

ISO/FDIS-22007-1:2023(E)

ISO-/TC-61/SC-5

Secretariat:-DIN

Date: 2023-11-24

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~~*

Partie 1: Principes généraux

ITeH Standards
(<https://standards.iteh.ai>)
Document Preview

ISO/FDIS 22007-1

<https://standards.iteh.ai/catalog/standards/sist/89ed787a-4c00-4a91-8f8a-1ad0c00222c5/iso-fdis-22007-1>

FDIS stage

Edited DIS - MUST BE USED

© ISO 2023

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
~~Email~~E-mail: copyright@iso.org
Website: www.iso.org~~www.iso.org~~

Published in Switzerland

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

[ISO/FDIS 22007-1](#)

<https://standards.iteh.ai/catalog/standards/sist/89ed787a-4c00-4a91-8f8a-1ad0c00222c5/iso-fdis-22007-1>

Contents

Foreword	v
1 Scope	1
2 Normative references.....	1
3 Terms and definitions	1
4 Principles.....	3
5 Test methods	4
5.1 General	4
5.2 Hot-wire method.....	7
5.3 Line-source method	8
5.4 Transient plane source method	9
5.5 Temperature wave analysis method.....	10
5.6 Light flash method	11
5.7 Steady-state methods.....	11
5.7.1 Guarded hot-plate method	11
5.7.2 Guarded heat flow meter method and heat flow meter method	12
5.8 Comparative method for low thermal conductivities using a temperature-modulation technique	14
5.9 Intercomparison of thermal conductivity and thermal diffusivity methods for plastics.....	14
6 Test report	14
Annex A (informative) Sources of uncertainty on measuring thermal transport properties	16
Bibliography	22

<https://standards.iteh.ai/catalog/standards/sist/89ed787a-4c00-4a91-8f8a-1ad0c00222c5/iso-fdis-22007-1>

Foreword — iv

1 — Scope — 1

2 — Normative references — 1

3 — Terms and definitions — 1

4 — Principles — 2

5 — Test methods — 3

5.1 — General — 3

5.2 — Hot-wire method — 5

5.3 — Line-source method — 6

5.4 — Transient plane source method — 6

5.5 — Temperature wave analysis method — 7

5.6	Light flash method	8
5.7	Steady state methods	9
5.7.1	Guarded hot plate method	9
5.7.2	Guarded heat flow meter method and heat flow meter method	10
6	Test report	11
Annex A (informative) Sources of uncertainty on measuring thermal transport properties		12
A.1	General	12
A.2	Individual sources of uncertainty	12
A.3	Uncertainty with steady-state and transient methods	13
A.3.1	General	13
A.3.2	Guarded hot plate method (ISO 8302)	13
A.3.3	Hot wire method (ISO 8894-1 and ISO 8894-2)	13
A.3.4	Transient plane source (hot disc) method (ISO 22007-2)	13
A.3.5	Temperature wave analysis method (ISO 22007-3)	14
A.3.6	Light flash method (ISO 22007-4)	15
A.3.7	Temperature modulation technique (ISO 22007-6)	15
A.3.8	Statistical errors	15
A.3.9	Auxiliary errors	15
Bibliography		17

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

[ISO/FDIS 22007-1](#)

<https://standards.iteh.ai/catalog/standards/sist/89ed787a-4c00-4a91-8f8a-1ad0c00222c5/iso-fdis-22007-1>

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 document 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 249, *Plastics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 22007-1:2017), which has been technically revised.

The main changes are as follows:

- the terms and definitions which are not used in the document have been deleted from ~~Clause 3~~; ~~Clause 3~~;
- a new term contact resistance (~~3.7~~see 3.7) has been added;
- laser flash method has been changed to light flash method.

A list of all parts in the ISO 22007 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Plastics — Determination of thermal conductivity and thermal diffusivity —

Part 1: General principles

SAFETY STATEMENT — Persons using this document should be familiar with normal laboratory practice, if applicable. This document does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to determine any regulatory requirements prior to use.

1 Scope

This document 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 can be better suited than others for a particular type, state and form of material. This document provides a broad overview of these techniques. Standards specific to these techniques, as referenced in this document, are used to carry out the actual test method.

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 472, *Plastics — Vocabulary*

3 Terms and definitions

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

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

- ~~ISO~~ ISO Online browsing platform: available at <https://www.iso.org/obp>~~https://www.iso.org/obp~~
- ~~ECIEC~~ Electropedia: available at <https://www.electropedia.org/>~~https://www.electropedia.org/~~

3.1

heat pulse

heat change in the form of a pulse produced by a *heat source* ~~(3.1)~~**(3.1)**

3.2

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

3.3

heat flux

q

heat source ~~(3.1)~~(3.1) 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).

3.4

thermal 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

3.5

volumetric heat capacity

product of the density and the specific heat capacity

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

3.6

thermal effusivity

b

heat transport property given by the square root of the product of thermal conductivity and volumetric heat capacity ~~(3.5)~~(3.5):

$$b = \sqrt{\lambda \cdot \rho \cdot c_p}$$

$$b = \sqrt{\lambda \cdot \rho \cdot c_p}$$

iTeh Standards
(<https://standards.itih.ai>)
Document Preview

where

[ISO/FDIS 22007-1](#)

<https://standards.itih.ai/standards/iso-22007-1> is the thermal conductivity in watt per metre kelvin [W/(m · K)]; 1ad0c00222c5/iso-fdis-22007-1

ρ is the density in kilogram per cubic metre [kg/m³];

c_p is the specific 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 · s^{1/2})].

3.7

contact resistance

surface thermal resistance

STR

R

thermal resistance due to the conditions of contact of solids

Note 1-to-entry: The amount of heat that passes through a unit heat transfer area is proportional to the temperature difference between its two sides and inversely proportional to the thermal resistance R .

The thermal resistance R of a material of thickness d and thermal conductivity λ is defined as

$$R = \frac{d}{\lambda}$$

$$R = \frac{d}{\lambda}$$

If heat passes in series through different materials, the overall thermal resistance is found as the sum of the individual materials.

Note 2 to entry: It is expressed in square meter kelvin per watt [(m² · 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 light 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 front heating/front detection. 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 methods 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).

NOTE 2 Poly (methyl methacrylate) and glass fibre board IRMM-440 and glass ceramic BCR-724¹ 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.

NOTE 3 The thermal conductivity λ can be obtained by multiplying the thermal diffusivity α with the volumetric heat capacity such as the specific heat capacity at constant pressure c_p multiplied by density ρ , i.e. $\lambda = \alpha \cdot c_p \cdot \rho$.

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)

¹ Glass fibre board IRMM-440 and glass ceramic BCR-724 are products supplied by the Joint Research Centre (JRC) of the European Commission. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the products named.

Type of method	Heat source/ heat source geometry	Mode of heat generation	Heat source/temperature sensor configuration	Measured and/or derived parameters
				versions of the method)
Pulse transient	Plane	Pulse	Separate	α, c_p, λ
Transient plane source	Contact/Plane	Pulse, step- wise	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 capacity.
a. — One sensor.
b. — Two sensors.

Annex A provides information on sources of uncertainty on measuring thermal transport properties.

5 Test methods

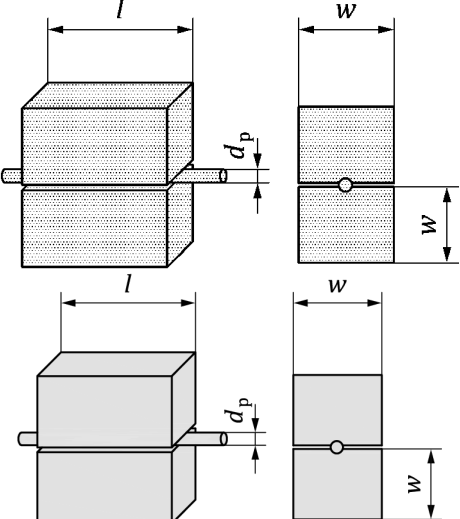
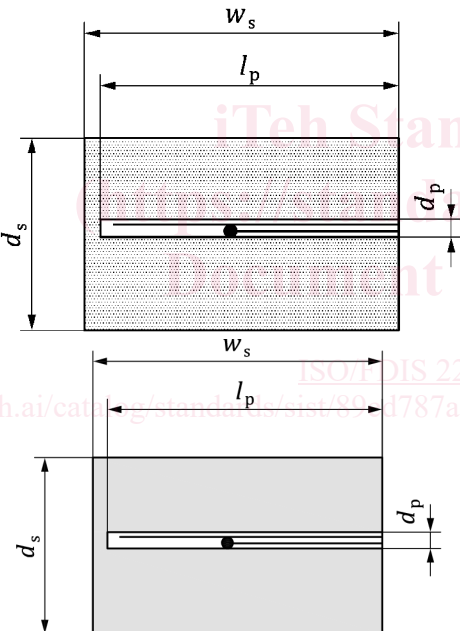
5.1 General

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 [5.4.5.4](#) to [5.6.5.6](#) can be found in ISO 22007-2, [ISO 22007-3](#) and [ISO 22007-4](#).

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.

NOTE In some cases, heat sink pastes are used to improve thermal contact.

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

Method	Specimen set-up	Characteristic parameters	Ideal model
<p>Hot wire^a</p>		<p> l = specimen length w = specimen width, thickness d_p = wire probe diameter </p>	<p> $200d_p < w$ $l > 4w$ </p>
<p>Line source^a</p>		<p> w_s = active zone l_p = probe length d_p = probe diameter d_s = specimen diameter </p>	<p> $w_s > 1,5l_p$ $l_p > 33d_p$ $d_s > 6d_p$ </p>