Designation: D5418 – 23

Standard Test Method for Plastics: Dynamic Mechanical Properties: In Flexure (Dual Cantilever Beam)[1]

This standard is issued under the fixed designation D5418; 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 outlines the use of dynamic mechanical instrumentation for determining and reporting the viscoelastic properties of thermoplastic and thermosetting resins and composite systems in the form of rectangular bars molded directly or cut from sheets, plates, or molded shapes. The elastic modulus data generated is used to identify the thermomechanical properties of a plastics material or composition.

1.2 This test method is intended to provide a means for determining the viscoelastic properties of a wide variety of plastics using nonresonant, forced-vibration techniques as outlined in Practice D4065. In particular, this method identifies the procedures used to measure properties using what is known as a dual-cantilever beam flexure arrangement. Plots of the elastic (storage) modulus, loss (viscous) modulus, and complex modulus, and tan delta as a function of frequency, time, or temperature are indicative of significant transitions in the thermomechanical performance of the polymeric material systems.

1.3 This test method is valid for a wide range of frequencies, typically from 0.01 Hz to 100 Hz.

1.4 Test data obtained by this test method are relevant and appropriate for use in engineering design.

1.5 The values stated in SI units are to be regarded as 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—There is no known ISO equivalent to this standard.

1.7 *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
D883 Terminology Relating to Plastics
D4065 Practice for Plastics: Dynamic Mechanical Properties: Determination and Report of Procedures
D4092 Terminology for Plastics: Dynamic Mechanical Properties
D5279 Test Method for Plastics: Dynamic Mechanical Properties: In Torsion
E456 Terminology Relating to Quality and Statistics

3. Terminology

3.1 Terms used in this standard are defined in accordance Standard D4092 and Terminology D883 unless otherwise specified. For terms relating to precision and bias and other associated statistical issues, the terms used in this standard are defined in accordance with Terminology E456.

4. Summary of Test Method

4.1 This test method covers the determination of the elastic modulus of plastics using dynamic mechanical techniques. A bar of rectangular cross section is tested as a beam in dynamic linear displacement or bending. The dual-cantilever beam specimen is gripped between two clamps. The specimen of known geometry is placed in mechanical linear displacement, with the displacement strain or deformation applied at the center of the dual-cantilever beam. The forced-strain displacement is at either a fixed frequency or variable frequencies, and at either isothermal conditions or with a linear temperature variation. The elastic or loss modulus, or both, of the polymeric material system are measured in flexure.[3]

[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] 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 particular method for measurement of the elastic and loss moduli and tan delta depends upon the individual instrument's operating principles.

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

5. Significance and Use

5.1 This test method provides a simple means of characterizing the thermomechanical behavior of plastic compositions using a very small amount of material. Since small test specimen geometries are used, it is essential that the specimens be representative of the material being tested. The data obtained can be used for quality control and/or research and development purposes. For some classes of materials, such as thermosets, it can also be used to establish optimum processing conditions.

5.2 Dynamic mechanical testing provides a sensitive means for determining thermomechanical characteristics by measuring the elastic and loss moduli as a function of frequency, temperature, or time. Plots of moduli and tan delta of a material versus these variables can be used to provide a graphic representation indicative of functional properties, effectiveness of cure (thermosetting-resin systems), and damping behavior under specified conditions.

5.2.1 Observed data are specific to experimental conditions. Reporting in full (as described in this test method) the conditions under which the data was obtained is essential to assist users with interpreting the data an reconciling apparent or perceived discrepancies.

5.3 This test method can be used to assess the following:

5.3.1 The modulus as a function of temperature or aging, or both,

5.3.2 The modulus as a function of frequency,

5.3.3 The effects of processing treatment, including orientation, induced stress, and degradation of physical and chemical structure,

5.3.4 Relative resin behavioral properties, including cure and damping,

5.3.5 The effects of substrate types and orientation (fabrication) on elastic modulus,

5.3.6 The effects of formulation additives that might affect processability or performance,

5.3.7 The effects of annealing on modulus and glass transition temperature,

5.3.8 The effect of aspect ratio on the modulus of fiber reinforcements, and

5.3.9 The effect of fillers, additives on modulus and glass transition temperature.

5.4 Before proceeding with this test method, refer to the specification of the material being tested. Any test specimen preparation, conditioning, dimensions, or testing parameters, or combination thereof, covered in the relevant ASTM material specification shall take precedence over those mentioned in this test method. If there are no relevant ASTM material specifications, then the default conditions apply.

6. Apparatus

6.1 The function of the apparatus is to hold a rectangular cross-sectional bar so that the material acts as the elastic and dissipative element in a mechanically driven linear displacement system. Dynamic mechanical instruments described in this standard generally operate in a forced, constant amplitude mode at either a fixed frequency or variable frequencies.

6.2 The apparatus consists of the following:

6.2.1 *Fixed Grips*—A fixed or essentially stationary fixture consisting of two grips to secure the rectangular specimen horizontally in a dual cantilever configuration.

6.2.2 *Movable Grip*—A movable grip applying the linear displacement at the center of the rectangular beam.

6.2.3 *Grip Alignments*—The grips shall be mechanically aligned or centered, that is, they shall be attached in such a manner that they will move into alignment as soon as any load is applied.

6.2.3.1 The test specimen shall be held in such a way that slippage relative to the grips is minimized as much as possible.

6.2.4 *Deformation (Strain) Device*—A device for applying a continuous linear deformation (strain) to the specimen. In the force-displacement device the deformation (strain) is applied and then released (see Table 1 of Practice D4065).

6.2.5 *Detectors*—A device or devices for determining dependent and independent experimental parameters, such as force (stress), deformation (strain), frequency, and temperature. Measure temperature with a precision of ±1°C, frequency, strain, and force to ±1 %.

6.2.6 *Temperature Controller and Oven*—A device for controlling the temperature, either by heating (in steps or ramps), cooling (in steps or ramps), or maintaining a constant specimen environment, or a combination thereof. Use a temperature controller that is sufficiently stable to permit measurement of environmental chamber temperature to within 1°C.

6.3 *Nitrogen,* or other inert-gas supply for purging purposes if appropriate.

7. Test Specimens

7.1 Prepare the test specimens by molding to the desired finished dimensions or cutting from sheets, plaques, or molded shapes. Any rectangular specimen (representative of the material being tested and within the fixturing capabilities of the test equipment) is permitted as long as it is clearly stated in the test report.

8. Calibration

8.1 Calibrate the instrument according to procedures recommended by the manufacturer.

9. Conditioning

9.1 *Conditioning*—Condition the test specimens at 23.0 ± 2.0°C and 50 ± 10 % relative humidity for not fewer than 40 h prior to test in accordance with Procedure A of Practice D618 unless otherwise specified by contract or relevant ASTM material specification.

10. Procedure

10.1 Use an untested specimen for each measurement. Measure the width and thickness of the specimen to the nearest 0.03 mm (0.001 in.) at the center of the specimen.

10.2 Clamp the test specimen between the movable and stationary members; use shim stock, if necessary, to minimize slippage within the clamp.