TECHNICAL REPORT

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Energy performance of buildings — Hygrothermal performance of building components and building elements —

Part 2: Explanation and justification

Performance énergétique des bâtiments — Performances hygrothermiques des composants et parois de bâtiments —

Partie 2: Explication et justification

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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/TR 52019-2 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).

A list of all parts in the ISO 52019 series can be found on the ISO website.

Introduction

The set of EPB standards, technical reports and supporting tools

In order to facilitate the necessary overall consistency and coherence, in terminology, approach, input/output relations and formats, for the whole set of EPB-standards, the following documents and tools are available:

a) a document with basic principles to be followed in drafting EPB-standards: CEN/TS 16628:2014, *Energy Performance of Buildings - Basic Principles for the set of EPB standards*[8];

b) a document with detailed technical rules to be followed in drafting EPB-standards; CEN/TS 16629:2014, *Energy Performance of Buildings - Detailed Technical Rules for the set of EPB-standards*[9].

The detailed technical rules are the basis for the following tools:

1) a common template for each EPB-standard, including specific drafting instructions for the relevant clauses;

2) a common template for each technical report that accompanies an EPB standard or a cluster of EPB standards, including specific drafting instructions for the relevant clauses;

3) a common template for the spreadsheet that accompanies each EPB standard, to demonstrate the correctness of the EPB calculation procedures.

Each EPB-standards follows the basic principles and the detailed technical rules and relates to the overarching EPB-standard, ISO 52000-1[5].

One of the main purposes of the revision of the EPB-standards is to enable that laws and regulations directly refer to the EPB-standards and make compliance with them compulsory. This requires that the set of EPB-standards consists of a systematic, clear, comprehensive and unambiguous set of energy performance procedures. The number of options provided is kept as low as possible, taking into account national and regional differences in climate, culture and building tradition, policy and legal frameworks (subsidiarity principle). For each option, an informative default option is provided (Annex B).

Rationale behind the EPB technical reports

There is a risk that the purpose and limitations of the EPB standards will be misunderstood, unless the background and context to their contents – and the thinking behind them – is explained in some detail to readers of the standards. Consequently, various types of informative contents are recorded and made available for users to properly understand, apply and nationally or regionally implement the EPB standards.

If this explanation would have been attempted in the standards themselves, the result is likely to be confusing and cumbersome, especially if the standards are implemented or referenced in national or regional building codes.

Therefore each EPB standard is accompanied by an informative technical report, like this one, where all informative content is collected, to ensure a clear separation between normative and informative contents (see CEN/TS 16629[9]):

— to avoid flooding and confusing the actual normative part with informative content,

— to reduce the page count of the actual standard, and

— to facilitate understanding of the set of EPB standards.

This was also one of the main recommendations from the European CENSE project[5] that laid the foundation for the preparation of the set of EPB standards.

This document

This technical report accompanies the suite of EPB standards on thermal transmission properties of building elements. It relates to ISO 6946, ISO 10211, ISO 13370, ISO 13786, ISO 13789 and ISO 14683, which form part of a set of standards related to the evaluation of the energy performance of buildings (EPB).

The role and the positioning of the accompanied standards in the set of EPB standards is defined in the introductions to ISO 6946, ISO 10211, ISO 13370, ISO 13786 and ISO 14683.

Accompanying spreadsheets

Concerning ISO 6946, ISO 10211, ISO 13370, ISO 13786 and ISO 14683, spreadsheets were produced for:

— ISO 6946;

— ISO 13370;

— ISO 13789.

These spreadsheets are available at www.epb.center.

In this document, examples of each of these calculation sheets are included in Annex M.

No accompanying calculation spreadsheets were prepared on:

— ISO 10211: this document does not provide a calculation procedure; it provides test cases and performance criteria for calculation procedures.

— ISO 13786: this document provides complex matrix calculation procedures. Instead of a spreadsheet, Annex I contains examples of calculation results obtained by a computer program.

— ISO 14683: this document does not provide a calculation procedure; it provides choices between procedures provided elsewhere and default tabulated values. Instead, Annex L contains examples of the use of default values.

The first series of standards on thermal and hygrothermal properties of building components and elements were prepared by ISO Technical Committee TC 163 in the 1980s, as a result of growing global concern on future fuel shortages and inadequate health and comfort levels in buildings. During the following decades these first standards were revised and new standards were added, to cope with new developments and additional needs. From the 1990s on, these standards were developed in close collaboration with CEN.

Energy performance of buildings — Hygrothermal performance of building components and building elements —

Part 2: Explanation and justification

1 Scope

This document contains information to support the correct understanding and use of ISO 6946, ISO 10211, ISO 13370, ISO 13786, ISO 13789 and ISO 14683.

This document does not contain any normative provision.

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 6946:2017, *Building components and building elements — Thermal resistance and thermal transmittance — Calculation methods*

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

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

ISO 13370:2017, *Thermal performance of buildings — Heat transfer via the ground — Calculation methods*

ISO 13786, *Thermal performance of building components — Dynamic thermal characteristics — Calculation methods*

ISO 13789, *Thermal performance of buildings — Transmission and ventilation heat transfer coefficients — Calculation method*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6946, ISO 7345, ISO 10211, ISO 13370, ISO 13786, ISO 13789 and ISO 14683 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

4 Symbols and subscripts

For the purposes of this document, the symbols and subscripts given in ISO 6946, ISO 7345, ISO 10211, ISO 13370, ISO 13786, ISO 13789 and ISO 14683 apply.

5 Description of the methods

5.1 Outputs

The main outputs of ISO 6946, ISO 7345, ISO 10211, ISO 13370, ISO 13786, ISO 13789 and ISO 14683 are:

— thermal transmission properties of building elements (thermal resistance, thermal transmittance or dynamic thermal characteristics of a wall, floor or roof);

— heat transfer coefficient for the whole building (or part of a building).

5.2 General description

Together with ISO 10456, ISO 10077-1, ISO 10077-2 and ISO 12631, these documents (ISO 6946, ISO 7345, ISO 10211, ISO 13370, ISO 13786, ISO 13789 and ISO 14683) provide the methodology to obtain heat transfer coefficients for a building starting from the properties of materials used for its construction and the size and geometry of the building.

The results provide input for calculation of energy needs for heating and cooling by ISO 52016-1[7] when one of the simplified (monthly or hourly) calculation methods is being used in ISO 52016-1. In the case of detailed dynamic simulations, the component (or subcomponent) properties are used directly as inputs for the building simulation.

In applications where individual component properties are needed, these documents provide:

— in the case of minimum component requirements, the *U*-value or *R*-value of the construction;

— for multi-zone calculations with assumed thermal interaction between the zones, the thermal transmission properties of the separating construction;

Figure 1 illustrates the linkages between these documents.

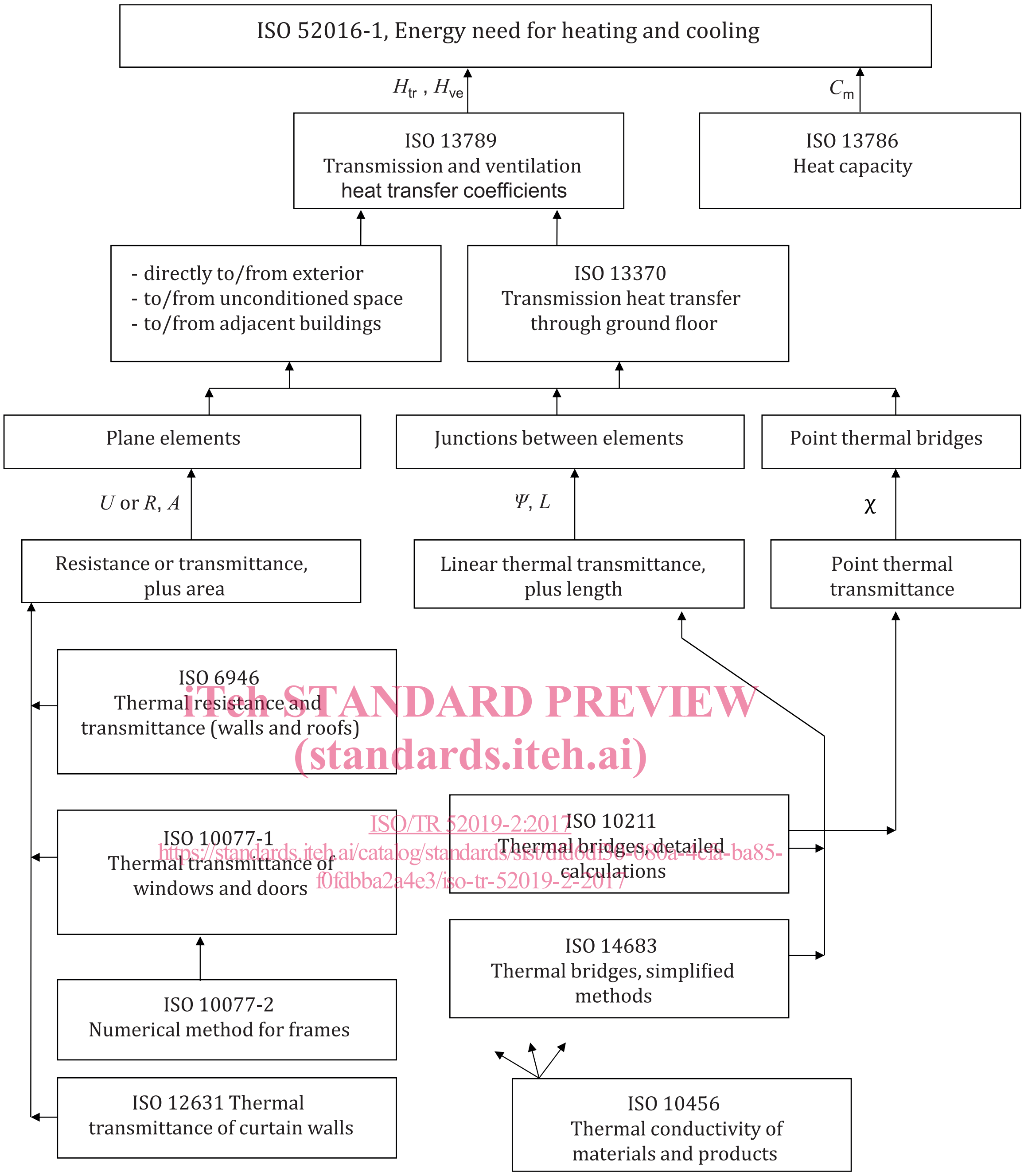

Figure 1 — Linkage between documents

More information can be found in [20] and [21].

6 ISO 6946

ISO 6946 provides a calculation method that is valid for most building components (walls and roofs). It is based on calculating the upper limit of thermal resistance of the component (which would apply if the heat flow were unidirectional from warm side to cold side) and the lower limit (in which the plane separating each layer is isothermal). Except for components consisting entirely of homogeneous layers (for which the upper and lower limits are equal) the true thermal resistance of a component is between these two limits. ISO 6946 specifies use of the arithmetic mean of the two limits provided that their ratio does not exceed 1,5.

7 ISO 10211

ISO 10211 specifies the method for detailed calculation of thermal bridges. It can be applied to a whole building or part of it, and also to the calculation of linear and point thermal transmittances which are used in ISO 13789.

8 ISO 13370

8.1 General

ISO 13370 is used for calculation of heat transfer via the ground, taking account of its contribution to the total thermal resistance in the case of U-value calculations and of its thermal inertia in the case of time-dependent calculations.

The following sub-clauses provide information in addition to that given in ISO 13370.

More background information can be found in references [12]–[19].

8.2 Thermal properties of the ground

ISO 13370 specifies thermal properties for three representative types of ground. Particular values can be provided in ISO 13370:2017, Annex A.

Annex A provides background information on the properties of the ground.

8.3 The influence of flowing ground water

In most cases it is not necessary to take account of ground water since its flow rate is usually sufficiently small that it has a negligible effect on heat transfer rates. Further information and a method of allowing for the effect of ground water when its flow rate is known are given in Annex B.

8.4 Application to dynamic simulation programmes

ISO 13370:2017, Annex F contains a procedure for the application to dynamic simulation programmes.

Annex C provides background information and validation of this procedure.

8.5 Embedded heating or cooling systems

Annex D describes a modification of the methodology in ISO 13370 for floors with an embedded heating or cooling system.

8.6 Cold stores

Annex E provides a method to calculate the heat gain to a cold store from heating elements in the ground (included to avoid frost heave).

9 ISO 13786

ISO 13786 defines a method of calculation of the dynamic thermal characteristics of a building component. Annex G gives background to the matrix method given in ISO 13786.

Annex H provides information on computer programming for complex numbers and Annex I gives the results of some sample calculations.

10 ISO 13789

ISO 13789 defines the calculation of the transmission heat transfer coefficient of a building, using the heat transmission properties of the building elements and thermal bridge used in its construction. A decision is needed on the system of dimensions to be used – internal, overall internal or external. Annex J illustrates the three systems and the effect of the systems on the linear thermal transmittance of junctions between elements. Annex J is relevant also to ISO 10211 and ISO 14683.

For the ventilation heat transfer coefficient the air flow rate through conditioned spaces is needed. Annex K provides a possible method, with associated data.

11 ISO 14683

ISO 14683 defines the methodology for determination of linear thermal transmittances and provides default values for when specific information is not available. Annex L provides examples of the influence of thermal bridges on the transmission heat loss coefficient.

Annex A
(informative)

ISO 13370: Thermal properties of the ground

For the purposes of this annex, the symbols and subscripts given in ISO 13370 apply.

The thermal properties of the ground depend on several factors, including density, degree of water saturation, particle size, type of mineral constituting the particles, and whether frozen or unfrozen. As a result, the thermal properties vary considerably from one location to another, and at different depths at a given location, and also may vary with time due to changes in moisture content or due to freezing and thawing.

Values of the properties of the ground used for heat transfer calculations, including measured values, should be representative of the ground in the vicinity of the building and over the period of time to which the calculation refers (e.g., the heating season).

Table A.1 indicates the range of thermal conductivity for various types of unfrozen ground, and shows the representative values specified in ISO 13370.

Table A.1 — Thermal conductivity of ground

Ground type	Dry density ρ kg/m³	Moisture content u kg/kg	Degree of saturation %	Thermal conductivity λ_g W/(m·K)	Representative value of λ W/(m·K)
silt	1 400 to 1 800	0,10 to 0,30	70 to 100	1,0 to 2,0	1,5
clay	1 200 to 1 600	0,20 to 0,40	80 to 100	0,9 to 1,4	1,5
peat	400 to 1 100	0,05 to 2,00	0 to 100	0,2 to 0,5	—
dry sand	1 700 to 2 000	0,04 to 0,12	20 to 60	1,1 to 2,2	2,0
wet sand	1 700 to 2 100	0,10 to 0,18	85 to 100	1,5 to 2,7	2,0
rock	2 000 to 3 000	[a]	[a]	2,5 to 4,5	3,5

[a] Usually very small (moisture content < 0,03 mass), except for porous rocks.

The heat capacity per volume, $\rho \cdot c$, can be obtained from Formula (A.1).

$$\rho \cdot c = \rho \cdot \left(c_s + c_w \cdot u\right) \quad \text{(A.1)}$$

where

c is the specific heat capacity of the ground, in J/(kg·K);

ρ is the dry density, in kg/m³;

c_s is the specific heat capacity of minerals, in J/(kg·K);

c_w is the specific heat capacity of water, in J/(kg·K);

u is the moisture content mass by mass referred to the dry state, in kg/kg.

For most minerals, c_s approximately 1 000 J/(kg·K), and c_w = 4 180 J/(kg·K) at 10 °C.

The representative values of $\rho \cdot c$ specified in ISO 13370 are obtained from Formula (A.1), as follows (rounding to one significant figure):

— clay/silt: $\rho \cdot c = 1\,600 \times (1\,000 + 4\,180 \times 0{,}20) = 2{,}94 \times 10^6 \rightarrow 3 \times 10^6$

— sand: $\rho \cdot c = 1\,800 \times (1\,000 + 4\,180 \times 0{,}05) = 2{,}18 \times 10^6 \rightarrow 2 \times 10^6$

— rock: $\rho \cdot c = 2\,500 \times 800 = 2{,}00 \times 10^6 \rightarrow 2 \times 10^6$

Annex B
(informative)

ISO 13370: The influence of flowing ground water

For the purposes of this annex, the symbols and subscripts given in ISO 13370 apply.

The effect of flowing ground water can be assessed by multiplying the steady-state heat flow rate by a factor, G_W. To determine the factor, knowledge is required of the depth of the water table and the rate of ground water flow. For slab-on-ground floors and basements, G_W multiplies the steady-state ground heat transfer coefficient, H_g. For suspended floors, G_W multiplies the ground thermal transmittance, U_g. The factor should not be applied to the periodic heat transfer coefficients, H_{pi} and H_{pe}.

Values of G_W are given in Table B.1 as a function of the dimensionless ratios $\frac{z_W}{B}$, $\frac{l_c}{B}$ and $\frac{d_f}{B}$, where

z_W is the depth of the water table below ground level, in m;

l_c is a calculation length which relates the heat flow by conduction to the heat flow due to ground water, in m;

B Is the characteristic dimension of floor, in m;

d_f Is the total equivalent thickness of the slab on ground floor, in m.

The length l_c is given by Formula (B.1).

$$l_c = \frac{\lambda}{\rho_W c_W q_W} \quad \text{(B.1)}$$

where

q_W is the mean drift velocity of the ground water, in m/s;

ρ_W is the density of water, in kg/m3;

c_W is the specific heat capacity of water, in J/(kg·K).

NOTE 1 $\rho_W \cdot c_W$ = 4,18 × 106, in J/(m3·K) at 10 °C.

NOTE 2 If $l_c >> B$, the conduction heat flow predominates. If $l_c << B$, the ground water heat flow predominates.

Table B.1 — Values of G_W

z_W/B	l_c/B	G_W		
		d_f/B = 0,1	d_f/B = 0,5	d_f/B = 1,0
0,0	1,0	1,01	1,01	1,00
0,0	0,2	1,16	1,11	1,07
0,0	0,1	1,33	1,20	1,13
0,0	0,0	—	1,74	1,39
0,5	1,0	1,00	1,00	1,00
0,5	0,1	1,06	1,04	1,02
0,5	0,02	1,11	1,07	1,05

Table B.1 *(continued)*

z_W/B	l_c/B	G_W		
		$d_f/B = 0,1$	$d_f/B = 0,5$	$d_f/B = 1,0$
0,5	0,0	1,20	1,12	1,08
1,0	0,1	1,05	1,03	1,02
2,0	0,0	1,02	1,01	1,00