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01-september-2016

Polimerni materiali - Ugotavljanje toplotne prevodnosti in toplotne razprševalnosti - 1. del: Splošna načela (ISO/DIS 22007-1:2016)

Plastics - Determination of thermal conductivity and thermal diffusivity - Part 1: General principles (ISO/DIS 22007-1:2016)

Kunststoffe - Bestimmung der Wärmeleitfähigkeit und der Temperaturleitfähigkeit - Teil 1: Allgemeine Grundlagen (ISO/DIS 22007-1:2016)

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Plastiques - Détermination de la conductivité thermique et de la diffusivité thermique - Partie 1: Principes généraux (ISO/DIS 22007-1:2016)

Ta slovenski standard je istoveten z: **prEN ISO 22007-1**

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ICS:

83.080.01	Polimerni materiali na splošno	Plastics in general

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DRAFT INTERNATIONAL STANDARD
ISO/DIS 22007-1

ISO/TC **61**/SC **5** Secretariat: **DIN**

Voting begins on: **2016-06-15** Voting terminates on: **2016-09-06**

Plastics — Determination of thermal conductivity and thermal diffusivity —

Part 1: General principles

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

Partie 1: Principes généraux

ICS: 83.080.01

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ISO/CEN PARALLEL PROCESSING

This draft has been developed within the International Organization for Standardization (ISO), and processed under the **ISO lead** mode of collaboration as defined in the Vienna Agreement.

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Reference number
ISO/DIS 22007-1:2016(E)

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The committee responsible for this document is ISO/TC 61, *Plastics*, Subcommittee SC 5, *Physical-chemical properties*.

This second edition cancels and replaces the first edition (ISO 22007-1:2009), which has been technically revised.

ISO 22007-1, *Plastics — Determination of thermal conductivity and thermal diffusivity,* consists of the following parts:

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— Part 1: General principles

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

— Part 3: Temperature wave analysis method

— Part 4: Laser flash method

— Part 5: Results of interlaboratory testing of poly(methyl methacrylate) samples [Technical Report]

— Part 6: Comparative method for low thermal conductivities using a temperature-modulation technique

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Plastics — Determination of thermal conductivity and thermal diffusivity —

Part 1: General principles

1 Scope

This part of ISO 22007 describes the background to methods for the determination of the thermal conductivity and thermal diffusivity of polymeric materials. Different techniques are available for these measurements and some may be better suited than others for a particular type, state and form of material. This part of ISO 22007 provides a broad overview of these techniques. Standards specific to these techniques, as referenced in this part of ISO 22007, are used to carry out the actual test method.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 472, *Plastics — Vocabulary*

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3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 472 and the following apply.

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3.1
heat pulse
heat change in the form of a pulse produced by a heat source

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3.2
heat pulse energy
amount of heat produced by a heat source within the heat pulse

Note 1 to entry: It is expressed in joules (J).

3.3
heat source
heater in the form of a wire, strip, plate or foil embedded within or attached to a test specimen or an area irradiated by incident light, e.g. a laser

3.4
heat flux
q
heat source output produced by a planar source per unit time and unit area

Note 1 to entry: It is expressed in watts per square metre (W/m2).

3.5
linear heat flow
heat source output produced by a linear source per unit time and unit length

Note 1 to entry: It is expressed in watts per metre (W/m).

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3.6
penetration depth
characteristic depth used for describing the extent of heat penetration into the specimen during a transient measuring process

Note 1 to entry: It is expressed in metres (m).

3.7
temperature transient
temporary perturbation of temperature in a system initially at a uniform temperature due to a heat pulse for a period during which the system does not attain equilibrium

3.8
volumetric heat capacity
product of the density and the heat capacity

Note 1 to entry: It is expressed in joules per cubic metre kelvin [J/(m3·K)].

3.9
thermal effusivity
b

heat transport property given by the square root of the product of thermal conductivity and volumetric heat capacity: $b = \sqrt{\lambda \cdot \rho \cdot c}$

where

λ is the thermal conductivity in watt per metre kelvin [W/(m·K)];

ρ is the density in kilogram per cubic metre [kg/m^3];

c_p is the heat capacity in joule per kelvin kilogram [J/(K·kg)]

Note 1 to entry: It is expressed in joules per square metre kelvin square root second [J/(m2·K·s1/2)].

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3.10
thermal resistivity
reciprocal of thermal conductivity

Note 1 to entry: It is expressed in metre kelvins per watt [(m·K)/W].

4 Principles

Thermal conductivity refers specifically to the mode of heat transfer via conduction. In thermal conductivity measurements, other modes of heat transfer, such as convection, radiation and mass transfer, may occur. Where these modes are significant, the measured property is usually referred to as apparent or effective thermal conductivity. Thermal conductivity is affected by the conditions under which it is measured, such as temperature and pressure, as well as compositional variation of the material and orientation of the specimen since some materials are not isotropic.

In steady-state methods, an appropriately sized specimen of simple geometry in contact with a heat source, together with one or more temperature sensors, which may be combined with the heat source or separate from it, is allowed to equilibrate at a given temperature. Transient methods may be contact or non-contact. A thermal transient is produced by a heat pulse to generate a dynamic temperature field within the specimen. The temperature change with time (temperature response) is measured by one or more sensors which may be combined with the heat source, placed at a fixed distance from the source or, as in the case of the laser flash method, located on the other side of the specimen. For measuring very thin films (with thicknesses in the nm range), the thermal reflectance method – an ultra-fast variant of the laser flash analysis – is well suited. Two modes are available: Rear heating/Front detection and

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Front heating/Front detection [[16]]. In any case the response is analysed in accordance with a model, and a set of solutions developed for the representative set-up and designed for the specific geometry and the assumed boundary conditions. Depending upon the geometry of the specimen and source and the means of generating the temperature field, one or more thermo-physical properties can be obtained, either separately or simultaneously. Table 1 contains a summary of the characteristics of different types of transient method and the properties that may be determined by their use.

NOTE 1 Most unfilled plastics fall into the category of materials of intermediate thermal conductivity (0,1 W/m·K to 1 W/m·K). They are an order of magnitude more conductive than foams and insulation but about five times less conductive than ceramics and glass. Their thermal conductivity can increase dramatically if fillers are added. A variety of test methods may be used, depending on the form and state of the plastic. An overview of these methods is given in Clause 5. Detailed test methods are contained in other parts of ISO 22007 and in other standards referenced.

NOTE 2 Reference materials are necessary to verify the performance of primary methods and to calibrate secondary methods. A number of solid materials have been characterized by national standards laboratories, such as NPL, NIST, LNE, NMIJ and PTB, but currently only poly(methyl methacrylate) and PyrexText ® 7740Text[1)] glass have a thermal conductivity which is in the same range as those of most polymer and polymer-filled materials. Polydimethylsiloxane and glycerol are well characterized fluid reference materials with thermal conductivities in the same range as those of plastics.

Table 1 — Basic characteristics of transient methods

Type of method	Heat source/ heat source geometry	Mode of heat generation	Heat source/temperature sensor configuration	Measured and/or derived parameters
Hot wire/line source/ hot strip	Contact/ Line, strip	Step-wise	Combined [a] or separate [b]	λ, α (C_p and b in some versions of the method)
Pulse transient	Plane	Pulse	Separate	α, C_p, λ
Plane source transient	Contact/ Plane	Pulse	Combined	α, C_p, λ
Laser or Light Flash	Laser, Xenon lamp/plane	Pulse	Separate	α, C_p, λ
λ = thermal conductivity; α = thermal diffusivity; b = thermal effusivity; C_p = specific heat				
[a] One sensor.				
[b] Two sensors.				

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5 Test methods

5.1 General

A number of test methods have been developed to provide a means of measuring thermal conductivity and thermal diffusivity based upon the basic principle outlined above. An overview of these methods is given in the following subclauses. Some of the contact methods are summarized in Table 2 and then further explained in more detail. Complete details of the contact and non-contact test methods described in 5.4 to 5.6 can be found in ISO 22007-2, ISO 22007-3, ISO 22007-4 and ISO 22007-6.

1) Pyrex is a registered trademark of Corning Incorporated. This information is given for the convenience of users of this part of ISO 22007 and does not constitute an endorsement by ISO of this product.

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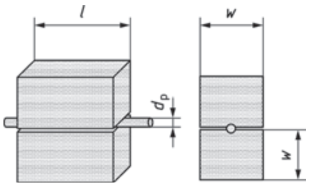
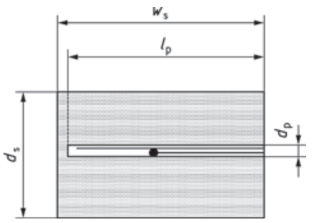
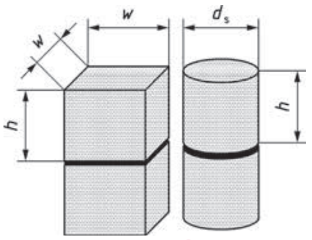
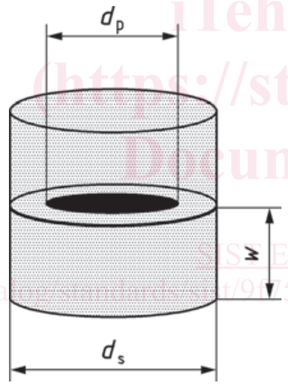
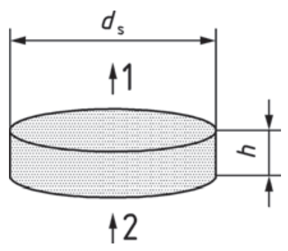
Table 2 — Schematic diagrams of various transient experimental methods showing critical dimensions

Method	Specimen set-up	Characteristic parameters	Ideal model
Hot wire [a]		l = specimen length w = specimen width, thickness d_p = wire probe diameter	$200d_p < w$ $l > 4w$
Line source [a]		w_s = active zone l_p = probe length d_p = probe diameter **d_s = specimen diameter**	$w_s > 1{,}5l_p$ $l_p > 33d_p$ **$d_s > 6d_p$**
Hot plate [b]		w = width, thickness h = height **d_s = specimen diameter**	$w, h, d_s > 3\sqrt{\propto t_{max}}$ where t_{max} is the maximum measurement time
Plane source transient [b]		d_p = heat source diameter d_s = specimen diameter w = specimen thickness	$d_s - d_p > 4\sqrt{\propto t_{max}}$ where t_{max} is the maximum measurement time
Laser or light flash[c]		h = specimen thickness d_s/h = ratio between specimen diameter (d_s) and thickness (h) 1 = IR detector 2 = power source (laser or xenon lamp)	$d_s/h > 5$ The diameter d_s or side length of the sample shall be > 10 mm

[a] Unless the specimen is a liquid, a suitable groove or hole has to be made for the hot wire or line source.

[b] Good thermal contact has to be established between the strip or disc and the specimen.

[c] Round or rectangular sample geometries possible

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In contact methods, the accuracy of the measurement result depends strongly on a good thermal contact between the sensor and the sample. Enough uniaxial pressure should therefore be applied to press the various parts of the specimen and the heat source together. Heat sink paste can be used to improve contact, but there should be no heat sink paste outside the heater, or the temperature field can be disturbed. Furthermore, the use of heat sink pastes can contribute to the uncertainty of the measurement and their effect must be adequately quantified for accurate results.

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