SLOVENSKI STANDARD

oSIST prEN ISO 22007-2:2021

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Polimerni materiali - Ugotavljanje toplotne prevodnosti in toplotne razprševalnosti - 2. del: Metoda s tranzientnim ploskovnim toplotnim virom (vroči disk) (ISO/DIS 22007-2:2021)

Plastics - Determination of thermal conductivity and thermal diffusivity - Part 2: Transient plane heat source (hot disc) method (ISO/DIS 22007-2:2021)

Kunststoffe - Bestimmung der Wärmeleitfähigkeit und der Temperaturleitfähigkeit - Teil 2: Transientes Flächenquellenverfahren (Hot-Disk-Verfahren) (ISO/DIS 22007-2:2021)

Plastiques - Détermination de la conductivité thermique et de la diffusivité thermique - Partie 2: Méthode de la source plane transitoire (disque chaud) (ISO/DIS 22007-2:2021)

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Plastics — Determination of thermal conductivity and thermal diffusivity —

Part 2:
Transient plane heat source (hot disc) method

Plastiques — Détermination de la conductivité thermique et de la diffusivité thermique —

Partie 2: Méthode de la source plane transitoire (disque chaud)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 5, *Physical-chemical properties*.

This third edition cancels and replaces the second edition (ISO 22007-2:2015), which has been technically revised.

Introduction

A significant increase in the development and application of new and improved materials for broad ranges of physical, chemical, biological, and medical applications has necessitated better performance data from methods of measurement of thermal-transport properties. The introduction of alternative methods that are relatively simple, fast, and of good precision would be of great benefit to the scientific and engineering communities. [1]

A number of measurement techniques described as transient methods have been developed and several have been commercialized. These are being widely used and are suitable for testing many types of materials. In some cases, they can be used to measure several properties separately or simultaneously. [2],[3]

A further advantage of some of these methods is that it has become possible to measure the true bulk properties of a material. This feature stems from the possibility of eliminating the influence of the thermal contact resistance (see 8.1.1) that is present at the interface between the probe and the specimen surfaces. [1],[3],[4],[5],[6]

Plastics — Determination of thermal conductivity and thermal diffusivity —

Part 2: Transient plane heat source (hot disc) method

1 Scope

This document specifies a method for the determination of the thermal conductivity and thermal diffusivity, and hence the specific heat capacity per unit volume of plastics. The experimental arrangement can be designed to match different specimen sizes. Measurements can be made in gaseous and vacuum environments at a range of temperatures and pressures.

This method is suitable for testing homogeneous and isotropic materials, as well as anisotropic materials with a uniaxial structure. The homogeneity of the material extends throughout the specimen and no thermal barriers (except those next to the probe) are present within a range defined by the probing depth(s) (see 3.2 below).

The method is suitable for materials having values of thermal conductivity, λ, in the approximate range $0{,}010\ \mathrm{W \cdot m^{-1} \cdot K^{-1}} < \lambda < 500\ \mathrm{W \cdot m^{-1} \cdot K^{-1}}$, values of thermal diffusivity, α, in the range $5 \times 10^{-8}\ \mathrm{m^2 \cdot s^{-1}} < \alpha < 10^{-4}\ \mathrm{m^2 \cdot s^{-1}}$, and for temperatures, T, in the approximate range 50 K < T < 1 000 K.

NOTE 1 The specific heat capacity per unit volume, C, $C = p \cdot c_p$, where p is the density and c_p is the specific heat per unit mass and at constant pressure, can be obtained by dividing the thermal conductivity, λ, by the thermal diffusivity, α, i.e. $C = \lambda / \alpha$, and is in the approximate range $0{,}005\ \mathrm{MJ \cdot m^{-3} \cdot K^{-1}} < C < 5\ \mathrm{MJ \cdot m^{-3} \cdot K^{-1}}$. It is also referred to as the volumetric heat capacity.

NOTE 2 If the intention is to determine the thermal resistance or the apparent thermal conductivity in the through-thickness direction of an inhomogeneous product (for instance a fabricated panel) or an inhomogeneous slab of a material, reference is made to ISO 8301, ISO 8302 and ISO 472.

The thermal-transport properties of liquids can also be determined, provided care is taken to minimize thermal convection.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 22007-1, *Plastics — Determination of thermal conductivity and thermal diffusivity — Part 1: General principles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 22007-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
penetration depth
Δp_{pen}
measure of how far into the specimen, in the direction of heat flow, a heat wave has travelled

Note 1 to entry: For this method, the penetration depth is given by

$$\Delta p_{pen} = \kappa \sqrt{\alpha \cdot t_{tot}}$$

where

t_{tot} is the total measurement time for the transient recording;

α is the thermal diffusivity of the specimen material;

κ is a constant dependent on the sensitivity of the temperature recordings.

Note 2 to entry: It is expressed in metres (m).

3.2
probing depth
Δp_{prob}
measure of how far into the specimen, in the direction of heat flow, a heat wave has travelled during the time window used for calculation

Note 1 to entry: The probing depth is given by

$$\Delta p_{prob} = \kappa \sqrt{\alpha \cdot t_{max}}$$

where

t_{max} is the maximum time of the time window used for calculating the thermal-transport properties.

Note 2 to entry: It is expressed in metres (m).

Note 3 to entry: A typical value in hot disc measurements is $\kappa = 2$, which is assumed throughout this document.

3.3
sensitivity coefficient
β_q
coefficient defined by the formula

$$\beta_q = q \frac{\partial [\Delta T(t)]}{\partial q}$$

where

q is the thermal conductivity, λ, the thermal diffusivity, α, or the volumetric specific heat capacity, C;

$\Delta T(t)$ is the mean temperature increase of the probe.

Note 1 to entry: Different sensitivity coefficients are defined for thermal conductivity, thermal diffusivity, and specific heat per unit volume. [7]

Note 2 to entry: To define the time window that is used to determine both the thermal conductivity and diffusivity from one single experiment, the theory of sensitivity coefficients is used. Through this theory, which deals with a large number of experiments and considers the constants, q, as variables, it has been established that

$$0{,}30 < t_{max} \cdot \alpha / r^2 < 1{,}0$$

where

r is the mean radius of the outermost spiral of the probe.

Assuming $\kappa = 2$, this expression can be rewritten as

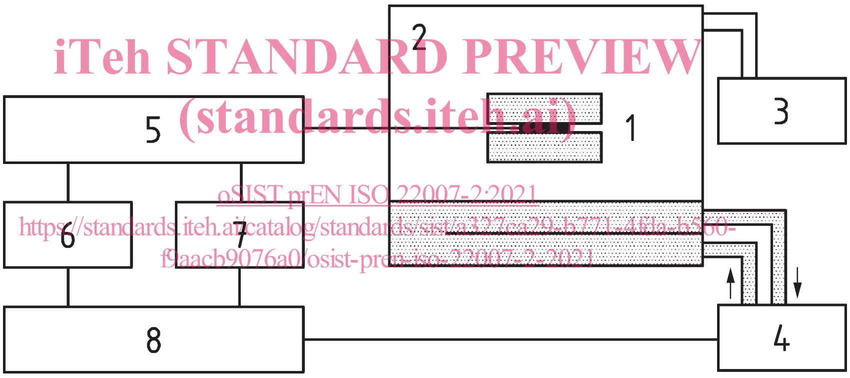
$$1{,}1r < \Delta p_{prob} < 2{,}0r$$

4 Principle

A specimen containing an embedded hot disc probe of negligible heat capacity is allowed to equilibrate at a given temperature. A heat pulse in the form of a stepwise function is produced by an electrical current through the probe to generate a dynamic temperature field within the specimen. The increase in the temperature of the probe is measured as a function of time. The probe operates as a temperature sensor unified with a heat source (i.e. a self-heated sensor). The response is then analysed in accordance with the model developed for the specific probe and the assumed boundary conditions.

5 Apparatus

5.1 A schematic diagram of the apparatus is shown in Figure 1.



Key

1 specimen with probe
2 chamber
3 vacuum pump
4 thermostat
5 bridge circuit
6 voltmeter
7 voltage source
8 computer

Figure 1 — Basic layout of the apparatus

5.2 A typical hot disc probe is shown in Figure 2. Convenient probes can be designed with diameters from 2 mm to 200 mm, depending on the specimen size and the thermal-transport properties of the material to be tested. The probe is constructed as a bifilar spiral etched out of a (10 ± 2) µm thick metal foil and covered on both sides by thin (from 7 µm to 100 µm) insulating film. It is recommended that nickel or molybdenum be used as the heater/temperature-sensing metal foil due to their relatively high temperature coefficient of electrical resistivity and stability over a wide temperature range. It is recommended that polyimide, mica, aluminium nitride, or aluminium oxide be used as the insulating film, depending on the ultimate temperature of use. The arms of the bifilar spiral forming an essentially circular probe shall have a width of (0,20 ± 0,03) mm for probes with an overall diameter of 15 mm or