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Standard Method of Test for THERMAL CONDUCTIVITY OF CELLULAR PLASTICS BY MEANS OF A PROBE[1]

This Standard is issued under the fixed designation D 2326; 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.

The committee responsible for this standard has voted its withdrawal. In the absence of substantial reasons that it should be continued, the Society will approve withdrawal from publication in April 1977.

1. Scope

1.1 This method covers the determination, by means of a probe, of the thermal conductivity of cellular plastics having thermal conductivities that are not in excess of 0.058 W/m · K (0.4 Btu · in./h · ft^2 · deg F). The test may be run over a range of temperatures within the temperature limits of the material being tested.

1.2 The probe method is a transient method for determining thermal conductivity. Heat is applied at a constant rate along a line. The temperature rise of the line source is proportional to the logarithm of time and inversely proportional to the thermal conductivity of the surrounding medium.

NOTE 1—The values stated in SI units are to be regarded as the standard.

2. Significance

2.1 The probe method is an absolute method for determination of *k* values directly, so that no calibration based on a specimen of known thermal conductivity is required. Low cost and simplicity of operation makes the method especially useful for screening purposes in laboratory and in plant use. In cases of dispute ASTM Method C 177, Test for Thermal Conductivity of Materials by Means of the Guarded Hot Plate,[2] shall be used.

3. Symbols and Definitions

3.1 For symbols and definitions, see Method C 177.

4. Apparatus

4.1 The general features of a suitable probe for this method are shown in Fig. 1. It consists of a heater and thermocouple in a protective sheath that terminates in a plastic handle. The layout and electrical schematic drawing for the probe is shown in Fig. 2. In addition, a constant-temperature enclosure as specified in 4.6 is required.

4.2 The heating element shall be made in the form of a bifilar coil. This construction eliminates inductive effects and makes possible high resistance which greatly simplifies the problem of supplying a constant voltage for the power source. At the same time, it places the heater nearer the surface of the probe and decreases the axial heat flow along the heater wire.

4.3 The probe need not be of specified length or diameter and need not have a specified length-to-diameter ratio; however, in practice it has been found that a protective sheath 0.51 mm (0.020 in.) in diameter, a length of approximately 200 mm (8 in.), and a heater resistance of approximately 1800 Ω has proved satisfactory for cellular plastics. The resistance and length of the heater coil (ohms per unit length) must be known with an accuracy of at least ±0.5 percent.[3]

4.4 The power source (see Fig. 2) shall consist of a battery and variable series resistor, a precision milliammeter, and a resistance

[1] This method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D-20.22 on Cellular Plastics.

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[2] *Annual Book of ASTM Standards*, Part 35.

[3] A commercially available probe which has proven to be satisfactory for cellular plastics is available from Custom Scientific Instruments, Inc., P.O. Box A, Whippany, N. J.

equal to that of the probe to stabilize the battery before placing a voltage across the probe. The precision of the milliammeter (or potentiometer and Standard resistance) must be at least ±0.25 percent of full scale. A milliammeter with a range from 0 to 10 mA has been satisfactory for most cellular plastics. The power source shall be capable of holding the current constant to at least ±0.2 percent over the duration of the test. The test current shall match the warm-up current within ±$^1/_2$ percent.

NOTE 2—A lead storage battery or mercury batteries will hold their voltage level under heater load more consistently than the common zinc battery. If zinc batteries are used, they should be changed at least annually.

4.5 The temperature difference between the probe thermocouple and the reference junction shall be measured with a galvanometer or other instrument capable of measuring thermocouple voltages and having a period no greater than 3 s. The meter and thermocouple should be calibrated in the range to be used with a water bath and a Beckmann differential thermometer (range = 5 C) to provide a calibration curve with a precision of at least ±0.006 C (±0.01 F). The reference junction should be maintained in an isothermal chamber, such as a vacuum flask of distilled water, whose temperature is constant within ±0.0006 C (±0.001 F) over a 10-min period. The reference junction serves as a zero reference for the probe thermocouple and the vacuum flask should be placed in the constant-temperature enclosure referred to in 4.6.

4.6 For a satisfactory test, the entire specimen and probe must be at constant temperature before the run is started. A constant-temperature enclosure for the test specimen shall be provided to allow the specimen to settle down to this condition. Any device that will maintain an air environment around the specimen within ±0.02 C (±0.04 F), or sufficiently constant so as not to affect the linearity of the temperature versus time plot in 7.1 is satisfactory.

4.7 A timer to measure times from 1 to 10 min with an accuracy of ±$^1/_2$ s.

5. Sampling and Preparation of Test Specimen

5.1 Specimens to be evaluated should normally not be tested for at least 24 h after foaming. In the event that at least one dimension of a sample is not less than 200 mm (8 in.), the sample size should be reduced accordingly and conditioned at room temperature for at least 4 h prior to cutting the test specimens.

5.2 In the event that the foam is not isotropic, the direction of test shall be specified or as agreed upon by the seller and the purchaser.

5.3 The minimum size of specimen is dependent upon the properties of the sample, the probe heater current, the change in probe temperature, and dimensions of the probe. However, for a probe such as described in 4.3, a specimen size of 100 by 100 by 300 mm (4 by 4 by 12 in.) cut lengthwise in half and mated on the cut sides has proven satisfactory for cellular plastics. A groove should be made to permit insertion of the probe handle.

5.4 Cellular plastics may be cut with a band saw. Dust should be removed by a vacuum cleaner or a similar means before remating the halves.

5.5 The test specimen shall be assembled and conditioned at 23 ± 1 C (73.4 ± 2 F) and 50 percent relative humidity for at least 6 h prior to exposure to test temperature.

5.6 The density of the foam samples to be tested should be determined in accordance with ASTM Method D 1622, Test for Apparent Density of Rigid Cellular Plastics,[4] and recorded.

5.7 Three specimens shall be tested for each sample.

6. Procedure

6.1 Sandwich the probe between the mated halves of the cellular plastic specimen. To ensure a close fit the halves should be held together securely by any suitable means.

6.2 Place the assembled probe and specimen into the constant-temperature enclosure. The specimen should be conditioned in the enclosure until the galvanometer deflection is constant within ±0.006 C (±0.01 F) for at least 30 min. If the temperatures markedly differ from the conditioning temperature prescribed in 5.5, then additional equilibrium

[4] *Annual Book of ASTM Standards*, Part 36.