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Standard Test Method for Flexural Fatigue Properties of Plastics¹

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1. Scope*

1.1 This test method covers the determination of dynamic fatigue properties of plastics in flexure. This method is applicable to rigid and semi-rigid plastics. Stress and strain levels are below the proportional limit of the material where the strains and stresses are relatively elastic. Three-point or four-point bending systems are used to determine these properties.

1.2 This test method can be used with two procedures:

1.2.1 *Procedure A*, designed for materials that use three-point loading systems to determine flexural strength. Three-point loading system is used for this procedure.

1.2.2 *Procedure B*, designed for materials that use four-point loading systems to determine flexural strength. Four-point loading system is used for this procedure.

1.3 Comparative tests can be run in accordance with 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 standard and ISO 13003 address the same subject matter, but differ in technical content and results cannot be directly compared 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.*

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.

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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
- D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
- D883 Terminology Relating to Plastics
- D1505 Test Method for Density of Plastics by the Density-Gradient Technique
- D2839 Practice for Use of a Melt Index Strand for Determining Density of Polyethylene
- D3479/D3479M Test Method for Tension-Tension Fatigue of Polymer Matrix Composite Materials
- D4883 Test Method for Density of Polyethylene by the Ultrasound Technique
- 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 Calibration and Verification of Testing Machines
- E83 Practice for Verification and Classification of Extensometer Systems
- E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
- E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
- E1942 Guide for Evaluating Data Acquisition Systems Used in Cyclic Fatigue and Fracture Mechanics Testing

2.2 ISO Standard:

- ISO 13003 Fibre-Reinforced Plastics—Determination of Fatigue Properties Under Cyclic Loading Conditions³

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. Terminology

3.1 *Definitions*—Definitions applying to this test method appear in Terminology D883.

3.2 *mean strain, n*—the algebraic average of the maximum and minimum strains in one cycle.

3.3 *mean stress, n*—the algebraic average of the maximum and minimum stresses in one cycle.

3.4 *R Ratio, n*—the ratio of the minimum stress or strain to the maximum stress or strain that the specimen is loaded.

3.5 *proportional limit, n*—the maximum elastic stress or strain exhibited by the material as observed during Test Methods D790 (for Procedure A) or Test Method D6272 (for Procedure B).

4. Summary of Test Method

4.1 *Procedure A*—A specimen of rectangular cross section is braced by two double-sided supports and is loaded by means of a double-sided loading nose midway between the supports. A support span-to-depth ratio of 16:1 is used. The specimen is cyclically loaded to predetermined stress or strain range at a uniform frequency and R ratio until the specimen ruptures or yields. From these tests, fatigue strengths can be determined at specified numbers of cycles. At least four different stress or strain levels are tested to construct a stress versus number of cycles to failure (S-N) curve or a strain versus number of cycles to failure (r-N) to determine the flexural endurance limit of the material at a specific R ratio.

4.2 *Procedure B*—A specimen of rectangular cross section is braced by two double-sided supports and is loaded by means of two double-sided loading noses, each an equal distance from the adjacent support. Load span-to-support span ratios can be 1:2 or 1:3. The specimen is cyclically loaded to a predetermined stress or strain range at a uniform frequency and R ratio until the specimen ruptures or yields. From these tests, fatigue strengths can be determined at specified numbers of cycles. At least four different stress or strain levels are tested to construct a stress versus number of cycles to failure (S-N) curve or a strain versus number of cycles to failure (r-N) to determine the flexural endurance limit of the material at a specific R ratio.

5. Significance and Use

5.1 These fatigue tests are used to determine the effect of processing, surface condition, stress, and so forth, on the fatigue resistance of plastic material subjected to flexural stress for relatively large numbers of cycles. The results can also be used as a guide for the selection of plastic materials for service under conditions of repeated flexural stress.

5.2 Properties can vary with specimen depth and test frequency. Test frequency can be 1-25 Hz but it is recommended that a frequency of 5 Hz or less be used.

5.3 Material response in fatigue is not identical for all plastics. If a plastic does not exhibit an elastic region, where strain is reversible, plastic deformation will occur during fatigue testing, causing the amplitude of the programmed load or deformation to change during testing. In this situation,

caution shall be taken when using the results for design as they are generally not indicative of the true fatigue properties of the material.

5.4 The results of these fatigue tests are suitable for application in design only when the specimen test conditions realistically simulate service conditions or some methodology of accounting for service conditions is available and clearly defined.

5.5 This procedure accommodates various specimen preparation techniques. Comparison of results obtained from specimens prepared in different manners shall not be considered comparable unless equivalency has been demonstrated.

6. Apparatus

6.1 *Testing Machine*—The testing machine shall essentially meet the specifications of Test Method D790 except as described below. The error in the deflection measuring system shall not exceed $\pm 0.5\%$ of the maximum deflection. The machine shall be able to execute sinusoidal or square/trapezoidal load or deflection programs at the specified test frequency and maintain an error of $\pm 1\%$ or less of the maximum programmed load or deflection.

6.2 *Recording Equipment*—Calibrated equipment must be used to record the following information during testing at a data acquisition rate and filter in accordance with Guide E1942:

- 6.2.1 Load versus time,
- 6.2.2 Deflection versus time, and
- 6.2.3 Number of cycles.

6.3 *Micrometers*—Applicable apparatus in accordance with Test Methods D5947 shall be used to measure the width and thickness of the test specimen.

6.4 Bending Fixture

6.4.1 *Procedure A*—A three-point bending fixture shall be used. A double-sided loading nose and two double-sided supports are required for this procedure. One side loads or supports the top of the specimen and the other loads or supports the bottom of the specimen. The dimensions of both sides shall be identical. The radii of the noses and supports will be in accordance with Test Method D790. An example of a fixture configuration for Procedure A is shown in Fig. 1. This fixture has a support span range of 50.8 to 254 mm (2 to 10 in.) at 50.8 mm (2 in.) intervals.

6.4.1.1 The supports are set to simply support the specimen using minimal pressure to hold the specimen in place. The specimen shall be long enough so that the ends do not slip from the supports during testing.

6.4.2 *Procedure B*—Four-point bending fixture shall be used. Two double-sided loading noses and two double-sided supports are required for this procedure. One side loads or supports the top of the specimen and the other loads or supports the bottom of the specimen. The dimensions of both sides shall be identical. The radii of the noses and supports will be in accordance with Test Method D6272. Load-span-to-support-span ratios shall be set at 1:2 or 1:3. An example of a 1:3 load-span-to-support-span ratio fixture configuration for Procedure B is shown in Fig. 2. This fixture has a load span range