



Designation: ~~E831~~—19 E831 – 24

## Standard Test Method for Linear Thermal Expansion of Solid Materials by Thermomechanical Analysis<sup>1</sup>

This standard is issued under the fixed designation E831; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

### 1. ~~Scope~~ Scope\*

1.1 This test method determines the technical coefficient of linear thermal expansion of solid materials using thermomechanical analysis techniques.

1.2 This test method is applicable to solid materials that exhibit sufficient rigidity over the test temperature range such that the sensing probe does not produce indentation of the specimen.

1.3 The recommended lower limit of coefficient of linear thermal expansion measured with this test method is  $5 \mu\text{m}/(\text{m}\cdot^\circ\text{C})$ . The test method may be used at lower (or negative) expansion levels with decreased accuracy and precision (see Section ~~H12~~ H12).

1.4 This test method is applicable to the temperature range from  $-120^\circ\text{C}$  to  $900^\circ\text{C}$ . The temperature range may be extended depending upon the instrumentation and calibration materials used.

1.5 ~~The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this 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.*

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*:<sup>2</sup>

[D696 Test Method for Coefficient of Linear Thermal Expansion of Plastics Between  \$-30^\circ\text{C}\$  and  \$30^\circ\text{C}\$  with a Vitreous Silica Dilatometer](#)

[D3386 Test Method for Coefficient of Linear Thermal Expansion of Electrical Insulating Materials \(Withdrawn 2005\)](#)<sup>3</sup>

[E228 Test Method for Linear Thermal Expansion of Solid Materials With a Push-Rod Dilatometer](#)

[E473 Terminology Relating to Thermal Analysis and Rheology](#)

<sup>1</sup> 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, 2019; May 1, 2024. Published April 2019; May 2024. Originally approved in 1981. Last previous edition approved in 2014; 2019 as E831 – 14; E831 – 19. DOI: 10.1520/E0831-19; 10.1520/E0831-24.

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

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

[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](#)

[E3142 Test Method for Thermal Lag of Thermal Analysis Apparatus](#)

### 3. Terminology

3.1 *Definitions*—Thermal analysis terms in Terminologies [E473](#) and [E1142](#) shall apply to this test method, including *coefficient of linear thermal expansion*, *thermodilatometry*, and *thermomechanical analysis*.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *mean coefficient of linear thermal expansion, ( $\alpha_m$ ), n*—the change in length, relative to the specimen length at ambient temperature, accompanying a unit change in temperature identified by the midpoint temperature of the temperature range of measurement.

### 4. Summary of Test Method

4.1 This test method uses a thermomechanical analyzer or similar device to determine the linear thermal expansion of solid materials when subjected to a constant heating rate.

4.2 The change of the specimen length is electronically recorded as a function of temperature. The coefficient of linear thermal expansion can be calculated from these recorded data.

### 5. Significance and Use

5.1 Coefficients of linear thermal expansion are used, for example, for design purposes and to determine if failure by thermal stress may occur when a solid body composed of two different materials is subjected to temperature variations.

5.2 This test method is comparable to Test Method [D3386](#) for testing electrical insulation materials, but it covers a more general group of solid materials and it defines test conditions more specifically. This test method uses a smaller specimen and substantially different apparatus than Test Methods [E228](#) and [D696](#).

5.3 This test method may be used in research, specification acceptance, regulatory compliance, and quality assurance.

### 6. Apparatus

6.1 *Thermomechanical Analyzers (TMA)*—The essential instrumentation required providing minimum thermomechanical analytical or thermodilatometric capability for this test method includes:

6.1.1 *Rigid Specimen Holder*, of inert, low coefficient of expansion material ( $\leq 0.5 \mu\text{m}/(\text{m}\cdot^\circ\text{C})$ ) to center the specimen in the furnace and to fix the specimen to mechanical ground.

6.1.2 *Rigid Expansion Probe*, of inert, low coefficient of expansion material ( $\leq 0.5 \mu\text{m}/(\text{m}\cdot^\circ\text{C})$ ) that contacts the specimen with an applied compressive force.

6.1.3 *Sensing Element*, linear over a minimum range of ~~2 mm~~ 2 mm to measure the displacement of the rigid expansion probe readable to within  $\pm 50$  nm resulting from changes in length of the specimen.

6.1.4 *Weight or Force Transducer*, to generate a constant force of 1 mN to 100 mN (0.1 g to 10 g) that is applied through the rigid expansion probe to the specimen.

6.1.5 *Furnace*, capable of providing uniform controlled heating (cooling) of a specimen to a constant temperature or at a constant rate between  $2^\circ\text{C}/\text{min}$  and  $10^\circ\text{C}/\text{min}$  within the applicable temperatures range of between  $-150^\circ\text{C}$  and  ~~$+1000^\circ\text{C}$~~   $1000^\circ\text{C}$ .

6.1.6 *Temperature Controller*, capable of executing a specific temperature program by operating the furnace between selected temperature limits at a rate of temperature change of  $2^\circ\text{C}/\text{min}$  to  $10^\circ\text{C}/\text{min}$  constant to within  $\pm 0.1^\circ\text{C}/\text{min}$  or at an isothermal temperature constant to  $\pm 0.5^\circ\text{C}$ .