INTERNATIONAL

Designation: C158 – 23

Standard Test Methods for Strength of Glass by Flexure (Determination of Modulus of Rupture)[1]

This standard is issued under the fixed designation C158; 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 U.S. Department of Defense.

1. Scope

1.1 These test methods cover the determination of the flexural strength (the modulus of rupture in bending) of glass and glass-ceramics.

1.2 These test methods are applicable to annealed and prestressed glasses and glass-ceramics available in varied forms. Alternative test methods are described; the test method used shall be determined by the purpose of the test and geometric characteristics of specimens representative of the material.

1.2.1 Test Method A is a test for flexural strength of flat glass.

1.2.2 Test Method B is a comparative test for flexural strength of glass and glass-ceramics.

1.3 The test methods appear in the following order:

	Sections
Test Method A	7 to 10
Test Method B	11 to 16

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:*[2]

C148 Test Methods for Polariscopic Examination of Glass Containers

E4 Practices for Force Calibration and Verification of Testing Machines

SI10-02 IEEE/ASTM SI 10 American National Standard for Use of the International System of Units (SI): The Modern Metric System

3. Terminology

3.1 *Definitions:*

3.1.1 *glass-ceramics*—solid materials, predominantly crystalline in nature, formed by the controlled crystallization of glasses.

3.1.2 *flexural strength*—the value of maximum tensile stress in the extreme fiber of a beam loaded to failure in bending.

3.1.3 *prestressed*—material in which a significant and controlled degree of compressive stress has been deliberately produced in the surfaces.

3.1.4 *standard laboratory atmosphere*—an atmosphere having a temperature of 23 °C ± 2 °C and a relative humidity of 40 % ± 10 %.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *abraded*—describes a test specimen that has at least a portion of the area of maximum surface tensile stress during testing subjected to an operationally defined procedure for mechanical abrasion. The severity and uniformity of abrasion should be sufficient to ensure origin of failure substantially in the region of maximum stress.

3.2.2 *annealed glass*—describes a specimen that shall not have a temper or degree of residual stress resulting from prior

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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.

thermal treatment in excess of the following limits when measured polarimetrically (see Annex A1):

3.2.2.1 Specimens of rectangular section shall not have a tensile stress at the midplane of more than 1.4 MPa (200 psi) nor more than 2.8 MPa (400 psi) compression at the surface.

3.2.2.2 Specimens in rod form may be examined by viewing through a diameter at least four diameters from an end. The *apparent* central axial tension shall not exceed 0.90 MPa (130 psi). Surface compression, if measured on sections cut from the rods, shall not exceed 2.8 MPa (400 psi) when viewed axially.

4. Significance and Use

4.1 For the purpose of this test, glasses and glass-ceramics are considered brittle (perfectly elastic) and to have the property that fracture normally occurs at the surface of the test specimen from the principal tensile stress. The flexural strength is considered a valid measure of the tensile strength subject to the considerations that follow.

4.2 The flexural strength for a group of test specimens is influenced by variables associated with the test procedure. Such factors are specified in the test procedure or required to be stated in the report. These include but are not limited to the rate of stressing, the test environment, and the area of the specimen subjected to stress.

4.2.1 In addition, the variables having the greatest effect on the flexural strength value for a group of test specimens are the condition of the surfaces and glass quality near the surfaces in regard to the number and severity of stress-concentrating discontinuities or flaws, and the degree of prestress existing in the specimens. Each of these can represent an inherent part of the strength characteristic being determined or can be a random interfering factor in the measurement.

4.2.2 Test Method A is designed to include the condition of the surface of the specimen as a factor in the measured strength. Therefore, subjecting a fixed and significant area of the surface to the maximum tensile stress is desirable. Since the number and severity of surface flaws in glass are primarily determined by manufacturing and handling processes, this test method is limited to products from which specimens of suitable size can be obtained with minimal dependence of measured strength upon specimen preparation techniques. This test method is therefore designated as a test for flexural strength of flat glass.

4.2.3 Test Method B describes a general procedure for test, applicable to specimens of rectangular or elliptical cross section. This test method is based on the assumption that a comparative measurement of strength on groups of specimens is of significance for many purposes such as: determining the effect of environment or stress duration, the effectiveness of varied prestressing techniques, and strengths characteristic of glass-ceramics of differing composition or heat treatment. In this test method, the surfaces of the specimens are not assumed to be characteristic of a product or material, but are considered to be determined by the procedures used to prepare the specimens. Though the stated procedure permits a wide variation in both specimen size and test geometry, use of identical test conditions and equivalent procedures for specimen preparation is necessary to obtain comparable strength values. The use of a controlled abrasion of the specimen as a final normalizing procedure is recommended for such comparative tests.

4.2.4 A comparative abraded strength, determined as suggested in Test Method B, is not to be considered as a minimum value characteristic of the material tested nor as directly related to a maximum attainable strength value through test of specimens with identical flaws. The operationally defined abrasion procedure undoubtedly produces flaws of differing severity when applied to varied materials, and the measured comparative strengths describe the relative ability to withstand externally induced stress as affected by the specific abrasion procedure.

4.2.5 Test environment (ambient air, inert gas, vacuum, etc.) including moisture content (for example, relative humidity) may have an influence on the flexural strength. Testing to evaluate the maximum strength potential of a glass can be conducted in inert environments and/or at sufficiently rapid testing rates to minimize any environmental effects. Conversely, testing can be conducted in environments, test modes, and test rates representative of service conditions to evaluate flexural performance under use conditions.

5. Interferences

5.1 Additional experimental errors which may arise during testing should be minimized (**1-3**).[3]

5.2 Calculation of the flexural strength using equations derived based on linear bending theory will lead to an overestimate of the flexural strength when large beam deflections are present.

5.3 Wedging stress effects along the tensile surface in the vicinity of the contact load line may lead to failure when the ratio of thickness to moment or distance between adjacent support and loading edges is large.

5.4 Eccentric loading, improper choice of span dimensions, non-parallel rollers, friction, contact stresses, wedging stresses caused by non-rotating rollers, beam overhang, and contact point tangency shifting can introduce localized failure not representative of the flexural strength under ideal loading conditions.

5.5 Fabrication of test specimens can introduce dimensional variations that may have pronounced effects on the measured flexural mechanical properties and behavior (for example, flexural strength, failure location, etc.).

5.5.1 Initial beam curvature and nonflat and nonparallel thickness along the length of the specimen may lead to errors (for example, beam twisting).

5.5.2 Rounded or chamfered corners should be used to reduce edge failures in specimens of rectangular cross section. Corner radii and chamfers should be kept small such that the change in moment of inertia is small.

[3] The boldface numbers in parentheses refer to a list of references located at the end of this standard.