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# Fine ceramics (advanced ceramics, advanced technical ceramics) — Measurement method for normal spectral emissivity using blackbody reference with an FTIR spectrometer

*Céramiques techniques — Méthode de mesure de l'émissivité spectrale normale utilisant un corps noir de référence avec un spectromètre FTIR*



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# Contents

Page





 

# Foreword

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This document was prepared by Technical Committee ISO/TC 206, *Fine ceramics*.



# Fine ceramics (advanced ceramics, advanced technical ceramics) — Measurement method for normal spectral emissivity using blackbody reference with an FTIR spectrometer

## 1 Scope

This document specifies a method used for the determination of normal spectral emissivity and normal quasi-total emissivity of fine ceramics using blackbody reference with a Fourier transform infrared spectrometer (FTIR) at elevated temperatures. This method is applicable to fine ceramics, ceramic matrix composites, and continuous fibre-reinforced ceramic matrix composites which are opaque and highly non-reflective at wavelengths between 1,67 µm and 25 µm. The applicable temperature range is approximately 350 K to 1 100 K.

## 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.



IEC 60584-2, *Thermocouples — Part 2: Tolerances*

IEC 60751, *Industrial platinum resistance thermometers and platinum temperature sensors*



## 3 Terms, definitions and symbols

For the purposes of this document, the following terms and definitions apply.

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

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

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

**3.1**
**emissivity**
$\varepsilon$
ratio of the radiant emittance of a substance (specimen) to the radiant emittance of a *blackbody* (3.2) at the same temperature

**3.2**
**blackbody**
ideal thermal radiator that absorbs all incident radiation completely, whatever the wavelength, direction of incidence or polarization

**3.3**
**spectral emissivity**
$\varepsilon_S(\lambda, T)$
*emissivity* (3.1) of a specimen at a defined wavelength $\lambda$ and temperature $T$

**3.4**
**normal spectral emissivity**
$\varepsilon_{ns}(\lambda, T)$
*emissivity* (3.1) perpendicular to the specimen at a defined wavelength $\lambda$ and temperature $T$

**3.5**
**normal total emissivity**
$\varepsilon_n(T)$
ratio of the normal component of the total emissive power of a specimen surface to the normal component of the total emissive power of a blackbody at the same temperature $T$

**3.6**
**normal quasi-total emissivity**
$\varepsilon_n(\lambda_1, \lambda_2, T)$
normal emissivity between $\lambda_1$ and $\lambda_2$ at temperature $T$

Note 1 to entry: Calculated as the ratio of the normal component of the emissive intensity of a specimen between $\lambda_1$ and $\lambda_2$ to the normal component of the emissive intensity of a blackbody between $\lambda_1$ and $\lambda_2$ at the same temperature $T$.

## 4 Principle

The infrared radiance spectrum data from a specimen surface and from a blackbody furnace are measured using an FTIR spectrometer. The normal spectrum emissivity of a specimen is determined by direct comparison to a blackbody reference data at the same temperature.



Integrating the infrared radiance spectrum data in the specified wavelength range numerically, normal quasi-total emissivity is calculated.



## 5 Apparatus

### 5.1 Measurement system

The measurement system consists of a Fourier transform infrared spectrometer (FTIR), specimen heating device, blackbody furnace, and temperature measuring devices as shown in Figure 1.

### 5.2 Fourier transform infrared spectrometer (FTIR)

Infrared radiation from a specimen or a blackbody furnace is let into a Mickelson interferometer of an FTIR through an external optical path. Thereby, an interferogram of infrared radiation is obtained. The infrared radiance spectrum is obtained numerically by Fourier transformation processing from the interferogram.

The optical system including a Mickelson interferometer of an FTIR shall be filled with dry $N_2$ or dry air of which the dew point is lower than 220 K to reduce the effect of $H_2O$ and $CO_2$ in air. Vacuum may be used.

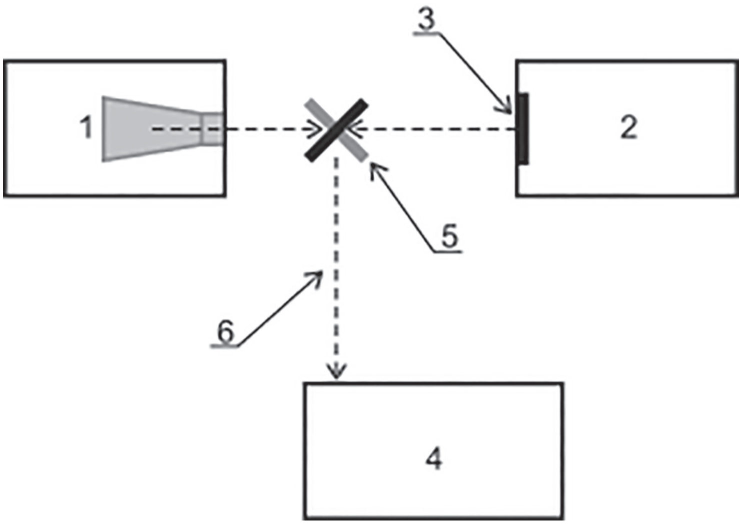
The measurement spot area at the sample position and at the blackbody furnace positions shall be measured preliminarily.

### 5.3 Specimen heating device

A specimen shall be heated using a heating device such as electrical resistance heating elements, heat-pipes, heat-transfer media, etc. The specimen surface temperature shall be well controlled to within ± 3 K.

An example of a specimen heating device is depicted in Figures 2 and 3.



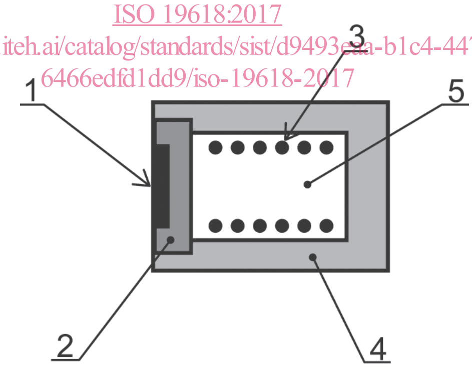

**Key**

1 blackbody furnace
2 specimen heating device
3 specimen
4 FTIR spectrometer
5 switchable mirror
6 external optical path



**Figure 1 — Measurement system**

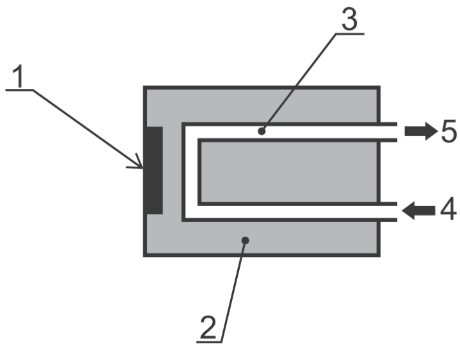





**Key**

1 specimen
2 hot plate (block)
3 resistance heater elements
4 thermal insulator
5 cavity

**Figure 2 — Example of a specimen heating device: electrical resistance furnace**




**Key**

1 specimen
2 device body
3 channel for heat transfer media
4 inlet
5 outlet

**Figure 3 — Example of a specimen heating device: heat transfer media**

### 5.4 Blackbody furnace



Total emissivity of a blackbody furnace shall be higher than 0,95 and shall be internationally traceable. The aperture size shall be greater than three times the measurement spot area of an FTIR.

### 5.5 Temperature measuring devices and thermometer



All temperature measuring devices (temperature sensor) shall be internationally traceable.

The temperature sensor used for a test specimen shall be thermocouple in accordance with IEC 60584-2, or resistance temperature detector in accordance with IEC 60751.

The sensor diameter shall be as small as possible to prevent heat transfer through the sensor wires.

### 5.6 Mirror

A mirror with reflection index of more than 0,95 is used to measure background infrared radiance spectrum at room temperature. A gold-coated mirror should be used.

## 6 Test specimens

A material shall be opaque and highly non-reflective at wavelengths between 1,67 µm and 25 µm.

— The specimen shall have plain plate geometry. The specimen area shall be more than three times the measurement spot area of a spectrometer at a measurement position. Typical dimensions are 2 mm to 6 mm thick, and 10 mm to 50 mm in diameter or in square.

— The back side of a specimen shall be flat and smooth to be in close contact with a specimen heating device.

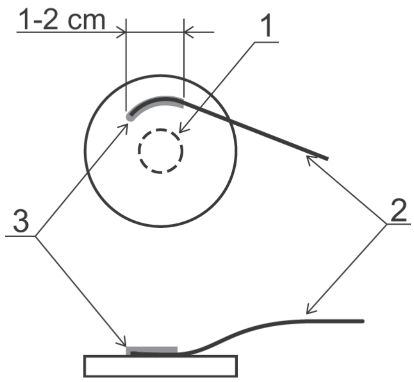
— The machining parameters for specimen surfaces should be documented.

A temperature sensor such as a thermocouple shall be contacted firmly to a specimen. The two methods shown in Figure 4 should be used.

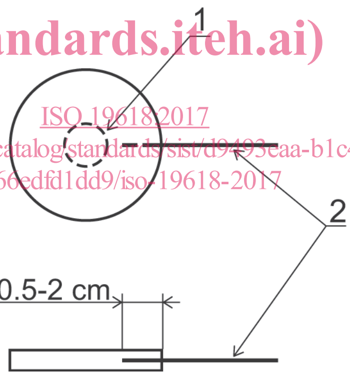
— A temperature sensor is bonded on a specimen surface using welding or adhesion. The temperature sensor and adhesive shall not appear inside of the measurement spot area. A few centimetres of the temperature sensor should be bonded on the surface to prevent thermal conduction through the sensor wires.

— A temperature sensor is embedded into a small hole machined from a specimen side surface. The embedded length should be more than 5 mm to 20 mm to prevent thermal conduction through the sensor wires.




**a) Bonded on a specimen using adhesive**






**b) Embedded in a specimen from side surface**

**Key**

1 measurement spot area

2 temperature sensor

3 adhesive

**Figure 4 — Temperature sensor attachment methods**