



# Standard 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<sup>1</sup>

This standard is issued under the fixed designation D696; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

## 1. Scope\*

1.1 This test method covers determination of the coefficient of linear thermal expansion for plastic materials having coefficients of expansion greater than  $1\ \mu\text{m}/(\text{m}\cdot^{\circ}\text{C})$  by use of a vitreous silica dilatometer. At the test temperatures and under the stresses imposed, the plastic materials shall have a negligible creep or elastic strain rate or both, insofar as these properties would significantly affect the accuracy of the measurements.

1.1.1 Test Method E228 shall be used for temperatures other than  $-30^{\circ}\text{C}$  to  $30^{\circ}\text{C}$ .

1.1.2 This test method shall not be used for measurements on materials having a very low coefficient of expansion (less than  $1\ \mu\text{m}/(\text{m}\cdot^{\circ}\text{C})$ ). For materials having very low coefficient of expansion, interferometer or capacitance techniques are recommended.

1.1.3 Alternative technique commonly used for measuring this property is thermomechanical analysis as described in Test Method E831, which permits measurement of this property over a scanned temperature range.

1.2 The thermal expansion of a plastic is composed of a reversible component on which are superimposed changes in length due to changes in moisture content, curing, loss of plasticizer or solvents, release of stresses, phase changes and other factors. This test method is intended for determining the coefficient of linear thermal expansion under the exclusion of these factors as far as possible. In general, it will not be possible to exclude the effect of these factors completely. For this reason, the test method can be expected to give only an approximation to the true thermal expansion.

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

1.4 *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:*<sup>2</sup>

D618 Practice for Conditioning Plastics for Testing

D883 Terminology Relating to Plastics

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

E228 Test Method for Linear Thermal Expansion of Solid Materials With a Push-Rod Dilatometer

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E831 Test Method for Linear Thermal Expansion of Solid Materials by Thermomechanical Analysis

## 3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology D883 unless otherwise specified.

## 4. Summary of Test Method

4.1 This test method is intended to provide a means of determining the coefficient of linear thermal expansion of plastics which are not distorted or indented by the thrust of the dilatometer on the specimen. For materials that indent, see 8.4. The specimen is placed at the bottom of the outer dilatometer tube with the inner one resting on it. The measuring device which is firmly attached to the outer tube is in contact with the top of the inner tube and indicates variations in the length of the specimen with changes in temperature. Temperature changes are brought about by immersing the outer tube in a liquid bath or other controlled temperature environment maintained at the desired temperature.

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.30 on Thermal Properties (Section D20.30.07).

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<sup>2</sup> 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.

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

**5. Significance and Use**

5.1 The coefficient of linear thermal expansion,  $\alpha$ , between temperatures  $T_1$  and  $T_2$  for a specimen whose length is  $L_0$  at the reference temperature, is given by the following equation:

$$\alpha = (L_2 - L_1) / [L_0(T_2 - T_1)] = \Delta L / L_0 \Delta T$$

where  $L_1$  and  $L_2$  are the specimen lengths at temperatures  $T_1$  and  $T_2$ , respectively.  $\alpha$  is, therefore, obtained by dividing the linear expansion per unit length by the change in temperature.

5.2 The nature of most plastics and the construction of the dilatometer make  $-30$  to  $+30^\circ\text{C}$  ( $-22^\circ\text{F}$  to  $+86^\circ\text{F}$ ) a convenient temperature range for linear thermal expansion measurements of plastics. This range covers the temperatures in which plastics are most commonly used. Where testing outside of this temperature range or when linear thermal expansion characteristics of a particular plastic are not known through this temperature range, particular attention shall be paid to the factors mentioned in 1.2.

NOTE 2—In such cases, special preliminary investigations by thermo-mechanical analysis, such as that prescribed in Practice D4065 for the location of transition temperatures, may be required to avoid excessive error. Other ways of locating phase changes or transition temperatures

using the dilatometer itself may be employed to cover the range of temperatures in question by using smaller steps than  $30^\circ\text{C}$  ( $86^\circ\text{F}$ ) or by observing the rate of expansion during a steady rise in temperature of the specimen. Once such a transition point has been located, a separate coefficient of expansion for a temperature range below and above the transition point shall be determined. For specification and comparison purposes, the range from  $-30^\circ\text{C}$  to  $+30^\circ\text{C}$  ( $-22^\circ\text{F}$  to  $+86^\circ\text{F}$ ) (provided it is known that no transition exists in this range) shall be used.

**6. Apparatus**

6.1 *Fused-Quartz-Tube Dilatometer* suitable for this test method is illustrated in Fig. 1. A clearance of approximately 1 mm is allowed between the inner and outer tubes.

6.2 *Device* for measuring the changes in length (dial gauge, LVDT, or the equivalent) is fixed on the mounting fixture. Adjust its position to accommodate specimens of varying length (see 8.2). The accuracy shall be such that the error of indication will not exceed  $\pm 1.0 \mu\text{m}$  ( $4 \times 10^{-5}$  in.) for any length change. The weight of the inner silica tube plus the measuring device reaction shall not exert a stress of more than 70 kPa (10 psi) on the specimen so that the specimen is not distorted or appreciably indented.

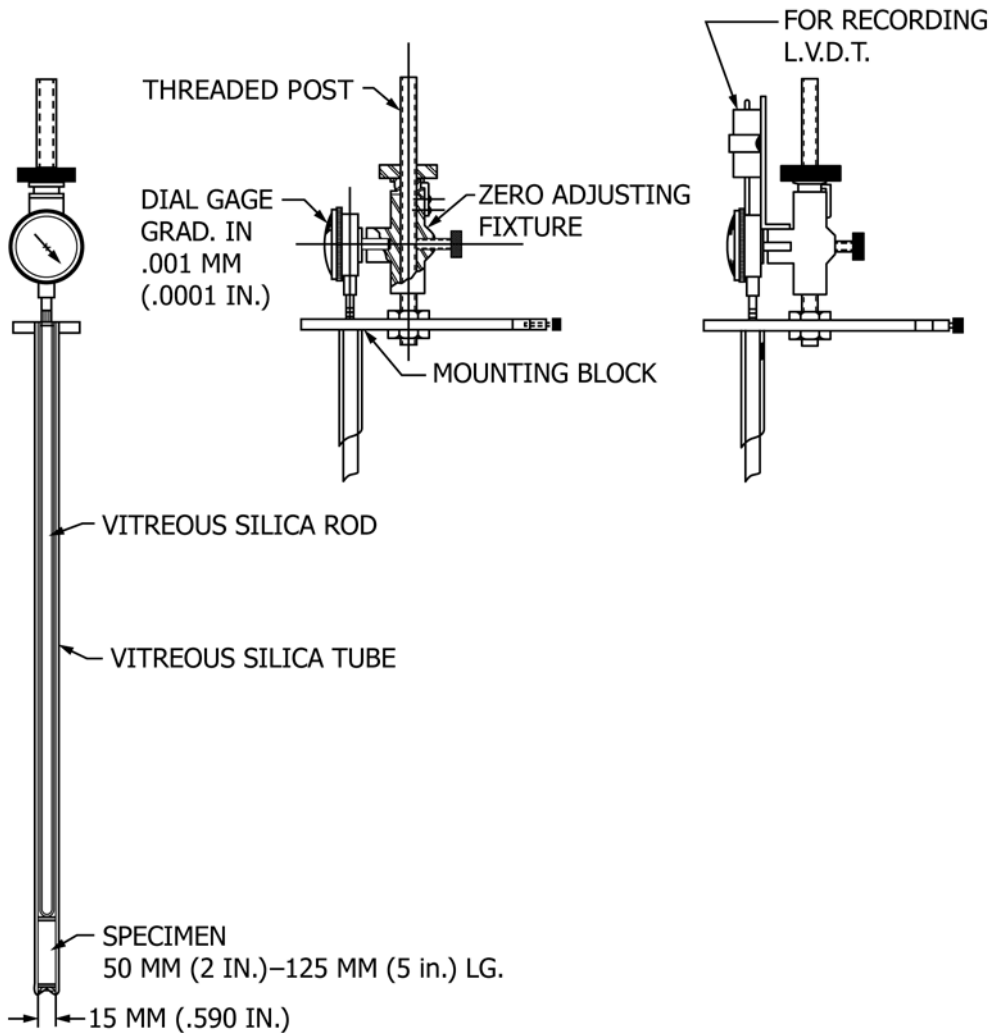


FIG. 1 Quartz-Tube Dilatometer