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ISO 13789

Third edition
2017-06

Thermal performance of buildings — Transmission and ventilation heat transfer coefficients — Calculation method

Performance thermique des bâtiments — Coefficients de transfert de chaleur par transmission et par renouvellement d'air — Méthode de calcul

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Contents

Page

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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 13789 was prepared by ISO Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 2, *Calculation methods*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 89, *Thermal performance of buildings and building components,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 13789:2007), which has been technically revised.

The changes in this third edition are mostly editorial. The document has been re-drafted according to CEN/TS 16629:2014.

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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 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 of 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. 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 (ISO/TR 52019-2) accompanying this document.

The subset of EPB standards prepared under the responsibility of ISO/TC 163/SC 2 cover *inter alia*:

— calculation procedures on the overall energy use and energy performance of buildings;

— calculation procedures on the internal temperature in buildings (e.g. in case of no space heating or cooling);

— indicators for partial EPB requirements related to thermal energy balance and fabric features;

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— calculation methods covering the performance and thermal, hygrothermal, solar and visual characteristics of specific parts of the building and specific building elements and components, such as opaque envelope elements, ground floor, windows and facades.

ISO/TC 163/SC 2 cooperates with other technical committees for the details on appliances, technical building systems, indoor environment, etc.

This document provides the means (in part) to assess the contribution that building products and services make to energy conservation and to the overall energy performance of buildings.

The aims of ISO 13789 are

— to clarify the international market through the harmonized definition of intrinsic characteristics of buildings;

— to help in judging compliance with regulations;

— to provide input data for calculation of annual energy use for heating or cooling of buildings.

The result of the calculations can be used as input for calculation of annual energy use and heating or cooling load of buildings, for expressing the thermal transmission and/or ventilation characteristics of a building or for judging compliance with specifications expressed in terms of transmission and/or ventilation heat transfer coefficients.

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.

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Table 1 — Position of this document (*in casu* M2-5 and M2-6) 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	Applica-tions		(Free) Indoor conditions without systems		Maximum load and power									

a The shaded modules are not applicable.

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	Overarching		Building (as such)		Technical building systems									
Sub mo dule	Descrip tions		Descrip tions		Descrip tions	Hea ting	Coo ling	Ven tila tion	Hu mi difi ca tion	De hu mi difi ca tion	Do mes tic hot wat er	Ligh ting	Buil ding auto ma tion and cont rol	PV, wind, ..
sub1		M1		M2		M3	M4	M5	M6	M7	M8	M9	M10	M11
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 13689	Emission and control									
6	Building occupancy and operating conditions		Heat transfer by infiltration and ventilation	ISO 13689	Distribution and control									
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									

a The shaded modules are not applicable.

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Table 1 *(continued)*

	Overarching		Building (as such)		Technical building systems									
Submodule	**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**
12	Ways to express indoor comfort				BMS									
13	External environment conditions													
14	Economic calculation													

[a] The shaded modules are not applicable.

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Thermal performance of buildings — Transmission and ventilation heat transfer coefficients — Calculation method

1 Scope

This document specifies a method and provides conventions for the calculation of the steady-state transmission and ventilation heat transfer coefficients of whole buildings and parts of buildings. It is applicable both to heat loss (internal temperature higher than external temperature) and to heat gain (internal temperature lower than external temperature). For the purpose of this document, the heated or cooled space is assumed to be at uniform temperature.

Annex C provides a steady-state method to calculate the temperature in unconditioned spaces adjacent to conditioned spaces.

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.

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2 Normative references

The following documents are referred to in 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 10077-1, *Thermal performance of windows, doors and shutters — Calculation of thermal transmittance — Part 1: General*

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

ISO 12631, *Thermal performance of curtain walling — Calculation of thermal transmittance*

ISO 13370, *Thermal performance of buildings — Heat transfer via the ground — Calculation methods*

ISO 14683, *Thermal bridges in building construction — Linear thermal transmittance — Simplified methods and default values*

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

NOTE 1 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).

NOTE 2 In this document, there are no choices in references to other EPB standards. The sentence and note above is kept to maintain uniformity between all EPB standards.

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3 Terms and definitions

For the purposes of this document, the terms and definitions in ISO 7345 and 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
heated space
room or enclosure that, for the purposes of a calculation, is assumed to be heated for a given duration or durations to a given set-point temperature or set point temperatures

3.2
cooled space
room or enclosure that, for the purposes of a calculation, is assumed to be cooled for a given duration or durations to a given set-point temperature or set-point temperatures

3.3
conditioned space
heated and/or cooled space

Note 1 to entry: The heated and/or cooled spaces are used to define the thermal envelope.

3.4
unconditioned space
room or enclosure which is not part of a conditioned space

3.5
heat transfer coefficient
heat flow rate divided by temperature difference between two environments

Note 1 to entry: Specifically used for heat transfer coefficient by transmission or ventilation.

3.6
transmission heat transfer coefficient
heat flow rate due to thermal transmission through the fabric of a building, divided by the difference between the environment temperatures on either side of the construction

Note 1 to entry: By convention, if the heat is transferred between a conditioned space and the external environment, the sign is positive if the heat flow is from the space to outside (heat loss).

3.7
ventilation heat transfer coefficient
heat flow rate due to air entering a conditioned space either by infiltration or ventilation, divided by the temperature difference between the internal air and the supply air temperature

Note 1 to entry: The supply temperature for infiltration is equal to the external temperature.

3.8
building heat transfer coefficient
sum of transmission and ventilation heat transfer coefficients

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3.9
thermal envelope area
total area of all elements of a building that enclose thermally conditioned spaces through which thermal energy is transferred, directly or indirectly, to or from the external environment

Note 1 to entry: The thermal envelope area depends on whether internal, overall internal or external dimensions are being used.

3.10
mean thermal transmittance of building envelope
transmission heat transfer coefficient divided by envelope area

3.11
internal dimension
dimension measured from wall to wall and floor to ceiling inside a room of a building

Note 1 to entry: See Figure 1.

3.12
overall internal dimension
dimension measured on the interior of a building, ignoring internal partitions

Note 1 to entry: See Figure 1.

3.13
external dimension
dimension measured on the exterior of a building

Note 1 to entry: See Figure 1.

3.14
EPB standard
standard that complies with the requirements given in ISO 52000-1, CEN/TS 16628[4] and CEN/TS 16629[5]

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 and support essential requirements of EU Directive 2010/31/EU on the energy performance of buildings. Several EPB standards and related documents are developed or revised under the same mandate.

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

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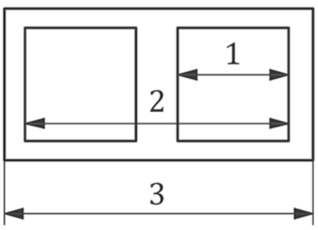

Key

1 internal dimension

2 overall internal dimension

3 external dimension

Figure 1 — Dimension systems

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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	Quantity	Unit
A	area	m^2
b	adjustment factor for heat transfer coefficient	—
c_p	specific heat capacity of air at constant pressure	Wh/(kg·K)
H	heat transfer coefficient	W/K
h	surface heat transfer coefficient	$W/(m^2 \cdot K)$
l	length	m
n	air change rate	h^{-1}
q, q_V	volumetric air flow rate	m^3/h
U	thermal transmittance	$W/(m^2 \cdot K)$
V	volume	m^3
κ	thermal capacity	$J/(m^2 \cdot K)$
ρ	density	kg/m^3
Φ	heat flow rate	W
Ψ	linear thermal transmittance	W/(m·K)
χ	point thermal transmittance	W/K
θ	Celsius temperature	°C

4.2 Subscripts

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

a	adjacent
adj	adjusted
air	air
c	opaque element
cw	curtain wall
ce, ci	convective external, internal
d	direct; door
e	external
eff	effective
f	floor construction
g	ground
int	internal
ia	between a conditioned space and the adjacent building
iu	between a conditioned space and the unconditioned space
l	leakage
m	month number
mn	mean
re, ri	radiative external, internal
tot	total

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tr	transmission
tb	thermal bridge
u	unconditioned
ue	between the unconditioned space and the external environment
ve	ventilation
vi	virtual
w	window
ws	window with closed shutter
50	50 Pa (pressure difference)

5 Description of the method

5.1 Output

The outputs of this document are the transmission and ventilation heat transfer coefficients of a building. These quantities take account of the thermal properties of the construction elements bounding the conditioned space in the building and air leakage characteristics.

5.2 General description

The thermal properties of components of the building structure (calculated using other standards) are combined so as to provide heat transfer data related to the building as a whole.

6 Calculation of heat transfer coefficients

6.1 Output data

The output of this document is transmission and ventilation heat transfer coefficients, as shown in Table 2.

Table 2 — Output data

Description	Symbol	Unit	Destination module (Table 1)	Validity interval	Varying
direct transmission heat transfer coefficient between the heated or cooled space and the exterior, for the whole building	H_d	W/K	M2–2	≥0	No
steady-state transmission heat transfer coefficient through the ground	H_g	W/K	M2–2 [M][b]	≥0	No
transmission heat transfer coefficient through unconditioned spaces	H_u	W/K	M2–2	≥0	No
direct heat transfer coefficient between the conditioned space and the unconditioned space	H_{iu}	W/K	M2–2	≥0	No
heat transfer coefficient between the unconditioned space and the external environment	H_{ue}	W/K	M2–2	≥0	No

a These quantities are calculated in other standards and listed here as part of the data transferred to destination modules.

b M2–2 [H]: hourly calculation method; M2–2 [M]: monthly calculation method.

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Table 2 *(continued)*

Description	Symbol	Unit	Destination module (Table 1)	Validity interval	Varying
transmission heat transfer coefficient between the unconditioned space and the external environment	$H_{tr;ue}$	W/K	M2–2	≥0	No
steady-state transmission and ventilation heat transfer coefficient to adjacent buildings	H_a	W/K	M2–2	≥0	No
transmission heat transfer coefficient due to thermal bridges	H_{tb}	W/K	M2–2	≥0	No
transmission heat transfer coefficient	H_{tr}	W/K	M2–2	≥0	No
ventilation heat transfer coefficient	H_{ve}	W/K	M2–2	≥0	No
mean thermal transmittance of building fabric	U_{mn}	W/(m²·K)	M2–4	≥0	No
thermal transmittance of opaque element (from ISO 6946)[a]	U_c	W/(m²·K)	M2–2 [M][b]	≥0	No
thermal resistance of opaque element (from ISO 6946)[a]	R_c	m²·K/W	M2–2 [H][b]	≥0	No
ground transmission heat transfer coefficient for each month (see 7.4)	$H_{g;an;m}$	W/K	M2–2 [M][b]	≥0	Yes
ground transmission heat transfer coefficient for the heating season (from ISO 13370)[a]	$H_{g;H;adj}$	W/K	M2–2 [M][b]	≥0	No
ground transmission heat transfer coefficient for the cooling season (from ISO 13370)[a]	$H_{g;C;adj}$	W/K	M2–2 [M][b]	≥0	No
effective thermal resistance of floor construction, including the effect of the ground (from ISO 13370)	$R_{f;eff}$	m²·K/W	M2–2 [H][b]	≥0	No
thermal resistance of 0,5 m thick ground layer, for floor construction (from ISO 13370)[a]	R_g	(m²·K)/W	M2–2 [H][b]	≥0	No
thermal capacity of 0,5 m of ground, for floor construction (from ISO 13370)[a]	κ_g	J/(m²·K)	M2–2 [H][b]	≥0	No
thermal resistance of a virtual ground layer, for floor construction (from ISO 13370)[a]	$R_{g;v}$	(m²·K)/W	M2–2 [H][b]	≥0	No
virtual temperature in ground, for floor construction for each month (from ISO 13370)[a]	$\theta_{g;v;m}$	°C	M2–2 [H][b]	−50 to +50	Yes
thermal transmittance of window (from ISO 10077-1)[a]	U_w	W/(m²·K)	M2–2	≥0	No
thermal transmittance of window with closed shutters (from ISO 10077-1)[a]	U_{ws}	W/(m²·K)	M2–2	≥0	No
thermal transmittance of door (from ISO 10077-1)[a]	U_d	W/(m²·K)	M2–2	≥0	No
thermal transmittance of curtain wall (from ISO 12631)[a]	U_{cw}	W/(m²·K)	M2–2	≥0	No
glazed area (from ISO 10077-1)[a]	A_g	m²	M2–2	≥0	No

[a] These quantities are calculated in other standards and listed here as part of the data transferred to destination modules.

[b] M2–2 [H]: hourly calculation method; M2–2 [M]: monthly calculation method.

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Table 2 *(continued)*

Description	Symbol	Unit	Destination module (Table 1)	Validity interval	Varying
convective heat transfer coefficient internal surface, of building element (see 9.5)	h_{ci}	W/(m²·K)	M2–2	≥0	No
long-wave radiative heat transfer coefficient internal surface, of building element (see 9.5)	h_{re}	W/(m²·K)	M2–2	≥0	No
convective heat transfer coefficient external surface, of building element (see 9.5)	h_{ce}	W/(m²·K)	M2–2	≥0	No
long-wave radiative heat transfer coefficient external surface, of building element (see 9.5)	h_{ri}	W/(m²·K)	M2–2	≥0	No
area of building element	A_e	m²	M2–2	≥0	No
linear thermal transmittance of thermal bridge (from ISO 10211 or ISO 14683)[a]	Ψ	W/(m·K)	M2–2	≥0	No
length of thermal bridge	l	m	M2–2	≥0	No

[a] These quantities are calculated in other standards and listed here as part of the data transferred to destination modules.

[b] M2–2 [H]: hourly calculation method; M2–2 [M]: monthly calculation method.

6.2 Calculation time intervals

For monthly heat transfer through the ground, the time interval is 1 month. For other quantities, the input, the method and the output data are for steady-state conditions and assumed to be independent of actual conditions, such as indoor temperature or effect of wind or solar radiation, so there is no need to consider a specific time interval length.

6.3 Input data

Tables 3, 4 and 5 list identifiers for input data required for the calculation.

Table 3 — Identifiers for building geometric characteristics

Name	Symbol	Unit	Value	Range	Origin	Varying
area of building envelope element *i*	$A_{e;i}$	m²		≥0	—	No
length of linear thermal bridge *k*	l_k	m		≥0	—	No

Table 4 — Identifiers for building boundary conditions

Name	Symbol	Unit	Value	Range	Origin	Varying
indoor environment temperature in the building under consideration	θ_{int}	°C		0 to 50	—	Yes
indoor environment temperature in adjacent unconditioned space	$\theta_{int;u}$	°C		0 to 50	—	Yes
indoor environment temperature in the adjacent building	$\theta_{int;adj}$	°C		0 to 50	—	Yes
external temperature	θ_e	°C		−50 to +50	—	Yes

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Table 5 — Identifiers for thermal characteristics of building fabric

Name	Symbol	Unit	Value	Range	Origin	Varying
thermal transmittance of element *i*	U_i	W/(m²·K)		0 to 10	M2–5 (ISO 6946)	No
linear thermal transmittance of thermal bridge *k*	Ψ_k	W/(m·K)		0 to 10	M2–5 (ISO 14683 or ISO 10211)	No
monthly ground heat transfer coefficient	$H_{g;m}$	W/K		≥0	M2–5 (ISO 13370)	Yes
annual average ground heat transfer coefficient	H_g	W/K		≥0	M2–5 (ISO 13370)	No
air flow rate through heated or cooled space	q_V	m³/h		≥0	M5–5	No
heat flow rate generated within an unconditioned space (e.g. solar gains)	Φ	W		≥0	—	No

If the purpose is to provide data for estimation of building energy needs or indoor temperature (EPB module M2-2), additional data are needed from ISO 13370, depending on the time interval of the calculation procedure (hourly or monthly). These are listed in the overview of output data in Table 2.

NOTE The EPB standard under module M2–2 is ISO 52016-1.

Table 6 lists identifiers for constants.

Table 6 — Identifiers for constants

Name	Symbol	Unit	Value	Range	Origin	Varying
density of air	ρ_a	kg/m³	1,205	—	—	No
specific heat capacity of air at constant pressure	c_p	Wh/(kg·K)	1,008	—	—	No

6.4 Measurement of dimensions

The dimensions of construction elements shall be measured using one of these systems:

— internal dimensions;

— overall internal dimensions;

— external dimensions.

NOTE These are described further in ISO/TR 52019-2.

The chosen system shall be used consistently in all calculations.

A template for the choice of dimensional system is given in Table A.2.

6.5 Boundaries of conditioned space

Before calculation, the conditioned space of the building under consideration shall be clearly defined. The building elements considered in the calculations are the boundaries of the spaces that are heated or cooled (directly or indirectly).

The building envelope above ground is modelled by plane and beam-shaped elements as shown on Figure 2.

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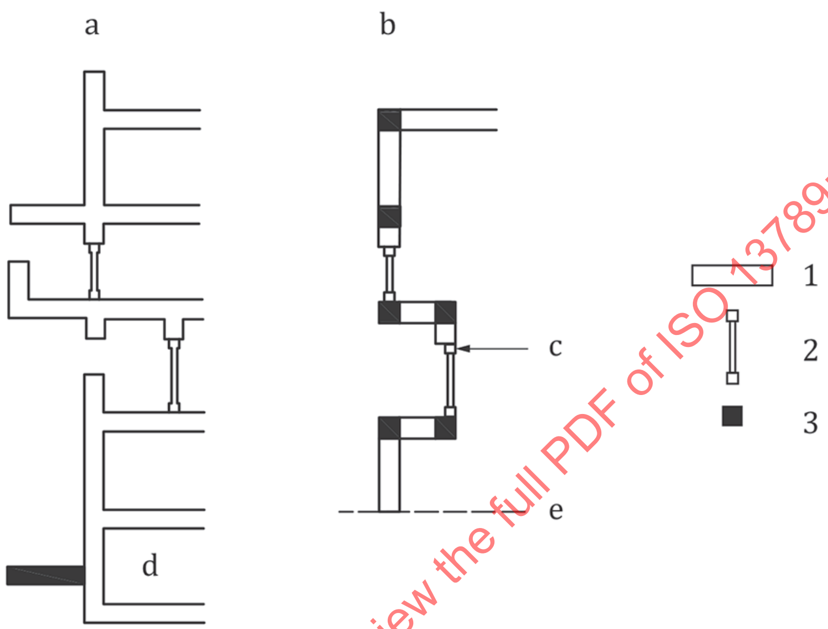
Boundaries between the “underground” part, involving heat transmission through the ground, and the “above-ground” part of the building, having direct heat transfer to the external environment or to unconditioned spaces, are as defined in ISO 13370:

— for buildings with slab-on-ground floors, suspended floors and unheated basements: the level of the internal surface of the ground floor (excluding any floor coverings such as carpets);

— for buildings with a heated basement: the external ground level.



Key

1 flat envelope elements: ISO 6946 is applicable

2 windows and doors, with their frames: ISO 10077-1 and ISO 10077-2 are applicable

3 potential thermal bridges: ISO 14683 or ISO 10211 are applicable

a reality

b model

c window/wall junctions that are also potential thermal bridges

d unheated

e application limit of ISO 13370

Figure 2 — Modelling the building envelope by plane and beam-shaped components

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If calculations are performed for parts of buildings, the boundaries of these parts shall be clearly defined, so that the sum of the transmission heat transfer coefficients of all parts equals that of the building.

NOTE For further information, see ISO/TR 52019-2.

7 Transmission heat transfer coefficient

7.1 Basic formula

The transmission heat transfer coefficient, H_{tr}, is calculated according to Formula (1):

$$H_{tr} = H_d + H_g + H_u + H_a \tag{1}$$

where

H_{tr} is the transmission heat transfer coefficient, in W/K;

H_d is the direct transmission heat transfer coefficient between the heated or cooled space and the exterior through the building envelope, defined by Formula (3), in W/K;

H_g transmission transfer coefficient through the ground defined in 7.4, in W/K;

H_u is the transmission heat transfer coefficient through unconditioned spaces defined in Formula (5), in W/K;

H_a is the transmission heat transfer coefficient to adjacent buildings, determined according to 7.6, in W/K.

NOTE 1 The modelling rules given in ISO 10211 can be used for the calculation of the total thermal coupling coefficient of the complete envelope or any part of it, including ground heat transfer. Where no unconditioned space is involved, the total thermal coupling coefficient corresponds to the transmission heat transfer coefficient as defined in this document.

NOTE 2 In some applications, the heat transfer via the ground is treated in terms of a constant part related to the annual average temperature difference and a varying part related to the monthly variations of internal and external temperature difference.

7.2 Mean thermal transmittance of building fabric

The mean thermal transmittance of the building fabric is the transmission heat transfer coefficient divided by the thermal envelope area according to Formula (2):

$$U_{mn} = \frac{H_{tr}}{\sum A_i} \tag{2}$$

where

U_{mn} is the mean thermal transmittance of the building fabric, in W/(m²·K);

H_{tr} is the transmission heat transfer coefficient not including H_a to adjacent buildings, in W/K;

A_i is the area of element i of the thermal envelope not including the area to adjacent buildings, in m².

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7.3 Direct transmission between internal and external environments

The transmission heat transfer coefficient through the building elements separating the conditioned space and the external environment is calculated either directly by numerical methods using the modelling rules given in ISO 10211 or according to Formula (3):

$$H_\mathrm{d} = \sum_i A_i \cdot U_i + \sum_k l_k \cdot \Psi_k + \sum_j \chi_j \tag{3}$$

where

H_d is the direct heat transfer coefficient between the heated or cooled space and the exterior through the building envelope, in W/K;

A_i is the area of element i of the building envelope, in m^2 (the dimensions of windows and doors are taken as the dimensions of the aperture in the wall);

U_i is the thermal transmittance of element i of the building envelope, in W/(m^2·K);

l_k is the length of linear thermal bridge k, in m;

Ψ_k is the linear thermal transmittance of thermal bridge k, in W/(m·K);

χ_j is the point thermal transmittance of point thermal bridge j, in W/K.

NOTE 1 The area of the window, as used to establish the thermal transmittance of the window, can be slightly larger than the aperture in the wall. The effect of any differences in area is incorporated in the values of Ψ_k for the junctions between walls and window.

Linear and point thermal bridges which have been taken into account in the thermal transmittance of plane building elements shall not be included in Formula (3).

The summations shall be done over all the building components separating the internal and the external environments.

Thermal transmittance values, U, shall be calculated by the methods in

— ISO 10077-1 for windows and doors (thermal transmittance can also be determined by measurement in accordance with ISO 12567-1 or ISO 12567-2),

— ISO 12631 for curtain walls, and

— ISO 6946 for other walls and for roofs.

NOTE 2 These standards include both detailed and simplified methods and contain rules for making choices between their methods.

Linear thermal transmittance values, Ψ, and point thermal transmittance values, χ, shall be taken from tables or catalogues prepared in accordance with ISO 14683 or calculated according to ISO 10211.

Where details of the thermal bridges are not known, for example in existing buildings, the second and third terms on the right-hand side of Formula (3) may be replaced by a default allowance for thermal bridges, H_tb.

Party walls (dividing a building into separate premises) of cavity construction can give rise to heat transmission to the external environment via a thermal bypass mechanism. This can be allowed for by assigning a thermal transmittance to the party wall and including any party walls in Formula (3).

A template for restrictions on the use of the Formula (3) is given in Table A.3, with an informative default choice in Table B.3.

A template for specifying heat transmission via party walls is included is given in Table A.4, with an informative default choice in Table B.4.

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A template specifying whether measured values of thermal transmittance are allowed is given in Table A.4, with an informative default choice in Table B.4.

A template for identifying sources of tabulated values of linear and/or point thermal transmittance, providing data for existing buildings, providing methods of obtaining H_{tb}, and identifying thermal bridges that can be neglected, is given in Table A.6, with an informative default choice in Table B.6.

A template specifying conditions under which a linear thermal bridge may be neglected is given in Table A.6, with an informative default choice in Table B.6.

7.4 Transmission heat transfer coefficient through the ground

The coefficient for heat transfer via the ground, H_g, is calculated according to ISO 13370.

If there are unconditioned spaces alongside the building (see 7.5), H_g is calculated as if the unconditioned spaces were not present.

ISO 13370 provides methods for calculating the heat transfer coefficient on a monthly basis, $H_{g;an;m}$, taking account of the thermal inertia of the ground. These monthly coefficients may be related to the annual average coefficient, H_g, by adjustment factors, b_m, for each month m.

$$b_m = \frac{H_{g;an;m}}{H_g} \tag{4}$$

Values of b_m may be set at the national level on a monthly or seasonal basis.

NOTE 1 The values of b_m are typically less than 1 in winter and greater than 1 in summer because during winter, the effective temperature difference through the ground is smaller than the temperature difference between the internal and external environments, and in summer, it is higher. If the average monthly external temperature is higher than the internal temperature, the value of b_m can be negative.

A template for values of b_m is given in Table A.7, with an informative default choice in Table B.7.

If the purpose is to provide data for estimation of building energy needs or indoor temperature (EPB module M2-2), additional data are needed from ISO 13370, depending on the time interval of the calculation procedure (hourly or monthly). These are listed in the overview of output data in Table 4.

NOTE 2 The EPB standard under module M2–2 is ISO 52016-1.

7.5 Transmission heat transfer coefficient through unconditioned spaces

The transmission heat transfer coefficient, H_u, between a conditioned space and the external environments via unconditioned spaces alongside the building is obtained from Formula (5):

$$H_u = H_{iu} \cdot b \quad \text{with} \quad b = \frac{H_{ue}}{H_{iu} + H_{ue}} \tag{5}$$

where

- H_u is the transmission heat transfer coefficient between a conditioned space and the external environments via unconditioned spaces, in W/K;
- H_{iu} is the direct heat transfer coefficient between the conditioned space and the unconditioned space, in W/K;
- H_{ue} is the heat transfer coefficient between the unconditioned space and the external environment, in W/K.

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NOTE 1 In Formula (5), the adjustment factor, b, allows for the unconditioned space being at a different temperature to the external environment (see Annex C). The conditioned space is assumed to be at a uniform temperature.

NOTE 2 This does not apply to an unheated basement, the heat transfer through which is included in Hg (see ISO 13370).

NOTE 3 Heat transmission through the ground is not included in either H_{iu} or H_{ue}.

H_{iu} and H_{ue} include the transmission and ventilation heat transfers. They are calculated according to Formula (6):

$$H_{iu} = H_{tr;iu} + H_{ve;iu} \quad \text{and} \quad H_{ue} = H_{tr;ue} + H_{ve;ue} \tag{6}$$

The transmission coefficients, $H_{tr:iu}$ and $H_{tr;ue}$ are calculated according to 7.3 and the ventilation heat transfer coefficients, $H_{ve;ue}$ and $H_{ve;iu}$, by Formula (7):

$$H_{ve;iu} = \rho \cdot c_p \cdot q_{iu} \quad \text{and} \quad H_{ve;ue} = \rho \cdot c_p \cdot q_{ue} \tag{7}$$

where

ρ is the density of air, in kg/m^3;

c_p is the specific heat capacity of air, in Wh/(kg·K);

q_{ue} is the air flow rate between the unconditioned space and the external environment, in m^3/h;

q_{iu} is the air flow rate between the conditioned and unconditioned spaces, in m^3/h.

NOTE 4 ISO 6946 provides approximate methods for some particular unheated spaces and rules for when they can be used.

7.6 Heat transfer to adjacent buildings

Where the heat transfer to an adjacent building, at a temperature different from that of the building under consideration, is to be taken into account, the heat transfer coefficient between the two buildings is obtained using Formula (8):

$$H_a = b \cdot H_{ia} \tag{8}$$

where

H_a is the heat transfer coefficient between the two buildings, in W/K;

H_{ia} is the direct heat transfer coefficient between the conditioned space and the adjacent building, in W/K.

$$b = \frac{\theta_{int} - \theta_a}{\theta_{int} - \theta_e} \tag{9}$$

where

θ_{int} is the internal temperature of the building under consideration, in °C;

θ_a is the temperature of the adjacent building, in °C;

θ_e is the external temperature, in °C.

NOTE The value of b can be negative.

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8 Ventilation heat transfer coefficient

The ventilation heat transfer coefficient, H_{ve}, is calculated from Formula (10):

$$H_{ve} = \rho_{air} \cdot c_p \cdot q_v \tag{10}$$

where

H_{ve} is the ventilation heat transfer coefficient, in W/K;

q_v is the air flow rate through the heated or cooled space, in m^3/s;

$\rho_{air} \cdot c_p$ is the heat capacity of air per volume, in $J/(m^3 \cdot K)$.

If the air flow rate, q_v, is in m^3/s, $\rho_{air} \cdot c_p = 1\ 200\ J/(m^3 \cdot K)$. If q_v is given in m^3/h, $\rho_{air} \cdot c_p = 0,33\ Wh/(m^3 \cdot K)$.

Table A.8 gives a template for defining the determination of the air flow rate, with an informative default choice in Table B.8.

NOTE ISO/TR 52019-2 contains a method which can be applied in the absence of a method in international standards or in national provisions.

9 Additional conventions

9.1 General

If the purpose of the calculation is to provide data for estimation of annual energy requirement, the best available data should be used as input for the calculations.

If the purpose is to express the thermal-transmission and/or ventilation characteristics of a building considered as a product or for judging compliance with specifications expressed in terms of the thermal-transmission and/or ventilation coefficient, the values defined in 9.2 to 9.4 shall be used. The result of the calculations is then independent of location and use of the building.

9.2 Transmission heat transfer coefficient through the ground

This coefficient is the steady-state component, H_g, calculated according to ISO 13370, the thermal conductivity of the ground being taken as 2 W/(m·K).

9.3 Variable thermal transmittance

Where thermal transmittance can vary, the maximum value shall be used.

9.4 Air change rates of unconditioned spaces

In order not to underestimate the transmission heat transfer, the air flow rate between a conditioned space and an unconditioned space, q_{iu}, shall be assumed to be zero:

$$q_{iu} = 0 \tag{11}$$

The air flow rate between the unheated space and the external environment is calculated according to Formula (12):

$$q_{ue} = V_u \cdot n_{ue} \tag{12}$$

where

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q_{ue} is the air flow rate between the unheated space and the external environment, in m^3/h;

V_u is the volume of air in the unconditioned space, in m^3;

n_{ue} is the conventional air change rate between the unconditioned space and the external environment, in h^{-1}.

The air change rate, n_{ue}, may be taken as the value from Table 7 which best corresponds to the unconditioned space under consideration.

Table 7 — Conventional air change rates between the unconditioned space and the external environment

No	Air tightness type	n_{ue} h^{-1}
1	No doors or windows, all joints between components well-sealed, no ventilation openings provided.	0,1
2	All joints between components well-sealed, no ventilation openings provided.	0,5
3	All joints well-sealed, small openings provided for ventilation.	1
4	Not airtight due to some localized open joints or permanent ventilation openings.	3
5	Not airtight due to numerous open joints, or large or numerous permanent ventilation openings.	10

If the air change at 50 Pa, n_{50}, or the equivalent leakage area, A_l, is known, the air change rate, n, can be estimated by one of the following empirical relations:

$$n = \frac{n_{50}}{20} \quad \text{or} \quad n = \frac{A_l}{10 \times V_u} \qquad (13)$$

where

n is the air change rate, in h^{-1};

n_{50} is the air change rate at 50 Pa, in h^{-1};

A_l is equivalent leakage area, in cm^2;

V_u is the volume of air in the unconditioned space, in m^3.

The value in Table 9 that is the closest to n is taken for n_{ue}.

Table A.9 gives a template for defining values of air change rates of unconditioned spaces, with an informative default choice in Table B.9.

9.5 Conventional values of surface heat transfer coefficient

Conventional values of surface heat transfer coefficient are given in Table 8.

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Table 8 — Conventional surface heat transfer coefficients

Surface heat transfer coefficient W/(m²·K)	**Direction of heat flow**		
	Upwards	**Horizontal**	**Downwards**
convective coefficient; internal surface, h_{ci}	5,0	2,5	0,7
convective coefficient; external surface, h_{ce}	20	20	20
radiative coefficient; internal surface, h_{ri}	5,13	5,13	5,13
radiative coefficient; external surface, h_{re}	4,14	4,14	4,14
NOTE The values given for internal surface are calculated for ε = 0,9 and with h_{r0} evaluated at 20 °C. The value given for external surface is calculated for ε = 0,9, h_{r0} evaluated at 10 °C, and for v = 4 m/s.			

NOTE These values are needed as input in the EPB standard under module M2–2 (ISO 52016-1). The combined convective and radiative surface coefficients are in agreement with the conventional surface resistances in ISO 6946 (rounded to two decimals).

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10 Report

The report shall contain the following information:

a) reference to this document, i.e. ISO 13789;

b) identification of the building;

c) plans of the building, with the assumed boundaries of the heated or cooled space marked on it;

d) description of the components of the building envelope, that is their elements including dimensions and the materials used;

e) a list of these components, with their areas and surface thermal transmittances, the lengths and linear transmittances of linear thermal bridges as well as the number and point thermal transmittances of point thermal bridges;

f) if there are unconditioned spaces, the assumed air-change rates;

g) transmission heat transfer coefficients to the exterior, H_d, through the ground, H_g, and through unconditioned spaces, H_u, rounded to three significant figures;

h) total transmission heat transfer coefficient, H_{tr}, rounded to three significant figures;

i) ventilation heat transfer coefficient, H_{ve}, rounded to three significant figures;

j) if variable thermal transmittances are taken into account, results for both maximum and minimum values shall be given, together with the description of the varied thermal transmittances and their extreme values;

k) any deviation from this standard and the rationale for the deviation.

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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 module code number, are given in Table A.1.

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Table A.1 — References

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

[a] If a reference comprises more than one document, the references may be differentiated.

[b] 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 Selection of methods

In this document, there is no need to specify choices in methods. A.3 is kept to maintain uniformity between all EPB standards.

A.4 Input data and choices

Table A.2 — System of dimensions (see 6.4)

Item	Choice
System of dimension	internal, overall internal or external

Table A.3 — Transmission heat transfer coefficient (see 7.3)

Item	Restrictions to use of Formula (3)
Restrictions apply	Yes/No
If Yes, formulate the restrictions	List restrictions

Table A.4 — Heat transfer via party walls (see 7.3)

Item	Choice or value[a]
Heat transfer through party walls included in Formula (3)	Yes/No
If yes, give values of thermal transmittance	Values of thermal transmittance for different cases

[a] Values should be accompanied by qualifying data such as building type and party wall construction.

Table A.5 — Measured values of thermal transmittance (see 7.3)

Item	Choice
Measured values of thermal transmittance can be used	Yes/No
If yes, any restrictions or conditions	List restrictions or conditions

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