Designation: D 3386 – 00

An American National Standard

Standard Test Method for Coefficient of Linear Thermal Expansion of Electrical Insulating Materials[1]

This standard is issued under the fixed designation D 3386; 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.

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

1. Scope

1.1 This test method covers determination of the coefficient of linear thermal expansion of electrical insulating materials by use of a thermomechanical analyzer.

1.2 This test method is applicable to materials that are solid over the entire range of temperature used, and that retain sufficient hardness and rigidity over the temperature range so that irreversible indentation of the specimen by the sensing probe does not occur.

1.3 Transition temperatures also may be obtained by this test method.

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.*

1.5 The values stated in SI units are the standard.

NOTE 1—There is no similar or equivalent ISO/IEC standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 374M Test Methods for Thickness of Solid Electrical Insulation (Metric)[2]

D 696 Test Method for Coefficient of Linear Thermal Expansion of Plastics Between − 30°C and 30°C[3]

D 1711 Terminology Relating to Electrical Insulation[2]

D 6054 Practice for Coordinating Electrical Insulating Materials for Testing[4]

3. Terminology

3.1 See Terminology D 1711 for definitions of other terms relating to electrical insulation.

4. Summary of Test Method

4.1 This test method uses a thermomechanical analyzer to determine the change of dimension as a function of temperature of a small specimen of a solid electrical insulating material. Coefficients of linear thermal expansion are calculated from the values. Other thermal observations may also be made.

5. Significance and Use

5.1 Measurements of coefficient of linear thermal expansion are useful in evaluating the suitability of solid insulating materials for use in combination with other materials where mechanical stresses may develop as a result of differences in coefficients.

5.2 This test method may be compared with Test Method D 696, but tests made with this test method use much smaller specimens. This eliminates the need for large liquid baths and greatly reduces the time required to reach temperature equilibrium. As a result, the time required for making a test is less than for Test Method D 696, and the test method can conveniently be used over a wider temperature range than for Test Method D 696.

6. Apparatus

6.1 The thermomechanical analyzer shall include:

6.1.1 A specimen holder and probe, into which the specimen can be placed. Changes in height of the specimen are sensed by movement of the probe. Use a probe of a shape and size such that, for the material being tested, the load applied to the specimen by the probe shall not cause indentation of the specimen within the range of test temperatures of interest.

6.1.2 Means for sensing movement of the probe resulting from changes in height of the specimen and for translating these movements into a signal suitable for input to the recorder. The sensing element should be capable of sensing a change in height of 0.1 µm of the test specimen, with provisions for less sensitive ranges when needed.

6.1.3 Means for uniformly heating the specimen holder at a predetermined rate over the range of temperatures of interest. This will consist of a furnace and temperature controller with

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[1] This test method is under the jurisdiction of ASTM Committee D09 on Electrical and Electronic Insulating Materials and is the direct responsibility of Subcommittee D09.01 on Electrical Insulating Varnishes, Powders, and Encapsulating Compounds.

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[2] *Annual Book of ASTM Standards*, Vol 10.01.

[3] *Annual Book of ASTM Standards*, Vol 08.01.

[4] *Annual Book of ASTM Standards*, Vol 10.02.

provisions for precooling the furnace and specimen holder when measurements of subambient temperatures are to be made.

6.1.4 Means for measuring temperature in immediate proximity to the test specimen.

6.1.5 Equipment for recording changes in specimen height as a function of specimen temperature.

6.1.6 Micrometer, meeting the requirements of Test Methods D 374M.

NOTE 2—Instruments from TA Instruments and Perkin-Elmer have been found suitable.

7. Test Specimens

7.1 Specimens shall be between 2.5 and 7.5 mm in height and shall have flat and parallel upper and lower surfaces. Lateral dimensions shall not exceed 10 mm.

8. Calibration

8.1 Calibrate the apparatus in accordance with the instrument manufacturer's recommendations.

9. Conditioning

9.1 Condition the test specimens for 1 h at 10°C above the maximum specified temperature of the run, followed by 40 h at the standard laboratory atmosphere in accordance with Practice D 6054.

10. Procedure

10.1 Measure the height of the specimen to within 0.01 mm.

10.2 Place the specimen in the specimen holder under the probe. Place the thermocouple or other means for sensing specimen temperature in contact with the specimen, or as near the specimen as possible.

10.3 Assemble the furnace to the specimen holder. If measurements at subambient temperatures are to be made, cool the specimen holder and furnace to at least 20°C below the lowest temperature of interest, using procedures as given by the instrument manufacturer. Do not allow the refrigerant used for cooling to come into direct contact with the specimen.

10.4 Increase the furnace temperature at 5 ± 0.5°C/min over the desired temperature range.

NOTE 3—A gas purge may be used to replace the air around the specimen for measurement of expansion in different atmospheres.

10.5 Record the specimen temperature and change in specimen height.

11. Calculation

11.1 Calculate the average coefficient of thermal expansion, α, over the temperature intervals of interest as follows:

$$\alpha = (\Delta H/\Delta T)/H \quad (1)$$

where:

H = original height of specimen,

ΔH = change in height of the specimen (in the same units) over the temperature interval ΔT, and

ΔT = temperature interval, °C (see Fig. 1).

NOTE 4—ΔH and ΔT may on some instruments be read directly from the recorder chart. On other instruments constant factors may need to be applied to the chart readings to obtain these values.

12. Report

12.1 Report the following information:

12.1.1 Designation of the material, including the name of the manufacturer and information on composition when known,

12.1.2 Method of preparation of the test specimen,

12.1.3 Specimen orientation with respect to original sample, if applicable,

12.1.4 Specimen height,

12.1.5 Temperatures between which the coefficient of linear thermal expansion has been determined,

12.1.6 Average coefficient of linear thermal expansion per degree Celsius,

12.1.7 Transition temperatures, if noted,

12.1.8 Instrument manufacturer and model number,

12.1.9 Purge gas, if used, and rate of gas flow, and

12.1.10 *X-Y* chart record.

13. Precision and Bias

13.1 The precision of this test method has not been determined.

13.2 Operators familiar with this test method estimate that individual values may vary from the mean value by as much as 25 %, both within a given laboratory and between laboratories. By closely controlling both the dimensions and the orientation of the test specimens, better reproducibility has been achieved.

13.3 The bias of this test method has not been determined.

14. Keywords

14.1 linear thermal expansion; thermomechanical analyzer; transition temperature

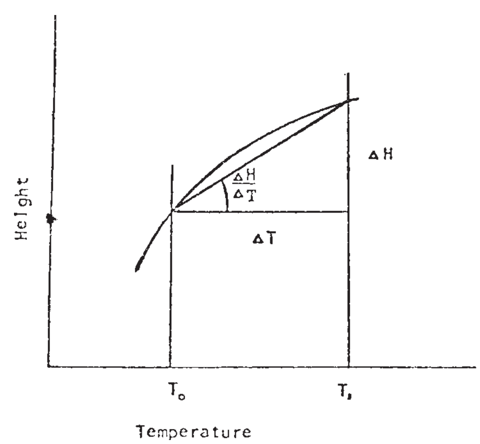

FIG. 1 Specimen Height versus Temperature