path must be cosine corrected (see Fig. 1).

4.3 Other systems of determining stress-optical retardation are acceptable provided that the technique selected meets the sensitivity of the Friedel polarimeter, which has a least count of approximately 3 nm (1° analyzer rotation).

4.4 For batch or continuous processes, testing and reporting may be done by statistical sampling.

5. Calculation of Stress

5.1 *Retardation/Path*—The retardation per unit path, *R*, as determined with the Friedel polarimeter is given by:

$$R = \frac{FA}{t} \quad (1)$$

where:

A = angular rotation of analyzer, degree,
R = retardation per unit path, nm/cm,
F = conversion factor: 3.15 nm/degree for white light; λ/180° for monochromatic light where λ is the wavelength of peak intensity, nm, and
t = light path (glass thickness) for the particular viewing direction, cm.

5.2 *Stress Calculation*—The stress is determined by the following equation

$$\sigma = \frac{R}{K} \quad (2)$$

where:

σ = stress, MPa, and
K = stress-optical constant of the glass (Note 2), nm/cm · MPa.

NOTE 2—The appropriate value for the glass in question can be supplied by the glass manufacturer.

6. Report

6.1 Report the following information:

6.1.1 Identification of article, type of glass,

6.1.2 Manufacturing source and date,

6.1.3 System for optical retardation measurement,

6.1.4 Sketch of article with key measurement points,

6.1.5 Table of data, coding measuring points and giving analyzer readings, light path, statistical analyses, special considerations, such as slant path corrections in cylinders, and calculated stress,

6.1.6 Stress-optical constant used, and

6.1.7 Date of test and name of operator.

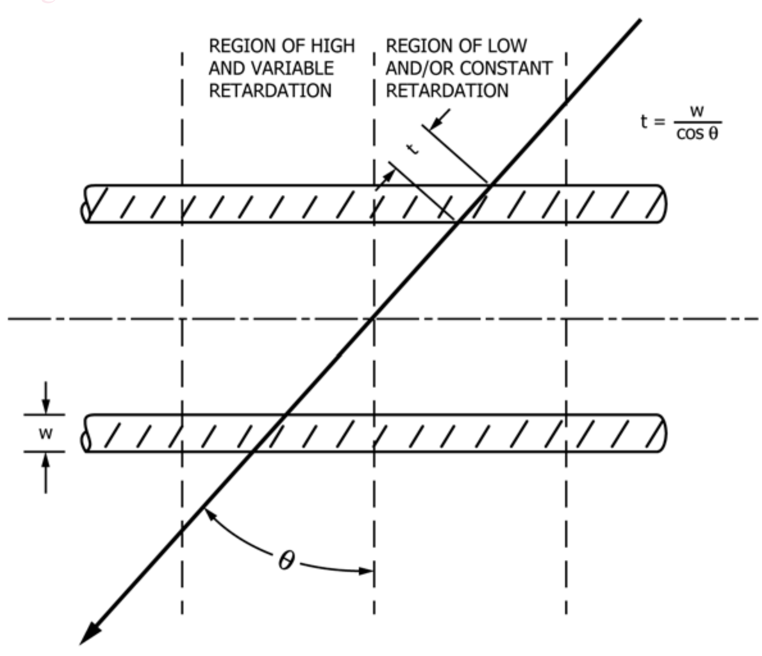

FIG. 1 Scheme for Measuring Retardation in Cylinder with Circumferentially Variable Retardation