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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Determining Flexural Properties of Plastics¹

This standard is issued under the fixed designation D 5943; 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 This test method specifies a procedure for determining the flexural properties of plastics under defined conditions. A standard test specimen is defined, but parameters are included for alternative specimen sizes for use where appropriate. A range of testing speeds is included.

1.2 The procedure is used for investigating the flexural behavior of the test specimens and for determining the flexural strength, flexural modulus, and other aspects of the flexural stress/strain relationship under the conditions defined. It applies to a freely supported beam, loaded at midspan (three-point loading test).

1.3 The procedure is suitable for use with the following range of materials:

1.3.1 Thermoplastics molding and extrusion materials, including filled and reinforced compounds in addition to unfilled types; rigid thermoplastics sheets;

1.3.2 Thermosetting molding materials, including filled and reinforced compounds; thermosetting sheets, including laminates; and

1.3.3 Thermotropic liquid-crystal polymers.

1.4 The procedure is not normally suitable for use with rigid cellular materials and sandwich structures containing cellular material.

NOTE 1—For certain types of textile-fiber-reinforced plastics, a four-point bending test is preferred. This is currently under consideration in ISO.

1.5 The procedure is performed using specimens that may be either molded to the chosen dimensions, machined from the central portion of a standard multipurpose test specimen (see ISO 3167 (Specification D 5936)), or machined from finished and semi-finished products such as moldings, laminates, and extruded or cast sheet.

1.6 The procedure specifies preferred dimensions for the test specimen. Tests that are conducted on specimens of different dimensions, or on specimens that are prepared under different conditions, may produce results that are not comparable. Other factors, such as the speed of testing and conditioning of the specimens, can also influence the results. Consequently, when comparative data are required, these

factors must be controlled and recorded carefully.

1.7 Flexural properties can be used for engineering design purposes only for materials with linear stress/strain behavior. For non-linear material behavior the flexural properties are only nominal. The bending test should be used preferentially with brittle materials, for which tensile tests are difficult.

1.8 This test method is identical to ISO 178. This test method is comparable to Test Methods D 790, but neither test method should be substituted for the other. The two test methods may differ with respect to test specimen dimensions, test specimen conditioning, test equipment, testing conditions, etc. The two test methods may not give the same results.

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

1.10 *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:

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials²

D 5936 Specification for Multipurpose Test Specimens Used for Testing Plastics³

D 5939 Practice for Preparing Multipurpose Test Specimens and Bars of Thermoplastics by Injection Moulding³

D 5940 Practice for Preparing Small Plate Test Specimens of Thermoplastics by Injection Moulding³

2.2 ISO Standards:⁴

ISO 178 Determination of Flexural Properties

ISO 291:1977 Plastics—Standard Atmospheres for Conditioning and Testing

ISO 293:1986 Plastics—Compression Moulding Test Specimens of Thermoplastic Materials

ISO 294 Plastics—Injection Moulding of Test Specimens of Thermoplastic Materials

ISO 295:1991 Plastics—Compression Moulding of Test

¹ Bias This test method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.61 on USA Technical Advisory Group for ISO/TC 61 on Plastics.

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² Annual Book of ASTM Standards, Vol 08.01.

³ Annual Book of ASTM Standards, Vol 08.03.

⁴ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

Specimens of Thermosetting Materials
 ISO 1209-1:1990 Cellular Plastics, Rigid—Flexural Tests—
 Part 1: Bending Test
 ISO 1209-2:1990 Cellular Plastics, Rigid—Flexural Tests—
 Part 2: Determination of Flexural Properties
 ISO 1268:1974 Plastics—Preparation of Glass Fibre Rein-
 forced, Resin Bonded, Low-Pressure Laminated Plates or
 Panels for Test Purposes
 ISO 2557-1:1989 Plastics—Amorphous Thermoplastics—
 Preparation of Test Specimens with a Specified Maximum
 Reversion—Part 1: Bars
 ISO 2557-2:1986 Plastics—Amorphous Thermoplastics—
 Preparation of Test Specimens with a Specified
 Reversion—Part 2: Plates
 ISO 2602:1980 Statistical Interpretation of Test Results—
 Estimation of the Mean—Confidence Interval
 ISO 2818 Plastics—Preparation of Test Specimens by Ma-
 chining
 ISO 3167 Plastics—Multipurpose Test Specimens
 ISO 5893:1985 Rubber and Plastics Test Equipment—
 Tensile, Flexural and Compression Types (Constant Rate of
 Traverse)—Description

3. Terminology

3.1 *Definitions*—For the purposes of this test method, the following definitions apply:

3.1.1 *conventional deflection*, s_C —deflection equal to 1.5 times the thickness, h , of the test specimen.

3.1.1.1 *Discussion*—It is expressed in millimetres. Using the span $L = 16h$, the conventional deflection corresponds to a flexural strain of 3.5 % (see section 3.8).

3.1.2 *deflection*, s —the distance over which the top or bottom surface of the test specimen at midspan has deviated during flexure from its original position.

3.1.2.1 *Discussion*—It is expressed in millimetres.

3.1.3 *flexural strain*, ϵ_f —a nominal fractional change in the length of an element of the outer surface of the test specimen at midspan.

3.1.3.1 *Discussion*—It is expressed as a dimensionless ratio or a percentage. It is calculated according to the relationship given in 10.2, (Eq 4).

3.1.4 *flexural strain at break*, ϵ_{fB} —flexural strain at break of the test specimen (see Fig. 1, curves a and b).

3.1.4.1 *Discussion*—It is expressed as a dimensionless ratio or a percentage (%).

3.1.5 *flexural strain at flexural strength*, ϵ_{fM} —flexural strain at maximum flexural stress (see Fig. 1, curves a and b).

3.1.5.1 *Discussion*—It is expressed as a dimensionless ratio or a percentage.

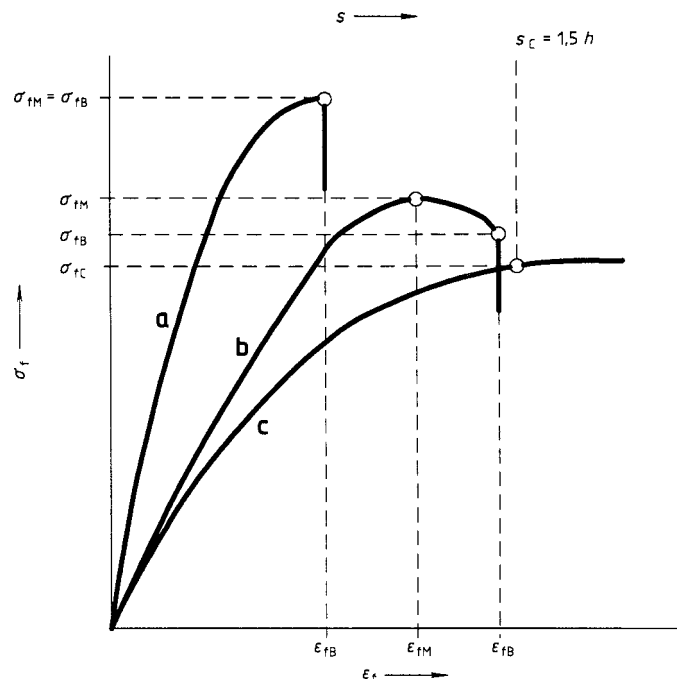
3.1.6 *flexural strength*, σ_{fM} —the maximum flexural stress sustained by the test specimen during a bending test (see Fig. 1, curves a and b).

3.1.6.1 *Discussion*—It is expressed in megapascals.

3.1.7 *flexural stress*, σ_f —nominal stress of the outer surface of the test specimen at midspan.

3.1.7.1 *Discussion*—It is calculated according to the relationship given in 10.1, (Eq 3), and is expressed in megapascals.

3.1.8 *flexural stress at break*, σ_{fB} —flexural stress at break of the test specimen (see Fig. 1, curves a and b).



NOTE 1—Curve a: specimen that breaks before yielding; Curve b: specimen that shows a maximum and then breaks before the conventional deflection, s_C ; Curve c: specimen that neither has a yield point nor breaks before the conventional deflection, s_C .

FIG. 1 Typical Curves of Flexural Stress, σ_f , Versus Flexural Strain, ϵ_f , and Deflection, s

3.1.8.1 *Discussion*—It is expressed in megapascals.

3.1.9 *flexural stress at conventional deflection*, σ_{fC} —flexural stress at the conventional deflection, s_C , according to 3.1.1.1 (see Fig. 1, curve c).

3.1.9.1 *Discussion*—It is expressed in megapascals.

3.1.10 *modulus of elasticity in flexure, flexural modulus*, E_f —the ratio of the stress difference, $\sigma_{f2} - \sigma_{f1}$, to the corresponding strain difference values ($\epsilon_{f2} = 0.0025$) - ($\epsilon_{f1} = 0.0005$) (see 10.2, (Eq 5)).

3.1.10.1 *Discussion*—It is expressed in megapascals.

The flexural modulus is only an approximate value of Young's modulus of elasticity.

With computer-aided equipment, determination of the modulus, E_f , using two distinct stress/strain points can be replaced by a linear regression procedure applied on the part of the curve between these two points.

3.1.11 *speed of testing*, v —the rate of relative movement between the supports and the striking edge, expressed in millimetres per minute.

4. Principle

4.1 The test specimen, supported as a beam, is deflected at constant rate at the midspan until the specimen fractures or until the deformation reaches some predetermined value. The force applied to the specimen is measured during this procedure.

5.

6. Apparatus

6.1 *Testing Machine*: