Designation: E2585 – 09 (Reapproved 2022)

Standard Practice for Thermal Diffusivity by the Flash Method[1]

This standard is issued under the fixed designation E2585; 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 practice covers practical details associated with the determination of the thermal diffusivity of primarily homogeneous isotropic solid materials. Thermal diffusivity values ranging from 10^{-7} to 10^{-3} m^2/s are readily measurable by this from about 75 K to 2800 K.

1.2 This practice is adjunct to Test Method E1461.

1.3 This practice is applicable to the measurements performed on materials opaque to the spectrum of the energy pulse, but with special precautions can be used on fully or partially transparent materials.

1.4 This practice is intended to allow a wide variety of apparatus designs. It is not practical in a document of this type to establish details of construction and procedures to cover all contingencies that might offer difficulties to a person without pertinent technical knowledge, or to stop or restrict research and development for improvements in the basic technique. This practice provides guidelines for the construction principles, preferred embodiments and operating parameters for this type of instruments.

1.5 This practice is applicable to the measurements performed on essentially fully dense materials; however, in some cases it has shown to produce acceptable results when used with porous specimens. Since the magnitude of porosity, pore shapes, and parameters of pore distribution influence the behavior of the thermal diffusivity, extreme caution must be exercised when analyzing data. Special caution is advised when other properties, such as thermal conductivity, are derived from thermal diffusivity obtained by this method.

1.6 The flash can be considered an absolute (or primary) method of measurement, since no reference materials are required. It is advisable to use only reference materials to verify the performance of the instrument used.

1.7 This method is applicable only for homogeneous solid materials, in the strictest sense; however, in some cases it has been shown to produce data found to be useful in certain applications:

1.7.1 *Testing of Composite Materials*—When substantial non-homogeneity and anisotropy is present in a material, the thermal diffusivity data obtained with this method may be substantially in error. Nevertheless, such data, while usually lacking absolute accuracy, may be useful in comparing materials of similar structure. Extreme caution must be exercised when related properties, such as thermal conductivity, are derived, as composite materials, for example, may have heat flow patterns substantially different than uniaxial. In cases where the particle size of the composite phases is small compared to the specimen thickness (on the order of 1 to 25 % of thickness) and where the transient thermal response of the specimen appears homogenous when compared to the model, this method can produce accurate results for composite materials. Anisotropic materials can be measured by various techniques, as long as the directional thermal diffusivities (two dimensional or three dimensional) are mutually orthogonal and the measurement and specimen preparation produce heat flow only along one principle direction. Also, 2D and 3D models and either independent measurements in one or two directions, or simultaneous measurements of temperature response at different locations on the surface of the specimen, can be utilized.

1.7.2 *Testing Liquids*—This method has found an especially useful application in determining thermal diffusivity of molten materials. For this technique, specially constructed specimen enclosures must be used.

1.7.3 *Testing Layered Materials*—This method has also been extended to test certain layered structures made of dissimilar materials, where the thermal properties of one of the layers are considered unknown. In some cases, contact conductance of the interface may also be determined.

[1] This practice is under the jurisdiction of ASTM Committee E37 on Thermal Measurements and is the direct responsibility of Subcommittee E37.05 on Thermophysical Properties.

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1.8 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.9 *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.*

1.10 *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]

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

E1461 Test Method for Thermal Diffusivity by the Flash Method

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *thermal conductivity, λ, of a solid material*—the time rate of steady heat flow through unit thickness of an infinite slab of a homogeneous material in a direction perpendicular to the surface, induced by unit temperature difference. The property must be identified with a specific mean temperature, since it varies with temperature.

3.1.2 *thermal diffusivity, α, of a solid material*—the property given by the thermal conductivity divided by the product of the density and heat capacity per unit mass.

3.2 *Description of Symbols and Units Specific to This Standard:*

3.2.1 C_p—specific heat capacity, J/(kg·K).

3.2.2 D—diameter, metres.

3.2.3 k—constant depending on percent rise.

3.2.4 K—correction factors.

3.2.5 K_1, K_2—constants depending on β.

3.2.6 L—specimen thickness, m.

3.2.7 t—response time, s.

3.2.8 $t_{½}$ —half-rise time or time required for the rear face temperature rise to reach one half of its maximum value, s.

3.2.9 t^*—dimensionless time ($t^* = 4\alpha_s \ t/D_T^2$).

3.2.10 T—temperature, K.

3.2.11 α—thermal diffusivity, m^2/s.

3.2.12 λ—thermal conductivity, (W/m·K).

3.2.13 β—fraction of pulse duration required to reach maximum intensity.

3.2.14 ρ—density, kg/m^3.

3.2.15 Δt_5—$T(5t_{½}) / T(t_{½})$.

3.2.16 Δt_{10}—$T(10t_{½}) / T(t_{½})$.

3.2.17 ΔT_{max}—temperature difference between baseline and maximum rise, K.

3.3 *Description of Subscripts Specific to This Standard:*

3.3.1 C—Cowan.

3.3.2 m—maximum.

3.3.3 o—ambient.

3.3.4 R—ratio.

3.3.5 s—specimen.

3.3.6 t—time.

3.3.7 T—thermocouple.

3.3.8 x—percent rise.

4. Summary of Practice

4.1 A small, thin disc specimen is subjected to a high-intensity short duration radiant energy pulse (Fig. 1). The energy of the pulse is absorbed on the front surface of the specimen and the resulting rear face temperature rise (thermogram) is recorded. The thermal diffusivity value is calculated from the specimen thickness and the time required for the rear face temperature rise to reach certain percentages of its maximum value. When the thermal diffusivity of the sample is to be determined over a temperature range, the measurement must be repeated at each temperature of interest. This is described in detail in a number of publications (**1**, **2**)[3] and review articles (**3**, **4**, **5**). A summary of the theory can be found in Test Method E1461, Appendix 1.

[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.

[3] The boldface numbers given in parentheses refer to a list of references at the end of the text.

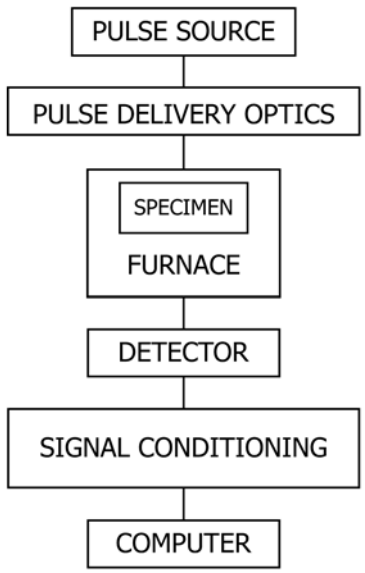

FIG. 1 Block Diagram of a Flash System