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TEST REPORT

Issued for :	FENSOR SAS 4, rue du docteur Heulin, 75017 PARIS France
Purchase order :	Order n° BC210690 of 09 June 2021
Object :	Measurement of the spectral near-normal emissivity in the spectral range 3 to 17 µm,
Sample Identification :	Black body surface for calibrator models T-30NIR / T-30NIR-H, 25NL, 35NL and 45NL

1 OBJECT OF THE TEST

The test consisted in :

- Measuring the spectral near-normal emissivity on the surface of the sample at 23°C in the spectral range 3 to 17 µm.

2 IDENTIFICATION OF THE SAMPLE

The sample supplied by FENSOR was identified: "Black body surface for model calibrator T-30NIR / T-30NIR-H, 25NL, 35NL and 45NL ». The sample was in circular shape with a diameter of 14.5 mm.

3 CONDITIONS OF MEASUREMENT

The parameter measured was the near-normal hemispherical spectral reflectance. The measurements were done using a BRUCKER Vertex 70 Fourier Transform Spectrometer (FTIR) equipped with an integrating sphere. The reflectance measurement method is described in Annex 1.

The spectral near-normal emissivity was calculated from the measured reflectance.

The parameters set for the measurements were:

- Sample temperature : 23 ± 2°C,
- Analysed surface area : diameter 8 mm,
- Angle of incidence : 8°,
- Spectral range : 3 à 17 µm.
- Spectral resolution : 4 cm^{-1}.

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4 RESULTS OF SPECTRAL NEAR-NORMAL EMISSIVITY MEASUREMENTS

The table below gives, by step of 1 µm, the spectral near-normal emissivity results. The average spectral near-normal emissivity curve obtained is presented in Annex 2.

Wavelength (µm)	Spectral near-normal emissivity	Uncertainty
3.0	0.971	0.006
4.0	0.917	0.006
5.0	0.906	0.006
6.0	0.948	0.006
7.0	0.937	0.006
8.0	0.989	0.006
9.0	0.983	0.006
10.0	0.987	0.006
11.0	0.973	0.006
12.0	0.953	0.006
13.0	0.940	0.006
14.0	0.931	0.008
15.0	0.920	0.010
16.0	0.913	0.012
17.0	0.925	0.015

The uncertainties are expressed by multiplying the standard deviations determined for the results by the conventional coefficient k = 2 (95% confidence level).

The measurements were done by Marc Grélard on 17 June 2021.

Trappes, 2 July 2021

The Test Officer

Jacques HAMEURY

The results mentioned are applicable only to samples, products or materials submitted to the LNE and as defined in this document.

ANNEX 1

SPECTRAL NEAR-NORMAL EMISSIVITY MEASUREMENT

1. PRINCIPLE OF MEASUREMENT

The measured parameter is the near-normal hemispherical reflectance (denoted $\rho'^{\cap}_{\lambda}$); this parameter represents the proportion of radiation reflected in a solid angle of 2π steradians (half-space) when the surface is irradiated by a spectral directional beam coming from a defined direction. The near-normal hemispherical reflectance being known, the near-normal emissivity (denoted ε'_{λ}) can be calculated but only for opaque materials. If the material is not opaque, the spectral transmittance ($\tau'^{\cap}_{\lambda}$) must be known.

The relation used for the calculation of the emissivity is, for opaque materials, a consequence of Kirchoff's laws:

$$\varepsilon'_{\lambda} = 1 - \rho'^{\cap}_{\lambda}$$

or if the material is isothermal and semi-transparent:

$$\varepsilon'_{\lambda} = 1 - \rho'^{\cap}_{\lambda} - \tau'^{\cap}_{\lambda}$$

The principal interest of this indirect technique for measurement of near-normal emissivity is that it doesn't require a very precise measurement of the surface temperature as it is required for the direct technique of measurement by comparison to a black body. The indirect technique gives acceptable uncertainties whatever the material.

2. DESCRIPTION OF THE MEASUREMENT SETUP

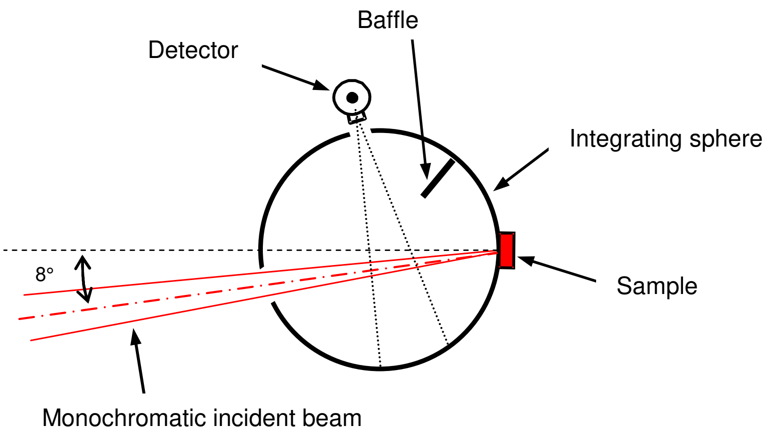

Figure 1 : Optical configuration for the measurement of the spectral near-normal reflectance with an integrating sphere

The incident beam is shaped by a set of mirrors and optical stops. The incident beam is produced by a hot source (a lamp or a heated ceramic rod) and is spectrally filtered or modulated. The internal walls of the integrating sphere are very reflective and very diffusing. After the reflection of the incident beam on the sample surface, the radiation is reflected several times on the internal walls of the sphere and is diffused angularly at each reflection. A radiation, in theory uniformly distributed, exists in the sphere. The detector sees a portion of the sphere wall and delivers a signal proportional to the incident radiation flux multiplied by the product of the near-normal reflectance of the sample by the mean reflectance of the sphere. The system (sphere and detector) must be calibrated by measuring the signal for a reference sample calibrated in spectral near-normal reflectance.

The measurement procedure is:

- the reference sample is placed at the "sample port" of the sphere,
- the reference signal is measured,
- the sample to be tested is placed at the "sample port",
- the sample signal is measured,
- the spectral reflectance is calculated using the relation:

$$\rho_\lambda = \frac{S_\lambda}{S_{\lambda ref}} * \rho_{\lambda\,\mathrm{ref}}$$

where :

- ρ_λ : spectral reflectance of the sample,
- $\rho_{\lambda\,\mathrm{ref}}$: spectral reflectance of the reference standard,
- S_λ : sample signal,
- $S_{\lambda\,\mathrm{ref}}$: reference *signal.*

In practice, the measured signals are corrected of the standard/sample substitution. Indeed, the replacement of the reference standard by the tested sample modifies the mean reflectance of the cavity created by the sphere and the sample area visible from the inside of the sphere. Thus, the overall sensitivity of the system depends on the reflectance of the sample placed at the sample port.

ANNEX 2

THE AVERAGE SPECTRAL NEAR-NORMAL EMISSIVITY CURVE (8°) OF :
« BLACK BODY SURFACE FOR MODEL CALIBRATOR T-30NIR / T-30NIR-H, 25NL, 35NL AND 45NL ».