Standard Practices for Verification and Calibration of Polarimeters[1]

This standard is issued under the fixed designation C1426; 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 Polarimeters and polariscopes used for measuring stress in glass are described in Test Methods F218, C148, and C978. These instruments include a light source and several optical elements (polarizers, optical retarders, filters, and so forth) that require occasional cleaning, realigning, and calibration. The objective of these practices is to describe the calibration and verification procedures required to maintain these instruments in calibration and ensure that the optical setup is within specification for satisfactory measurements.

1.2 It is mandatory throughout these practices that both verification and calibration are carried out by qualified personnel who fully understand the concepts used in measurements of stress retardation and are experienced in the practices of measuring procedures described in Test Methods F218, C148, and C978.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C148 Test Methods for Polariscopic Examination of Glass Containers
C162 Terminology of Glass and Glass Products
C770 Test Method for Measurement of Glass Stress—Optical Coefficient
C978 Test Method for Photoelastic Determination of Residual Stress in a Transparent Glass Matrix Using a Polarizing Microscope and Optical Retardation Compensation Procedures
F218 Test Method for Measuring Optical Retardation and Analyzing Stress in Glass

3. Terminology

3.1 For definitions of terms used in these practices, see Terminology C162.

4. Principles of Verification and Calibration Procedures

4.1 Verification and calibration of polarimeters are accomplished using the following procedures:

4.1.1 *Procedure A: (Verification)*—Measure individual components and their orientation to ensure that the requirements of Test Methods F218, C148, and C978 are satisfied.

4.1.2 *Procedure B: (Calibration)*—Determine the accuracy of the polarimeter using a calibrated gage or retarder.

5. Auxiliary Component Requirements

5.1 The following are required to verify and calibrate a polarimeter:

5.1.1 *Verification of Components (Procedure A):*

5.1.1.1 *Verification of Polarization Efficiency,* a light-intensity meter, linear over the range of measured values.

5.1.1.2 *Verification of Quarter-Wave Plate,* a Babinet compensator equipped polarimeter, with a monochromatic light source of traceable wavelength.

5.1.1.3 *Reference Polarizer with Known Axis.*

5.1.2 *Calibration of Polarimeter (Procedure B):*

5.1.2.1 Procedure B requires a gage with a calibrated, known retardation. The calibrated gage must have sufficient retardation to calibrate the instrument within its intended use range. For example, a polariscope/polarimeter used in Test Methods C148 should be calibrated using a gage exhibiting a retardation range of from 0 to 227 nm (0 to 10 temper grade).

5.1.2.2 Alternately, a rectangular cross-section specimen prepared from an SRM glass having a known stress-optical constant, subjected to uniaxial compression in a calibrated testing machine, may be used instead of a calibrated gage with known retardation.

6. Verification and Calibration Procedures

6.1 *Procedure A—Verification and Aligning of Components:*

6.1.1 *Verification of Polarization Efficiency*—Using a light-intensity meter, measure the light intensity, with polarizers crossed, I_c (dark field) and then with polarizers parallel, I_p. Calculate the polarization efficiency, E, as follows:

$$E = \frac{(I_p - I_c)}{I_p} \quad (1)$$

[1] These practices are under the jurisdiction of ASTM Committee C14 on Glass and Glass Productsand are the direct responsibility of Subcommittee C14.04 on Physical and Mechanical Properties.

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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.

The efficiency must satisfy the requirements of the test method for which the polarimeter is used.

6.1.2 *Verification of Position of Axes*—Using a reference polarizer, verify that the polarizer, *P*, is oriented at 45 ± 1° to the instrument reference axis. Rotate the analyzer to attain the maximum dark field, and record the analyzer reading to the nearest degree or 0.05 fringe. Repeat this measurement five times and compute the average. This "zero" reading to the nearest degree or 0.05 fringe must be algebraically applied to retardations measured with this polarimeter.

6.1.3 *Verification of Quarter-Wave Plate, Q*—Using a polarimeter equipped with a Babinet compensator, measure the retardation of the quarter-wave plate. The retardation must be 141 ± 5 nm.

6.2 *Procedure B—Calibration of Polarimeter Using a Calibrated Retarder:*

6.2.1 *Use of a Calibrated Gage*—The gage must have uniform and known direction of axes and a calibrated value of retardation, R_c, in at least one location, marked permanently on the gage.

6.2.1.1 If using a variable-field retarder, place the gage in the field of view with its axes aligned with the reference direction of the polarimeter (see Figs. 1 and 2). Rotate the analyzer clockwise from the zero position until the black fringe is centered over the calibrated gage mark (the objective is to minimize the light intensity at the gage mark) and take a reading from the analyzer dial. If using a uniform-field retarder, place the gage in the field of view with its tensile axis aligned parallel to the reference direction of the polarimeter. In this position, the retarder will appear brightest (maximum light intensity) and the field will appear darker as the analyzer dial is rotated clockwise. If that does not occur, rotate the retarder 90° in the field of view to bring it into the correct orientation. Rotate the analyzer clockwise from the zero position until the retarder is uniformly at its darkest hue (maximum extinction) and take the reading from the analyzer dial. Convert the analyzer reading to retardation in nanometers (See Test Methods F218). Repeat five times and calculate the average retardation. The result of the measurement should equal R_c within 1 % or 10 nm, whichever is greater.

NOTE 1—The reference direction of your polarimeter may be along a different axis than that shown. If the reference direction is unknown, rotate the analyzer with the retarder removed from the field of view. When the field of view is darkest, stop rotating the analyzer and note the location of the 45º mark on the analyzer dial. This will identify the reference axis of the polarimeter (see 6.1.2).

6.2.1.2 The use of strain disks (described in Test Methods C148) in series at a point 6.4 mm from the disk's outer circumferences, tangentially parallel or perpendicular to the polarimeter reference direction, will give optical retardations of 22.8, 45.6, 68.4, and so forth, with uncertainties of ±4 %. Five repeat retardation averages for any selected level of disks in series must be within 4 % of these values for a successful calibration.

6.2.2 *Use of an SRM Glass*—Following Procedure C of Test Method C770, measure the stress-optical constant of an SRM glass having a certified value for this constant.[3] The ratio of the certified value of the stress-optical constant to the measured value should be used as a corrective factor for measurements with the polarimeter.

7. Report

7.1 Report the following in the verification and calibration report:

7.1.1 Date of verification and calibration,

7.1.2 Auxiliary components used,

7.1.3 Significant data obtained, and

7.1.4 Organization performing the calibration.

8. Keywords

8.1 calibration; glass; polarimeter

[3] SRM 709 has a stress-optical constant of -1.359×10^{-12} Pa^{-1}. This SRM produces retardations from 0 to 136 nm when following Procedure C of Test Method C770.

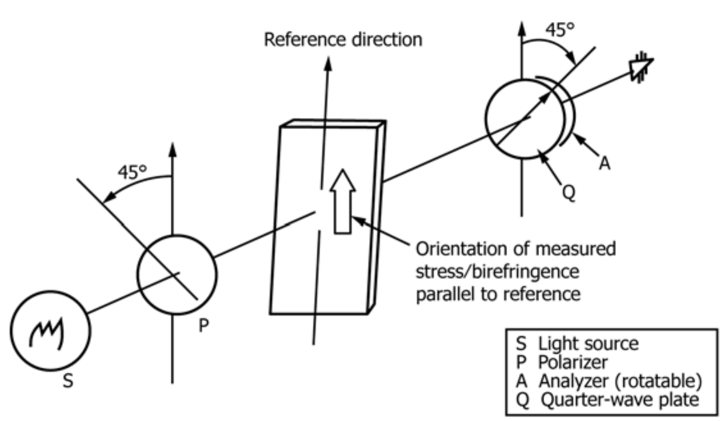

FIG. 1 Components of the Polarimeter Showing Stress Birefringence Orientation

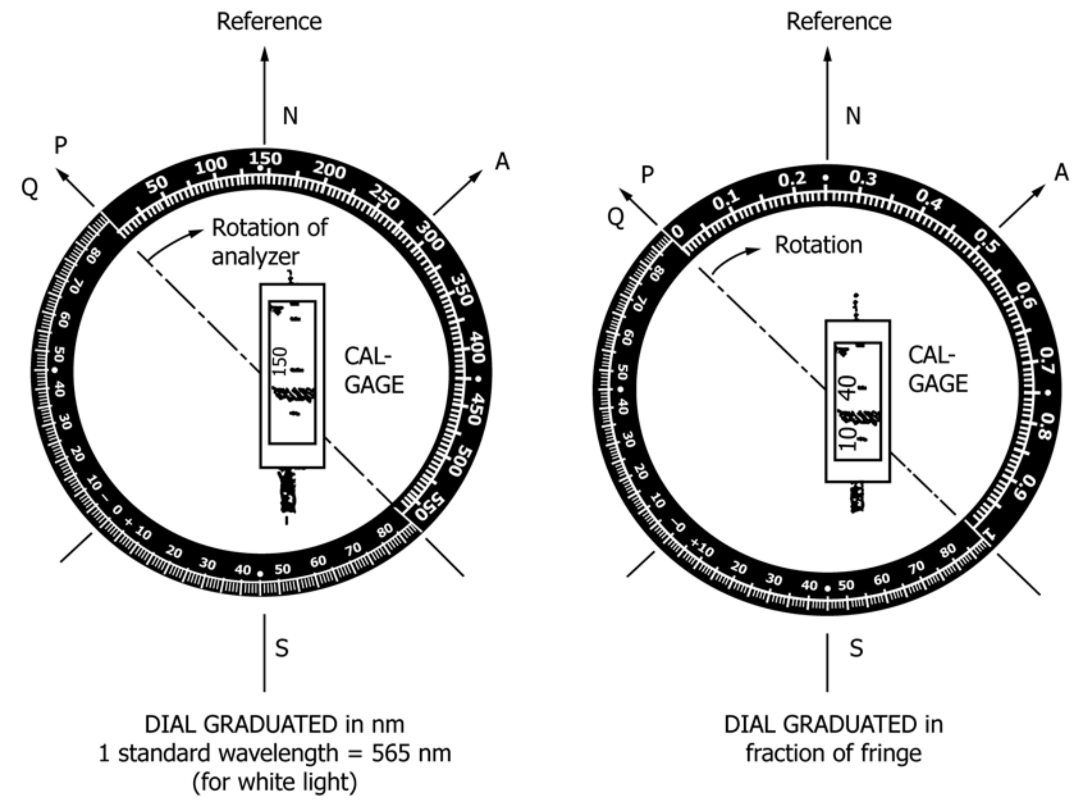

FIG. 2 Orientation of Calibrated Retardation Gage in Procedure B