INTERNATIONAL STANDARD

ISO 10077-1

Third edition
2017-06

Corrected version
2020-02

Thermal performance of windows, doors and shutters — Calculation of thermal transmittance —

Part 1: General

Performance thermique des fenêtres, portes et fermetures — Calcul du coefficient de transmission thermique —
Partie 1: Généralités

Reference number
ISO 10077-1:2017(E)

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Published in Switzerland

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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 10077-1 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 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).

This third edition cancels and replaces the second edition (ISO 10077-1:2006), of which it constitutes a minor revision. The necessary editorial revisions were made to comply with the requirements for the EPB set of standards.

In addition, the following clauses and subclauses of the previous version have been revised.

— In Clause 6 (previous edition), the boundary condition “determined with the glazing replaced with a material of thermal conductivity not exceeding 0,04 W/(m^2·K)” was deleted, because the rules are defined in EN 12412-2.

— In Clause 6 (previous edition), the measurement according to EN 12412-2 for the determination of Ψ_g and/or Ψ_p was deleted. It is not within the scope of EN 12412-2 to determine Ψ values.

— In Clause 6 (previous edition), the second paragraph was deleted. It is not necessary to give further possibilities. Determination of the input data in unambiguous is defined.

— In 5.2.2 (previous edition), the formula was deleted. Determination of U_g is according to ISO 10292.[1)]

— Formulae (1) and (2) were extended for the consideration of glazing bars.

— Tabulated values were added for the linear thermal transmittance of glazing bars.

— Status of Annex C (previous edition) was changed to normative; some values were revised to give the values to two significant figures.

1) See Table C.1 for alternative regional references in line with ISO Global Relevance Policy.

— Table C.2 (previous edition) was moved to ISO/TR 52022-2:2017.

— Annex E (previous edition) was moved to the main body of the document.

— Annex G and Annex H (previous edition) were moved to ISO/TR 52022-2:2017.

It also incorporates the Technical Corrigendum ISO 10077-1:2006/Cor. 1:2009.

A list of all parts in the ISO 10077 series can be found on the ISO website.

This corrected version of ISO 10077-1:2017 incorporates the following corrections:

— In the Introduction, the reference to Annex D was changed to Annex F;

— In the Introduction, the reference to Annex E was changed to Annex G;

— In 6.3.2.2, the reference to Annex G was changed to Annex H;

— In 6.3.2.3.2, Ug was changed to U_g;

— In the Note in 6.4.2.1.2, the reference to Annex F was changed to Annex E;

— In the header of Tables H.2, H.3 and H.4, the value was changed from 0,8 to 0,80;

— In Table H.3, in the thirteenth column and first row after the header, the value was changed from 51 to 5,1;

— In Table H.3, in the third column and twenty-ninth row after the header, the value was changed from 0,18 to 0,81.

Introduction

This document is part of a series of standards aiming at international harmonization of the methodology for the assessment of the energy performance of buildings, called "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 of this document are manufacturers of windows.

Use by or for regulators: In case the 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 in 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 standard 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. 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 in 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 calculation method described in this document is used to evaluate the thermal transmittance of windows and doors, or as part of the determination of the energy use of a building.

An alternative to calculation is testing of the complete window or door according to ISO 12567-1 or, for roof windows, according to ISO 12567-2.

The calculation is based on four component parts of the overall thermal transmittance:

— for elements containing glazing, the thermal transmittance of the glazing, calculated using EN 673 or measured according to EN 674 or EN 675;

— for elements containing opaque panels, the thermal transmittance of the opaque panels, calculated according to ISO 6946 and/or ISO 10211 (all parts) or measured according to ISO 8301 or ISO 8302;

— thermal transmittance of the frame, calculated using ISO 10077-2, measured according to EN 12412-2, or taken from Annex F;

— linear thermal transmittance of the frame/glazing junction, calculated according to ISO 10077-2 or taken from Annex G.

The thermal transmittance of curtain walling can be calculated using ISO 12631.

EN 13241-1 gives procedures applicable to doors intended to provide access for goods and vehicles.

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.

Table 1 — Position of this document (in case M2–5) 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	ISO 10077-1	Emission and control									
6	Building occupancy and operating conditions		Heat transfer by infiltration and ventilation		Distribution 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**
7	Aggregation of energy services and energy carriers		Internal heat gains		Storage and control									
8	Building zoning		Solar heat gains		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.

Thermal performance of windows, doors and shutters — Calculation of thermal transmittance —

Part 1: General

1 Scope

This document specifies methods for the calculation of the thermal transmittance of windows and pedestrian doors consisting of glazed and/or opaque panels fitted in a frame, with and without shutters.

This document allows for

— different types of glazing (glass or plastic; single or multiple glazing; with or without low emissivity coatings, and with spaces filled with air or other gases),

— opaque panels within the window or door,

— various types of frames (wood, plastic, metallic with and without thermal barrier, metallic with pinpoint metallic connections or any combination of materials), and

— where appropriate, the additional thermal resistance introduced by different types of closed shutter or external blind, depending on their air permeability.

The thermal transmittance of roof windows and other projecting windows can be calculated according to this document, provided that the thermal transmittance of their frame sections is determined by measurement or by numerical calculation.

Default values for glazing, frames and shutters are given in the annexes. Thermal bridge effects at the rebate or joint between the window or door frame and the rest of the building envelope are excluded from the calculation.

The calculation does not include

— effects of solar radiation (see standards under M2-8),

— heat transfer caused by air leakage (see standards under M2-6),

— calculation of condensation,

— ventilation of air spaces in double and coupled windows, and

— surrounding parts of an oriel window.

The document is not applicable to

— curtain walls and other structural glazing (see other standards under M2-5), and

— industrial, commercial and garage doors.

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 6946, *Building components and building elements — Thermal resistance and thermal transmittance — Calculation method*

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

ISO 8301, *Thermal insulation — Determination of steady-state thermal resistance and related properties — Heat flow meter apparatus*

ISO 8302, *Thermal insulation — Determination of steady-state thermal resistance and related properties — Guarded hot plate apparatus*

ISO 10077-2, *Thermal performance of windows, doors and shutters — Calculation of thermal transmittance — Part 2: Numerical method for frames*

ISO 10211, *Thermal bridges in building construction — Heat flows and surface temperatures — Detailed calculations*

ISO 10291, *Glass in building — Determination of steady-state U values (thermal transmittance) of multiple glazing — Guarded hot plate method*

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

ISO 10293, *Glass in building — Determination of steady-state U values (thermal transmittance) of multiple glazing — Heat flow meter method*

ISO 10456, *Building materials and products — Hygrothermal properties — Tabulated design values and procedures for determining declared and design thermal values*

ISO 12567-2, *Thermal performance of windows and doors — Determination of thermal transmittance by hot box method — Part 2: Roof windows and other projecting windows*

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

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 12412-2, *Thermal performance of windows, doors and shutters — Determination of thermal transmittance by hot box method — Frames*

EN 12664, *Thermal performance of building materials and products — Determination of thermal resistance by means of guarded hot plate and heat flow meter methods — Dry and moist products of medium and low thermal resistance*

EN 12667, *Thermal performance of building materials and products — Determination of thermal resistance by means of guarded hot plate and heat flow meter methods — Products of high and medium thermal resistance*

EN 13125, *Shutters and blinds — Additional thermal resistance — Allocation of a class of air permeability to a product*

EN 13561, *External blinds and awnings — Performance requirements including safety*

EN 13659, *Shutters and external venetian blinds — Performance requirements including safety*

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 10292, ISO 7345, 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

NOTE In Clause 6, descriptions are given of a number of geometrical characteristics of glazing and frame.

3.1
EPB standard
standard that complies with the requirements given in ISO 52000-1, CEN/TS 16628[3] and CEN/TS 16629[4]

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
A	area	m^2
R	thermal resistance	$m^2 \cdot K/W$
U	thermal transmittance	$W/(m^2 \cdot K)$
b	width	m
d	distance, thickness	m
l	length	m
q	density of heat flow rate	W/m^2
Ψ	linear thermal transmittance	W/(m·K)
λ	thermal conductivity	W/(m·K)

4.2 Subscripts

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

Subscript	Description
D	door
W	window
WS	window with closed shutter or blind
d	developed
e	external
f	frame
g	glazing
gb	glazing bar
i	internal
j	summation index
p	panel (opaque)
s	space (air or gas space)
se	external surface
sh	shutter or blind
si	internal surface

5 Description of the method

5.1 Output of the method

The output of this document is the thermal transmittance of windows and pedestrian doors consisting of glazed and/or opaque panels fitted in a frame, with and without shutters:

Depending on the type of product or assembly, it is one of the following:

— the thermal transmittance of a single window, U_W;

— the thermal transmittance, U_W, of a system consisting of two separate windows;

— the thermal transmittance, U_W, of a system consisting of one frame and two separate sashes or casements;

— the thermal transmittance of a window with closed shutters or external blinds, U_{WS};

— the thermal transmittance, U_D, of a door set of which the door leaf is fully glazed, or if the door consists of frame, glazing and opaque panels, or if the door has no glazing.

5.2 General description

In general, the thermal transmittance or *U*-value of the window or door product or assembly is calculated as a function of the thermal transmittance of the components and their geometrical characteristics, plus the thermal interactions between the components.

— The calculation procedures depend on the composition of the product or assembly.

— Components may include (where appropriate): glazings, opaque panels, frames, and closed shutters or external blinds.

— Thermal interactions are lateral heat flow (linear thermal bridge effect) between adjacent components and surface and cavity thermal resistances (thermal radiation and convection).

— The geometrical characteristics concern the sizes and positions of the components and the tilt angle of the window or door.

5.3 Other general topics

Results obtained for the purposes of comparison of products (declared values) shall be calculated or measured for horizontal heat flow.

If design values are taking into account the actual inclination of the window, they shall be determined for the actual inclination and boundary conditions, by including the effect of the inclination of the window in the determination of U_g. However, U_f and Ψ_g and/or Ψ_p as determined for the window in the vertical position are used for all inclinations of the window. The design value is to be calculated only if it is needed for the calculation of the energy demand of the building.

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 of thermal transmittance

6.1 Output data

The outputs of this document are transmission heat transfer coefficients as shown in Table 2.

Table 2 — Output data

Description	Symbol	Unit	Destination module	Validity interval	Varying
Thermal transmittance of window	U_W	W/(m²·K)	M2-2, M2-3, M2-4	0 to ∞	No
Thermal transmittance of door	U_D	W/(m²·K)	M2-2, M2-3, M2-4	0 to ∞	No
Thermal transmittance of window with closed shutter or external blind	U_{WS}	W/(m²·K)	M2-2, M2-3, M2-4	0 to ∞	No

6.2 Calculation time intervals

The input, the method and the output data are for steady state conditions and assumed to be independent of actual conditions, such as indoor and outdoor temperature or effect of wind or solar radiation.

6.3 Input data

6.3.1 Geometrical characteristics

6.3.1.1 General

Table 3 shows the necessary geometrical characteristics.

Table 3 — Identifiers for geometric characteristics

Name	Symbol	Unit	Range	Origin module[a]	Varying
Geometrical data					
Window area	A_W	m^2	0 to ∞	Window or door product or assembly	No
Door area	A_D	m^2	0 to ∞	Window or door product or assembly	No
Glazed area	A_g	m^2	0 to ∞	Window or door product or assembly	No
Frame area	A_f	m^2	0 to ∞	Window or door product or assembly	No
Opaque panel area	A_p	m^2	0 to ∞	Window or door product or assembly	No
Total perimeter of the glazing	l_g	m	0 to ∞	Window or door product or assembly	No
Total perimeter of the panel	l_p	m	0 to ∞	Window or door product or assembly	No
Total length of the glazing bar	l_{gb}	m	0 to ∞	Window or door product or assembly	No

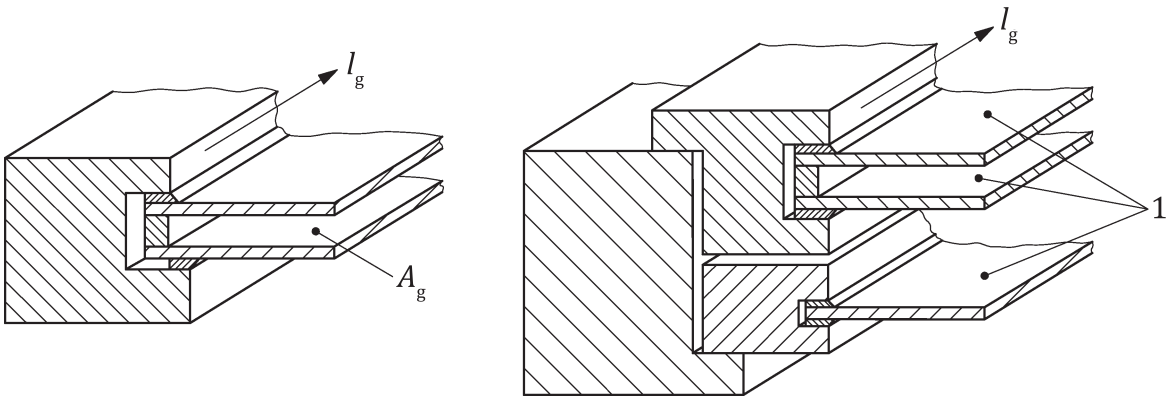
[a] According to specifications given in 6.3.1.2 to 6.3.1.5.

6.3.1.2 Glazed area, opaque panel area

The glazed area, A_g, or the opaque panel area, A_p, of a window or door is the smaller of the visible areas seen from both sides; see Figure 2. Any overlapping of gaskets is ignored.

6.3.1.3 Total visible perimeter of the glazing

The total perimeter of the glazing, l_g, (or the opaque panel, l_p) is the sum of the visible perimeter of the glass panes (or opaque panels) in the window or door. If the perimeters are different on either side of the pane or panel, then the larger of the two shall be used; see Figure 1.



Key

1 glass

Figure 1 — Illustration of glazed area and perimeter

6.3.1.4 Frame areas

For the definition of the areas, see also Figure 2.

$A_{f,i}$ Internal projected frame area:

The internal projected frame area is the area of the projection of the internal frame, including sashes if present, on a plane parallel to the glazing panel.

$A_{f,e}$ External projected frame area:

The external projected frame area is the area of the projection of the external frame, including sashes if present, on a plane parallel to the glazing panel.

A_f Frame area:

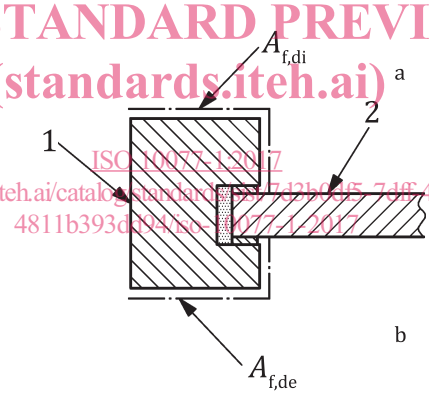
The frame area is the larger of the two projected areas seen from both sides.

$A_{f,di}$ Internal developed frame area:

The internal developed frame area is the area of the frame, including sashes if present, in contact with the internal air (see Figure 2).

$A_{f,de}$ External developed frame area:

The external developed frame area is the area of the frame, including sashes if present, in contact with the external air (see Figure 2).



Key

1 frame
2 glazing
a Internal.
b External.

Figure 2 — Internal and external developed area

6.3.1.5 Window area and door area

The window area, A_W, or the door area, A_D; A is the sum of the frame area, A_f, and the glazing area, A_g, (or the panel area, A_p).

The frame area and the glazed area are defined by the edge of the frame, i.e. sealing gaskets are ignored for the purposes of determination of the areas.

Window or door dimensions (height, width, frame width and frame thickness) shall be determined to the nearest millimetre.