Designation: D6744 – 23

Standard Test Method for Determination of the Thermal Conductivity of Anode Carbons by the Guarded Heat Flow Meter Technique[1]

This standard is issued under the fixed designation D6744; 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.

1. Scope*

1.1 This test method covers a steady-state technique for the determination of the thermal conductivity of carbon materials in thicknesses of less than 25 mm. The test method is useful for homogeneous materials having a thermal conductivity in the approximate range $1 < \lambda < 30$ W/(m·K), (thermal resistance in the range from 10 to 400×10^{-4} m^2 ·K/W) over the approximate temperature range from 150 K to 600 K. It can be used outside these ranges with reduced accuracy for thicker specimens and for thermal conductivity values up to 60 W⁄(m·K).

NOTE 1—It is not recommended to test graphite cathode materials using this test method. Graphites usually have a very low thermal resistance, and the interfaces between the specimen to be tested and the instrument become more significant than the specimen itself.

1.2 This test method is similar in concept to Test Methods E1530 and C518. Significant attention has been paid to ensure that the thermal resistance of contacting surfaces is minimized and reproducible.

1.3 The values stated in SI units are regarded as standard.

1.3.1 *Exception*—The values given 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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:*[2]

C518 Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus

D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants

E1530 Test Method for Evaluating the Resistance to Thermal Transmission by the Guarded Heat Flow Meter Technique

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method, refer to Terminology D4175.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *average temperature, n*—the average temperature of a surface is the area-weighted mean temperature of that surface.

3.2.2 *heat flux transducer, HFT, n*—a device that produces an electrical output that is a function of the heat flux, in a predefined and reproducible manner.

3.2.3 *thermal conductance, C, n*—the time rate of heat flux through a unit area of a body induced by unit temperature difference between the body surfaces.

3.2.4 *thermal conductivity, λ, of a solid material, n*—the time rate of heat flow, under steady conditions, through unit area, per unit temperature gradient in the direction perpendicular to the area.

3.2.5 *thermal resistance, R, n*—the reciprocal of thermal conductance.

3.3 *Symbols:*

λ = thermal conductivity, W/(m·K), [Btu·in/(h·ft^2·°F)]
C = thermal conductance, W/(m^2·K), [Btu/(h·ft^2·°F)]
R = thermal resistance, m^2·K/W, (h·ft^2·°F/Btu)
Δx = specimen thickness, mm, (in.)
A = specimen cross sectional area, m^2, (ft^2)

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.05 on Properties of Fuels, Petroleum Coke and Carbon Material.

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[2] 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**

Q = heat flow, W, (Btu/h)
φ = heat flux transducer output, mV
N = heat flux transducer calibration constant, W/(m^2·mV), [Btu/(h·ft^2·mV)]
$N\varphi$ = heat flux, W/m^2, [Btu/(h·ft^2)]
ΔT = temperature difference,° C, (°F)
T_g = temperature of guard heater, °C, (°F)
T_u = temperature of upper heater, °C, (°F)
T_l = temperature of lower heater, °C, (°F)
T_1 = temperature of one surface of the specimen, °C, (°F)
T_2 = temperature of the other surface of the specimen, °C, (°F)
T_m = mean temperature of the specimen, °C, (°F)
s = unknown specimen
r = known calibration or reference specimen
o = contacts

4. Summary of Test Method

4.1 A specimen and a heat flux transducer (HFT) are sandwiched between two flat plates controlled at different temperatures, to produce a heat flow through the test stack. A reproducible load is applied to the test stack by pneumatic or hydraulic means, to ensure that there is a reproducible contact resistance between the specimen and plate surfaces. A cylindrical guard surrounds the test stack and is maintained at a uniform mean temperature of the two plates, in order to minimize lateral heat flow to and from the stack. At steady-state, the difference in temperature between the surfaces contacting the specimen is measured with temperature sensors embedded in the surfaces, together with the electrical output of the HFT. This output (voltage) is proportional to the heat flow through the specimen, the HFT and the interfaces between the specimen and the apparatus. The proportionality is obtained through prior calibration of the system with specimens of known thermal resistance measured under the same conditions, such that contact resistance at the surface is made reproducible.

5. Significance and Use

5.1 This test method is designed to measure and compare thermal properties of materials under controlled conditions and their ability to maintain required thermal conductance levels.

6. Apparatus

6.1 A schematic rendering of a typical apparatus is shown in Fig. 1. The relative position of the HFT to sample is not important (it may be on the hot or cold side) as the test method is based on maintaining axial heat flow with minimal heat losses or gains radially. It is also up to the designer whether to choose heat flow upward or downward or horizontally, although downward heat flow in a vertical stack is the most common one.

6.2 *Key Components of a Typical Device:*

6.2.1 The compressive force for the stack is to be provided by either a regulated pneumatic or hydraulic cylinder (1) or a spring loaded mechanism. In either case, means must be provided to ensure that the loading can be varied and set to certain values reproducibility.

6.2.2 The loading force must be transmitted to the stack through a gimball joint (2) that allows up to 5° swivel in the plane perpendicular to the axis of the stack.

6.2.3 Suitable insulator plate (3) separates the gimball joint from the top plate (4).

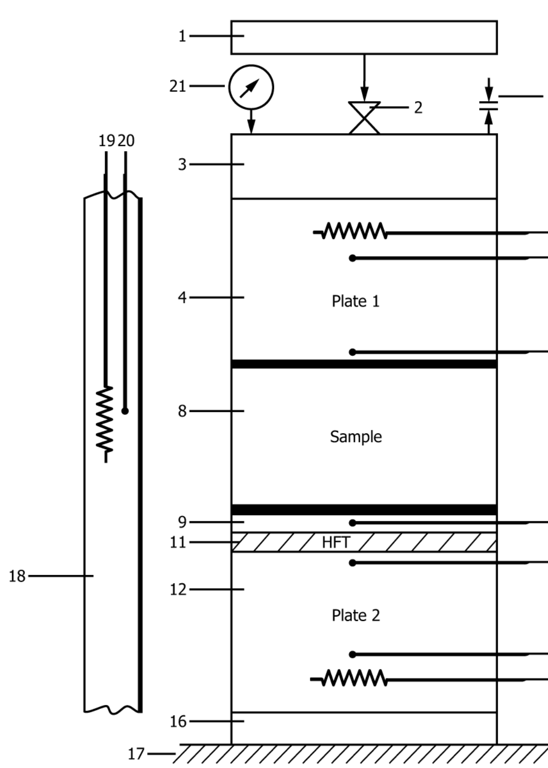

FIG. 1 Key Components of a Typical Device