Designation: C 148 – 00

Standard Test Methods for Polariscopic Examination of Glass Containers[1]

This standard is issued under the fixed designation C 148; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 These test methods describe the determination of relative optical retardation associated with the state of anneal of glass containers. Two alternative test methods are covered as follows:

	Sections
Test Method A—Comparison with Reference Standards Using a Polariscope	6 to 9
Test Method B—Determination with Polarimeter	10 to 12

1.2 Test Method A is useful in determining retardations less than 150 nm, while Test Method B is useful in determining retardations less than 565 nm.

NOTE 1—The apparent temper number as determined by these test methods depends primarily on (*1*) the magnitude and distribution of the residual stress in the glass, (*2*) the thickness of the glass (optical path length at the point of grading), and (*3*) the composition of the glass. For all usual soda-lime silica bottle glass compositions, the effect of the composition is negligible. In an examination of the bottom of a container, the thickness of glass may be taken into account by use of the following formula, which defines a real temper number, T_R, in terms of the apparent temper number, T_A, and the bottom thickness, t:

$$T_R = T_A\,(0.160/t)$$

where t is in inches, or

$$T_R = T_A\,(4.06/t)$$

where t is in millimetres.

This thickness should be measured at the location of the maximum apparent retardation. Interpretation of either real or apparent temper number requires practical experience with the particular ware being evaluated.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *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 162 Terminology of Glass and Glass Products[2]

C 224 Practice for Sampling Glass Containers[2]

C 1426 Practices for Verification and Calibration of Polarimeters[2]

3. Terminology

3.1 *Definitions*— For definitions of terms used in these test methods see Terminology C 162.

4. Significance and Use

4.1 These two test methods are provided for evaluating the quality of annealing. These test methods can be used in the quality control of glass containers or other products made of similar glass compositions, where the degree of annealing must be verified to ensure quality products. These test methods apply to glass containers manufactured from commercial soda-lime-silica glass compositions.

5. Sampling

5.1 Methods of sampling a minimum lot from a group of containers of a given type are given in Practice C 224 for the various situations to which that method may apply.

TEST METHOD A—COMPARISON WITH REFERENCE STANDARDS USING A POLARISCOPE

6. Apparatus

6.1 *Polariscope*, conforming to the following requirements:

6.1.1 The degree of polarization of the field at all points shall not be less than 99 %.

6.1.2 The field shall be a minimum of 51 mm (2 in.) in diameter greater than the diameter of the container to be measured. The distance between the polarizing and analyzing elements shall be sufficient to allow the inside bottle bottom surface to be viewed through the open container finish.

6.1.3 A sensitive tint plate, having a nominal optical retardation of 565 nm, with a variation across the field of view of less than 5 nm and with its slow axis at 45° to the plane of

[1] These test methods are under the jurisdiction of ASTM Committee C14 on Glass and Glass Products and are the direct responsibility of Subcommittee C14.07 on Glass Containers.

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

polarization, shall be used. Such an orientation will produce a magenta background in the field of view. The brightness of the polarized field illuminating the sample shall be a minimum of 300 cd/m^2.

NOTE 2—Color discrimination remains satisfactory with retardations between 510 and 580 nm, but optimum conditions are attained at 565 nm.

7. Calibration and Standardization

7.1 A set of not less than five standardized glass disks[3] of known retardation stress shall be used to cover the range of commercial container annealing. Such disks shall be circular plates of glass not less than 76 mm (3 in.) nor more than 102 mm (4 in.) in diameter. Each disk shall have a nominal retardation at the calibration point, 6.4 mm (0.25 in.) from the outer circumference of the disk, corresponding to not less than 21.8 nm nor more than 23.8 nm of optical retardation.

8. Procedure

8.1 *Examination of the Bottom of Cylindrical Flint Containers*—View the inside bottom of the container through the open container finish. Rotate the container to determine the location of the highest order of retardation color at the inside knuckle position. Compare the highest order retardation color observed at the bottom of the container to the retardation color seen at the calibration point in various numbers of the standard disks stacked one on top of the other and held parallel to the surface of the polarizer. Determine whether the maximum order of retardation color in the container bottom is less than that in one disk, less than that in two and greater than one, less than that in three and greater than two, and so forth. It is seldom possible to obtain an exact match of the order of retardation color scheme in the container with the reference standards. Accordingly, record the temper number of the container using the following procedure:

8.1.1 *Temper Number Determination*—When a maximum order retardation color observed in the container bottom is greater than that of N disks but less than $N+1$ disks, the apparent temper grade is judged to be that of $N+1$ disks. The apparent temper number is always determined to be the next integral temper number greater in value than the actual observed value as seen in the following table:

Apparent Temper Number	Observed Temper
1	less than 1 disk
2	less than 2, greater than 1 disk
3	less than 3, greater than 2 disks
4	less than 4, greater than 3 disks
5	less than 5, greater than 4 disks
6	less than 6, greater than 5 disks
7	[A]

[A]Evaluation by polarimeter (Test Method B) should be used for apparent temper numbers greater than six.

8.2 *Examination of Square, Oval, and Irregular Shapes*—Make the polariscopic examination of that container curve or corner that shows the maximum order of retardation color and record the temper number in accordance with the procedure outlined in 8.1.

8.3 *Examination of the Container Sidewalls*—Match the maximum retardation color observed in the container sidewall with the maximum retardation color at the calibration point of the standard reference disks, and record the apparent temper number in accordance with the procedure outlined in 8.1.1.

8.4 *Examination of Colored Ware*—Using the polariscope with the tint plate in the field of view, rotate the container to determine the location of the highest order retardation color at the inside knuckle position. View the bottom of the container through the open container finish and select as a reference area the darkest appearing area of the container bottom having minimum retardation, usually found at the center of the container bottom. Then, with the tint plate in position, hold a standard reference disk under the reference area in the bottom of the container such that the calibration point on the disk is directly under the reference area in the center bottom of the container. Compare the retardation color of the reference area in the container center bottom as modified by the standard reference disk with the maximum retardation color as normally observed at the inside knuckle of the container bottom. If this color is greater than the modified color of the reference area, use two or more disks and grade the annealing in accordance with the procedure outlined in 8.1.1.

9. Report

9.1 Report the temper number (real or apparent) obtained for each container.

TEST METHOD B—DETERMINATION WITH POLARIMETER

10. Apparatus

10.1 *Polarimeter*, conforming to the following requirements:

10.1.1 The degree of polarization of the field shall be at all points not less than 99 %.

10.1.2 The field shall be a minimum of 51 mm (2 in.) in diameter greater than the diameter of the container to be measured. The distance between the polarizing and analyzing elements shall be sufficient to allow the container to be positioned to permit the inside bottle bottom surface to be viewed through the open container finish.

10.1.3 A quarterwave plate with an optical retardation of 141 ± 14 nm shall be inserted between the specimen and the analyzer with the slow axis aligned with the plane of polarization of the polarimeter. The brightness of the polarized field illuminating the sample shall be a minimum of 300 cd/m^2.

NOTE 3—The retardation measurement will be affected by the combined effect of the quarterwave-plate deviation from its nominal value of 141 nm and by the deviation of the orientation of the measured stress direction from its ideal position of 45° to the polarizer axis.
A 14-nm deviation of the quarterwave plate and a stress-direction deviation of 10° will introduce an error not greater than 8 nm.

10.1.4 The analyzer shall be mounted so that it can be rotated with respect to the polarizer and the quarterwave plate and the angle of rotation determined.

[3] A limited supply of standard disks are available from American Glass Research International, 615 Whitestown Rd., Meridian, PA 16001; Precision Analytical, 500 S. Madison, Watkins Glen, NY 14891; and Strain optic Technologies, Inc., North Wales, PA 19454.