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

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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.

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.

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

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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.

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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:

$$R = \frac{FA}{t} \tag{1}$$

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

$$\sigma = \frac{R}{K} \tag{2}$$

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.

7. Sampling and Testing

7.1 For sampling and testing, refer to Specification E1157.

8. Keywords

8.1 annealed glass; residual; stress

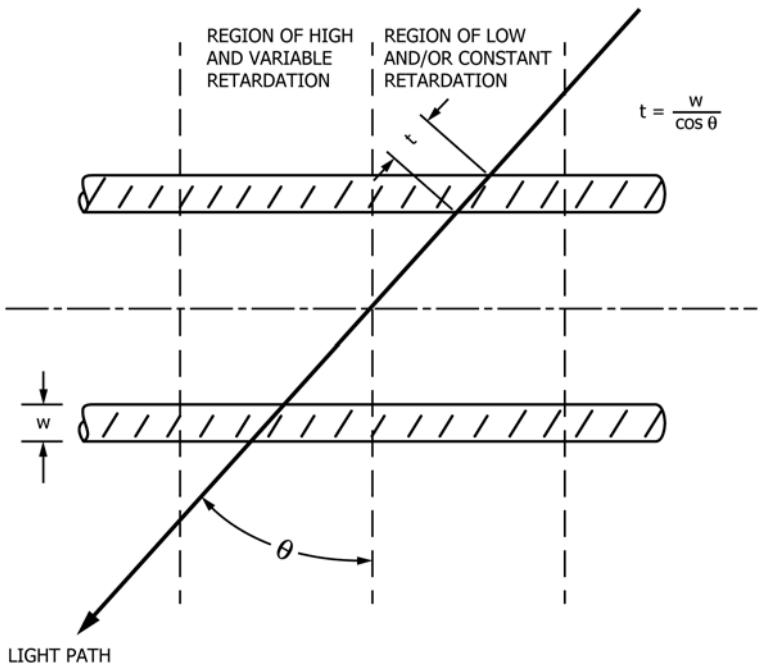

FIG. 1 Scheme for Measuring Retardation in Cylinder with Circumferentially Variable Retardation

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