Designation: D5023 – 23

Standard Test Method for Plastics: Dynamic Mechanical Properties: In Flexure (Three-Point Bending) [1]

This standard is issued under the fixed designation D5023; 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 visco-elastic 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 data generated, using three-point bending techniques, is used to identify the thermomechanical properties of a plastic material or compositions using a variety of dynamic mechanical instruments.

1.2 This test method is intended to provide means for determining the viscoelastic properties of a wide variety of plastics materials using nonresonant, forced-vibration techniques in accordance with Practice D4065. Plots of the elastic (storage) modulus; loss (viscous) modulus; complex modulus and tan delta as a function of frequency, time, or temperature are indicative of significant transitions in the thermomechanical performance of 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 Due to possible instrumentation compliance, the data generated are intended to indicate relative and not necessarily absolute property values.

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

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

1.7 *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 equivalent to ISO 6721, Part 5.

1.8 *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

D4000 Classification System for Specifying Plastic Materials

D4065 Practice for Plastics: Dynamic Mechanical Properties: Determination and Report of Procedures

D4092 Terminology for Plastics: Dynamic Mechanical Properties

E456 Terminology Relating to Quality and Statistics

2.2 *ISO Standard:*[3]

ISO 6721, Part 5 Plastics—Determination of Dynamic Mechanical Properties Part 5: Flexural Vibration—Non-Resonance Method

3. Terminology

3.1 *Definitions*—Terms used in this standard are defined in accordance Terminology 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 A specimen of rectangular cross section is tested in flexure as a beam. The bar rests on two supports and is loaded by means of a loading nose midway between the supports. Using three-point bending, the test specimen is placed in mechanical linear displacement at fixed frequencies with linear

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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] 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**

temperature variation or variable frequencies at isothermal conditions. The elastic moduli or loss moduli, or both, of the polymeric material system are measured.

NOTE 2—The particular method for measurement of the elastic and loss moduli and tan delta depends upon the individual instrument's operating principles.

5. Significance and Use

5.1 This test method provides a simple means of characterizing the thermomechanical behavior of plastic compositions using very small amounts of material. The data obtained is used for quality control, research and development as well as the establishment of 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 graphical representation indicative of functional properties, effectiveness of cure (thermosetting resin system), 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:

5.3.1 Modulus as a function of temperature,

5.3.2 Modulus as a function of frequency,

5.3.3 The effects of processing treatment,

5.3.4 Relative resin behavioral properties, including cure and damping.

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

5.3.6 The effects of formulation additives which 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 materials 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. Interferences

6.1 Since small test specimen geometries are used, it is essential that the specimens be representative of the polymeric material being tested.

7. Apparatus

7.1 The function of the apparatus is to hold a rectangular test specimen of a polymeric material system so that the material acts as the elastic and dissipative element in a mechanically driven linear displacement system. Dynamic mechanical instruments described in this test method generally operate in a forced, constant amplitude mode at a fixed frequency.

7.2 The apparatus shall consist of the following:

7.2.1 *Loading Nose and Supports*—The loading nose and supports shall have cylindrical surfaces having a sufficient radius to avoid excessive indentation or failure due to stress concentration directly under the loading nose.

7.2.2 *Linear Deformation (strain)*—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).

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

7.2.4 *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.

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

8. Test Specimens

8.1 Prepare test specimens by molding to the desired finished dimensions or cutting from molded shapes. Typically, the support span shall be 16 (tolerance +4 or −2) times the depth of the beam. Specimens shall be long enough to allow overhanging on each end of at least 10 % of the support span, but in no case less than 6.4 mm (0.25 in.) on each end. Overhang shall be sufficient to prevent the specimen from slipping through the supports. A typical rectangular test beam is 64 by 13 by 3 mm (2.5 by 0.5 by 0.125 in.) tested flatwise on a 50 mm (2 in.) support span, resulting in a span to depth ratio of 16. Rectangular test specimens of other dimensions are permitted as long as it is clearly identified in the test report.

9. Calibration

9.1 Calibrate the instrument using procedures recommended by the manufacturer.

10. Conditioning

10.1 Condition the test specimens at 23.0 ± 2°C (73.4 ± 3.6°F) and 50 ± 10 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D618 unless otherwise specified by contract or relevant ASTM material specification.

11. Procedure

11.1 Use an untested specimen for each measurement, such as temperature or time sweep. Measure the width and depth of the specimen to the nearest 0.03 mm (0.001 in.) at its center.