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Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials[1]

This standard is issued under the fixed designation D790; 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 are used to determine the flexural properties of unreinforced and reinforced plastics, including high-modulushighmodulus 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 utilizing a three-point loading system to apply a load to simply supported beam (specimen). The method is generally applicable to both rigid and semirigid materials. However,semi-rigid materials, but flexural strength cannot be determined for those materials that do not break or that do not fail yield in the outer surface of the test specimen within the 5.0 % strain limit of these test methods. These test methods utilize a three-point loading system applied to a simply supported beam. A four-point loading system method can be found in Test Method 5.0 % strain limit. D6272.

1.1.1 *Procedure A,* designed principally for materials that break at comparatively small deflections.

1.1.2 *Procedure B,* designed particularly for those materials that undergo large deflections during testing.

1.1.3 Procedure A shall be used for measurement of flexural properties, particularly flexural modulus, unless the material specification states otherwise. Procedure B may be used for measurement of flexural strength only. Tangent modulus data obtained by Procedure A tends to exhibit lower standard deviations than comparable data obtained by means of Procedure B.

1.2 Comparative tests may be run in accordance with either procedure, provided that the procedure is found satisfactory for the material being tested. Test specimens of rectangular cross section are injection molded or, cut from molded or extruded sheets or plates, or cut from molded or extruded shapes. Specimens must be solid and uniformly rectangular. The specimen rests on two supports and is loaded by means of a loading nose midway between the supports.

1.3 Measure deflection in one of two ways; using crosshead position or a deflectometer. Please note that studies have shown that deflection data obtained with a deflectometer will differ from data obtained using crosshead position. The method of deflection measurement shall be reported.

NOTE 1—Requirements for quality control in production environments are usually met by measuring deflection using crosshead position. However, more accurate measurement may be obtained by using an deflection indicator such as a deflectometer.

NOTE 2—Materials that do not rupture by the maximum strain allowed under this test method may be more suited to a 4-point bend test. The basic difference between the two test methods is in the location of the maximum bending moment and maximum axial fiber stresses. The maximum axial fiber stresses occur on a line under the loading nose in 3-point bending and over the area between the loading noses in 4-point bending. A four-point loading system method can be found in Test Method D6272.

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 *The text of this standard references notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.*

1.6 *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.*

NOTE 3—These test methods are not technically equivalent to ISO 178.This standard and ISO 178 address the same subject matter, but differ in technical content.

[1] These test methods are under the jurisdiction of ASTM Committee D20 on Plastics and are the direct responsibility of Subcommittee D20.10 on Mechanical Properties.

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D618 Practice for Conditioning Plastics for Testing
D638 Test Method for Tensile Properties of Plastics
D883 Terminology Relating to Plastics
D2309 Tests for Rubber Property—Compression Set Induced by Nuclear Radiation (Withdrawn 1981)[3]
D4000 Classification System for Specifying Plastic Materials
D4101 Specification for Polypropylene Injection and Extrusion Materials
D5947 Test Methods for Physical Dimensions of Solid Plastics Specimens
D6272 Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials by Four-Point Bending
E4 Practices for Force Verification of Testing Machines
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

2.2 *ISO Standard:*[4]

ISO 178 Plastics—Determination of Flexural Properties

3. Terminology

3.1 *Definitions*—Definitions of terms applying to these test methods appear in Terminology D883 and Annex ~~A1~~A2 of Test Method D638.

4. Summary of Test Method

4.1 A ~~bar~~ test specimen of rectangular cross section rests on two supports in a flat-wise position and is loaded by means of a loading nose located midway between the supports. ~~A support span-to-depth ratio of 16:1 shall~~Unless testing certain laminated materials (see 7 ~~be used unless there is reason to suspect that a larger span-to-depth ratio may be required, as may be the case for certain laminated materials (see Section~~for guidance), a support span-to-depth (of specimen) ratio 16:1 shall be used. The specimen is deflected until rupture occurs in the outer surface of the test specimen ~~7 and~~or until ~~Note 7 for guidance).~~a maximum strain (see 5.1.6) of 5.0 % is reached, whichever occurs first.

~~4.2 The specimen is deflected until rupture occurs in the outer surface of the test specimen or until a maximum strain (see 12.7) of 5.0 % is reached, whichever occurs first.~~

4.2 *Procedure A* is designed principally for materials that break at comparatively small deflections and it shall be used for measurement of flexural properties, particularly flexural modulus, unless the material specification states otherwise. Procedure A employs a strain rate of 0.01 mm/mm/min (0.01 in./in./min) and is the preferred procedure for this test ~~method, while Procedure B employs a strain rate of 0.10 mm/mm/min (0.10 in./in./min).~~method.

4.3 *Procedure B* is designed principally for those materials that do not break or yield in the outer surface of the test specimen within the 5.0 % strain limit when Procedure A conditions are used. of these test methods and it shall be used for measurement of flexural strength only. Procedure B employs a strain rate of 0.10 mm/mm/min (0.10 in./in./min). Procedure B employs a strain rate of 0.10 mm/mm/min (0.10 in./in./min).

4.4 Type I tests utilize crosshead position for deflection measurement.

4.5 Type II tests utilize an instrument (deflectometer) for deflection measurement.

4.6 The procedure used and test type shall be reported

NOTE 4—Comparative tests may be run in accordance with either procedure, provided that the procedure is found satisfactory for the material being tested. Tangent modulus data obtained by Procedure A tends to exhibit lower standard deviations than comparable results obtained by means of Procedure B.

5. Significance and Use

~~5.1 Flexural properties as determined by these test methods are especially useful for quality control and specification purposes.~~

5.1 ~~Materials that do not fail by the maximum strain allowed under these test methods (3-point bend) may be more suited to a 4-point bend test. The basic difference between the two test methods is in the location of the maximum bending moment and maximum axial fiber stresses. The maximum axial fiber stresses occur on a line under the loading nose in 3-point bending and over the area between the loading noses in 4-point bending.~~ Flexural properties as determined by this test method are especially useful for quality control and specification purposes. They include:

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

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

5.1.1 *Flexural Stress* (σ_f)—When a homogeneous elastic material is tested in flexure as a simple beam supported at two points and loaded at the midpoint, the maximum stress in the outer surface of the test specimen occurs at the midpoint. Flexural stress is calculated for any point on the load-deflection curve using equation (Eq 3) in Section 12 (see Notes 5 and 6).

NOTE 5—Eq 3 applies strictly to materials for which stress is linearly proportional to strain up to the point of rupture and for which the strains are small. Since this is not always the case, a slight error will be introduced if Eq 3 is used to calculate stress for materials that are not true Hookean materials. The equation is valid for obtaining comparison data and for specification purposes, but only up to a maximum fiber strain of 5 % in the outer surface of the test specimen for specimens tested by the procedures described herein.

NOTE 6—When testing highly orthotropic laminates, the maximum stress may not always occur in the outer surface of the test specimen.[5] Laminated beam theory must be applied to determine the maximum tensile stress at failure. If Eq 3 is used to calculate stress, it will yield an apparent strength based on homogeneous beam theory. This apparent strength is highly dependent on the ply-stacking sequence of highly orthotropic laminates.

5.1.2 *Flexural Stress for Beams Tested at Large Support Spans* (σ_f)—If support span-to-depth ratios greater than 16 to 1 are used such that deflections in excess of 10 % of the support span occur, the stress in the outer surface of the specimen for a simple beam is reasonably approximated using equation (Eq 4) in 12.3 (see Note 7).

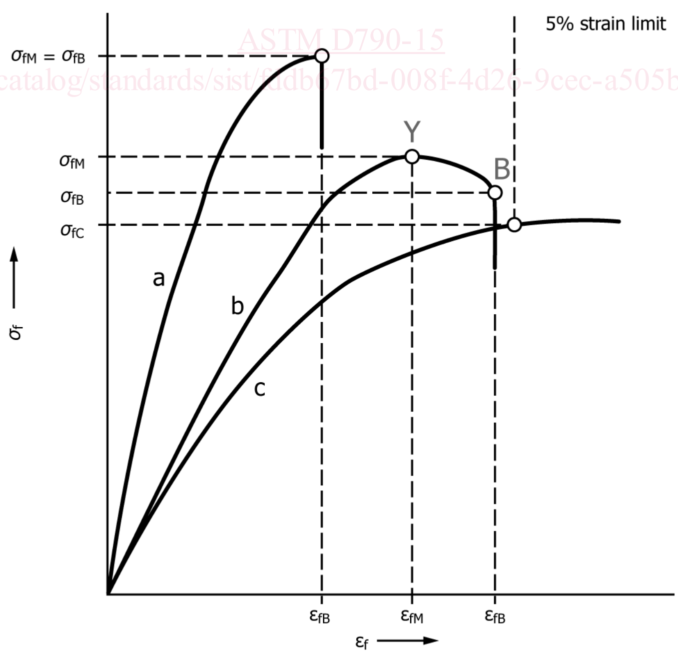
NOTE 7—When large support span-to-depth ratios are used, significant end forces are developed at the support noses which will affect the moment in a simple supported beam. Eq 4 includes additional terms that are an approximate correction factor for the influence of these end forces in large support span-to-depth ratio beams where relatively large deflections exist.

5.1.3 *Flexural Strength* (σ_{fM})—Maximum flexural stress sustained by the test specimen (see Note 6) during a bending test. It is calculated according to Eq 3 or Eq 4. Some materials that do not break at strains of up to 5 % give a load deflection curve that shows a point at which the load does not increase with an increase in strain, that is, a yield point (Fig. 1, Curve b), *Y*. The flexural strength is calculated for these materials by letting *P* (in Eq 3 or Eq 4) equal this point, *Y*.

5.1.4 *Flexural Offset Yield Strength*—Offset yield strength is the stress at which the stress-strain curve deviates by a given strain (offset) from the tangent to the initial straight line portion of the stress-strain curve. The value of the offset must be given whenever this property is calculated.

NOTE 8—Flexural Offset Yield Strength may differ from flexural strength defined in 5.1.3. Both methods of calculation are described in the annex to Test Method D638.

[5] For a discussion of these effects, see Zweben, C., Smith, W. S., and Wardle, M. W., "Test Methods for Fiber Tensile Strength, Composite Flexural Modulus and Properties of Fabric-Reinforced ~~Laminates," ~~"Laminates," *Composite Materials: Testing and Design (Fifth Conference), ASTM STP 674*, 1979, pp. 228–262.



NOTE 1—Curve a: Specimen that breaks before yielding.
Curve b: Specimen that yields and then breaks before the 5 % strain limit.
Curve ~~a: Specimen that breaks before yielding.~~c: Specimen that
~~Curve b: Specimen that yields and then breaks before the 5 % strain limit.~~
~~Curve c: Specimen that~~ neither yields nor breaks before the 5 % strain limit.

FIG. 1 ~~—Typical~~Typical Curves of Flexural Stress (~~ε~~(σ_f) Versus Flexural Strain (ε_f)

5.1.5 *Flexural Stress at Break* (σ_{fB})—Flexural stress at break of the test specimen during a bending test. It is calculated according to Eq 3 or Eq 4. Some materials give a load deflection curve that shows a break point, *B*, without a yield point (Fig. 1, Curve a) in which case $\sigma_{fB} = \sigma_{fM}$. Other materials give a yield deflection curve with both a yield and a break point, *B* (Fig. 1, Curve b). The flexural stress at break is calculated for these materials by letting *P* (in Eq 3 or Eq 4) equal this point, *B*.

5.1.6 *Stress at a Given Strain*—The stress in the outer surface of a test specimen at a given strain is calculated in accordance with Eq 3 or Eq 4 by letting *P* equal the load read from the load-deflection curve at the deflection corresponding to the desired strain (for highly orthotropic laminates, see Note 6).

5.1.7 *Flexural Strain,* ε_f—Nominal fractional change in the length of an element of the outer surface of the test specimen at midspan, where the maximum strain occurs. Flexural strain is calculated for any deflection using Eq 5 in 12.4.

5.1.8 *Modulus of Elasticity:*

5.1.8.1 *Tangent Modulus of Elasticity*—The tangent modulus of elasticity, often called the "modulus of elasticity," is the ratio, within the elastic limit, of stress to corresponding strain. It is calculated by drawing a tangent to the steepest initial straight-line portion of the load-deflection curve and using Eq 6 in 12.5.1 (for highly anisotropic composites, see Note 15).

NOTE 9—Shear deflections can seriously reduce the apparent modulus of highly anisotropic composites when they are tested at low span-to-depth ratios.[5] For this reason, a span-to-depth ratio of 60 to 1 is recommended for flexural modulus determinations on these composites. Flexural strength should be determined on a separate set of replicate specimens at a lower span-to-depth ratio that induces tensile failure in the outer fibers of the beam along its lower face. Since the flexural modulus of highly anisotropic laminates is a critical function of ply-stacking sequence, it will not necessarily correlate with tensile modulus, which is not stacking-sequence dependent.

5.1.8.2 *Secant Modulus*—The secant modulus is the ratio of stress to corresponding strain at any selected point on the stress-strain curve, that is, the slope of the straight line that joins the origin and a selected point on the actual stress-strain curve. It shall be expressed in megapascals (pounds per square inch). The selected point is chosen at a pre-specified stress or strain in accordance with the appropriate material specification or by customer contract. It is calculated in accordance with Eq 6 by letting m equal the slope of the secant to the load-deflection curve. The chosen stress or strain point used for the determination of the secant shall be reported.

5.1.8.3 *Chord Modulus* (E_f)—The chord modulus is calculated from two discrete points on the load deflection curve. The selected points are to be chosen at two pre-specified stress or strain points in accordance with the appropriate material specification or by customer contract. The chosen stress or strain points used for the determination of the chord modulus shall be reported. Calculate the chord modulus, E_f using Eq 7 in 12.5.2.

5.2 ~~Flexural properties may~~ Experience has shown that flexural properties vary with specimen depth, temperature, atmospheric conditions, and ~~the difference in rate of straining~~ strain rate as specified in Procedures A and ~~B (see also~~ B.~~Note 7).~~

5.3 Before proceeding with these test methods, ~~reference should be made~~ refer to the ASTM specification of the material being tested. Any test specimen preparation, conditioning, dimensions, or testing parameters, or combination thereof, covered in the ASTM material specification shall take precedence over those mentioned in these test methods. Table 1 in Classification System D4000 lists the ASTM material specifications that currently exist for plastics.

6. Apparatus

~~6.1 *Testing Machine*— A properly calibrated testing machine that can be operated 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 the 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~~

TABLE 1 Flexural Strength

Material	Mean, 10^3 psi	Values Expressed in Units of % of 10^3 psi			
		V_r[A]	V_R[B]	r[C]	R[D]
ABS	9.99	1.59	6.05	4.44	17.2
DAP thermoset	14.3	6.58	6.58	18.6	18.6
Cast acrylic	16.3	1.67	11.3	4.73	32.0
GR polyester	19.5	1.43	2.14	4.05	6.08
GR polycarbonate	21.0	5.16	6.05	14.6	17.1
SMC	26.0	4.76	7.19	13.5	20.4

[A] V_r = within-laboratory coefficient of variation for the indicated material. It is obtained by first pooling the within-laboratory standard deviations of the test results from all of the participating laboratories: $Sr = [[(s_1)^2 + (s_2)^2 \ldots + (s_n)^2]/n]^{1/2}$ then $V_r = (S_r$ divided by the overall average for the material$) \times 100$.
[B] V_r = between-laboratory reproducibility, expressed as the coefficient of variation: $S_R = \{S_r^2 + S_L^2\}^{1/2}$ where S_L is the standard deviation of laboratory means. Then: $V_R = (S_R$ divided by the overall average for the material$) \times 100$.
[C] r = within-laboratory critical interval between two test results = $2.8 \times V_r$.
[D] R = between-laboratory critical interval between two test results = $2.8 \times V_R$.

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.

6.1 *Loading Noses and Supports*—*Testing Machine*—The loading nose and supports shall have cylindrical surfaces. The default radii of the loading nose and supports shall be 5.0 ± 0.1 mm (0.197 ± 0.004 in.) unless otherwise specified in an ASTM material specification or as agreed upon between the interested parties. When the use of an ASTM material specification, or an agreed upon modification, results in a change to the radii of the loading nose and supports, the results shall be clearly identified as being obtained from a modified version of this test method and shall include the specification (when available) from which the modification was specified, for example, Test Method A testing machine capable of being operated at constant rates of crosshead motion over the range indicated and comprised of the following: D790 in accordance with Specification D4101.

6.1.1 *Load Frame*—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.

6.1.1.1 *Fixed Member*—A fixed or essentially stationary member holding the specimen supports;

6.1.1.2 *Movable Member*—A movable member carrying the loading nose.

6.1.2 *Other Radii for Loading Noses and Supports*—When other than default loading noses and supports are used, in order to avoid excessive indentation, or failure due to stress concentration directly under the loading nose, they must comply with the following requirements: they shall have a minimum radius of 3.2 mm (⅛ in.) for all specimens. For specimens 3.2 mm or greater in depth, the radius of the supports may be up to 1.6 times the specimen depth. They shall be this large if significant indentation or compressive failure occurs. The arc of the loading nose in contact with the specimen shall be sufficiently large to prevent contact of the specimen with the sides of the nose. The maximum radius of the loading nose shall be no more than four times the specimen depth.The loading nose and supports shall have cylindrical surfaces.

6.1.2.1 The radii of the loading nose and supports shall be 5.0 ± 0.1 mm (0.197 ± 0.004 in.) unless otherwise specified in an ASTM material specification or as agreed upon between interested parties.

6.1.2.2 *Other Radii for Loading Noses and Supports*—Alternative loading noses and supports are permitted to be used in order to avoid excessive indentation or failure due to stress concentration directly under the loading nose or if required by an ASTM material specification. If alternative loading nose and support radii are used, the dimensions of the loading nose and supports shall be clearly identified in the test report and reference shall be made to any applicable specifications.

(1) Alternative supports shall have a minimum radius of 3.2 mm (⅛ in.) When testing specimens 3.2 mm or greater in depth, the radius of the loading nose and supports are permitted to be up to 1.6 times the specimen depth.

(2) The arc of the loading nose in contact with the specimen shall be sufficiently large to prevent contact of the specimen with the sides of the nose. Alternative loading noses shall be sufficiently large to prevent contact of the specimen with the sides of the nose. The maximum radius of the loading nose shall be no more than four times the specimen depth.

6.1.3 *Drive Mechanism*—A drive mechanism for imparting to the movable member a uniform, controlled velocity with respect to the stationary member, with this velocity to be regulated as specified in Procedure A or B.

6.1.4 *Load Indicator*—A suitable load-indicating mechanism capable of showing the total load applied to specimen when in position on the flex fixture. This mechanism shall be essentially free of inertia lag at the specified rate of testing and shall indicate the load with an accuracy of ±1 % of the indicated value, or better. The accuracy of the testing machine shall be verified in accordance with Practices E4.

6.1.5 *Deflection Measuring Device*—The deflection measuring device used shall be selected from the following two choices:

6.1.5.1 *Type I—Crosshead Position Indicating System*—A suitable deflection indicating mechanism capable of showing the amount of change in crosshead movement. This mechanism shall be essentially free of inertial lag at the specified rate of testing and shall indicate the crosshead movement. The crosshead position indicating system shall be verified in accordance with Practice D2309 and minimally meets the requirements of a Class D system.

6.1.5.2 *Type II—Deflection Indicator (Deflectometer)*—A suitable instrument for more accurately determining the deflection of the specimen distance between two designated points. This instrument shall be essentially free of inertia at the specified speed of testing. The deflection indicator system shall be verified in accordance with Practice D2309 and minimally meets the requirements of a Class B system.

NOTE 10—It is desirable, but not essential, that this instrument automatically record this distance, or any change in it, as a function of the load on the test specimen or of the elapsed time from the start of the test, or both. If only the latter is obtained, it has been found useful to also record load-time data.

6.2 *Micrometers*—Suitable micrometers Apparatus for measuring the width and thickness of the test specimen to an incremental discrimination of at least 0.025 mm (0.001 in.) should be used. All width and thickness measurements of rigid and semirigid plastics may be measured with a hand micrometer with ratchet. A suitable instrument for measuring the thickness of nonrigid test specimens shall have: a contact measuring pressure of 25 ± 2.5 kPa (3.6 ± 0.36 psi), a movable circular contact foot 6.35 ± 0.025 mm (0.250 ± 0.001 in.) in diameter and a lower fixed anvil large enough to extend beyond the contact foot in all directions and being parallel to the contact foot within 0.005 mm (0.002 in.) over the entire foot area. Flatness of foot and anvil shall conform to the portion of the Calibration section of Test Methodsshall comply with the requirements of Test Method D5947.

7. Test Specimens

7.1 ~~The~~Test specimens ~~may be~~that are cut from sheets, plates, or molded or extruded shapes, or ~~may be~~ molded to the desired finished ~~dimensions.~~ dimensions are acceptable. The actual dimensions used ~~in Section 4.2, Calculation,~~ shall be measured in accordance with Test Methods D5947. The depth of the specimen shall be defined as the thickness of the material. The depth shall not exceed the width (see Note 11). The crosssection of the specimens shall be rectangular with opposite sides flat and parallel (±0.2 mm) and adjacent sides perpendicular along the full length of the specimen.

~~NOTE 2—Any necessary polishing of specimens shall be done only in the lengthwise direction of the specimen.~~

7.2 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. Consequently, any specifications for flexural properties on 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. Any necessary polishing of specimens shall be done only in the lengthwise direction of the specimen.

NOTE 11—The value obtained on specimens with machined surfaces may differ from those obtained on specimens with original surfaces.

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

7.3.1 *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 (½ 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 (¼ in.) on each end. Overhang shall be sufficient to prevent the specimen from slipping through the supports. A support span of 16 ± 1 times the depth of the specimen is used for these specimens.

~~NOTE 3—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. The value obtained on specimens with machined surfaces may differ from those obtained on specimens with original surfaces. Consequently, any specifications for flexural properties on 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 4—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.~~

7.3.2 *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 (½ in.) wide, tested flatwise on a 25.4-mm (1-in.) support span.

NOTE 12—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 13—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. All dimensions must be stated in the report (see also Note ~~5~~12).

7.4 *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 ~~(~~(0.5~~½~~ 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~~moment. As ~~Note 7). Therefore, a ratio larger than 16:1 may be necessary~~ a general rule, support span-to-specimen depth ratios of 16:1 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 (32:1 or 40:1 are recommended). When laminated materials exhibit low compressive strength perpendicular to the laminations, they shall be loaded with a large radius loading nose (up to four times the specimen depth to prevent premature damage to the outer fibers.

7.5 *Molding Materials (Thermoplastics and Thermosets)*—The ~~recommended~~preferred specimen dimensions for molding materials is ~~127 by 12.7 by 3.2 mm (5 by~~12.7 mm (0.5 in.) wide, 3.2 mm (0.125 in.) ~~½ by~~thick, and ~~1/8 in.)~~ 127 mm (5.0 in.) long. They are tested flatwise on ~~a~~the support span, resulting in a support span-to-depth ratio of ~~16~~16:1 (tolerance ±1). Thicker specimens ~~should~~ are to be avoided if they exhibit significant ~~shrink~~sink marks or bubbles when molded.

7.6 *High-Strength Reinforced Composites, Including Highly Orthotropic Laminates*—The span-to-depth ratio shall be chosen such that failure occurs in the outer fibers of the specimens and is due only to the bending ~~moment (see~~moment. As ~~Note 7). A span-to-depth ratio larger than 16:1 may be necessary~~ a general rule, support span-to-depth ratios of 16:1 are satisfactory when