



Designation: F144 – 80 (Reapproved 2019)

# Standard Practice for Making Reference Glass-Metal Sandwich Seal and Testing for Expansion Characteristics by Polarimetric Methods<sup>1</sup>

This standard is issued under the fixed designation F144; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This practice covers the preparation and testing of a reference glass-metal sandwich seal for determining stress in the glass or for determining the degree of thermal expansion (or contraction) mismatch between the glass and metal. Tests are in accordance with Test Method **F218** (Section 2).

1.2 This practice applies to all glass and metal (or alloy) combinations normally sealed together in the production of electronic components.

1.3 The practical limit of the test in deriving mismatch is approximately 300 ppm, above which the glass is likely to fracture.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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:*<sup>2</sup>

- F15** Specification for Iron-Nickel-Cobalt Sealing Alloy
- F30** Specification for Iron-Nickel Sealing Alloys
- F31** Specification for Nickel-Chromium-Iron Sealing Alloys
- F47** Test Method for Crystallographic Perfection of Silicon

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee **C14** on Glass and Glass Products and is the direct responsibility of Subcommittee **C14.04** on Physical and Mechanical Properties.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

- by **Preferential Etch Techniques** (Withdrawn 1998)<sup>3</sup>
- F79** Specification for Type 101 Sealing Glass
- F105** Specification for Type 58 Borosilicate Sealing Glass
- F218** Test Method for Measuring Optical Retardation and Analyzing Stress in Glass
- F256** Specification for Chromium-Iron Sealing Alloys with 18 or 28 Percent Chromium

## 3. Summary of Practice

3.1 Seals of a standard configuration are prepared from representative specimens of the glass and metal to be tested. The glass and metal are cleaned, treated, and sized to specified proportions. Plane-interfaced seals are formed, annealed, and measured for residual optical retardation. The stress parallel to the interface in each seal is calculated from the optical retardation, and the average stress and thermal expansion mismatch are computed for the sample.

## 4. Significance and Use

4.1 The term “reference” as employed in this practice implies that either the glass or the metal of the reference glass-metal seal will be a “standard reference material” such as those supplied for other physical tests by the National Institute of Standards and Technology, or a secondary reference material whose sealing characteristics have been determined by seals to a standard reference material (see NBS Special Publication 260). Until standard reference materials for seals are established by the NIST, secondary reference materials may be agreed upon between manufacturer and purchaser.

## 5. Apparatus

5.1 *Polarimeter*, as specified in Test Method **F218** for measuring optical retardation and analyzing stress in glass.

5.2 *Cut-Off Saw*, with diamond-impregnated wheel and No. 180 grit abrasive blade under flowing coolant for cutting and fine-grinding glass rod.

5.3 *Glass Polisher*, buffing wheel with cerium oxide polishing powder or laboratory-type equipment with fine-grinding and polishing laps.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

5.4 *Heat-Treating and Oxidizing Furnaces*, with suitable controls and with provisions for appropriate atmospheres (Annex A1) for preconditioning metal, if required.

5.5 *Sealing Furnace*, radiant tube, muffle or r-f induction with suitable controls and provision for use with inert atmosphere.

5.6 *Annealing Furnace*, with capability of controlled cooling.

5.7 *Ultrasonic Cleaner*, optional.

5.8 *Fixture for Furnace Sealing*, design as suggested in Annex A2.

5.9 *Micrometer Caliper*, with index permitting direct reading of 0.02 cm.

5.10 *Immersion Mercury Thermometer*.

## 6. Materials

6.1 *Metal*—Five representative specimen pairs of the metal from either rod or plate stock with dimensions satisfying the requirements of 7.1. The surfaces to be sealed should be relatively free of scratches, machine marks, pits, or inclusions that would induce localized stresses. The sealing surfaces should terminate in sharp edges at the peripheral corners to act as a glass stop. Edges that are rounded, such as appear on tumbled parts, will have the tendency to permit glass overflow. The opposite faces of each plate should be parallel within  $0.5^\circ$ .

6.2 *Glass*—Five representative specimens of rod or plate glass, cut with either diamond-impregnated or other abrasive cutting wheels under flowing water. Dimensions (volume) must satisfy the requirements of 7.2, and the faces should be flat and parallel within  $0.5^\circ$  for uniform flow during sealing.

## 7. Test Specimens

7.1 The metal specimens may take the form of circular, square, or rectangular plates. In each case the dimension  $d$ , Fig. 1, designates the path along which the optical retardation in the finished seal is measured. Two identical metal plates of any of the indicated shapes are required for a seal. The thickness,  $t_m$ , of each plate should be at least 0.7 mm and  $d/t_m$  should be at least 6.

7.2 Glass with suitable optical transmission of any shape may be used, provided it flows essentially bubble-free to fill the entire volume between the metal plates as in Fig. 2. Experience indicates, however, that best results are obtained with flat glass conforming closely to the outline of the metal plates. The thickness of the glass before sealing shall be such that it equals  $t_m$  after sealing within 15%. Thus, the volume of glass

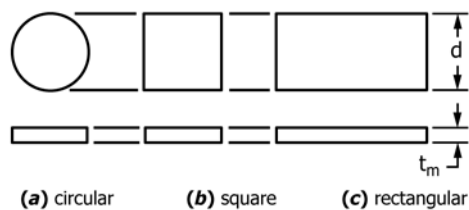


FIG. 1 Permissible Metal Shapes.

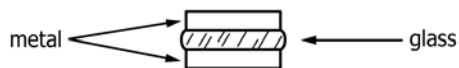


FIG. 2 General Seal Configuration.

necessary to fill the void between the metal plates to a thickness equal to that of a single plate becomes the determining dimensional criterion for the glass.

7.3 When used as an acceptance test by producer and user, the number of test seals representing one determination shall be established by mutual agreement. However two seals are a minimum requirement for one determination.

## 8. Preparation of Specimens

8.1 *Metal*—Chemically clean the specimens to remove surface contaminants, especially lubricants and fingerprints from fabrication and handling. Usually it is advisable to preoxidize parts as described in Annex A1. Preoxidation promotes a better glass-to-metal bond and relieves cold working stresses.

8.2 *Glass*—Using optical glass techniques grind and polish the sealing surfaces of the glass specimens with either wet abrasive wheels or water slurries of abrasive on a lap. The polished surfaces should satisfy the dimensional criteria of 6.2 and 7.2, and be without chips, nicks, or scratches. Remove any surface contaminants which could produce bubbly seals. An ultrasonic wash may be used. See Annex A1.

## 9. Procedure for Making the Sandwich Seal

9.1 Record dimensions of metal plates and glass parts.

9.2 Make the seal in a furnace or by induction heating of the metal utilizing suitable specimen holders or supports under controlled conditions of temperature and time. See Annex A2.

## 10. Annealing

10.1 Once a symmetrical, bubble-free seal has been made, proper annealing of the seal becomes the most critical part of the procedure. It is by this operation that all stresses are relieved except those due to the difference in thermal contraction of the two materials from annealing temperature levels. This process involves heating the seal to a temperature somewhat higher than the annealing point of the glass and maintaining this temperature for a time sufficient to relieve the existing strain. The test specimen is then cooled slowly at a constant rate. As an alternative, annealing can proceed directly on cooling during the making of a seal.

10.2 Seal stress and associated expansion mismatch can be varied markedly by annealing schedule modification. For this reason, when the test is used as an acceptance specification, it is strongly recommended that producer and user mutually define the annealing schedule and establish rigid controls for its maintenance.

## 11. Procedure for Measuring Optical Retardation

11.1 For each specimen measure the retardation in the annealed seal due to the stress parallel to the interface according to Test Method F218.