



Designation: D7791 – 12

Standard Test Method for Uniaxial 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 uniaxial loading. This method is applicable to rigid and semi-rigid plastics. Uniaxial loading systems with tension and compression capabilities are used to determine these properties. Stress and strain levels are below the proportional limits of the material where the strains and stresses are relatively elastic.

1.2 This test method can be used with two procedures:

1.2.1 *Procedure A*, fatigue testing in tension.

1.2.2 *Procedure B*, fatigue testing in compression, only for rigid plastics.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—There is no known ISO equivalent to 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

D695 Test Method for Compressive Properties of Rigid Plastics

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

D883 Terminology Relating to Plastics

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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.

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

E4 Practices for Force Verification of Testing Machines

E83 Practice for Verification and Classification of Extensometer Systems

E466 Practice for Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials

E1942 Guide for Evaluating Data Acquisition Systems Used in Cyclic Fatigue and Fracture Mechanics Testing

3. Terminology

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

3.2 *Definitions:*

3.2.1 *compressive proportional limit*—maximum elastic stress or strain exhibited by a material in compression as observed in Test Method D695.

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

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

3.2.4 *R ratio*—ratio of the minimum stress or strain to the maximum stress or strain that the specimen is loaded.

3.2.5 *tensile proportional limit*—maximum elastic stress or strain exhibited by a material in tension as observed in Test Method D638.

4. Summary of Test Method

4.1 *Procedure A*—A specimen of rectangular or circular cross section is gripped by the ends of the specimen, pulled equally in opposite directions, and released back to its original position or load. The specimen is cyclically loaded in tension to a specific stress or strain level at a uniform frequency 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 uniaxial endurance limit of the material in tension.

4.2 *Procedure B*—A specimen of rectangular or circular cross section is compressed equally from opposite directions and released back to its original position or load. The specimen is cyclically loaded in compression to a specific stress or strain level at a uniform frequency 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 uniaxial endurance limit of the material in compression.

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 uniaxial 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 set forth by Test Method **D638** for Procedure A and Test Method **D695** for Procedure B 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 Change in length versus time
- 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 or diameter of the test specimen.

6.4 *Extensometers/Compressometer*—A suitable instrument shall be used for determining the distance between two designated points within the gage length of the test specimen as the specimen is stretched or compressed. This instrument shall be essentially free of inertia at the specified speed of testing. Extensometers shall be classified and their calibration periodically verified in accordance with Practice **E83**. An extensometer/compressometer with a maximum strain error of 0.0002 mm/mm (in./in.) that automatically and continuously records shall be used. Crosshead stroke of the testing machine can also be used to record deflection as long as it meets the same error requirements listed above.

6.5 *Supporting Jig (Procedure B Only)*—A supporting jig can be used for thin specimens or high compressive loads and shall be in accordance with Test Method **D695**.

7. Sampling, Test Specimens, and Test Units

7.1 Specimens shall be taken from samples that accurately represent the material or design that is being tested.

7.2 The specimens can be cut from sheets, plates, or molded shapes, or can be molded to the desired finished dimensions. The actual dimensions used for calculations shall be measured in accordance with Test Methods **D5947**.

7.3 *Procedure A*—Specimen dimensions, shape, surface conditions, and limitations shall be in compliance with Test Method **D638**.

7.4 *Procedure B*—Specimen dimensions, shape, surface conditions, and limitations shall be in compliance with Test Method **D695**.

7.5 Specimens cut from non-uniform thick molded part sections shall be machined equally and minimally on both sides to create a uniform thickness in the gage. It must be noted that machining the thickness of plastic can change the mechanical properties and caution shall be taken when applying the results to design.

7.6 It is recommended that density measurements be taken from each sample in the gage in accordance with Test Methods **D792**, Test Method **D1505**, Practice **D2839**, or Test Method **D4883** to ensure that the process used to fabricate the specimens creates consistent and uniform material.

8. Number of Test Specimens

8.1 At least three test specimens shall be tested at each of the four stress or strain levels (minimum of twelve specimens for each test). For additional sample sizes consult Table 1 of Test Method **D3479/D3479M**.