



Designation: C1470 – 20

## Standard Guide for Testing the Thermal Properties of Advanced Ceramics<sup>1</sup>

This standard is issued under the fixed designation C1470; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This guide covers the thermal property testing of advanced ceramics, to include monolithic ceramics, particulate/whisker-reinforced ceramics, and continuous fiber-reinforced ceramic composites. It is intended to provide guidance and information to users on the special considerations involved in determining the thermal properties of these ceramic materials.

1.2 Five thermal properties (specific heat capacity, thermal conductivity, thermal diffusivity, thermal expansion, and emittance/emissivity) are presented in terms of their definitions and general test methods. The relationship between thermal properties and the composition, microstructure, and processing of advanced ceramics (monolithic and composite) is briefly outlined, providing guidance on which material and specimen characteristics have to be considered in evaluating the thermal properties of advanced ceramics. Additional sections describe sampling considerations, test specimen preparation, and reporting requirements.

1.3 Current ASTM test methods for thermal properties are tabulated in terms of test method concept, testing range, specimen requirements, standards/reference materials, capabilities, limitations, precision, and special instructions for monolithic and composite ceramics.

1.4 This guide is based on the use of current ASTM standards for thermal properties, where appropriate, and on the development of new test standards, where necessary. It is not the intent of this guide to rigidly specify particular thermal test methods for advanced ceramics. Guidance is provided on how to utilize the most commonly available ASTM thermal test methods, considering their capabilities and limitations.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard. See [IEEE/ASTM SI 10](#).

1.6 *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*

*appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *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:*<sup>2</sup>

2.1.1 *Specific Heat:*

[C351 Test Method for Mean Specific Heat of Thermal Insulation \(Withdrawn 2008\)](#)<sup>3</sup>

[D2766 Test Method for Specific Heat of Liquids and Solids \(Withdrawn 2018\)](#)<sup>3</sup>

[E1269 Test Method for Determining Specific Heat Capacity by Differential Scanning Calorimetry](#)

[E2716 Test Method for Determining Specific Heat Capacity by Sinusoidal Modulated Temperature Differential Scanning Calorimetry](#)

2.1.2 *Thermal Conductivity:*

[C177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus](#)

[C182 Test Method for Thermal Conductivity of Insulating Firebrick](#)

[C201 Test Method for Thermal Conductivity of Refractories](#)

[C202 Test Method for Thermal Conductivity of Refractory Brick](#)

[C408 Test Method for Thermal Conductivity of Whiteware Ceramics](#)

[C518 Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus](#)

[C767 Test Method for Thermal Conductivity of Carbon Refractories](#)

[C1044 Practice for Using a Guarded-Hot-Plate Apparatus or Thin-Heater Apparatus in the Single-Sided Mode](#)

<sup>1</sup> This guide is under the jurisdiction of ASTM Committee C28 on Advanced Ceramics and is the direct responsibility of Subcommittee C28.03 on Physical Properties and Non-Destructive Evaluation.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

- C1045** Practice for Calculating Thermal Transmission Properties Under Steady-State Conditions
- C1113/C1113M** Test Method for Thermal Conductivity of Refractories by Hot Wire (Platinum Resistance Thermometer Technique)
- C1114** Test Method for Steady-State Thermal Transmission Properties by Means of the Thin-Heater Apparatus
- C1130** Practice for Calibration of Thin Heat Flux Transducers
- E1225** Test Method for Thermal Conductivity of Solids Using the Guarded-Comparative-Longitudinal Heat Flow Technique
- E1530** Test Method for Evaluating the Resistance to Thermal Transmission by the Guarded Heat Flow Meter Technique
- 2.1.3 *Thermal Expansion:*
- C372** Test Method for Linear Thermal Expansion of Porcelain Enamel and Glaze Frits and Fired Ceramic Whiteware Products by the Dilatometer Method
- C1300** Test Method for Linear Thermal Expansion of Glaze Frits and Ceramic Whiteware Materials by the Interferometric Method
- E228** Test Method for Linear Thermal Expansion of Solid Materials With a Push-Rod Dilatometer
- E289** Test Method for Linear Thermal Expansion of Rigid Solids with Interferometry
- E831** Test Method for Linear Thermal Expansion of Solid Materials by Thermomechanical Analysis
- 2.1.4 *Thermal Diffusivity:*
- C714** Test Method for Thermal Diffusivity of Carbon and Graphite by Thermal Pulse Method
- D4612** Test Method for Calculating Thermal Diffusivity of Rock and Soil
- E1461** Test Method for Thermal Diffusivity by the Flash Method
- E2585** Practice for Thermal Diffusivity by the Flash Method
- 2.1.5 *Emittance/Emissivity:*
- E408** Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques
- E423** Test Method for Normal Spectral Emittance at Elevated Temperatures of Nonconducting Specimens
- 2.1.6 *General Standards:*
- C168** Terminology Relating to Thermal Insulation
- C373** Test Methods for Determination of Water Absorption and Associated Properties by Vacuum Method for Pressed Ceramic Tiles and Glass Tiles and Boil Method for Extruded Ceramic Tiles and Non-tile Fired Ceramic Whiteware Products
- C1045** Practice for Calculating Thermal Transmission Properties Under Steady-State Conditions
- C1145** Terminology of Advanced Ceramics
- E122** Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process
- E473** Terminology Relating to Thermal Analysis and Rheology
- E1142** Terminology Relating to Thermophysical Properties

**IEEE/ASTM SI 10** American National Standard for Metric Practice

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *advanced ceramic, n*—a highly engineered, high-performance, predominantly nonmetallic, inorganic, ceramic material having specific functional attributes. **(C1145)**

3.1.2 *ceramic matrix composite, n*—a material consisting of two or more materials (insoluble in one another), in which the major continuous component (matrix component) is a ceramic, while the secondary component/s (reinforcing component) may be ceramic, glass-ceramic, glass, metal, or organic in nature. These components are combined on a macroscale to form a useful engineering material possessing certain properties or behavior not possessed by the individual constituents. **(C1145)**

3.1.3 *coefficient of linear thermal expansion,  $\alpha[T^{-1}]$ , n*—the change in length, relative to the length of the specimen, accompanying a unit change of temperature, at a specified temperature. (This property can also be considered the instantaneous expansion coefficient or the slope of the tangent to the  $\Delta L/L$  versus  $T$  curve at a given temperature.) **(E1142)**

3.1.4 *continuous fiber-reinforced ceramic composite (CFCC), n*—a ceramic matrix composite in which the reinforcing phase(s) consists of continuous filaments, fibers, yarns, or knitted or woven fabric. **(C1145)**

3.1.5 *differential scanning calorimetry (DSC), n*—a technique in which the difference in energy inputs into a test specimen and a reference material is measured as a function of temperature while the test specimen and reference material are subjected to a controlled temperature program. **(E1269)**

3.1.6 *discontinuous fiber-reinforced ceramic composite, n*—a ceramic matrix composite reinforced by chopped fibers. **(C1145)**

3.1.7 *emittance (emissivity),  $\epsilon$  (nd), n*—the ratio of the radiant flux emitted by a specimen per unit area to the radiant flux emitted by a black body radiator at the same temperature and under the same conditions. Emittance ranges from 0 to 1, with a blackbody having an emittance of 1.00. **(E423)**

3.1.8 *linear thermal expansion, [nd], n*—the change in length per unit length resulting from a temperature change. Linear thermal expansion is symbolically represented by  $\Delta L/L_0$ , where  $\Delta L$  is the observed change in length  $\Delta L = L_2 - L_1$ , and  $L_0$ ,  $L_1$ , and  $L_2$  are the lengths of the specimen at reference temperature  $T_0$  and test temperatures  $T_1$  and  $T_2$ . **(E228)**

3.1.9 *mean coefficient of linear thermal expansion,  $\alpha_L[T^{-1}]$ , n*—the change in length, relative to the length of the specimen, accompanying a unit change of temperature measured across a specified temperature range ( $T_1$  to  $T_2$ ). **(C372)**

3.1.10 *particulate-reinforced ceramic matrix composite, n*—a ceramic matrix composite reinforced by ceramic particulates. **(C1145)**

3.1.11 *specific heat (specific heat capacity),  $C$  [ $mL^{-1}T^{-2}\theta^{-1}$ ], n*—the quantity of heat required to provide a unit temperature increase to a unit mass of material. **(E1142)**