SLOVENSKI STANDARD
SIST EN 410:2011

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Steklo v gradbeništvu - Določevanje svetlobnih in sončnih karakteristik stekla

Glass in building - Determination of luminous and solar characteristics of glazing

Glas im Bauwesen - Bestimmung der lichtechnischen und trahlungsphysikalischen Kenngrößssen von Verglasungen

Verre dans la construction - Détermination des caractéristiques lumineuses et solaires des vitrages

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ICS:

81.040.20 Steklo v gradbeništvu Glass in building

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EUROPEAN STANDARD

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Glass in building - Determination of luminous and solar characteristics of glazing

Verre dans la construction - Détermination des caractéristiques lumineuses et solaires des vitrages

Glas im Bauwesen - Bestimmung der lichttechnischen und strahlungsphysikalischen Kenngrößen von Verglasungen

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Foreword

This document (EN 410:2011) has been prepared by Technical Committee CEN/TC 129 "Glass in building", the secretariat of which is held by NBN.

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of an identical text or by endorsement, at the latest by August 2011, and conflicting national standards shall be withdrawn at the latest by August 2011.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 410:1998.

The main changes compared to the previous edition are:

a) A procedure is provided for the calculation of the spectral properties of laminated glass.

b) A formula is introduced for determining the total shading coefficient.

c) Table 3 has been updated to make it more practical.

d) Table 6 has been updated in line with the 2004 edition of the publication CIE No 15.

e) The external and internal heat transfer coefficients have been amended slightly to reflect changes to EN 673.

f) Guidance is also given on how to determine the spectral characteristics of screen printed glass.

g) New drawings have been introduced for improved clarity and to conform with CEN rules.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

While this European Standard presents the formulae for the exact calculations of the spectral characteristics of glazing, it does not consider the uncertainty of the measurements necessary to determine the spectral parameters that are used in the calculations. It should be noted that, for simple glazing systems where few measurements are required, the uncertainty of the results will be satisfactory if correct measurements procedures have been followed. When the glazing systems become complex and a large number of measurements are required to determine the spectral parameters, the uncertainty is cumulative with the number of measurements and should be considered in the final results.

The term interface used in this European Standard, is considered to be a surface characterized by its transmission and reflections of light intensities. That is, the interaction with light is incoherent, all phase information being lost. In the case of thin films (not described in this European Standard), interfaces are characterized by transmission and reflections of light amplitudes, i.e. the interaction with light is coherent and phase information is available. Finally, for clarity, a coated interface can be described as having one or more thin films, but the entire stack of thin films is characterized by its resulting transmission and reflection of light intensities.

In Annex B, the procedure for the calculation of spectral characteristics of laminated glass makes specific reference to coated glass. The same procedure can be adopted for filmed glass (e.g. adhesive backed polymeric film applied to glass).

1 Scope

This European Standard specifies methods of determining the luminous and solar characteristics of glazing in buildings. These characteristic can serve as a basis for lighting, heating and cooling calculations of rooms and permit comparison between different types of glazing.

This European Standard applies both to conventional glazing and to absorbing or reflecting solar-control glazing, used as vertical or horizontal glazed apertures. The appropriate formulae for single, double and triple glazing are given.

This European Standard is accordingly applicable to all transparent materials except those which show significant transmission in the wavelength region 5 µm to 50 µm of ambient temperature radiation, such as certain plastic materials.

Materials with light-scattering properties for incident radiation are dealt with as conventional transparent materials subject to certain conditions (see 5.2).

Angular light and solar properties of glass in building are excluded from this standard. However, research work in this area is summarised in Bibliography [1], [2] and [3].

2 Normative references

The following referenced documents are indispensable for the application 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.

EN 673, *Glass in building — Determination of thermal transmittance (U value) — Calculation method*

EN 674, *Glass in building — Determination of thermal transmittance (U value) — Guarded hot plate method*

EN 675, *Glass in building — Determination of thermal transmittance (U value) — Heat flow meter method*

EN 12898, *Glass in building — Determination of the emissivity*

3 Terms and definitions

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

3.1
light transmittance
fraction of the incident light that is transmitted by the glass

3.2
light reflectance
fraction of the incident light that is reflected by the glass

3.3
total solar energy transmittance (solar factor)
fraction of the incident solar radiation that is totally transmitted by the glass

3.4
solar direct transmittance
fraction of incident solar radiation that is directly transmitted by the glass

3.5
normal emissivity
ratio, in a direction normal to the surface, of the emissive power of the surface of the glass to the emissive power of a black body

NOTE Normal emissivity is determined in accordance with EN 12898.

3.6
solar direct reflectance
fraction of the incident solar radiation that is reflected by the glass

3.7
ultraviolet transmittance
fraction of the incident UV component of the solar radiation that is transmitted by the glass

3.8
colour rendering index (in transmission)
change in colour of an object as a result of the light being transmitted by the glass

3.9
shading coefficient
ratio of the solar factor of the glass to the solar factor of a reference glass (clear float)

4 Symbols

Sym.	Deutsch/German/Allemand	Englisch/English/Anglais	Französisch/French/Français
D65	Normlichtart D65	standard illuminant D65	illuminant normalisé D65
UV	Ultravioletter Strahlungsbereich	ultraviolet radiation	rayonnement ultraviolet
τ_{UV}	Ultravioletter Transmissionsgrad	ultraviolet transmittance	facteur de transmission de l'ultraviolet
$\tau(\lambda)$	Spektraler Transmissionsgrad	spectral transmittance	facteur de transmission spectrale
$\rho(\lambda)$	Spektraler Reflexionsgrad	spectral reflectance	facteur de réflexion spectrale
τ_v	Lichtransmissionsgrad	light transmittance	facteur de transmission lumineuse
ρ_v	Lichtreflexionsgrad	light reflectance	facteur de réflexion lumineuse
τ_e	direkter Strahlungstrans-missionsgrad	solar direct transmittance	facteur de transmission directe de l'énergie solaire
ρ_e	direkter Strahlungs-reflexionsgrad	solar direct reflectance	facteur de réflexion directe de l'énergie solaire

g	Gesamtenergiedurchlaß- grad	total solar energy transmittance (solar factor)	facteur de transmission totale de l'énergie solaire ou facteur solaire
R_a	allgemeiner Farbwieder-gabeindex	general colour rendering index	indice général de rendu des couleurs
D_λ	relative spektrale Vertei- lung der Normlichtart D65	relative spectral distribution of illuminant D65	répartition spectrale relative de l'illuminant normalisé D65
$V(\lambda)$	spektraler Hellempfindlich-keitsgrad	spectral luminous efficiency	efficacité lumineuse relative spectrale
α_e	direkter Strahlungsabsorp tionsgrad	solar direct absorptance	facteur d'absorption directe de l'énergie solaire
ϕ_e	Strahlungsleistung (Strahlungsfluß)	incident solar radiant flux	flux énergétique solaire incident
q_i	sekundärer Wärmeabgabe-grad nach innen	secondary internal heat transfer factor	facteur de réémission thermique vers l'intérieur
q_e	sekundärer Wärme-abgabegrad nach außen	secondary external heat transfer factor	facteur de réémission thermique vers l'extérieur
S_λ	relative spektrale Vertei- lung der Sonnenstrahlung	relative spectral distribution of solar radiation	répartition spectrale relative du rayonnement solaire
h_e	Wärmeübergangs- koeffizient nach außen	external heat transfer coefficient	coefficient d'échange thermique extérieur
h_i	Wärmeübergangs- koeffizient nach innen	internal heat transfer coefficient	coefficient d'échange thermique intérieur
ε	korrigierter Emissionsgrad	corrected emissivity	émissivité corrigée
ε_n	normaler Emissionsgrad	normal emissivity	émissivité normale
Λ	Wärmedurchlaßkoeffizient	thermal conductance	conductance thermique
λ	Wellenlänge	wavelength	longueur d'onde
$\Delta\lambda$	Wellenlängenintervall	wavelength interval	intervalle de longueur d'onde
U_λ	relative spektrale Vertei- Lung der UV-Strahlung der Sonne	relative spectral distribution of UV in solar radiation	répartition spectrale relative du rayonnement ultraviolet solaire
SC	Durchlassfaktor	shading coefficient	coefficient d'ombrage

5 Determination of characteristics

5.1 General

The characteristics are determined for quasi-parallel, near normal radiation incidence (see Bibliography, [4]) using the radiation distribution of illuminant D65 (see Table 1), solar radiation in accordance with Table 2 and ultraviolet (UV) radiation in accordance with Table 3.

The characteristics are as follows:

— the spectral transmittance $\tau(\lambda)$ and the spectral reflectance $\rho(\lambda)$ in the wavelength range from 300 nm to 2500 nm;

— the light transmittance τ_v and the light reflectance ρ_v for illuminant D65;

— the solar direct transmittance τ_e and the solar direct reflectance ρ_e;

— the total solar energy transmittance (solar factor) g ;

— the UV-transmittance τ_{UV};

— the general colour rendering index R_a;

— the total shading coefficient, SC.

To characterize glazing, the principal parameters are τ_v and g; the other parameters are optional to provide additional information.

If the value of a given characteristic is required for different glass thicknesses (in the case of uncoated glass) or for the same coating applied to different substrates, it can be obtained by calculation (in accordance with Annex A).

A procedure for the calculation of the spectral characteristics of laminated glass is given in Annex B.

Guidelines on determining the spectral characteristics of screen printed glass are given in Annex C.

5.2 Light transmittance

The light transmittance τ_v of the glazing is calculated using the following formula:

$$\tau_v = \frac{\sum_{\lambda=380\text{ nm}}^{780\text{ nm}} D_\lambda \tau(\lambda) V(\lambda) \Delta\lambda}{\sum_{\lambda=380\text{ nm}}^{780\text{ nm}} D_\lambda V(\lambda) \Delta\lambda} \quad (1)$$

where

D_λ is the relative spectral distribution of illuminant D65 (see Bibliography [5]);

$\tau(\lambda)$ is the spectral transmittance of the glazing;

$V(\lambda)$ is the spectral luminous efficiency for photopic vision defining the standard observer for photometry (see Bibliography [5]);

$\Delta\lambda$ is the wavelength interval.

Table 1 indicates the values for $D_\lambda V(\lambda)\,\Delta\lambda$ for wavelength intervals of 10 nm. The table has been drawn up in such a way that $\sum D_\lambda V(\lambda)\,\Delta\lambda = 1$.

In the case of multiple glazing, the spectral transmittances $\tau(\lambda)$ are calculated from the spectral transmittances and reflectances of the individual components as follows :

For double glazing:

$$\tau(\lambda) = \frac{\tau_1(\lambda)\,\tau_2(\lambda)}{1 - \rho_1'(\lambda)\,\rho_2(\lambda)} \qquad (2)$$

where

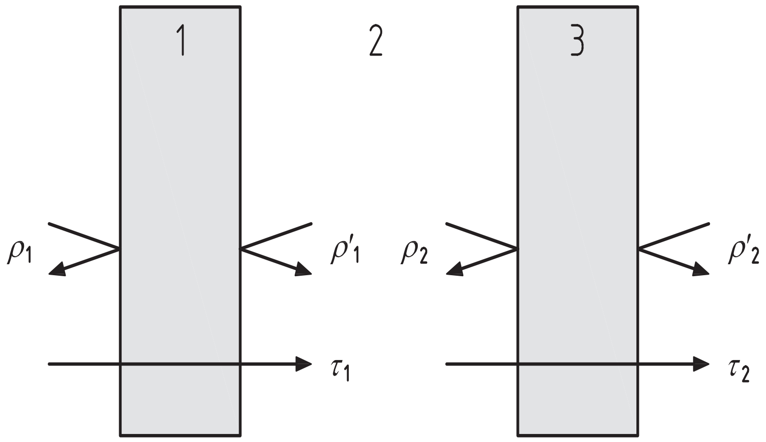
$\tau_1(\lambda)$ is the spectral transmittance of the first (outer) pane;

$\tau_2(\lambda)$ is the spectral transmittance of the second pane;

$\rho_1'(\lambda)$ is the spectral reflectance of the first (outer) pane, measured in the direction opposite to the incident radiation;

$\rho_2(\lambda)$ is the spectral reflectance of the second pane, measured in the direction of the incident radiation.

The above is illustrated in Figure 1.



Key

1 pane 1
2 cavity
3 pane 2

Figure 1 — Transmittance and reflectance in a double glazing insulating glass unit

For triple glazing:

$$\tau(\lambda) = \frac{\tau_1(\lambda)\,\tau_2(\lambda)\,\tau_3(\lambda)}{[1-\rho'_1(\lambda)\,\rho_2(\lambda)]\,[1-\rho'_2(\lambda)\,\rho_3(\lambda)] - \tau_2^2(\lambda)\,\rho'_1(\lambda)\,\rho_3(\lambda)} \quad (3)$$

where

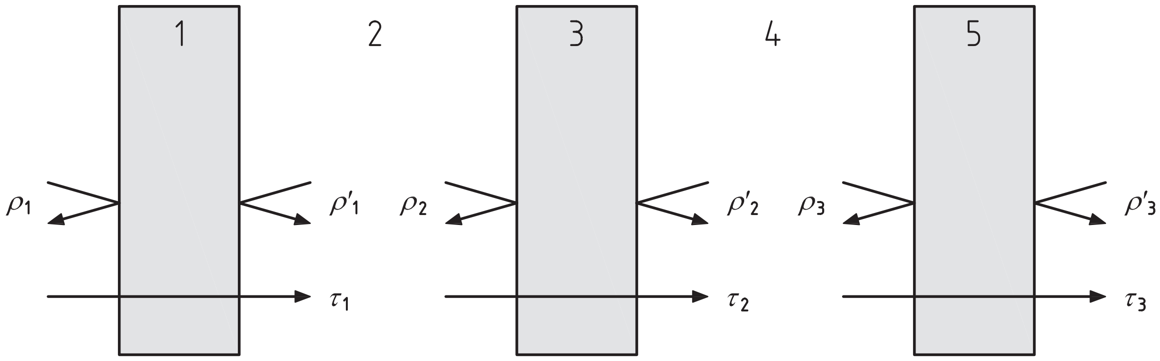
$\tau_1(\lambda)$, $\tau_2(\lambda)$, $\rho'_1(\lambda)$ and $\rho_2(\lambda)$ are as explained in Equation (2);

$\tau_3(\lambda)$ is the spectral transmittance of the third pane;

$\rho'_2(\lambda)$ is the spectral reflectance of the second pane, measured in the direction opposite to the incident radiation;

$\rho_3(\lambda)$ is the spectral reflectance of the third pane, measured in the direction of the incident radiation.

The above is illustrated in Figure 2.



Key

1 pane 1
2 cavity 1
3 pane 2
4 cavity 2
5 pane 3

Figure 2 — Transmittance and reflectance in a triple glazing insulating glass unit

For glazing with more than three components, formulae similar to Equations (2) and (3) are found to calculate $\tau(\lambda)$ of such glazing from the spectral coefficients of the individual components. As an example, glazing composed of five components may be treated as follows:

a) first consider the first three components as triple glazing and calculate the spectral characteristics of this combination;

b) next, run the same procedure for the next two components as double glazing;

c) then calculate $\tau(\lambda)$ for the five component glazing, considering it as double glazing consisting of the preceding triple and double glazing.

NOTE 1 The use of an integrating sphere is necessary when light scattering materials are tested. In this case the size of the sphere and its aperture shall be large enough to collect all possible scattered light and to obtain fair average values when surface patterns are irregularly distributed.

NOTE 2 Measurement of light scattering glass products is the subject of a round robin test programme under the responsibility of International Commission on Glass Technical Committee 10. The results of this programme are expected to include suggestions for improvements in measurement and prediction techniques.

5.3 Light reflectance

The light reflectance of the glazing ρ_v is calculated using the following formula:

$$\rho_v = \frac{\sum_{\lambda=380\text{ nm}}^{780\text{ nm}} D_\lambda \rho(\lambda) V(\lambda) \Delta\lambda}{\sum_{\lambda=380\text{ nm}}^{780\text{ nm}} D_\lambda V(\lambda) \Delta\lambda} \tag{4}$$

where

D_λ, $V(\lambda)$ and $\Delta\lambda$ are as explained in 5.2;

$\rho(\lambda)$ is the spectral reflectance of the glazing.

In the case of multiple glazing, the spectral reflectance $\rho(\lambda)$ is calculated from the spectral transmittances and the spectral reflectances of the individual components as follows.

For double glazing, the external light reflectance of the glazing is calculated as follows:

$$\rho(\lambda) = \rho_1(\lambda) + \frac{\tau_1^2(\lambda)\,\rho_2(\lambda)}{1 - \rho_1'(\lambda)\,\rho_2(\lambda)} \quad (5)$$

where

$\tau_1(\lambda)$, $\rho_2(\lambda)$ and $\rho_1'(\lambda)$ are as explained in 5.2;

$\rho_1(\lambda)$ is the spectral reflectance of the first (outer) pane, measured in the direction of incident radiation.

A corresponding equation can also be derived for calculating the internal light reflectance.

For triple glazing, the external light reflectance of the glazing is calculated as follows:

$$\rho(\lambda) = \rho_1(\lambda) + \frac{\tau_1^2(\lambda)\,\rho_2(\lambda)\left[1 - \rho_2'(\lambda)\,\rho_3(\lambda)\right] + \tau_1^2(\lambda)\,\tau_2^2(\lambda)\,\rho_3(\lambda)}{\left[1 - \rho_1'(\lambda)\,\rho_2(\lambda)\right]\left[1 - \rho_2'(\lambda)\,\rho_3(\lambda)\right] - \tau_2^2(\lambda)\,\rho_1'(\lambda)\,\rho_3(\lambda)} \quad (6)$$

where

$\rho_3(\lambda)$ is the spectral reflectance of the third pane, measured in the direction of the incident radiation;

$\tau_1(\lambda)$, $\tau_2(\lambda)$, $\rho_1(\lambda)$, $\rho_2(\lambda)$, $\rho_1'(\lambda)$ and $\rho_2'(\lambda)$ are as defined in 5.2 and 5.3.

A corresponding equation the internal light reflectance of triple glazing can also be derived.

For glazing with more than three elements the same method as described in 5.2 is used.

5.4 Total solar energy transmittance (solar factor)

5.4.1 Calculation

The total solar energy transmittance g is calculated as the sum of the solar direct transmittance τ_e and the secondary heat transfer factor q_i of the glazing towards the inside (see 5.4.3 and 5.4.6), the latter resulting from heat transfer by convection and longwave IR-radiation of that part of the incident solar radiation which has been absorbed by the glazing:

$$g = \tau_e + q_i \quad (7)$$

5.4.2 Division of incident solar radiant flux

The incident solar radiant flux ϕ_e is divided into the following three parts (see Figure 3):

a) the transmitted part, $\tau_e\phi_e$;

b) the reflected part, $\rho_e\phi_e$;

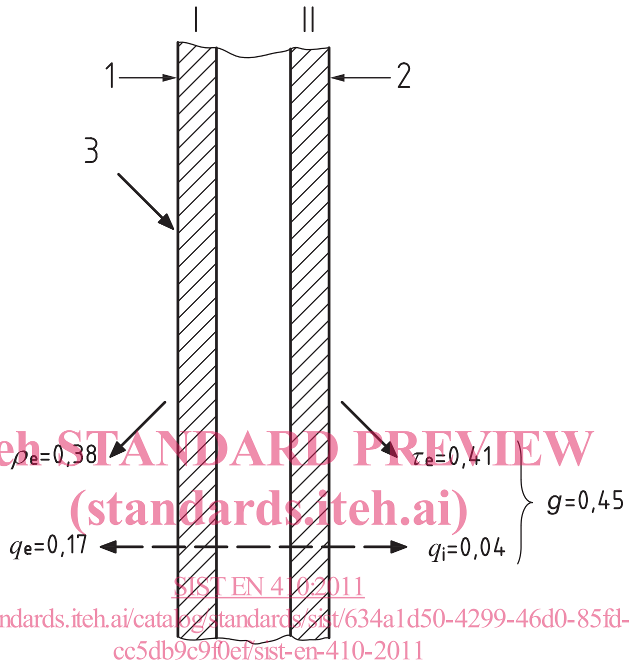
c) the absorbed part, $\alpha_e\phi_e$;

where

τ_e is the solar direct transmittance (see 5.4.3);

ρ_e is the solar direct reflectance (see 5.4.4);

α_e is the solar direct absorptance (see 5.4.5).



Key

1 outer pane
2 second inner pane
3 unit incident radiant flux

Figure 3 — Example of division of the incident radiant flux

The relation between the three characteristics is:

$$\tau_e + \rho_e + \alpha_e = 1 \quad (8)$$

The absorbed part $\alpha_e \phi_e$ is subsequently split into two parts $q_i \phi_e$ and $q_e \phi_e$ which are energy transferred to the inside and outside respectively:

$$\alpha_e = q_i + q_e \quad (9)$$

where

q_i is the secondary heat transfer factor of the glazing towards the inside;

q_e is the secondary heat transfer factor of the glazing towards the outside.