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IPC-TM-650
TEST METHODS MANUAL

Number	
2.4.41	
Subject	
Coefficient of Linear Thermal Expansion of Electrical Insulating Materials[1]	
Date	Revision
3/86	
Originating Task Group	
N/A	

1.0 Scope

1.1 This method covers determination of the coefficient of linear thermal expansion of electrical insulating materials[1] by use of a thermomechanical analyzer.

1.2 This 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 method.

2.0 Applicable Documents

ASTM D-618 Conditioning Plastics and Electrical Insulating Materials for Testing[2]

ASTM-D-696 Test for Coefficient of Linear Thermal Expansion of Plastics[3]

3.0 Summary of Method

3.1 This method used a thermomechanical analyzer with an X-Y recorder to graph the change of dimension as a function of temperature of a small specimen of a solid electrical insulating material. Coefficients of linear thermal expansion can be calculated from the graph. Other thermal observations may also be made.

Note 1—Other rapid thermal analysis methods are being studied by ASTM Subcommittees D09.17 and D20.30.

4.0 Significance

4.1 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.

4.2 This method may be compared with Method D-696, but tests made with this 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 Method D-696, and the method can conveniently be used over a wider temperature range than for Method D-696.

5.0 Apparatus

5.1 The thermomechanical analyzer shall include:

5.1.1 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. The shape and size of the probe shall be such that for the material tested the load applied to the specimen by the probe shall not cause indentation of the specimen within the range of temperatures of interest.

5.1.2 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 producing a movement of the recorder pen of at least 1000 times the change in height of the test specimen, with provisions for less sensitive ranges when needed.

5.1.3 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 provisions for precooking the furnace and specimen holder when measurements at subambient temperatures are to be made.

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

5.1.5 An X-Y recorder for recording changes in specimen height as a function of specimen temperature.

1. This method is under the jurisdiction of ASTM Committee D-9 on Electrical Insulating Materials and is the direct responsibility of Subcommittee D09.01 on Electrical Insulating Varnishes, Powders, and Encapsulating Compounds.
2. Annual Book of ASTM Standards, Part 39.
3. Annual Book of ASTM Standards, Part 35.

Note 2—Instruments from duPont and Perkin Elmer have been found suitable.

6.0 Test Specimens

6.1 The test specimen shall be between .05 and 0.3 inches thick. This thickness may be as received or may be laminated by the user from pre-impregnated ''B'' stage and copper free ''C'' stage material. It laminated by the user, the user shall be responsible to contact the manufacturer for the exact layup and process parameters used for quality acceptance at the manufacturers facility.

Note 3—Repeatability of Test Results will vary with layup, bake out, laminating pressure/ramp speed, press time, etc.

6.2 Specimens should be between 0.3 and 0.4 inches in height and have flat and parallel upper and lower surfaces. The surfaces to be measured shall be perpendicular to the fiber fillers and the identity of the direction of the fiber fillers shall be maintained throughout the test. The upper and lower surfaces shall be polished with 600 grit paper to remove burrs or strands of fiber filler. The specimens shall then be cleaned using isopropyl alcohol, and dried for 1 hour at 10°C above the maximum specified temperature of the run.

Note 4—The 1 hour prebake may be eliminated if Condition (7.), is performed immediately after final polish.

6.3 There shall be three specimens prepared from the same piece of material for each direction to be measured.

7.0 Conditioning

7.1 Conditioning of test specimen shall include immersion in isopropyl alcohol with agitation for 20 seconds, followed by Condition E-1/110 and $C_1$40/23/50 in accordance with D-618.

8.0 Calibration

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

9.0 Procedure

9.1 Measure the height of the specimen.

9.2 Place the specimen in the specimen holder under the probe. The thermocouple or other means for sensing specimen temperature should be in contact with the specimen, or as near to the specimen as possible.

9.3 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. The refrigerant used for cooling shall not come into direct contact with the specimen.

Note 5—The temperature range to be tested shall be specified by the user, so that the manufacturer and user will test over the same temperature range. If tested over different temperature ranges, the repeatability may be unacceptable.

9.4 Place weights on the sensing probe to ensure that the probe is in contact with the specimen with a 1 to 3-g load.

9.5 Increase the furnace temperature at 5 = 0.5°C/min. over the desired temperature range.

9.6 Record the specimen temperature and change in specimen height using appropriate ranges on the X-Y recorder.

Note 6—A gas purge may be used to replace the air around the specimen for measurement of expansion in different atmospheres.

9.7 Test at least three specimens of the same material. Retest of a specimen may be used only as reference and shall not be treated as an independent test of a new specimen.

10.0 Calculation

10.1 Calculate the average coefficient of thermal expansions, α, over the temperature intervals of interest as follows:

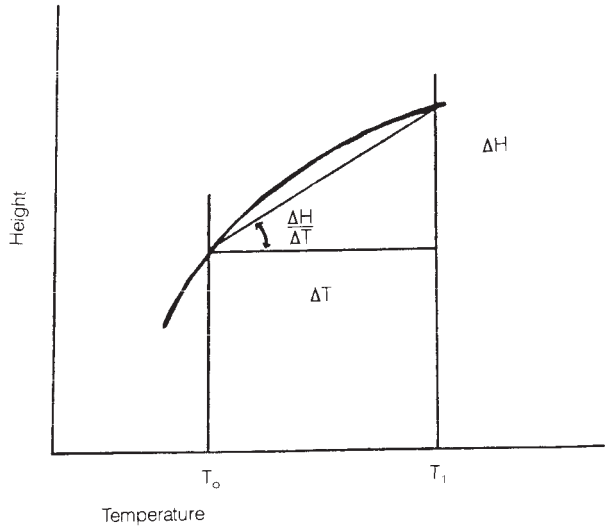
$$\alpha = (\Delta H/\Delta T)/H$$

where:

H = original height of specimen,
Δ H = change in height of the specimen (in the same units) over the temperature interval ΔT, and
Δ T = temperature interval, °C (see Figure 1).

Note 7—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.

11.0 Report



IPC-2441-1

Figure 1 Specimen height versus temperature

11.1 The report shall include the following:

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

11.1.2 Method of preparation of the test specimen.

11.1.3 Specimen orientation with respect to original sample, if applicable.

11.1.4 Sample size.

11.1.5 Temperatures between which the coefficient of linear thermal expansion has been determined.

11.1.6 Average coefficient of linear thermal expansion per degree Celsius.

11.1.7 Transition temperatures, if noted.

11.1.8 Instrument manufacturer and model number.

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

11.1.10 X-Y chart record.

NOTE The preceding test method was originally ASTM D3386-75, until modified for use by IPC for round-robin testing of organic substrate materials. Upon completion of the test program, recommendations for revision will be made to ASTM.