INTERNATIONAL STANDARD

ISO 52022-3

First edition
2017-06

Energy performance of buildings — Thermal, solar and daylight properties of building components and elements —

Part 3: Detailed calculation method of the solar and daylight characteristics for solar protection devices combined with glazing

Performance énergétique des bâtiments — Propriétés thermiques, solaires et lumineuses des composants et éléments du bâtiment —

Partie 3: Méthode de calcul détaillée des caractéristiques solaires et en lumière du jour pour les dispositifs de protection solaire combinés à des vitrages

Reference number
ISO 52022-3:2017(E)

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

ISO 52022-3 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 89, *Thermal performance of buildings and building components*, in collaboration with ISO Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 2, *Calculation methods*, in accordance with the agreement on technical cooperation between ISO and CEN (Vienna Agreement).

A list of parts in the ISO 52022 series can be found on the ISO website.

Introduction

This document is part of a series aimed at the international harmonization of the methodology for assessing the energy performance of buildings. Throughout, this series is referred to as a "set of EPB standards".

All EPB standards follow specific rules to ensure overall consistency, unambiguity and transparency.

All EPB standards provide a certain flexibility with regard to the methods, the required input data and references to other EPB standards, by the introduction of a normative template in Annex A and Annex B with informative default choices.

For the correct use of this document, a normative template is given in Annex A to specify these choices. Informative default choices are provided in Annex B.

The main target groups for this document are architects, engineers and regulators.

Use by or for regulators: In case this document is used in the context of national or regional legal requirements, mandatory choices may be given at national or regional level for such specific applications. These choices (either the informative default choices from Annex B or choices adapted to national/regional needs, but in any case following the template of this Annex A) can be made available as national annex or as separate (e.g. legal) document (national data sheet).

NOTE 1 So in this case:

— the regulators will **specify** the choices;

— the individual user will apply the document to assess the energy performance of a building, and thereby **use** the choices made by the regulators.

Topics addressed in this document can be subject to public regulation. Public regulation on the same topics can override the default values in Annex B of this document. Public regulation on the same topics can even, for certain applications, override the use of this document. Legal requirements and choices are in general not published in standards but in legal documents. In order to avoid double publications and difficult updating of double documents, a national annex may refer to the legal texts where national choices have been made by public authorities. Different national annexes or national data sheets are possible, for different applications.

It is expected, if the default values, choices and references to other EPB standards in Annex B are not followed due to national regulations, policy or traditions, that:

— national or regional authorities prepare data sheets containing the choices and national or regional values, according to the model in Annex A. In this case a national annex (e.g. NA) is recommended, containing a reference to these data sheets;

— or, by default, the national standards body will consider the possibility to add or include a national annex in agreement with the template of Annex A, in accordance to the legal documents that give national or regional values and choices.

Further target groups are parties wanting to motivate their assumptions by classifying the building energy performance for a dedicated building stock.

More information is provided in the Technical Report accompanying this document (ISO/TR 52022-2).

The framework for overall EPB includes:

a) common terms, definitions and symbols;

b) building and assessment boundaries;

c) building partitioning into space categories;

d) methodology for calculating the EPB (formulae on energy used, delivered, produced and/or exported at the building site and nearby);

e) a set of overall formulae and input-output relations, linking the various elements relevant for the assessment of the overall EPB;

f) general requirements for EPB dealing with partial calculations;

g) rules for the combination of different spaces into zones;

h) performance indicators;

i) methodology for measured energy performance assessment.

Table 1 shows the relative position of this document within the set of EPB standards in the context of the modular structure as set out in ISO 52000-1.

NOTE 2 In ISO/TR 52000-2 the same table can be found, with, for each module, the numbers of the relevant EPB standards and accompanying technical reports that are published or in preparation.

NOTE 3 The modules represent EPB standards, although one EPB standard could cover more than one module and one module could be covered by more than one EPB standard, for instance, a simplified and a detailed method respectively. See also Tables A.1 and B.1.

Table 1 — Position of this document (in casu M2-8) within the modular structure of the set of EPB standards

	Overarching		Building (as such)		Technical Building Systems									
Sub-module	Descriptions		Descriptions		Descriptions	Heating	Cooling	Ventilation	Humidification	Dehumidification	Domestic hot water	Lighting	Building automation and control	PV, wind, ..
sub1		M1		M2		M3	M4	M5	M6	M7	M8	M9	M10	M11
1	General		General		General									
2	Common terms and definitions; symbols, units and subscripts		Building energy needs		Needs								a	
3	Applications		(Free) indoor conditions without systems		Maximum load and power									
4	Ways to express energy performance		Ways to express energy performance		Ways to express energy performance									
5	Building categories and building boundaries		Heat transfer by transmission		Emission and control									
6	Building occupancy and operating conditions		Heat transfer by infiltration and ventilation		Distribution and control									
7	Aggregation of energy services and energy carriers		Internal heat gains		Storage and control									

a The shaded modules are not applicable.

Table 1 *(continued)*

	Overarching		Building (as such)		Technical Building Systems										
Sub-module	**Descriptions**		**Descriptions**		**Descriptions**	**Heating**	**Cooling**	**Ventilation**	**Humidification**	**Dehumidification**	**Domestic hot water**	**Lighting**	**Building automation and control**	**PV, wind, ..**
sub1		**M1**		**M2**		**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**
8	Building zoning		Solar heat gains	ISO 52022-3	Generation and control									
9	Calculated energy performance		Building dynamics (thermal mass)		Load dispatching and operating conditions									
10	Measured energy performance		Measured energy performance		Measured energy performance									
11	Inspection		Inspection		Inspection									
12	Ways to express indoor comfort				BMS									
13	External environment conditions													
14	Economic calculation													

[a] The shaded modules are not applicable.

Energy performance of buildings — Thermal, solar and daylight properties of building components and elements —

Part 3: Detailed calculation method of the solar and daylight characteristics for solar protection devices combined with glazing

1 Scope

This document specifies a detailed method, based on spectral data of the transmittance and reflectance of the constituent materials (solar protection devices and the glazing), to determine the total solar energy transmittance, the total light 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, venetian blinds, 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. The current method is limited to vertical installation ±15°. For situations outside the scope of this document; ISO 15099 covers a wider range of situations.

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

NOTE Table 1 in the Introduction shows the relative position of this document within the set of EPB standards in the context of the modular structure as set out in ISO 52000-1.

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.

ISO 7345, *Thermal insulation — Physical quantities and definitions*

ISO 9288, *Thermal insulation — Heat transfer by radiation — Physical quantities and definitions*

ISO 9488, *Solar energy — Vocabulary*

ISO 9050, *Glass in building — Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors*

ISO 10292, *Glass in building — Calculation of steady-state U values (thermal transmittance) of multiple glazing*

ISO 52000-1:2017, *Energy performance of buildings — Overarching EPB assessment — Part 1: General framework and procedures*

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 14500, *Blinds and shutters — Thermal and visual comfort — Test and calculation methods*

NOTE Default references to EPB standards other than ISO 52000-1 are identified by the EPB module code number and given in Annex A (normative template in Table A.1) and Annex B (informative default choice in Table B.1).

EXAMPLE EPB module code number: M5–5, or M5–5.1 (if module M5–5 is subdivided), or M5–5/1 (if reference to a specific clause of the standard covering M5–5).

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7345, ISO 9288, ISO 9488, ISO 52000-1 and the following 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
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 1 to entry: Sometimes called shortwave radiation, see ISO 9488.

3.2
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 to entry: The definition deviates from ISO 9288.

Note 2 to entry: Sometimes called longwave radiation, see ISO 9488.

3.3
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

3.4
light transmittance
transmitted fraction of the incident solar radiation in the visible part of the solar spectrum

Note 1 to entry: See also EN 410 and ISO 9050.

3.5
normalized radiant flow rate
radiant flow rate divided by the incident radiant flow rate

3.6
EPB standard
standard that complies with the requirements given in ISO 52000-1, CEN/TS 16628[2] and CEN/TS 16629[3]

Note 1 to entry: These three basic EPB documents were developed under a mandate given to CEN by the European Commission and the European Free Trade Association (Mandate M/480), and support essential requirements of EU Directive 2010/31/EU on the energy performance of buildings (EPBD). Several EPB standards and related documents are developed or revised under the same mandate.

[SOURCE: ISO 52000-1:2017, definition 3.5.14]

4 Symbols and subscripts

4.1 Symbols

For the purposes of this document, the symbols given in ISO 52000-1 and the following apply.

Symbol	Name of quantity	Unit
E_S	incident solar radiation flow rate, solar irradiation	W/m^2
I	normalized radiant flow rate	—
H	height of a ventilated space	m
T	thermodynamic temperature	K
U	thermal transmittance	$W/(m^2 \cdot K)$
Z	pressure loss factor	—
g	total solar energy transmittance (solar factor)	—
h	heat transfer coefficient or thermal conductance of gas space	$W/(m^2 \cdot K)$
q	density of heat flow rate	W/m^2
s	width of a space	m
z	vertical coordinate	m
ε	thermal emissivity	—
α	absorptance	—
α_e	solar direct absorptance	—
λ	thermal conductivity	$W/(m \cdot K)$
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	—
ρ_v	light reflectance	—
σ	Stefan-Boltzmann constant	$5{,}67 \times 10^{-8}$ $W/(m^2 \cdot K^4)$
τ_e	solar direct transmittance	—
τ_v	light transmittance	—

4.2 Subscripts

For the purposes of this document, the subscripts given in ISO 52000-1 and the following apply.

Subscript	Definition
a	absorbed
c	conductive/convective
d	diffuse

Subscript	Definition
e	external environment
g	gas
i	internal environment
j, *k*	integer, number of layer or space
r	radiant
tot	total
th	thermal radiation
v	ventilated
B	blind
D	direct

5 Description of the method

5.1 Output of the method

The possible outputs of this document are the following:

— the total solar energy transmittance for a glazing in combination with an external or internal or integrated solar protection device, g_{tot};

— the total solar direct transmittance for a glazing in combination with an external or internal or integrated protection device, $\tau_{\text{e,tot}}$;

— the total light transmittance for a glazing in combination with an external or internal or integrated solar protection device, $\tau_{\text{v,tot}}$.

5.2 General description

In general, the total solar energy transmittance, the total solar direct transmittance and the total light transmittance is calculated as a function of the thermal resistance and spectral "optical" properties (transmittance, reflectance) of the individual layers.

Throughout this document, where indicated in the text, Table C.1 shall be used to identify alternative regional references in line with ISO Global Relevance Policy.

6 Calculation method

6.1 Output data

The main output of this document are the total solar energy transmittance, the total solar direct transmittance and the total light transmittance for a glazing in combination with a solar protection device (see Table 2).

Table 2 — Output data

Description	Symbol	Unit	Destination module	Validity interval	Varying
Total solar energy transmittance	g_{tot}	—	M2-2, M2-3, M2-4	0 to 1	NO
Total solar direct transmittance	$\tau_{e,tot}$	—	M2-2, M2-3, M2-4	0 to 1	NO
Total light transmittance	$\tau_{v,tot}$	—	M2-2, M2-3, M2-4	0 to 1	NO

6.2 Calculation time intervals

The input, the method and the output data are for steady state conditions and therefore, there are no time intervals.

6.3 Input data

6.3.1 Solid layers

The glass panes and the solar protection devices are considered as solid layers. The relevant characteristics are as follows:

— 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.

For the determination of the characteristics of the glazing, see the procedures recommended for glazing materials in EN 410 or ISO 9050; for solar shading devices, procedures given in EN 14500 are used. However, for louvres or venetian blinds, Annex D gives a method to calculate equivalent values based on similarly determined material properties.

NOTE Usually, these values are determined directly by the most appropriate optical method. For more information on the determination of the characteristics, see CIE 130-1998 "Practical Methods for the measurement of reflectance and transmittance".

The individual layers are characterized by the quantities according to Table 3.

Table 3 — Identifiers for characteristics of the solid layers

Name	Symbol	Unit	Range	Origin	Varying
Spectral transmittance of the side of the solid layer facing the incident radiation	$\tau(\lambda)$	—	0 to1	ISO 9050 for glazing, EN 14500 for shading (or see Subject 1 in Table C.1)	No
Spectral transmittance of the side of the solid layer facing away from the incident radiation	$\tau'(\lambda)$	—	0 to1	ISO 9050 for glazing, EN 14500 for shading (or see Subject 1 in Table C.1)	No
Spectral reflectance of the side of the solid layer facing the incident radiation	$\rho(\lambda)$	—	0 to1	ISO 9050 for glazing, EN 14500 for shading (or see Subject 1 in Table C.1)	No

Table 3 *(continued)*

Name	Symbol	Unit	Range	Origin	Varying
Spectral reflectance of the side of the solid layer facing away from the incident radiation	$\rho'(\lambda)$	—	0 to1	ISO 9050 for glazing, EN 14500 for shading (or see Subject 1 in Table C.1)	No
Thermal transmittance of the side of the solid layer facing the incident radiation	τ_{th}	—	0 to1	ISO/CD 19597 (under preparation) (or see Subject 2 in Table C.1)	No
Emissivity of the side of the solid layer facing the incident radiation	ε	—	0 to1	ISO/CD 19597 (under preparation) (or see Subject 2 in Table C.1)	No
Emissivity of the side of the solid layer facing away from the incident radiation	ε'	—	0 to1	ISO/CD 19597 (under preparation) (or see Subject 2 in Table C.1)	No

6.3.2 Gas spaces

The thermal properties of closed spaces filled with air or gas shall be calculated in accordance with ISO 10292 (or see Subject 3 in Table C.1). The spaces are described by their width, and the physical properties of the gas Annex F shall be used to calculate the temperature dependent physical properties of the gas.

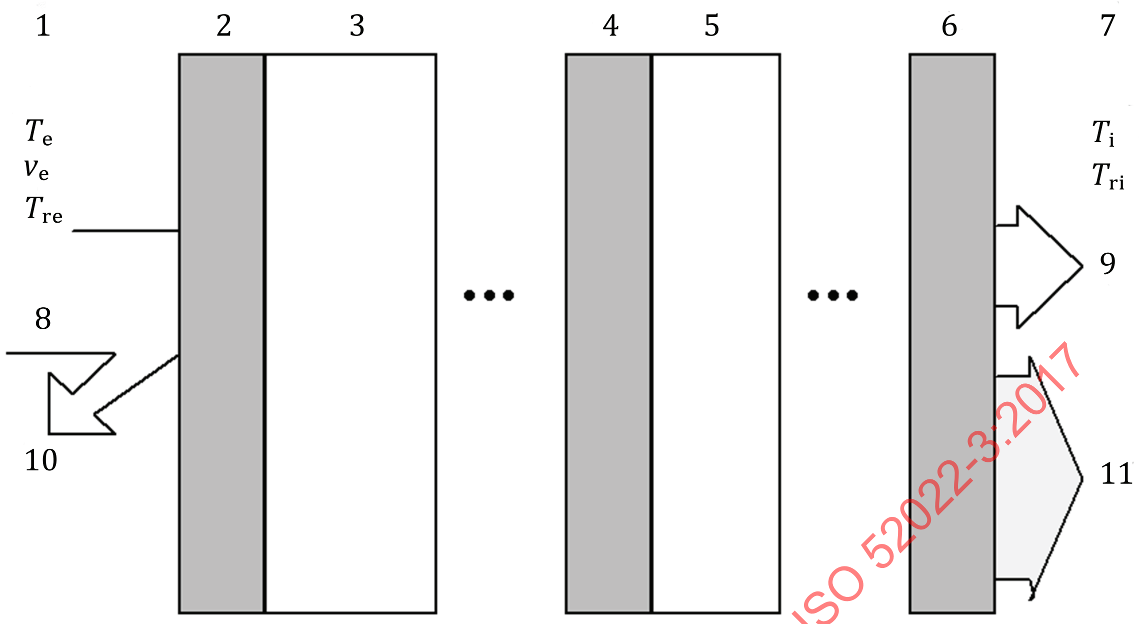
Ventilated air spaces are described by the width and the height of the space and the physical properties of the air.

6.4 Calculation procedure

6.4.1 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.

The layers and spaces are numbered by j from 1 to n each, where space 0 represents the exterior surface coefficient and layer 0 represents the external environment. Space n represents the interior surface coefficient and layer n+1 the internal 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 necessary due to the non-linear interaction of temperature and heat transport.



Key

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

NOTE 1 The internal and external environments are characterized by the air temperature and the radiant temperature; the external environment is additionally characterized by the wind velocity.

NOTE 2 Be aware not to mix the key numbers of Figure 1 with the numbering of layers and spaces.

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

6.4.2 Applicable time interval

The calculations described in this document are steady-state and do not have time intervals.

6.4.3 Solar radiation and light

The solar and optical properties are independent of the intensity of the solar irradiation and temperature in the system.

NOTE There are exceptions for certain materials (photochromic, thermochromic).

It is assumed that the spaces are completely transparent, without any absorption. Each solid layer is characterized 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 formulae are valid for the normalized radiant flow rates I and I' (see Figure 2), as given in Formula (1):

$$\begin{aligned} I_j(\lambda) &= \tau_j(\lambda) \cdot I_{j-1}(\lambda) + \rho'_j(\lambda) \cdot I'_j(\lambda) \\ I'_{j-1}(\lambda) &= \rho_j(\lambda) \cdot I_{j-1}(\lambda) + \tau'_j(\lambda) \cdot I'_j(\lambda) \end{aligned} \tag{1}$$

where

$\tau_j(\lambda)$ 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 incident radiation;

$\rho_j(\lambda)$ 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 normalized radiant flow rate inwards;

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

NOTE For light scattering materials, the transmittances $\tau(\lambda)$ and $\tau'(\lambda)$ might be different.

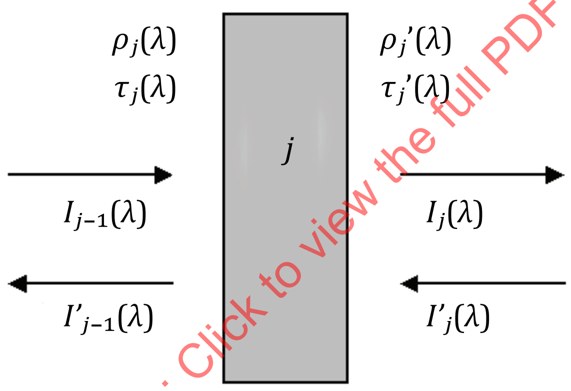


Figure 2 — Schematic presentation of the characteristic data of layer *j* and the spectral flow rates

Formula (1) is solved with the boundary conditions:

$$I_0(\lambda) = 1; \quad I'_{n(\lambda)} = 0$$

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

— the spectral transmittance, as given in Formula (2):

$$\tau(\lambda) = I_n(\lambda) \tag{2}$$

— the spectral reflectance of the side facing the incident radiation, as given in Formula (3):

$$\rho(\lambda) = I'_0(\lambda) \tag{3}$$

— the spectral absorptance of layer j, as given in Formula (4):

$$\alpha_j(\lambda) = \left[1 - \rho_j(\lambda) - \tau_j(\lambda)\right] \cdot I_{j-1}(\lambda) + \left[1 - \rho'_j(\lambda) - \tau'_j(\lambda)\right] \cdot I'_j(\lambda) \quad (4)$$

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 or ISO 9050. 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 Formula (1) with the following boundary conditions:

$I_0(\lambda) = 0$; $I'_{n(\lambda)} = 1$ and use $\rho'(\lambda) = I_n(\lambda)$

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.

6.4.4 Heat transfer

6.4.4.1 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 normalized form.

For thermal radiation, it is convenient to use the emissivity instead of the reflectance, thus each layer j is characterized by the following (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.

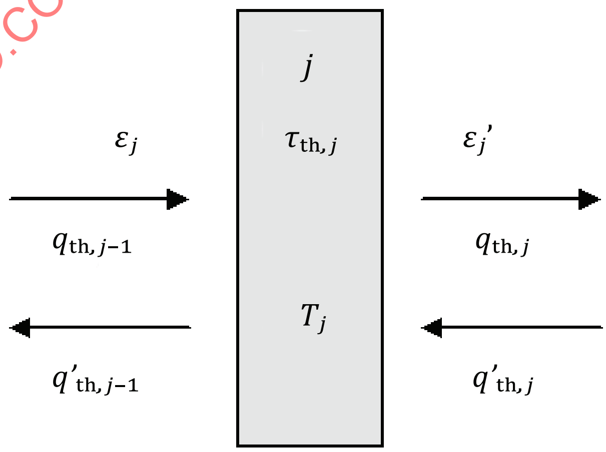


Figure 3 — Schematic presentation of the characteristic data of layer *j* and the thermal radiative heat flow density

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 or ISO 10292.

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 D.

For each layer j, the following set of formulae given in Formula (5) for the radiative heat flow densities is valid:

$$\begin{aligned} q_{\mathrm{th},j} &= \tau_{\mathrm{th},j} \cdot q_{\mathrm{th},j-1} + \left(1 - \varepsilon'_j - \tau_{\mathrm{th},j}\right) \cdot q'_{\mathrm{th},j} + \varepsilon'_j \cdot \sigma \cdot T_j^4 \\ q'_{\mathrm{th},j-1} &= \left(1 - \varepsilon_j - \tau_{\mathrm{th},j}\right) \cdot q_{\mathrm{th},j-1} + \tau_{\mathrm{th},j} \cdot q'_{\mathrm{th},j} + \varepsilon_j \cdot \sigma \cdot T_j^4 \end{aligned} \tag{5}$$

The boundary conditions are given by the external and internal radiant temperatures $T_{\mathrm{r,e}}$ and $T_{\mathrm{r,i}}$, respectively:

$$q_{\mathrm{th},0} = \sigma \cdot T_{\mathrm{r,e}}^4 ; \quad q'_{\mathrm{th},n} = \sigma \cdot {}_{\mathrm{r,i}}^4$$

Assuming the temperatures T_j are known, the system gives the following:

— the net radiant heat flow to the exterior, as given in Formula (6):

$$q_{\mathrm{th,e}} = q'_{\mathrm{th},0} - q_{\mathrm{th},0} \tag{6}$$

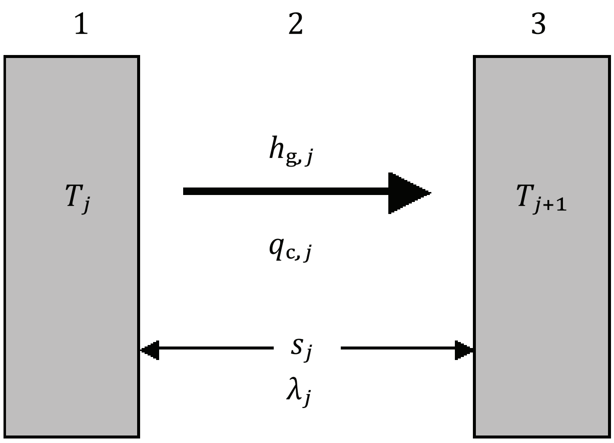
— the net radiant heat flow to the interior, as given in Formula (7):

$$q_{\mathrm{th,i}} = q_{\mathrm{th},n} - q'_{\mathrm{th},n} \tag{7}$$

— the net absorbed heat (transferred by thermal radiation) in the layer j, as given in Formula (8):

$$q_{\mathrm{th,\,a},j} = \varepsilon_j \cdot q_{\mathrm{th},j-1} + \varepsilon'_j \cdot q'_{\mathrm{th},j} - \left(\varepsilon_j + \varepsilon'_j\right) \cdot \sigma \cdot T_j^4 \tag{8}$$

6.4.4.2 Conductive and convective heat transfer in closed spaces



Key

1 layer *j*

2 space *j*

3 layer *j* + 1

λ_j thermal conductivity of the gas in space *j* at temperature $(T_j + T_{j+1})/2$

s_j width of space *j*

$h_{g,j}$ thermal conductance of the gas in space *j*

$q_{c,j}$ conductive-convective density of heat flow rate from layer *j* to layer *j* + 1

Figure 4 — Schematic presentation of the characteristic data of a closed space and the conduction-convective density of heat flow rate

The thermal conductance of the gas in a closed space *j* is given by Formula (9) (see Figure 4):

$$h_{g,j} = Nu_j \cdot \frac{\lambda_j}{s_j} \qquad (9)$$

where

λ_j is the thermal conductivity of the gas in space *j*;

s_j is the width of space *j*;

Nu_j is the Nusselt number in accordance with EN 673 or ISO 10292.

The external boundary conditions are given by the external air temperature and the external convective heat transfer coefficient:

$$T_0 = T_e; \quad h_{g,0} = h_{c,e}$$

Similarly, the internal boundary conditions are given by the internal air temperature and the internal convective heat transfer coefficient, as given in Formula (10):

$$T_{n+1} = T_i; \quad h_{g,n} = h_{c,i} \tag{10}$$

Assuming the temperatures are known for each layer, the net absorbed heat (transferred by conduction-convection) in the layer j is given by Formula (11):

$$q_{c,a,j} = h_{g,j-1} \cdot \left(T_{j-1} - T_j\right) + h_{g,j} \cdot \left(T_{j+1} - T_j\right) \tag{11}$$

The convective density of the heat flow rate to the external environment is given by Formula (12):

$$q_{c,e} = q_{c,a,0} = h_{g,0} \cdot \left(T_1 - T_e\right) \tag{12}$$

and from the internal environment, given by Formula (13):

$$q_{c,i} = q_{c,a,n} = h_{g,n} \cdot \left(T_i - T_n\right) \tag{13}$$

6.4.4.3 Ventilated air spaces

Air spaces may be connected to the external or internal environment or to other spaces. Assuming the mean velocity of the air in the space is known, the temperature profile and the heat flow may be calculated by a simple model. The mean air velocity can be directly calculated if the air space is mechanically ventilated, or calculated using Annex E if it is naturally ventilated.

Due to the airflow through the space, the air temperature in the space varies with height (see Figure 5). The temperature profile depends on the air velocity in the space and the heat transfer coefficient to both layers. The air temperature at height z in the ventilated space j is given by Formula (14):

$$T_j(z) = T_{m,j} - \left(T_{m,j} - T_{1,j}\right) \cdot e^{-z/H_{TP,j}} \qquad 0 \le z \le H_j \tag{14}$$

where

H_j is the height of space j;

$H_{TP,j}$ is the characteristic height (temperature penetration length), see Formula (15);

$T_{1,j}$ is the temperature of the incoming air;

$T_{m,j}$ is the mean temperature of layers j and j+1: $T_{m,j} = (T_j + T_{j+1})/2$

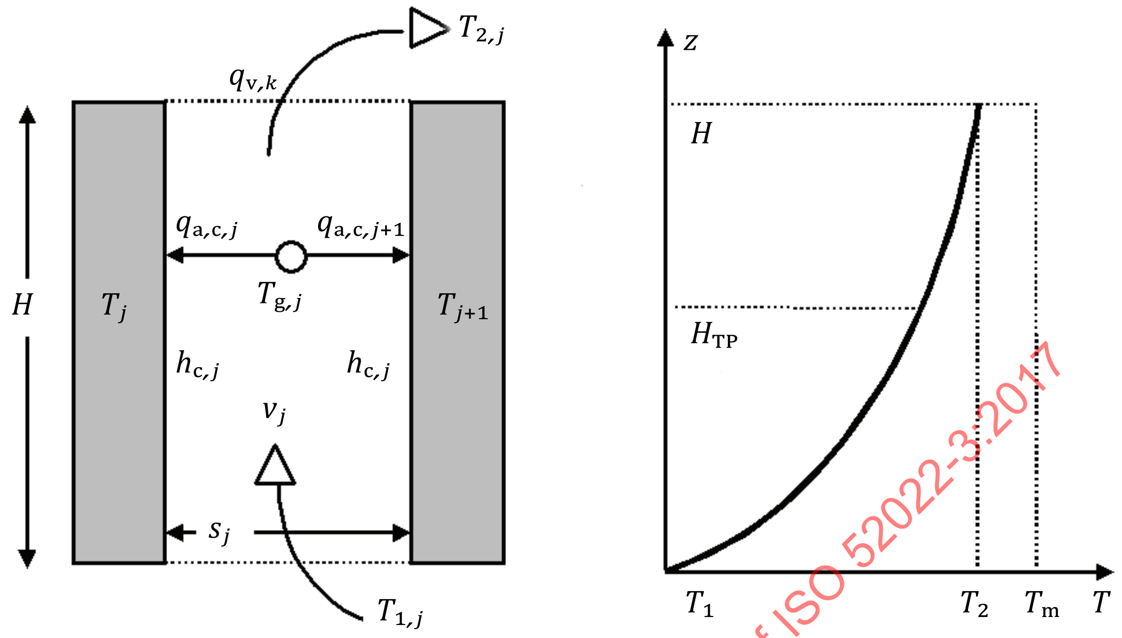


Figure 5 — Schematic presentation of the characteristic data of a ventilated space and the internal temperature profile assuming the incoming air is warmed up

The temperature penetration length is defined by Formula (15):

$$H_{TP,j} = \frac{\rho_j \cdot c_j \cdot s_j \cdot v_j}{2 \cdot h_{c,j}} \qquad (15)$$

where

ρ_j is the density of the air at temperature $T_{g,j}$;

c_j is the specific heat capacity of the air;

s_j is the width of the space j;

v_j is the mean velocity of the air flow in the space, calculated using Annex E if the space is naturally ventilated;

$h_{c,j}$ is the convective heat transfer coefficient for space j, as given in Formula (16):

$$h_{c,j} = 2 \cdot h_{g,j} + a \cdot v \qquad (16)$$

where

$h_{g,j}$ is the thermal conductance of a closed space, see 6.3.2;

a is the velocity coefficient [4 W·s/(m^3·K)].

The temperature of the air leaving the space is given by Formula (17):

$$T_{2,j} = T_{\mathrm{m},j} - \left(T_{\mathrm{m},j} - T_{1,j}\right) \cdot e^{-H_j / H_{\mathrm{TP},j}} \tag{17}$$

The equivalent temperature of the air (gas) in space j is defined by $T_{\mathrm{g},j} = \frac{1}{H_j} \int_0^{H_j} T_j(z)\,\mathrm{d}z$ and that results in Formula (18):

$$T_{\mathrm{g},j} = T_{\mathrm{m},j} - \frac{H_{\mathrm{TP},j}}{H_j}\left(T_{2,j} - T_{1,j}\right) \tag{18}$$

The absorbed heat in the layers j and j+1 in contact with the ventilated air space is given by Formulae (19) and (20):

$$q_{\mathrm{c,a},j} = h_{\mathrm{c},j} \cdot \left(T_{\mathrm{g},j} - T_j\right) \tag{19}$$

$$q_{\mathrm{c,a},j+1} = h_{\mathrm{c},j} \cdot \left(T_{\mathrm{g},j} - T_{j+1}\right) \tag{20}$$

and the heat flow from space j to the connected space k (e.g. the external and internal environments) as a result of air movement is given by Formula (21):

$$q_{\mathrm{v,a},k} = q_{\mathrm{c,a},j} + q_{\mathrm{c,a},j+1} \tag{21}$$

6.4.5 Energy balance

Assuming steady-state, the system of equations described before shall be solved for each layer j assuming, as given in Formula (22):

$$\alpha_{\mathrm{e},j} \cdot E_{\mathrm{S}} + q_{\mathrm{th,a},j} + q_{\mathrm{c,a},j} = 0 \tag{22}$$

where

E_{S} is the solar irradiation;

$\alpha_{\mathrm{e},j}$ is the solar absorptance of layer j;

$q_{\mathrm{th,a},j}$ is the absorbed thermal radiation;

$q_{\mathrm{c,a},j}$ is the absorbed heat by conduction/convection.

6.4.6 Boundary Conditions

Two sets of boundary conditions are given for the vertical position of the glazing and the blind.

a) Reference conditions: these boundary conditions are consistent with the general assumptions of EN 410 and ISO 10292.

They shall be used for product comparison and average solar gain calculations during the heating period.

b) Summer conditions: these boundary conditions are representative of more extreme conditions.

They shall be used for comfort evaluations and cooling load calculations.

Reference conditions[a]

External:

air temperature	T_e	278 K (5 °C)
radiant temperature	$T_{r,e}$	278 K (5 °C)
convective heat transfer coefficient	$h_{c,e}$	18 W/(m²·K)
incident solar radiation flow rate	E_S	300 W/m²

Internal:

air temperature	T_i	293 K (20 °C)
radiant temperature	$T_{r,i}$	293 K (20 °C)
convective heat transfer coefficient	$h_{c,i}$	3,6 W/(m²·K)

Summer conditions

External:

air temperature	T_e	25 °C
radiant temperature	$T_{r,e}$	25 °C
convective heat transfer coefficient[b]	$h_{c,e}$	8 W/(m²·K)
incident solar radiation flow rate	E_S	500 W/m²

Internal:

air temperature	T_i	25 °C
radiant temperature	$T_{r,i}$	25 °C
convective heat transfer coefficient[c]	$h_{c,i}$	2,5 W/(m²·K)

[a] The value given correspond to ISO 6946.

[b] The value corresponds to an air velocity of 1 m/s.

[c] The value corresponds to a temperature difference of 5 K.

7 Report

7.1 Contents of report

The calculation report shall include the following:

— reference to this document (ISO 52022-3);

— notation if the EN standards in the CEN area column in Table C.1 have been used;

— identification of the organization making the calculation;

— identification of the calculation software;

— date of calculation;

— items listed in 7.2 and 7.3.

7.2 Drawing

The report shall include a figure representing the thickness and the sequence of layers and spaces from the exterior to the interior.

7.3 Values used in the calculation

The report shall contain the names of the products and all the input data used for the calculation. The report of spectral data may be omitted; in that case, the source of the data and the integrated solar optical properties shall be given.

Furthermore:

— solar optical properties of each layer, type and position of coating;

— type of gas of each space and the type of ventilation;

— for a louvre or venetian blind system according to Annex D, the geometry and the solar optical properties of the material;

— for the ventilated space according to Annex E, the height and the geometry of the apertures and openness factor of fabric;

— the boundary conditions;

and if possible:

— characteristics of the glazing, e.g. U-value, g-value;

— characteristics of the blind system.

7.4 Presentation of results (see Table 4)

The three parts of the secondary internal heat transfer factor are defined as the difference of the secondary heat flow rate with and without solar radiation divided by the incident solar radiation flow rate.

The characteristic values shall be quoted to three decimal places, except for the total solar energy transmittance and the total light transmittance, which is rounded to two decimal places.

Table 4 — Presentation of results

Item	Energy to the interior by	Symbol	Reference
1	Direct solar transmittance	τ_e	$\tau(\lambda)$ [Formula (2)] evaluated according EN 410 or ISO 9050 for the total solar spectrum
2	Thermal radiation factor	g_{th}	$g_{th} = \frac{q_{th}(E_s) - q_{th}(0)}{E_s}$ [Formula (7)]
3	Convection factor	g_c	$g_c = \frac{q_c(E_s) - q_c(0)}{E_s}$ [Formula (13)]
4	Ventilation factor	g_v	$g_v = \frac{q_v(E_s) - q_v(0)}{E_s}$ (Formula (21))

Table 4 *(continued)*

Item	Energy to the interior by	Symbol	Reference
5	Secondary internal heat transfer factor	q_i	sum of items 2,3,4
6	Total solar energy transmittance	g_{tot}	sum of items 1,2,3,4
7	Total light transmittance	$\tau_{v,tot}$	$\tau(\lambda)$ [Formula (2)] evaluated according EN 410 or ISO 9050 for the visible spectrum

Annex A
(normative)

Input and method selection data sheet — Template

A.1 General

The template in Annex A of this document shall be used to specify the choices between methods, the required input data and references to other documents.

NOTE 1 Following this template is not enough to guarantee consistency of data.

NOTE 2 Informative default choices are provided in Annex B. Alternative values and choices can be imposed by national/regional regulations. If the default values and choices of Annex B are not adopted because of the national/regional regulations, policies or national traditions, it is expected that:

— national or regional authorities prepare data sheets containing the national or regional values and choices, in line with the template in Annex A; or

— by default, the national standards body will add or include a national annex (Annex NA) to this document, in line with the template in Annex A, giving national or regional values and choices in accordance with their legal documents.

NOTE 3 The template in Annex A is applicable to different applications (e.g., the design of a new building, certification of a new building, renovation of an existing building and certification of an existing building) and for different types of buildings (e.g., small or simple buildings and large or complex buildings). A distinction in values and choices for different applications or building types could be made:

— by adding columns or rows (one for each application), if the template allows;

— by including more than one version of a table (one for each application), numbered consecutively as a, b, c, ... For example: Table NA.3a, Table NA.3b;

— by developing different national/regional data sheets for the same standard. In case of a national annex to the standard these will be consecutively numbered (Annex NA, Annex NB, Annex NC, ...).

NOTE 4 In the section "Introduction" of a national/regional data sheet information can be added, for example about the applicable national/regional regulations.

NOTE 5 For certain input values to be acquired by the user, a data sheet following the template of Annex A, could contain a reference to national procedures for assessing the needed input data. For instance, reference to a national assessment protocol comprising decision trees, tables and pre-calculations.

The shaded fields in the tables are part of the template and consequently not open for input.

A.2 References

The references, identified by the EPB module code number, are given in Table A.1 (template).

Table A.1 — References

Reference	Reference document	
	Number	Title
Mx-y[a]	...	...
	...	...

[a] In this document there are no choices in references to other EPB standards. The Table is kept to maintain uniformity between all EPB standards

A.3 Calculation of solar and light transmittance

NOTE Currently, in this document, there are no choices between methods and the required input data foreseen that are to be kept open for completion as explained in A.1. To satisfy the need for congruence with all other EPB standards and to make explicitly clear that in this document, there are no choices kept open, Annex A and Annex B are kept.

Annex B
(informative)

Input and method selection data sheet — Default choices

B.1 General

The template in Annex A of this document shall be used to specify the choices between methods, the required input data and references to other documents.

NOTE 1 Following this template is not enough to guarantee consistency of data.

NOTE 2 Informative default choices are provided in Annex B. Alternative values and choices can be imposed by national/regional regulations. If the default values and choices of Annex B are not adopted because of the national/regional regulations, policies or national traditions, it is expected that:

— national or regional authorities prepare data sheets containing the national or regional values and choices, in line with the template in Annex A; or

— by default, the national standards body will add or include a national annex (Annex NA) to this document, in line with the template in Annex A, giving national or regional values and choices in accordance with their legal documents.

NOTE 3 The template in Annex A is applicable to different applications (e.g., the design of a new building, certification of a new building, renovation of an existing building and certification of an existing building) and for different types of buildings (e.g., small or simple buildings and large or complex buildings). A distinction in values and choices for different applications or building types could be made:

— by adding columns or rows (one for each application), if the template allows;

— by including more than one version of a table (one for each application), numbered consecutively as a, b, c, ... For example: Table NA.3a, Table NA.3b;

— by developing different national/regional data sheets for the same standard. In case of a national annex to the standard these will be consecutively numbered (Annex NA, Annex NB, Annex NC, ...).

NOTE 4 In the section “Introduction” of a national/regional data sheet information can be added, for example about the applicable national/regional regulations.

NOTE 5 For certain input values to be acquired by the user, a data sheet following the template of Annex A, could contain a reference to national procedures for assessing the needed input data. For instance, reference to a national assessment protocol comprising decision trees, tables and pre-calculations.

The shaded fields in the tables are part of the template and consequently not open for input.

B.2 References

The references, identified by the EPB module code number, are given in Table B.1.

Table B.1 — References

Reference	Reference document	
	Number	Title
Mx-y[a]	...	...
	...	...

[a] In this document there are no choices in references to other EPB standards. The Table is kept to maintain uniformity between all EPB standards.

B.3 Calculation of solar and light transmittance

NOTE Currently, in this document, there are no choices between methods and the required input data foreseen that are to be kept open for completion as explained in B.1. To satisfy the need for congruence with all other EPB standards and to make explicitly clear that in this document, there are no choices kept open, Annex A and Annex B are kept.

Annex C
(normative)

Regional references in line with ISO Global Relevance Policy

This document contains specific parallel routes in referencing other standards, in order to take into account existing national and/or regional regulations and/or legal environments while maintaining global relevance.

The standards that shall be used as called for in the successive clauses are given in Table C.1.

Table C.1 — Regional references in line with ISO Global Relevance Policy

Subject		Global	Regional: CEN area[a]
Optical properties			
1	— glazing	ISO 9050	EN 410
	— solar shading	National standard, or other appropriate document	EN 14500
Thermal properties/emissivity			
2	— solar shading — glazing	ISO/CD 19597 (under preparation)	EN 12898
Gas space			
3	— calculation of the thermal resistance	ISO 10292	EN 673
	— physical properties of the gas	Annex F of this document	Annex F of this document

[a] CEN area = Countries whose national standards body is a member of CEN. Attention is drawn to the need for observance of EU Directives transposed into national legal requirements.

Annex D
(normative)

Determination of equivalent solar and light optical characteristics for louvres or venetian blinds

D.1 Assumptions

It is assumed that

— louvres or venetian blinds are adjusted to eliminate direct transmission of the solar beam, and

— reflectance and transmittance of the blind material are diffused.

D.2 Symbols

$\Phi_{i,j}$ view factor from zone i to zone j (see Figure D.1)[5]

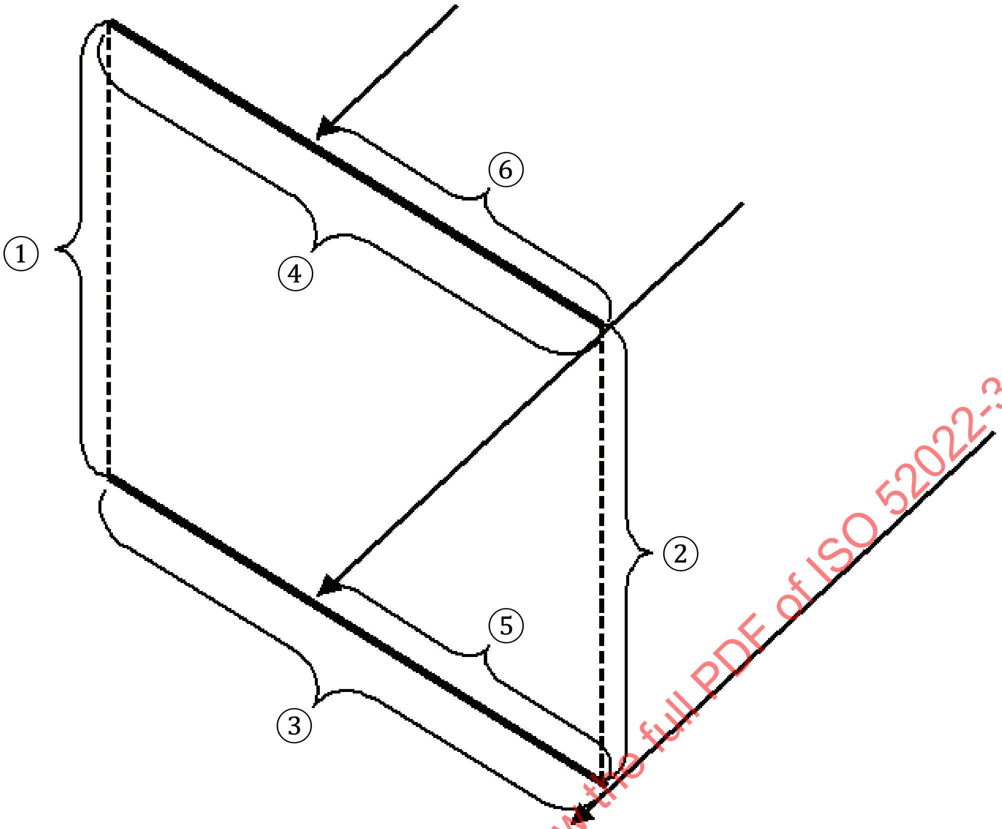
τ transmittance of the blind material

ρ reflectance of the side of blind facing the incident radiation

ρ' reflectance of the side of blind facing away from the incident radiation

τ_S transmittance of the system

ρ_S reflectance of the system to the exterior



NOTE Zones ① to ⑥ refer to the view factors $\Phi_{i,j}$.

Figure D.1 — Schematic presentation of a louvre or venetian blind

D.3 Direct radiation

$$\tau_{S,D} = \Phi_{51}\rho + \Phi_{61}\tau + \frac{\left(Z\Phi_{54}\rho' + \Phi_{63}\tau\right)\left(\Phi_{31}\rho + \Phi_{41}\tau\right) + \left(Z\Phi_{63}\tau + \Phi_{54}\rho\right)\left(\Phi_{41}\rho' + \Phi_{31}\tau\right)}{\Phi_{34}\rho \cdot \left(1 - ZZ'\right)} \cdot Z \quad \text{(D.1)}$$

$$\rho_{S,D} = \Phi_{52}\rho + \Phi_{62}\tau + \frac{\left(Z\Phi_{54}\rho' + \Phi_{63}\tau\right)\left(\Phi_{32}\rho + \Phi_{42}\tau\right) + \left(Z\Phi_{63}\tau + \Phi_{54}\rho\right)\left(\Phi_{42}\rho' + \Phi_{32}\tau\right)}{\Phi_{34}\rho \cdot \left(1 - ZZ'\right)} \cdot Z \quad \text{(D.2)}$$

where

$$Z = \frac{\Phi_{34}\rho}{1 - \Phi_{34}\tau}; \quad Z' = \frac{\Phi_{34}\rho'}{1 - \Phi_{34}\tau} \quad \text{(D.3)}$$

NOTE ρ_{dir} is the reflectance to the exterior; there is a second reflectance to the interior, which is mathematically identical if subscript 2 is replaced by 1 in Formula (D.2).

D.4 Diffuse radiation

$$\tau_{S,d} = \Phi_{21} + \frac{\left(\Phi_{23}\rho + \Phi_{24}\tau\right)\left(\Phi_{31} + Z'\Phi_{41}\right) + \left(\Phi_{24}\rho' + \Phi_{23}\tau\right)\left(\Phi_{41} + Z\Phi_{31}\right)}{\Phi_{34}\rho \cdot \left(1 - ZZ'\right)} \cdot Z \quad \text{(D.4)}$$