

Glass in building — Determination of the emissivity

The European Standard EN 12898:2001 has the status of a
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National foreword

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English version

Glass in building - Determination of the emissivity

Verre dans la construction - Détermination de l'émissivité

Glas im Bauwesen - Bestimmung des Emissionsgrades

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 129 "Glass in building", the secretariat of which is held by IBN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2001, and conflicting national standards shall be withdrawn at the latest by July 2001.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies a procedure for determining the emissivity at room temperature of the surfaces of glass and coated glass.

The emissivity is necessary for taking into account heat transfer by radiation from surfaces at the standard temperature of 283 K in the determination of the U value and of the total solar transmittance of glazing according to [1] to [5].

The procedure, being based on spectrophotometric regular reflectance measurements at near normal incidence on non-infrared transparent materials, is not applicable to glazing components with at least one of the following characteristics:

- a) with rough or structured surfaces where the incident radiation is diffusely reflected;
- b) with curved surfaces where the incident radiation is regularly reflected at angles unsuitable to reach the detector while using regular reflectance accessories;
- c) infrared transparent.

However, it may be applied with caution to any glazing component provided its surfaces are flat and non-diffusing (see 3.6) and it is non-infrared transparent (see 3.7).

2 Symbols

ε	total corrected emissivity at 283 K
ε_n	total normal emissivity at 283 K
E	reading of the spectrophotometer with the sample placed on the sample support of the reflectance accessory
E_0	the instrument reading without placing anything on the sample support
E_{st}	the instrument reading with the reference mirror replacing the sample
R_n	total normal reflectance at 283 K
$R_n(\lambda)$	spectral normal reflectance
$R_{n,st}$	spectral normal reflectance of the reference mirror
$T_n(\lambda)$	spectral normal transmittance
T_n	total normal transmittance at 283 K

3 Terms and definitions

For the purposes of this European Standard, the following terms and definitions apply:

3.1 infrared

5 μm to 50 μm spectral range.

3.2 emissivity

ratio of the energy emitted by a given surface at a given temperature to that of a perfect emitter (black body with normal and corrected emissivity = 1,0) at the same temperature.

NOTE Two different definitions of emissivity should theoretically be used to describe radiation exchange between:

- a) glass surfaces facing each other in multiple glazing (effective emissivity)
- b) a glass surface facing a room (hemispherical emissivity).

However, in practice numerical differences were found to be negligibly small (see [6]). Thus corrected emissivity is used to describe both types of heat exchange with a close approximation.

3.3

regular (specular) reflectance

reflectance according to the laws of geometrical optics, without diffusion.

3.4

diffuse reflectance

reflectance not containing any regular component, due to rough surfaces and/or transparent materials containing inhomogeneous particles.

3.5

hemispherical reflectance

the sum of regular and diffuse reflectance.

3.6

non-diffusing glazing component

glazing component with a diffuse reflectance, measured at the near infrared wavelength of $2\ \mu\text{m}$, $\leq 0,05$ (see clause 7).

NOTE The purpose of this measurement is to ensure that the sample is non-diffusing in the measurement range. Diffuse reflectance measurements in the infrared range are difficult to perform.

3.7

non-infrared transparent glazing component

glazing component with a total normal transmittance at 283 K, measured spectrophotometrically, $\leq 0,05$.

3.8

reference mirror

reference material whose spectral regular reflectance is traceable to a standard material certified by a metrological laboratory.

4 Brief outline of the procedure to determine corrected emissivity

The procedure for determining the corrected emissivity of coated glass surfaces includes the following steps:

- a) the spectral regular reflectance of a non-infrared transparent glazing component at near normal incidence, $R_{\eta}(\lambda)$, shall be determined with an infrared spectrophotometer in the range (5 to 50) μm (see clause 5);
- b) total normal reflectance at 283 K, R_{η} , shall be calculated using the integration procedure specified in clause 6 from the corresponding spectral reflectance values measured according to step a);
- c) total normal emissivity, ε_{η} , shall be calculated from the total normal reflectance as specified in clause 6;
- d) the corresponding corrected emissivity, ε , shall be determined by multiplying normal emissivity by the ratio, $\varepsilon/\varepsilon_{\eta}$, given in Table A.2.

NOTE 1 The corrected emissivity, calculated from the normal emissivity with the help of a multiplicative correction factor, takes into account the effect of the angular distribution of emissivity in the heat transfer calculations of glazing according to [1] to [5].

NOTE 2 Both the normal and the corrected emissivity are total emissivities at 283 K, i.e. they are integrated over the relevant spectral range using as a weighting function Planck's radiation function for a black body at 283 K (see [7]).

For uncoated soda lime glass surfaces or for soda lime glass surfaces with coatings which have no effects on the emissivity the corrected emissivity to be used in the calculations specified in [1] to [5] shall be 0,837 (see [8]). For all other glazing materials or components it shall be measured.

NOTE 3 With reasonable confidence $\varepsilon = 0,837$ can be used for uncoated borosilicate glass and glass ceramics (see [8]).

NOTE 4 For temperatures included in the range 253 to 313 K emissivity is not strongly dependent on the temperature (see [8] and [9]).

5 Spectral normal reflectance and transmittance measurements

5.1 Sample preparation

Samples with a size suitable for being inserted into the sample compartment or placed on the reflectance accessory shall be obtained by cutting or drilling. In doing so, care shall be taken to ensure that the portion of the coated surface probed by the instrument beam is free of damage or any surface contamination.

The procedures recommended by the producer for storing the samples and cleaning their surfaces shall be followed.

The sample shall be supported in a suitable way to ensure that the measuring spot during transmittance and reflectance measurements falls on a flat part.

5.2 Spectral normal reflectance measurements

The spectral regular reflectance curve of the sample at near normal incidence between (5 and 50) μm shall be determined with an infrared spectrophotometer equipped with a specular reflectance accessory at near normal incidence.

5.2.1 Test apparatus

The following equipment shall be used for the measurements:

- a spectrophotometer covering the spectral range 5 μm to 50 μm ;
- a reference mirror (free of surface scratches and contamination, see [7], [9] and [10]) whose spectral regular reflectance at near normal incidence $R_{n,st}(\lambda)$ shall be traceable to a standard material certified by a metrological laboratory;
- a specular reflectance accessory consisting of a suitable array of mirrors and a sample support. When the accessory is placed in the sample compartment of the spectrophotometer and the sample (or reference mirror) placed on the sample support, the instrument beam reaches the detector after being specularly reflected on the surface of the sample (reference mirror) at an angle of incidence $\leq 10^\circ$.

5.2.2 Measurement

The spectral regular reflectance curve of the sample at near normal incidence shall be determined with the relative method. The following measurements are required to determine the spectral normal reflectance of the sample $R_n(\lambda_i)$ at each wavelength λ_i reported in Table A.1:

- E the instrument reading with the sample placed on the sample support of the reflectance accessory;
- E_{st} the instrument reading with the standard replacing the sample;
- E_0 the instrument reading without placing anything on the sample support.

At each wavelength λ_i the sample reflectance $R_n(\lambda_i)$ shall be calculated as follows:

$$R_n(\lambda_i) = \frac{E - E_0}{E_{st} - E_0} \cdot R_{n,st}(\lambda_i) \quad (1)$$

with $R_{n,st}(\lambda_i)$ = spectral normal reflectance of the reference mirror at the wavelength λ_i .

NOTE Metrological laboratories determine the absolute reflectance by comparing the energy of the beam reflected from the sample to that of the incident beam or with the help of a double reflection accessory called "V-W" or "Strong-type" (see [10]). Commercial versions of such devices exist but their construction is far short of the careful layout of the original version. Their accuracy is critically dependent on alignment and beam characteristics (size and divergence)

and is difficult to control in conjunction with commercial spectrophotometers. They should be used only with great caution and under the supervision of a metrological laboratory.

5.2.3 Accuracy

The accuracy is estimated to be of the order of $\pm 0,02$, expressed as absolute uncertainty of regular reflectance (see [7]).

NOTE In annex B information on procedures to improve the measurement accuracy is given.

5.3 Transmittance measurements

Glazing components including at least one glass plate are not infrared transparent and do not request transmittance measurement.

For glazing components not including glass or coated glass the spectral regular transmittance curve of the sample at normal incidence between 5 μm and 50 μm shall be determined with an infrared spectrophotometer by placing it in the sample compartment perpendicularly to the beam.

6 Calculation of total normal reflectance, corrected emissivity and total normal transmittance

6.1 Total normal reflectance

Total normal reflectance, R_n , at a temperature of 283 K shall be determined from the spectral reflectance curve by taking the mathematical average of spectral reflectance, $R_n(\lambda_i)$, measured at the 30 wavelengths (λ_i) given in Table A.1.

$$R_n = \frac{1}{30} \sum_{i=1}^{i=30} R_n(\lambda_i) \quad (2)$$

Such wavelengths are selected at the centre of wavelength intervals for which the energy of Planck's radiation function for a blackbody at 283 K is constant (see [7]).

6.2 Emissivity

Total normal emissivity ε_n at 283 K is given by

$$\varepsilon_n = 1 - R_n \quad (3)$$

NOTE 1 The uncertainty resulting when the measurement range of the spectrometer does not cover the 30 selected wavelengths reported in Table A.1 is discussed in [7].

For soda lime glass and coated soda lime glass the corrected emissivity, ε , shall be determined by multiplying normal emissivity by the ratio given in Table A.2.

NOTE 2 For surfaces other than coated soda lime glass, uncoated soda lime glass, borosilicate glass and glass ceramics the table may be applied with caution, considering that it is not supported by experimental evidence comparable to that obtained for glass (see [6], [8] to [9] and [11] to [13]).

6.3 Total normal transmittance

Where applicable, total normal transmittance at a temperature of 283 K shall be determined from the spectral transmittance curve by taking the mathematical average of spectral transmittance, $T_n(\lambda)$, measured at 30 wavelengths (λ_i) given in Table A.1.

$$T_n = \frac{1}{30} \sum_{i=1}^{i=30} T_n(\lambda_i) \quad (4)$$

7 Diffuse reflectance measurements

Diffuse reflectance at 2 μm for near normal incidence irradiation is determined as the difference between hemispherical reflectance and regular reflectance (see [10]).

NOTE The purpose of this determination is to confirm that a given glazing component consisting of materials other than glass and coated glass is non-diffusing (see 3.6).

Glazing components consisting of float glass, coated float glass and laminated float glass have a negligible diffuse reflectance and do not request diffuse reflectance measurements.

8 Test report

The test report shall state the following

8.1 Sample identification

- sample size (millimetres)
- material(s) of glazing component
- thickness of glazing component (millimetres)
- type of coating (if any, if known) on the surface being measured
- storage, handling and cleaning conditions

8.2 Instrument description

- manufacturer and model code of the spectrophotometer
- type of spectrophotometer (single or double beam or FTIR; spectral range; specify if automatic, if interfaced to a computer; if purged with gas)
- operating conditions during the scan
- manufacturer and model of the reflectance accessory and angle of incidence
- type of reference mirror and source of calibration

8.3 Results of the measurements

- normal reflectance values at the 30 selected ordinates
- total normal reflectance
- total normal emissivity
- total corrected emissivity
- normal transmittance values at the 30 wavelengths, where applicable
- total normal transmittance, where applicable

Intermediate values shall be quoted to three decimals in the test report.

When normal and corrected emissivities are presented in manufacturers' promotional material, the data shall be given to two decimal figures.

Annex A
(normative)

Tables for determining total normal reflectance and total corrected emissivity

Table A.1 - 30 selected wavelengths (λ_i) for determining total normal reflectance, R_n , at 283 K

Ordinal number i	Wavelength(λ_i) μm	Ordinal number i	Wavelength (λ_i) μm
1	5,5	16	14,8
2	6,7	17	15,6
3	7,4	18	16,3
4	8,1	19	17,2
5	8,6	20	18,1
6	9,2	21	19,2
7	9,7	22	20,3
8	10,2	23	21,7
9	10,7	24	23,3
10	11,3	25	25,2
11	11,8	26	27,7
12	12,4	27	30,9
13	12,9	28	35,7
14	13,5	29	43,9
15	14,2	30	50,0 ^a

^a 50 μm has been chosen because this wavelength is the limit of most commercially available spectrophotometers. This approximation has a negligible effect on the accuracy of the calculation.

Table A.2 - Factors to compute total corrected emissivity ε from total normal emissivity ε_n

Total normal emissivity ε_n	Ratio $\varepsilon/\varepsilon_n$
0,03	1,22
0,05	1,18
0,1	1,14
0,2	1,10
0,3	1,06
0,4	1,03
0,5	1,00
0,6	0,98
0,7	0,96
0,8	0,95
0,89	0,94

Intermediate values are obtained with sufficient accuracy by linear interpolation or extrapolation.

Annex B (informative)

Procedures to improve the accuracy of spectral normal reflectance measurements

B.1 General

The method described in 5.2 is sensitive to misalignments. The influence of sample tilt errors can be minimized by averaging at least three measurements performed with re-positioned sample.

Specular reflectance measurements carried out with different spectrophotometers generally lead to different results owing to the different actual conditions of measurement vs. ideal conditions (angle of incidence, finite beam size and divergence, viewing angle of the detector, polarization, alignment of the mirrors of the reflectance accessory).

The accuracy of reflectance measurements is influenced by the quality of the instrument, reflectance accessory and reference mirror.

B.2 Spectrophotometer

Uncertainties arise from incorrect wavelength scale, detector non-linearity and non-uniform response over the sensitive window; stray light; divergence of the incident beam (potentially causing vignetting of the reflected beam as its path increases, see [10]).

A range of measurement errors typical of Fourier Transform spectrophotometers is described in [14].

The wavelength scale can be checked with polystyrene films whose absorption peaks feature minima at known wavelengths.

The photometric accuracy can be checked with the help of rotating sectors which produce a known transmittance by intercepting a given percentage of the instrument beam or of samples with a known transmittance traceable to a reference material certified by a metrological laboratory (see [15]).

B.3 Reference mirror

The reference mirror should have a reflectance as close as possible to that of the sample, to limit errors due to non-linearity of the detector (see [10]).

The accuracy of reflectance measurements improves if the reference mirror is carefully stored and handled (see [7], [9] and [10]).

Some laboratories use as a reference mirror an opaque first surface Al, Ag or Au mirror to which the spectral reflectance suggested by some literature source is attributed. In this case, discrepancies arise due to non-uniform production and storage conditions, non-uniform literature references, insufficient data for wavelengths $> 30 \mu\text{m}$. The experience of interlaboratory comparisons (see [7]) shows that the spread of results becomes worse when such domestically calibrated mirrors are used. For this reason a reference mirror traceable to a metrologically certified material shall be used.

B.4 Reflectance accessory

Care should be taken to ensure that the set of mirrors in the accessory is properly aligned, maximising the detector reading.

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