Designation: E2769 – 16

Standard Test Method for Elastic Modulus by Thermomechanical Analysis Using Three-Point Bending and Controlled Rate of Loading[1]

This standard is issued under the fixed designation E2769; 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 describes the use of linear controlled-rate-of-loading in three-point bending to determine the elastic modulus of isotropic specimens in the form of rectangular bars using a thermomechanical analyzer (TMA).

NOTE 1—This method is intended to provide results similar to those of Test Methods D790 or D5934 but is performed on a thermomechanical analyzer using smaller test specimens. Until the user demonstrates equivalence, the results of this method shall be considered independent and unrelated to those of Test Methods D790 or D5934.

1.2 This test method provides a means for determining the elastic modulus within the linear region of the stress-strain curves (see Fig. 1). This test is conducted under isothermal temperature conditions from –100 to 300°C.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 There is no ISO standard equivalent to this test method.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D618 Practice for Conditioning Plastics for Testing

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D5934 Test Method for Determination of Modulus of Elasticity for Rigid and Semi-Rigid Plastic Specimens by Controlled Rate of Loading Using Three-Point Bending (Withdrawn 2009)[3]

E473 Terminology Relating to Thermal Analysis and Rheology

E1142 Terminology Relating to Thermophysical Properties

E1363 Test Method for Temperature Calibration of Thermomechanical Analyzers

E2113 Test Method for Length Change Calibration of Thermomechanical Analyzers

E2206 Test Method for Force Calibration of Thermomechanical Analyzers

3. Terminology

3.1 *Definitions*—Definitions of technical terms used in this standard are defined in Terminologies E473 and E1142 including *anisotropic, Celsius, expansivity, isotropic, proportional limit, storage modulus, strain, stress, thermodilatometry, thermomechanical analysis,* and *yield point*.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *elastic modulus, n*—the ratio of stress to corresponding strain within the elastic limit on the stress-strain curve (see Fig. 1) expressed in Pascal units.

4. Summary of Test Method

4.1 A specimen of rectangular cross section is tested in three-point bending (flexure) as a beam. The beam rests on two supports and is loaded midway between the supports by means of a loading nose. A linearly increasing load (stress) is applied to the test specimen of known geometry while the resulting deflection (strain) is measured under isothermal conditions. The elastic modulus is obtained from the linear portion of the display of resultant strain versus applied stress.

5. Significance and Use

5.1 This test method provides a means of characterizing the mechanical behavior of materials using very small amounts of material.

5.2 The data obtained may be used for quality control, research and development and establishment of optimum

[1] This test method is under the jurisdiction of ASTM Committee E37 on Thermal Measurements and is the direct responsibility of Subcommittee E37.10 on Fundamental, Statistical and Mechanical Properties.

Current edition approved April 1, 2016. Published April 2016. Originally approved in 2011. Last previous version approved in 2015 as E2769 – 15. DOI: 10.1520/E2769-16.

[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.

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

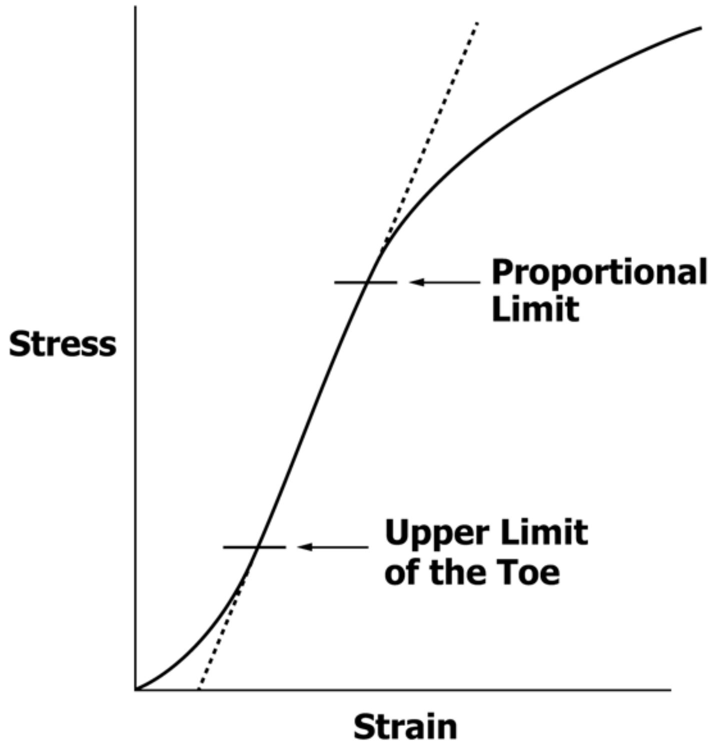

FIG. 1 Stress-Strain Curve (Linear Region)

processing conditions. The data are not intended for use in design or predicting performance.

NOTE 2—This test method may not be suitable for anisotropic materials.

6. Interferences

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

6.2 This test method is not applicable for strains greater than 3 %.

7. Apparatus

7.1 The function of the apparatus is to hold a rectangular test specimen (beam) so that the material acts as the elastic and dissipative element in a mechanically driven linear displacement system. Displacements (deflections) are generated using a controlled loading rate applied to a specimen in a three-point bending configuration.

7.2 *Thermomechanical Analyzer*—The essential instrumentation required to provide the minimum thermomechanical analytical or thermodilatometric capability for this method includes:

7.2.1 A rigid *specimen holder* of inert low expansivity material ≤30 µm m^{-1} K^{-1} to center the specimen in the furnace and to fix the specimen to mechanical ground.

7.2.2 A rigid *flexure fixture* of inert low expansivity material ≤30 µm m^{-1} K^{-1} to support the test specimen in a three-point bending mode (see Fig. 2).

7.2.3 A rigid *knife-edge compression probe* of inert low expansivity material ≤30 µm m^{-1} K^{-1} that contacts the specimen with an applied compressive force (see Fig. 1). The radius of the knife-edge shall not be larger than 1 mm.

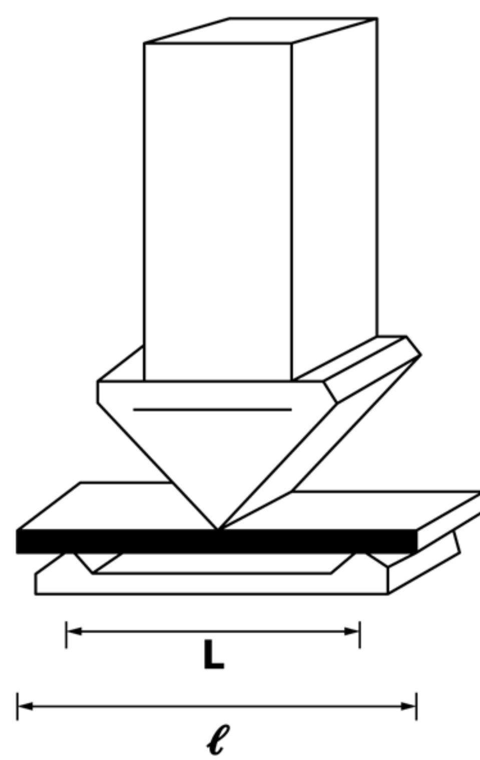

FIG. 2 Flexure Support Geometry

7.2.4 *Deflection sensing element*, having a linear output over a minimum range of 5 mm to measure the displacement of the rigid compression probe (see 7.2.3) to within ±0.1 µm.