Designation: C 1426 – 99

Standard Practices for Verification and Calibration of Polarimeters[1]

This standard is issued under the fixed designation C 1426; 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 F 218, C 148, and C 978. 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 F 218, C 148, and C 978.

2. Referenced Documents

2.1 *ASTM Standards:*

C 148 Test Methods for Polariscopic Examination of Glass Containers[2]

C 162 Terminology of Glass and Glass Products[2]

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

C 978 Test Method for Photoelastic Determination of Residual Stress in a Transparent Glass Matrix Using a Polarizing Microscope and Optical Retardation Compensation Procedures[2]

F 218 Test Method for Analyzing Stress in Glass[2]

3. Terminology

3.1 For definitions of terms used in these practices, see Terminology C 162.

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 F 218, C 148, and C 978 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 C 148 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 (dark field) and then with polarizers parallel, I_p. Calculate the polarization efficiency, E, as follows:

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

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

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

[1] These practices are under the jurisdiction of ASTM Committee C-14 on Glass and Glass Products and are the direct responsibility of Subcommittee C14.04 on Physical and Mechanical Properties.

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[2] *Annual Book of ASTM Standards*, Vol 15.02.

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*[3]—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 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 until the black fringe moves to the calibrated gage mark. (Convert the analyzer reading to retardation in nanometers in accordance with Test Methods C 148.) 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.

6.2.1.2 The use of strain disks (described in Test Methods C 148) 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 C 770, measure the stress-optical constant of an SRM glass having a certified value for this constant.[4] 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.

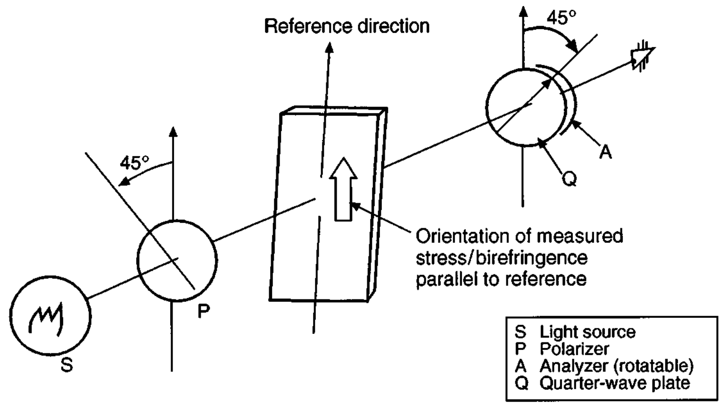

FIG. 1 Components of the Polarimeter Showing Stress Birefringence Orientation

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] Gages exhibiting a known retardation are available from Strainoptic Technologies, Inc., North Wales, PA and AGR International, Inc., Butler, PA.

[4] SRM 709 is presently available from NIST, SRM Program, Room 212, Bldg. 202, Gaithersburg, MD 20899-0001. It 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 C 770.

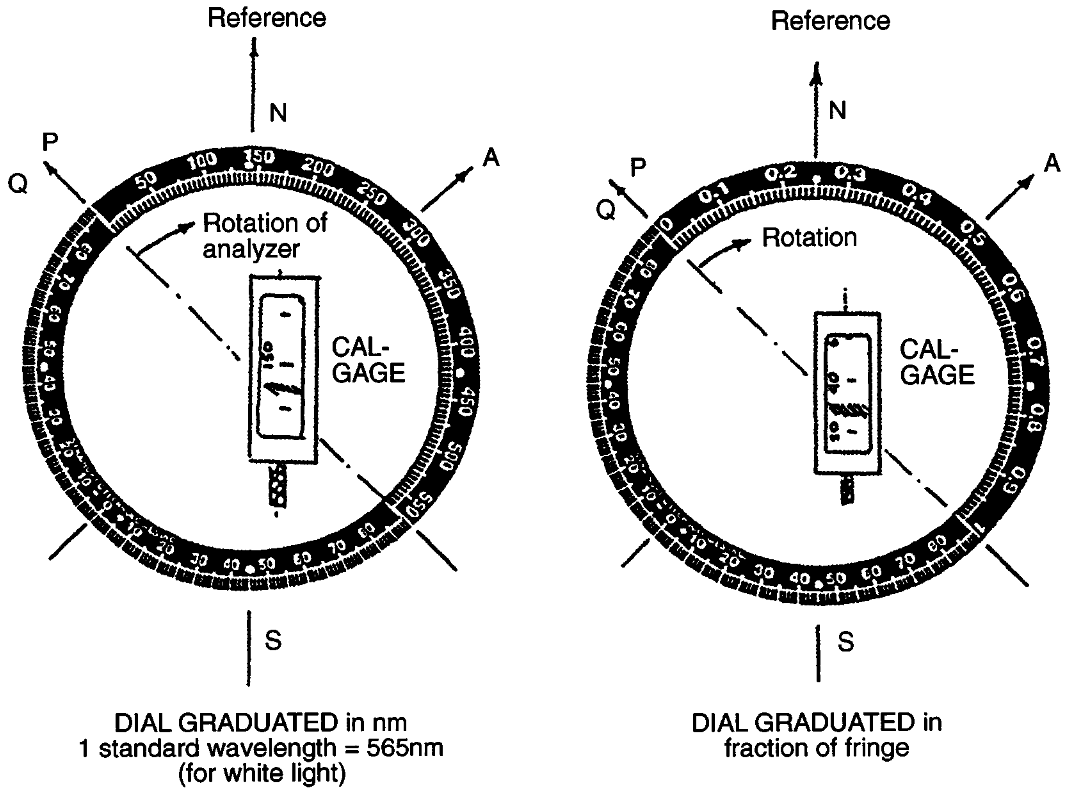

FIG. 2 Orientation of Calibrated Retardation Gage in Procedure B