SLOVENSKI STANDARD

SIST EN 13363-2:2005

01-julij-2005

Senļ ila v kombinaciji z zasteklitvijo - Izraļ un prepustnosti za energijo sonļ nega sevanja in prepustnosti svetlobe - 2. del: Podrobna raļ unska metoda

Solar protection devices combined with glazing - Calculation of total solar energy transmittance and light transmittance - Part 2: Detailed calculation method

Sonnenschutzeinrichtungen in Kombination mit Verglasungen - Berechnung der Solarstrahlung und des Lichttransmissionsgrades - Teil 2: Detailliertes Berechnungsverfahren

Dispositifs de protection solaire combinés a des vitrages - Calcul du facteur de transmission solaire et lumineuse - Partie 2: Méthode de calcul détaillée

Ta slovenski standard je istoveten z: EN 13363-2:2005

ICS:

17.180.20	Barve in merjenje svetlobe	Colours and measurement of light
91.120.10	Toplotna izolacija stavb	Thermal insulation

SIST EN 13363-2:2005 en

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13363-2

April 2005

ICS 17.180.20; 91.120.10

English version

Solar protection devices combined with glazing - Calculation of total solar energy transmittance and light transmittance - Part 2: Detailed calculation method

Dispositifs de protection solaire combinés à des vitrages - Calcul du facteur de transmission solaire et lumineuse - Partie 2: Méthode de calcul détaillée

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Ref. No. EN 13363-2:2005: E

Contents

Foreword

This document (EN 13363-2:2005) has been prepared by Technical Committee CEN/TC 89 “Thermal performance of buildings and building components”, the secretariat of which is held by SIS.

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of an identical text or by endorsement, at the latest by October 2005, and conflicting national standards shall be withdrawn at the latest by October 2005.

EN 13363 with the general title *Solar protection devices combined with glazing - Calculation of solar and light transmittance* consists of two parts:

– *Part 1: Simplified method;*

– *Part 2: Detailed calculation method.*

This document includes a Bibliography.

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

1 Scope

This document specifies a detailed method, based on the spectral transmission data of the materials, comprising the solar protection devices and the glazing, to determine the total solar energy transmittance and other relevant solar-optical data of the combination. If spectral data are not available the methodology can be adapted to use integrated data.

The method is valid for all types of solar protection devices parallel to the glazing such as louvres, or venetian, or roller blinds. The blind may be located internally, externally, or enclosed between the panes of the glazing. Ventilation of the blind is allowed for in each of these positions in determining the solar energy absorbed by the glazing or blind components, for vertical orientation of the glazing.

The blind component materials may be transparent, translucent or opaque, combined with glazing components with known solar transmittance and reflectance and with known emissivity for thermal radiation.

The method is based on a normal incidence of radiation and does not take into account an angular dependence of transmittance or reflectance of the materials. Diffuse irradiation or radiation diffused by solar protection devices is treated as if it were direct. Louvres or venetian blinds are treated as homogenous materials by equivalent solar optical characteristics, which may depend on the angle of the incidence radiation. For situations outside the scope of this document; ISO 15099 covers a wider range of situations.

The document also gives certain normalised situations, additional assumptions and necessary boundary conditions.

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 410, *Glass in building – Determination of luminous and solar characteristics of glazing*

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

EN ISO 7345:1995, *Thermal insulation – Physical quantities and definitions (ISO 7345:1987)*

EN ISO 9288:1996, *Thermal insulation – Heat transfer by radiation – Physical quantities and definitions (ISO 9288:1989)*

3 Terms, definitions, symbols and units

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 7345:1995, EN ISO 9288:1996 and the following apply.

3.1.1
solar radiation and light
radiation in the whole solar spectrum or any part of it, comprising ultra-violet, visible and near infra-red radiation in the wavelength range of 0,3 µm to 2,5 µm

NOTE Sometimes called shortwave radiation, see EN ISO 9488.

3.1.2
thermal radiation
radiation emitted by any surface at or near ambient temperature in the far infrared in the wavelength range of 3 µm to 100 µm

NOTE 1 The definition deviates from EN ISO 9288.

NOTE 2 Sometimes called longwave radiation, see EN ISO 9488.

3.1.3
total solar energy transmittance
total transmitted fraction of the incident solar radiation consisting of direct transmitted solar radiation and the part of the absorbed solar radiation transferred by convection and thermal radiation to the internal environment

3.1.4
light transmittance
transmitted fraction of the incident solar radiation in the visible part of the solar spectrum, see EN 410

3.1.5
normalized radiant flow rate
radiant flow rate divided by the incident radiant flow rate

3.2 Symbols and units

The following list includes the principal symbols used. Other symbols are defined where they are used in the text.

Symbol	Physical quantity	Unit
E_S	incident solar radiation flow rate, solar irradiation	W/m²
I	normalised radiant flow rate	–
H	height of a ventilated space	m
T	thermodynamic temperature	K
U	thermal transmittance	W/(m²·K)
g	total solar energy transmittance (solar factor)	–
h	heat transfer coefficient, or thermal conductance of gas space	W/(m²·K)
q	density of heat flow rate	W/m²
s	width of a space	m
z	vertical coordinate	m
ε	thermal emissivity	–
α	absorptance	–
α_e	solar direct absorptance	–
λ	thermal conductivity	W/(m·K)
λ	wavelength	µm
ρ	reflectance of the side facing the incident radiation	–
ρ'	reflectance of the side facing away from the incident radiation	–
ρ_e	solar direct reflectance	–
ρv	light reflectance	–
σ	Stefan-Boltzmann constant	$5{,}67 \times 10^{-8}$ W/(m²·K⁴)
τ_e	solar direct transmittance	–

τ_v	light transmittance	–

Subscripts

a	absorbed
c	conductive/convective
d	diffuse
e	external environment
g	gas
i	internal environment
j, k	integer, number of layer or space
r	radiant
th	thermal radiation
v	ventilated
B	blind
D	direct

4 Characteristic data

4.1 Solid layers

The glass panes and blinds are considered as solid layers. The relevant characteristics are:

- for solar radiation and light: the spectral transmittance and the spectral reflectances of both sides;
- for thermal radiation: the transmittance and the emissivities of both sides.

Usually, these values are determined directly by the most appropriate optical method[1]. For glazing, see the procedures recommended for glazing materials in EN 410. However, for louvres or venetian blinds, Annex A gives a method to calculate equivalent values based on similarly determined material properties.

4.2 Gas spaces

The thermal properties of closed spaces filled with air or gas shall be calculated in accordance with EN 673. The spaces are described by their width and the physical properties of the gas (see Annex D, Table D.1).

Ventilated air spaces are described by the width and the height of the space and the physical properties of the air.

5 Principles of calculation

5.1 General

The combination of glazing and solar protection devices consists of a series of solid layers separated by air or gas filled spaces. The solid layers are assumed to be homogeneous with a negligible thermal resistance. The transport of solar radiation and heat is considered to be one-dimensional, except for ventilated spaces, where the two-dimensional convection is reduced to a one-dimensional formula.

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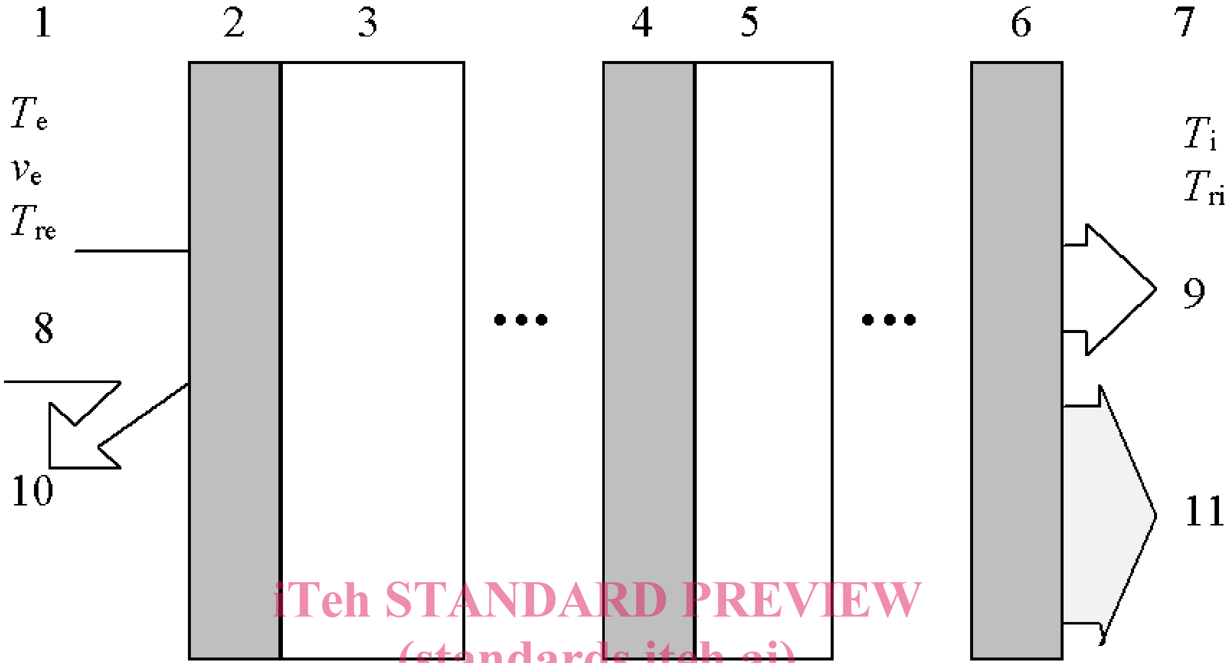
[1] See CIE Technical Report – CIE 130-1998 "Practical Methods for the measurement of reflectance and transmittance".

The layers and spaces are numbered by j from 1 to n, where space n represents the internal environment and space 0 the external environment. Within the physical model the number of layers is unlimited. The basic formulae for solar radiation and heat transfer are given to establish the energy balance of each layer. To solve the system of equations the use of an iterative procedure is recommended, due to the non-linear interaction of temperature and heat transport.



Key

T_e	external air temperature	1	external	7	internal
T_{re}	external radiant temperature	2	layer 1	8	solar radiation
v_e	external wind velocity	3	space 1	9	direct solar and light transmittance
T_i	internal air temperature	4	layer j	10	direct solar and light reflectance
T_{ri}	internal radiant temperature	5	space j	11	thermal radiation and convection (direct and indirect)
		6	layer n		

NOTE The internal and external environments are characterised by the air temperature and the radiant temperature; the external environment is additionally characterised by the wind velocity.

Figure 1 — Schematic presentation of a system consisting of layers and spaces

5.2 Solar radiation and light

The solar and optical properties are independent of the intensity of the solar irradiation and temperature in the system[2]. It is assumed that the spaces are completely transparent, without any absorption. Each solid layer is characterised by the spectral transmittance and reflectance in the wavelength region between 0,3 µm and 2,5 µm.

For each wavelength λ and each layer j the following equations are valid for the normalised radiant flow rates I and I' (see Figure 2):

$$I_j(\lambda) = \tau_j(\lambda) \cdot I_{j-1}(\lambda) + \rho'_j(\lambda) \cdot I'_j(\lambda)$$
$$I'_{j-1}(\lambda) = \rho_j(\lambda) \cdot I_{j-1}(\lambda) + \tau'_j(\lambda) \cdot I'_j(\lambda) \quad (1)$$

where

[2] There are exceptions for certain materials (photochromic, thermochromic).

$\tau_j(\lambda)$ is the spectral transmittance of the side facing the incident radiation;

$\tau'_j(\lambda)$ is the spectral transmittance of the side facing away from the interior[3)];

$\rho_j(\lambda)$ is the spectral reflectance of the side facing the incident radiation;

$\rho'_j(\lambda)$ is the spectral reflectance of the side facing away from the incident radiation;

$I_j(\lambda)$ is the spectral normalised radiant flow rate inwards;

$I'_j(\lambda)$ is the spectral normalised radiant flow rate outwards.

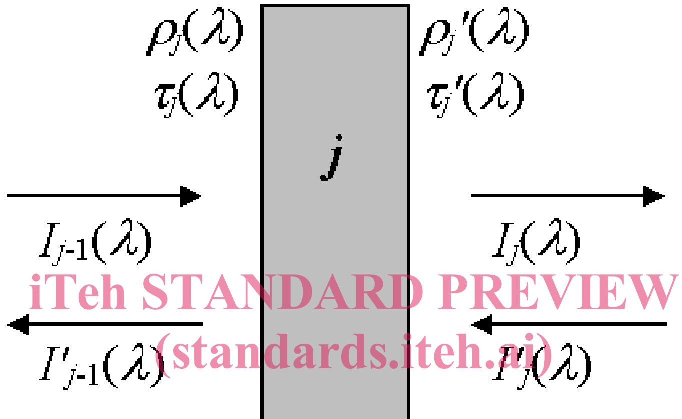


Figure 2 — Schematic presentation of the characteristic data of layer *j* and the spectral flow rates

Equation (1) is solved with the boundary conditions: $I_0(\lambda)=1; \quad I'_n(\lambda)=0$ (2)

If the spectral normalised radiant flow rates $I_j(\lambda)$ and $I'_j(\lambda)$ are known for each j, the spectral data of the system result in:

the spectral transmittance: $\tau(\lambda)=I_n(\lambda)$ (3)

the spectral reflectance of the side facing the incident radiation: $\rho(\lambda)=I'_0(\lambda)$ (4)

the spectral absorptance of layer j:

$$\alpha_j(\lambda)=\left(1-\rho_j(\lambda)-\tau_j(\lambda)\right)\cdot I_{j-1}(\lambda)+\left(1-\rho'_j(\lambda)-\tau'_j(\lambda)\right)\cdot I'_j(\lambda) \quad (5)$$

The solar direct transmittance τ_e, the solar direct reflectance ρ_e and the solar direct absorptance $\alpha_{e,j}$ of each layer j shall be calculated from the spectral data according to the procedure given in EN 410. Similarly, the light transmittance τ_v and the light reflectance ρ_v can be calculated.

If the spectral reflectance $\rho'(\lambda)$ of the system facing the interior is required, solve Equation (1) with the boundary conditions $I_0(\lambda)=0$; $I'_n(\lambda)=1$ and use $\rho'(\lambda)=I_n(\lambda)$.

[3)] For light scattering materials the transmittances $\tau(\lambda)$ and $\tau'(\lambda)$ might be different.

If spectral data are not available, the calculation can be done with integrated data, taking note that the accuracy is reduced for materials where the wavelength-dependent properties are different.

5.3 Heat transfer

5.3.1 Thermal radiation

The heat flow by thermal radiation depends on the temperatures in the system, and is coupled with other heat flows within the system. A separate solution is not possible in a normalised form.

For thermal radiation it is convenient to use the emissivity instead of the reflectance, thus each layer j is characterised by (see Figure 3):

- T_j temperature;
- $\tau_{th,j}$ transmittance for thermal radiation;
- ε_j effective emissivity of the side facing the exterior;
- ε'_j effective emissivity of the side facing the interior;
- q_{th} radiative heat flow density inwards;
- q'_{th} radiative heat flow density outwards.

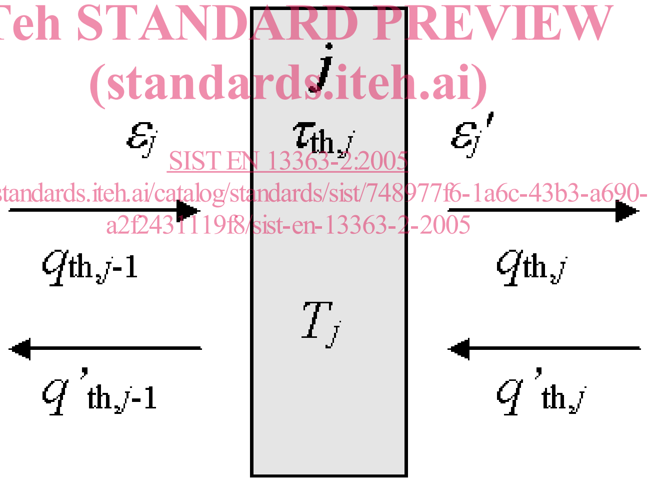


Figure 3 — Schematic presentation of the characteristic data of layer *j* and the thermal radiative heat flow density

Most solid layers are opaque in the region of thermal radiation (5 µm to 50 µm) and are described by an integrated value, the corrected emissivity ε. This emissivity is determined by the measurement of the spectral normal reflectance. The evaluation uses a correction for the hemispherical emission and assumes no transparency as described in EN 673.

For infrared transparent materials such as some plastic films, opaque layers with holes, and louvre systems, the characteristics shall be determined by an appropriate procedure. For louvres see Annex A.

For each layer j the following set of equations for the radiative heat flow densities is valid:

$$q_{th,j} = \tau_{th,j} \cdot q_{th,j-1} + (1 - \varepsilon'_j - \tau_{th,j}) \cdot q'_{th,j} + \varepsilon'_j \cdot \sigma \cdot T_j^4$$
$$q'_{th,j-1} = (1 - \varepsilon_j - \tau_{th,j}) \cdot q_{th,j-1} + \tau_{th,j} \cdot q'_{th,j} + \varepsilon_j \cdot \sigma \cdot T_j^4 \qquad (6)$$