



Designation: D6272 – 17^ε¹

Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials by Four-Point Bending¹

This standard is issued under the fixed designation D6272; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

^ε¹ NOTE—Editorially corrected 7.2.2 in July 2020.

1. Scope*

1.1 This test method covers the determination of flexural properties of unreinforced and reinforced plastics, including high-modulus composites and electrical insulating materials in the form of rectangular bars molded directly or cut from sheets, plates, or molded shapes. These test methods are generally applicable to rigid and semirigid materials. However, flexural strength cannot be determined for those materials that do not break or that do not fail in the outer fibers. This test method utilizes a four point loading system applied to a simply supported beam.

1.2 This test method describes two procedures (Procedure A and Procedure B), the selection of which depends on the behavior of the sample to be tested as explained below:

1.2.1 *Procedure A*, designed principally for materials that break at comparatively small deflections. It shall be used for measurement of flexural properties, particularly flexural modulus, unless the material specification states otherwise.

1.2.2 *Procedure B*, designed particularly for those materials that undergo large deflections during testing. It is suitable for measurement of flexural strength.

1.3 Comparative tests are permitted to be run according to either procedure, provided that the procedure is found satisfactory for the material being tested.

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

1.5 *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.*

NOTE 1—This test method is similar to ISO 14125, Method B.

¹ This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.10 on Mechanical Properties.

Current edition approved March 1, 2017. Published March 2017. Originally approved in 1998. Last previous edition approved in 2010 as D6272 - 10. DOI: 10.1520/D6272-17E01.

However, ISO 14125, Method B specifies only a load span of $\frac{1}{3}$ the support span whereas D6272 also permits a load span of $\frac{1}{2}$ the support span. For this reason and other differences in technical content, exercise extreme care if attempting to compare results between the two test methods.

1.6 *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

- D618 Practice for Conditioning Plastics for Testing
- D638 Test Method for Tensile Properties of Plastics
- D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
- D883 Terminology Relating to Plastics
- D4000 Classification System for Specifying Plastic Materials
- D5947 Test Methods for Physical Dimensions of Solid Plastics Specimens
- E4 Practices for Force Verification of Testing Machines
- E83 Practice for Verification and Classification of Extensometer Systems
- E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

2.2 ISO Standard:³

- ISO 14125 (Method B) Fibre-Reinforced Plastic Composites—Determination of Flexural Properties

3. Terminology

3.1 Definitions:

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.

³ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

*A Summary of Changes section appears at the end of this standard

3.1.1 Definitions of terms applying to these test methods appear in Terminology D883 and Annex A2 of Test Method D638.

4. Summary of Test Method

4.1 A bar of rectangular cross section rests on two supports and is loaded at two points (by means of two loading noses), each an equal distance from the adjacent support point. The distance between the loading noses (the load span) is either one third or one half of the support span (see Fig. 1). A support span-to-depth ratio of 16:1 shall be used unless there is reason to suspect that a larger span-to-depth ratio is required, such as with certain laminated materials (see Section 7 for guidance).

4.2 The specimen is deflected until rupture occurs in the outer fibers or until the maximum fiber strain (see 12.8) of 5 % is reached, whichever occurs first.

5. Significance and Use

5.1 Flexural properties determined by this test method are especially useful for quality control and specification purposes.

5.2 This test method is recommended for those materials that do not fail within the strain limits imposed by Test Method D790. The major difference between four point and three point bending modes is the location of the maximum bending moment and maximum axial fiber stress. In four point bending the maximum axial fiber stress is uniformly distributed between the loading noses. In three point bending the maximum axial fiber stress is located immediately under the loading nose.

5.3 Flexural properties vary with specimen depth, temperature, atmospheric conditions, and the difference in rate of straining specified in Procedures A and B.

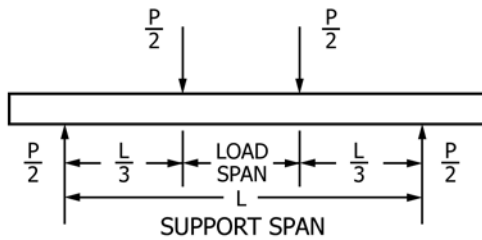
5.4 Before proceeding with this test method, reference the specification of the material being tested. Any test specimen preparation, conditioning, dimensions, or testing parameters covered in the material specification, or both, shall take precedence over those mentioned in this test method. If there are no material specifications, then these default conditions apply. Table 1 in Classification D4000 lists the ASTM materials standards that currently exist.

6. Apparatus

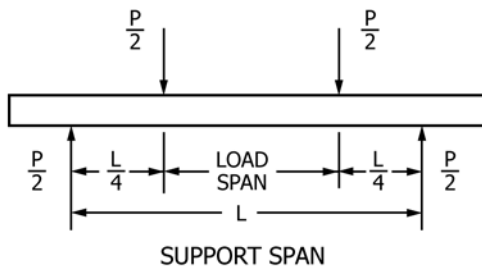
6.1 *Testing Machine*—A properly calibrated testing machine capable of operating at constant rates of crosshead motion over the range indicated, and in which the error in the load measuring system shall not exceed ± 1 % of maximum load expected to be measured. It shall be equipped with a deflection measuring device. The stiffness of the testing machine shall be such that the total elastic deformation of the system does not exceed 1 % of the total deflection of the test specimen during testing, or appropriate corrections shall be made. The load indicating mechanism shall be essentially free from inertial lag at the crosshead rate used. The accuracy of the testing machine shall be verified in accordance with Practices E4.

6.2 *Loading Noses and Supports*—The loading noses and supports shall have cylindrical surfaces. In order to avoid excessive indentation, or failure due to stress concentration directly under the loading noses, the radii of the loading noses and supports shall be 5.0 ± 0.1 mm (0.197 ± 0.004 in.) unless otherwise specified or agreed upon between the interested parties. When other loading noses and supports are used they must comply with the following requirements: they shall be at least 3.2 mm (1/8 in.) for all specimens, and for specimens 3.2 mm (1/8 in.) or greater in depth, the radius of the supports shall not exceed 1.6 times the specimen depth. They shall be this large if significant indentation or compressive failure occurs. The arc of the loading noses in contact with the specimen shall be sufficiently large to prevent contact of the specimen with the sides of the noses (see Fig. 2).

NOTE 2—Test data have shown that the loading noses and support dimensions can influence the flexural modulus and flexural strength values. The loading noses dimension has the greater influence. Dimensions of loading noses and supports are requirements for the material specifications.

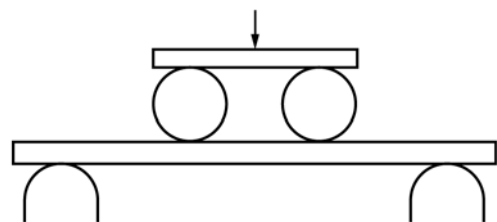


(one third of support span)



(one half of support span)

FIG. 1 Loading Diagram



NOTE 1—Default radii 5.0 mm; see 6.2.

FIG. 2 Loading Noses and Supports (Example of One Third Support Span)

6.3 Deflection Measuring Device—A properly calibrated device to measure the deflection of the beam at the common center of the loading span, that meets or exceeds Practice E83, Class B-2 for modulus, and Class C for other strain measurements, shall be used. The device shall automatically and continuously record the deflection during the test.

6.4 Micrometers—Suitable micrometers for measuring the width and thickness of the test specimen to an incremental discrimination of at least 0.025 mm (0.001 in.) shall be used. All width and thickness measurements of rigid and semi-rigid plastics are measurable with a hand micrometer with ratchet as described in Test Method D5947. A similar instrument for measuring the thickness of non-rigid test specimens shall have a reduced contact measuring pressure of 25 ± 2.5 kPa (3.6 ± 0.36 psi). Parallelism and flatness of foot and anvil shall conform to the portion of the calibration section of Test Method D5947.

7. Test Specimen

7.1 Methods to produce the specimens include cutting them from sheets, plates, or molded shapes, or molding them to the desired finished dimensions. The actual dimensions used in Section 12 (Calculation) shall be measured in accordance with Test Method D5947.

7.1.1 Any necessary polishing of specimens shall be done only in the lengthwise direction of the specimen.

7.2 Sheet Materials (Except Laminated Thermosetting Materials and Certain Materials Used for Electrical Insulation, Including Vulcanized Fiber and Glass Bonded Mica):

7.2.1 Materials 1.6 mm (1/16 in.) or Greater in Thickness—For flatwise tests, the depth of the specimen shall be the thickness of the material. For edgewise tests, the width of the specimen shall be the thickness of the sheet, and the depth shall not exceed the width (see Notes 3 and 4). For all tests, the support span shall be 16 (tolerance ± 1) times the depth of the beam. Specimen width shall not exceed one fourth of the support span for specimens greater than 3.2 mm (1/8 in.) in depth. Specimens 3.2 mm or less in depth shall be 12.7 mm (1/2 in.) in width. The specimen shall be long enough to allow for overhanging on each end of at least 10 % of the support span, but in no case less than 6.4 mm (1/4 in.) on each end. Overhang shall be sufficient to prevent the specimen from slipping through the supports.

7.2.1.1 Whenever possible, the original surface of the sheet shall be unaltered. However, where testing machine limitations make it impossible to follow the above criterion on the unaltered sheet, one or both surfaces shall be machined to provide the desired dimensions, and the location of the specimens with reference to the total depth shall be noted. It is feasible that the value obtained on specimens with machined surfaces will differ from those obtained on specimens with original surfaces. Consequently, any specifications for flexural properties on the thicker sheets must state whether the original surfaces are to be retained or not. When only one surface was machined, it must be stated whether the machined surface was on the tension or compression side of the beam.

NOTE 3—Edgewise tests are not applicable for sheets that are so thin that specimens meeting these requirements cannot be cut. If specimen

depth exceeds the width, buckling may occur.

7.2.2 Materials Less than 1.6 mm (1/16 in.) in Thickness—The specimen shall be 50.8 mm (2 in.) long by 12.7 mm (1/2 in.) wide, tested flatwise on a 25.4-mm (1-in.) support span.

NOTE 4—Use of the formulas for simple beams cited in these test methods for calculating results presumes that beam width is small in comparison with the support span. Therefore, the formulas do not apply rigorously to these dimensions.

NOTE 5—Where machine sensitivity is such that specimens of these dimensions cannot be measured, wider specimens or shorter support spans, or both, may be used, provided the support span-to-depth ratio is at least 14 to 1. Include all dimensions in the report.

7.3 Laminated Thermosetting Materials and Sheet and Plate Materials Used for Electrical Insulation, Including Vulcanized Fiber and Glass-Bonded Mica—For paper-base and fabric-base grades over 25.4 mm (1 in.) in nominal thickness, the specimens shall be machined on both surfaces to a depth of 25.4 mm. For glass-base and nylon-base grades, specimens over 12.7 mm (1/2 in.) in nominal depth shall be machined on both surfaces to a depth of 12.7 mm. The support span-to-depth ratio shall be chosen such that failures occur in the outer fibers of the specimens, due only to the bending moment (see Note 6). Three recommended support span-to-depth ratios are 16, 32, and 40 to 1. When laminated materials exhibit low compressive strength perpendicular to the laminations, they shall be loaded with a large radius loading noses (up to 1.5 times the specimen depth) to prevent premature damage to the outer fibers.

7.4 Molding Materials (Thermoplastics and Thermosets)—The recommended specimen for molding materials is 127 by 12.7 by 3.2 mm (5 by 1/2 by 1/8 in.) tested flatwise on a support span, resulting in a support span-to-depth ratio of 16 (tolerance + 4 or – 2). Avoid thicker specimens if they exhibit significant shrink marks or bubbles when molded.

7.5 High-Strength Reinforced Composites, Including Highly Orthotropic Laminates—The support span-to-depth ratio shall be chosen such that failures occur in the outer fibers of the specimens, due only to the bending moment (Note 6). Three recommended support span-to-depth ratios are 16:1, 32:1, and 40:1. However, for some highly anisotropic composites, shear deformation can significantly influence modulus measurements, even at span-to-depth ratios as high as 40:1. Hence, for these materials, an increase in span-to-depth ratio to 60:1 is recommended to eliminate shear effects when modulus data are required. The flexural modulus of highly anisotropic laminates is a strong function of ply-stacking sequence and will not necessarily correlate with tensile modulus, that is not stacking-sequence dependent.

NOTE 6—As a general rule, support span-to-depth ratios of 16 to 1 are satisfactory when the ratio of the tensile strength to shear strength is less than 8 to 1, but the support span-to-depth ratio must be increased for composite laminates having relatively low shear strength in the plane of the laminate and relatively high tensile strength parallel to the support span.

8. Number of Test Specimens

8.1 At least five specimens shall be tested for each sample in the case of isotropic materials or molded specimens.