INTERNATIONAL STANDARD

ISO 12631

Second edition
2017-06

Thermal performance of curtain walling — Calculation of thermal transmittance

Performance thermique des façades-rideaux — Calcul du coefficient de transmission thermique

Reference number
ISO 12631:2017(E)

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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. 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. 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: http://www.iso.org/iso/foreword.html

ISO 12631 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 89, *Thermal performance of buildings and building components*, in collaboration with ISO Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 2, *Calculation methods*, in accordance with the agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 12631:2012) which has been technically revised. 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 technically revised:

— Annex G and Annex H were deleted and moved to the technical report;

— Tabulated values in Annex D were checked and revised where necessary.

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 curtain wallings.

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 this Annex A) can be made available as national annex or as separate (e.g. legal) document (national data sheet).

NOTE 1 So in this case:

— the regulators will specify the choices;

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

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

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

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

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

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

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

The design and construction of curtain wall systems is complex. This document specifies a procedure for calculating the thermal transmittance of curtain wall structures.

Curtain walls often contain different kinds of materials, joined in different ways, and can exhibit numerous variations of geometrical shape. With such a complex structure, the likelihood of producing thermal bridges across the curtain wall envelope is quite high.

The results of calculations, carried out following the procedures specified in this document, can be used for comparison of the thermal transmittance of different types of curtain wall or as part of the input data for calculating the heat used in a building. This document is not suitable for determining whether or not condensation will occur on the structure surfaces nor within the structure itself. Two methods are given in this document:

— single assessment method (see Clause 7);

— component assessment method (see Clause 8).

Guidance on the use of these two methods is given in Clause 6. Calculation examples for these two methods are given in ISO/TR 52022-2.

Testing according to ISO 12567-1:2010 is an alternative to this calculation method.

The thermal effects of connections to the main building structure as well as fixing lugs can be calculated according to ISO 10211.

The thermal transmittance of the frame, U_f, is defined according to ISO 10077-2 or EN 12412-2 together with Annex D. The thermal transmittance of glazing units, U_g, is defined according to ISO 10291, ISO 10292, ISO 10293 (or see Subjects 1, 2 and 3 in Table C.1[1)]) which do not include the edge effects. The thermal interaction of the frame and the filling element is included in the linear thermal transmittance Ψ which is derived using the procedures specified in ISO 10077-2.

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.

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

Table 1 — Position of this document (*in casu* M2–5), within the modular structure of the set of EPB standards

	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**
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 12631	Emission and control									
6	Building occupancy and operating conditions		Heat transfer by infiltration and ventilation		Distribution and control									
7	Aggregation of energy services and energy carriers		Internal heat gains		Storage and control									

a The shaded modules are not applicable.

Table 1 *(continued)*

	Overarching		Building (as such)		Technical Building Systems									
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**
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 curtain walling — Calculation of thermal transmittance

1 Scope

This document specifies a method for calculating the thermal transmittance of curtain walls consisting of glazed and/or opaque panels fitted in, or connected to, frames.

The calculation includes:

- different types of glazing, e.g. glass or plastic; single or multiple glazing; with or without low emissivity coating; with cavities filled with air or other gases;
- frames (of any material) with or without thermal breaks;
- different types of opaque panels clad with metal, glass, ceramics or any other material.

Thermal bridge effects at the rebate or connection between the glazed area, the frame area and the panel area are included in the calculation.

The calculation does not include:

- effects of solar radiation;
- heat transfer caused by air leakage;
- calculation of condensation;
- effect of shutters;
- additional heat transfer at the corners and edges of the curtain walling;
- connections to the main building structure nor through fixing lugs;
- curtain wall systems with integrated heating.

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 9488, *Solar energy — Vocabulary*

ISO 10077-1, *Thermal performance of windows, doors and shutters — Calculation of thermal transmittance — Part 1: General*

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 12567-1, *Thermal performance of windows and doors — Determination of thermal transmittance by the hot-box method — Part 1: Complete windows and doors*

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 — Part 2: Frames*

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 6946, ISO 7345, ISO 9488, ISO 52000-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

NOTE Clause 4 includes descriptions of a number of geometrical characteristics of glazing units, frame sections and panels.

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	Quantity	Unit
A	area	m^2
A^*	Area as specified in figure 8	m^2
T	thermodynamic temperature	K
U	thermal transmittance	W/(m^2·K)
l	length	m
d	depth	m
Φ	heat flow rate	W
Ψ	linear thermal transmittance	W/(m·K)
Δ	difference	
Σ	summation	
ε	emissivity	

4.2 Subscripts

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

cw	curtain walling	m,f	mullion/frame
d	developed	m,g	mullion/glazing
e	external	n	normal
eq	equivalent	p	panel (opaque)
f	frame	s	screw
f,g	frame/glazing	t	transom
FE	filling element	t,f	transom/frame
g	glazing	t,g	transom/glazing
i	internal	tot	total
j	joint	TJ	thermal joint at a connection between two filling elements
m	mullion	W	window

4.3 Superscripts

Definition of areas for length-related treatment of thermal joints (see 7.3.1.2).

5 Description of the methods

5.1 Output of the method

The output of this document is the thermal transmittance of a curtain wall consisting of glazed and/or opaque panels fitted in a frame.

5.2 General description

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

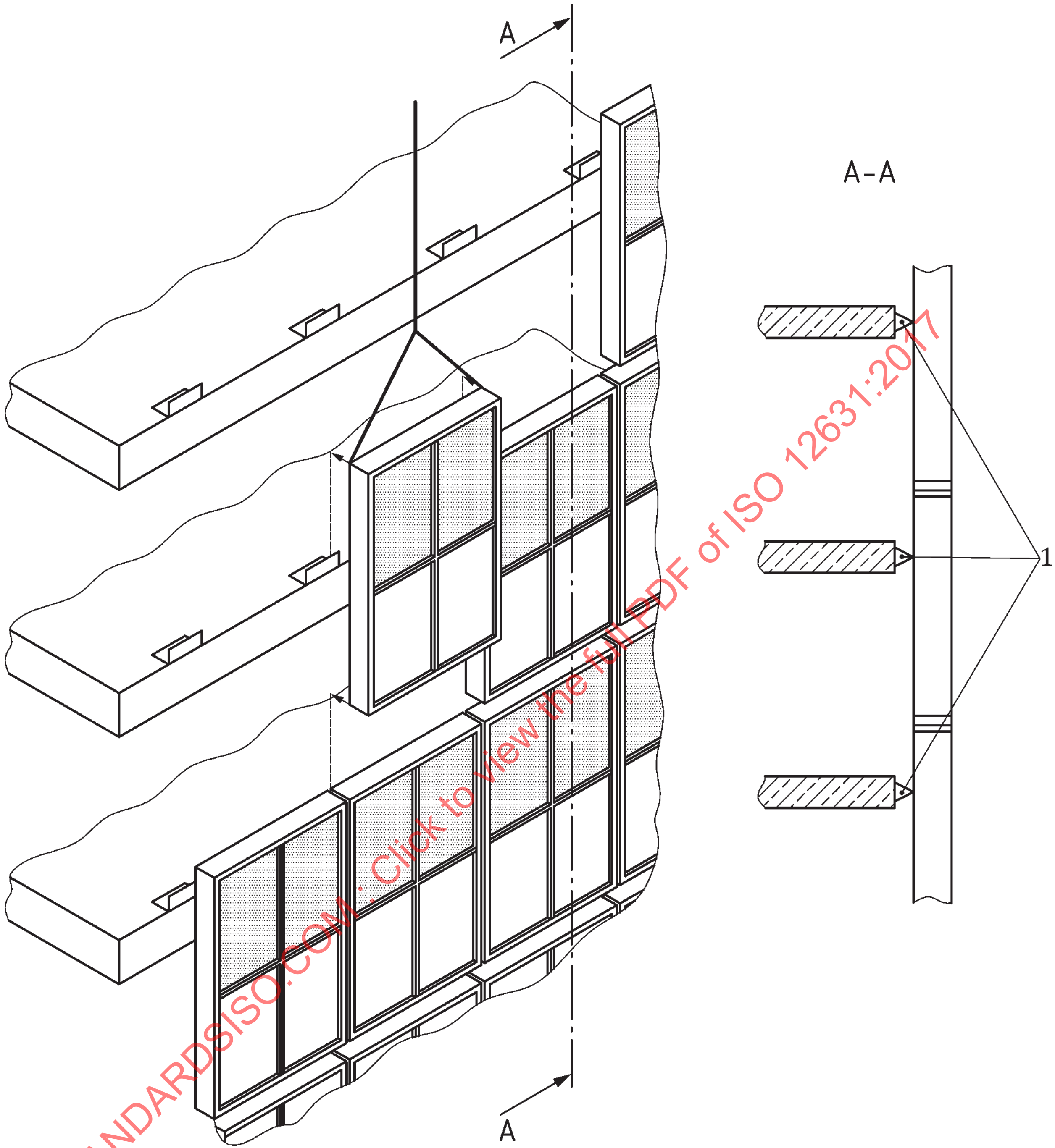
- The calculation procedures depend on the composition of the product or assembly;
- Components may include (where appropriate): glazings, opaque panels, frames, mullions, transoms;
- Thermal interactions are lateral heat flow (linear thermal bridge effect) between adjacent components and surface and cavity thermal resistances (thermal radiation and convection);
- The geometrical characteristics concern the sizes and positions of the components.

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.

5.3 Geometrical characteristics

5.3.1 Main principles

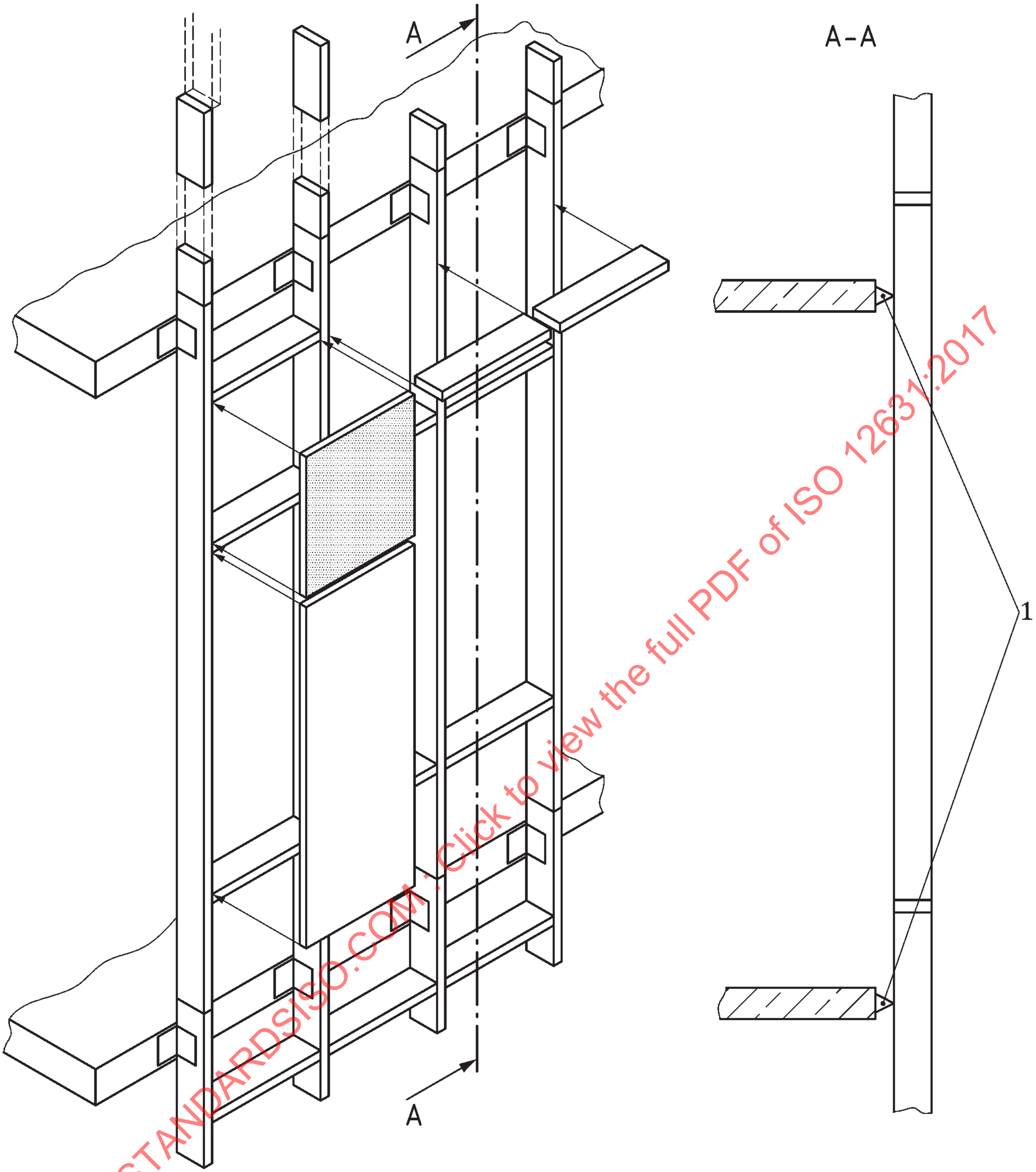
The main principles of curtain walling are shown in Figures 1 and 2.



Key

1 structure fixing bracket

Figure 1 — Principle of curtain walling construction: unitised construction



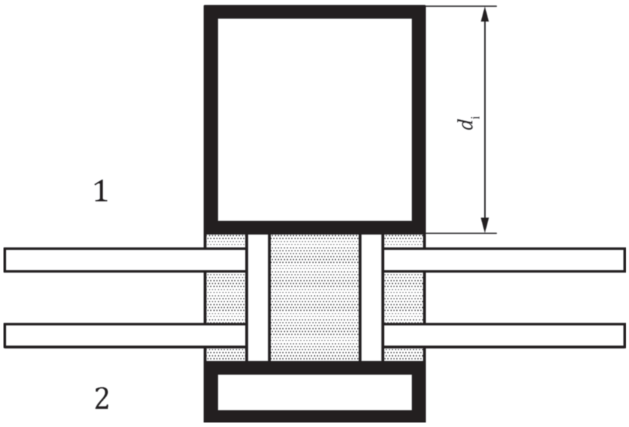
Key

1 structure fixing bracket

Figure 2 — Principle of curtain walling construction: stick construction

5.3.2 Internal depth

The internal depth is defined as shown in Figure 3.



Key

1 internal

2 external

d_i internal depth of mullion or transom

Figure 3 — Internal and external developed area, internal depth

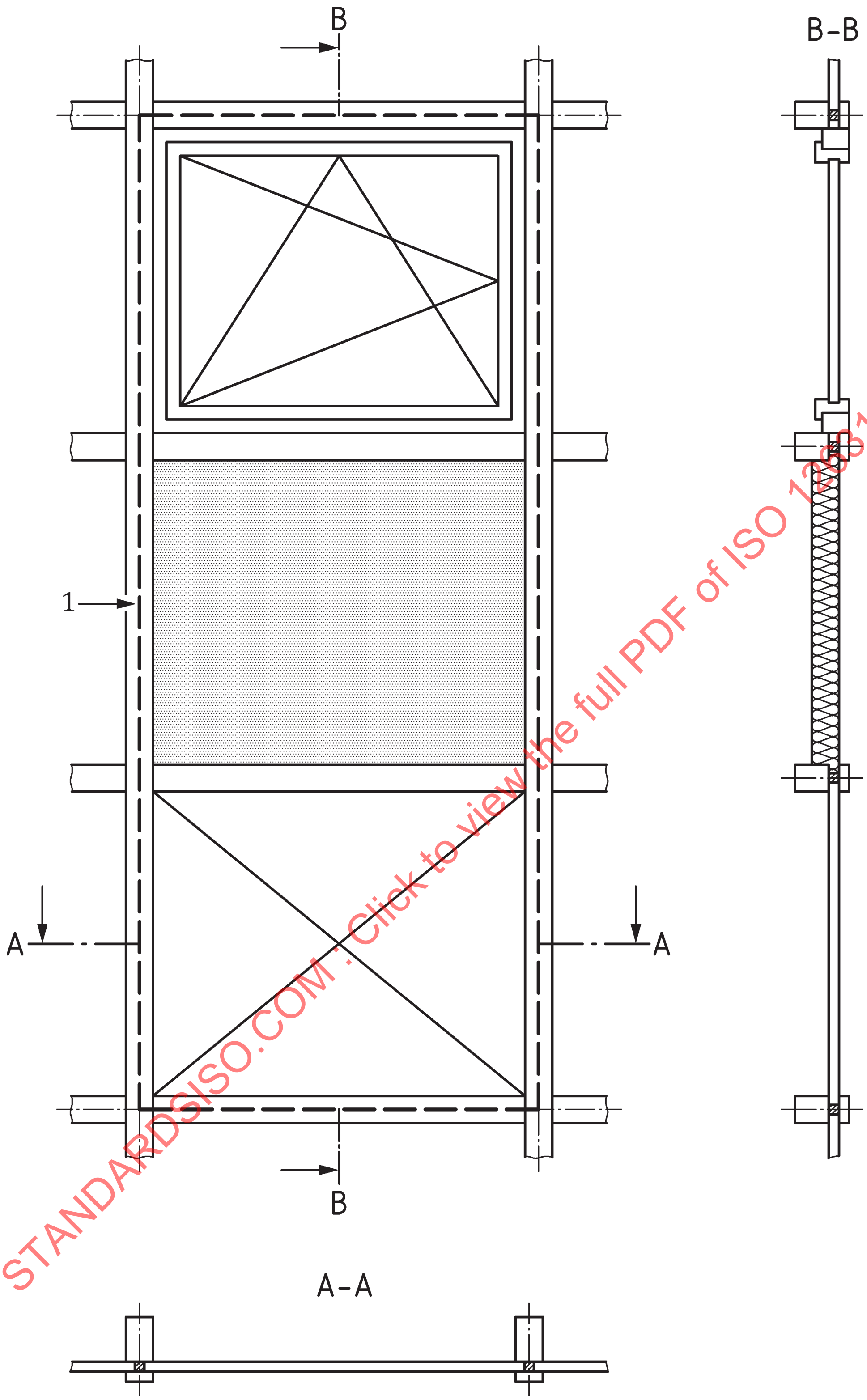
5.3.3 Boundaries of curtain wall structures

5.3.3.1 General

To evaluate the thermal transmittance of façades, representative reference areas should be defined. The following subclauses define the various areas.

5.3.3.2 Boundaries of a representative reference element

The boundaries of the representative reference element shall be chosen according to the principles shown in Figure 4.



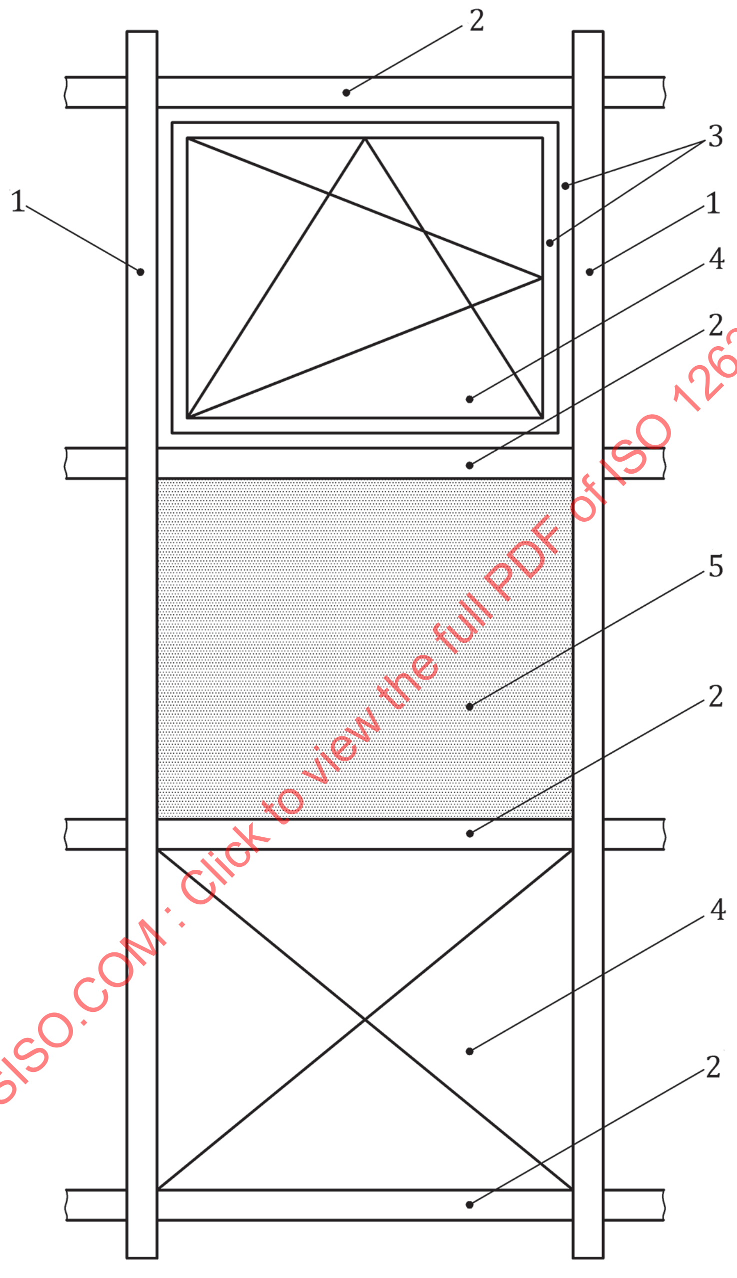
Key

1 boundaries of the representative element

Figure 4 — Boundaries of a representative reference element of a façade

5.3.3.3 Curtain wall areas

The representative reference element is divided into areas of different thermal properties (sash, frame, mullion, transom, glazing units and panel sections) as shown in Figure 5.



Key

1 mullion

2 transom

3 sash and frame

4 glazing

5 panel

Figure 5 — Areas with different thermal properties

5.3.4 Cut-off planes and partitioning of thermal zones

5.3.4.1 Rules for thermal modelling

In most cases, the façade can be partitioned into several sections by using cut-off planes so that the thermal transmittance of the overall façade can be calculated as the area-weighted average of the thermal transmittance of each section. The necessary input data (thermal properties of each section) can be evaluated by measurement, two-dimensional finite element or finite difference software calculation or by tables or diagrams. In general there are two possibilities:

— the single assessment method (see Clause 7);

— the component assessment method (see Clause 8).

The partitioning of the façade shall be performed in such a way as to avoid any significant differences in calculation results of the façade treated as a whole and the heat flow rate through the partitioned façade. Appropriate partitioning into several geometrical parts is achieved by choosing suitable cut-off planes.

5.3.4.2 Rules for thermal modelling

The geometrical model includes central elements (glazing units, spandrel panels etc.) and thermal joints (mullion, transom, silicone joint etc.), which connect the different central elements. The geometrical model is delimited by cut-off planes.

Curtain walling often contains highly conductive elements (glass and metals) which implies that significant lateral heat flow is possible. Cut-off planes shall represent adiabatic boundaries, which can be either

— a symmetry plane, or

— a plane where the heat flow through that plane is perpendicular to the plane of the curtain wall, i.e. no edge effect is present (e.g. at least 190 mm away from the edge of a double glazing unit).

Cut-off planes may be positioned only where there is a clear adiabatic situation (i.e. the heat flow is perpendicular to the plane). Figure 6 shows adiabatic lines (in the middle of the glass or panel far enough from the frame) where the heat flow will be perpendicular to the glass panes.

Cut-off planes do not necessarily fall at the same place as the geometrical boundaries of a unitised element (i.e. through the frame). The middle of a frame might not be an adiabatic boundary. This might be due to asymmetric geometrical shape of the frame, asymmetric material properties (e.g. different conductivity of sub-components at each side of the frame), or asymmetric connection of panels in a symmetric frame (e.g. a frame that connects a spandrel panel and a glazing unit, or two glazing units with different thermal properties).

6 Methodologies for the calculation of curtain wall transmittance

Two methods of calculating the thermal transmittance of curtain wall systems are specified (see Table 2):

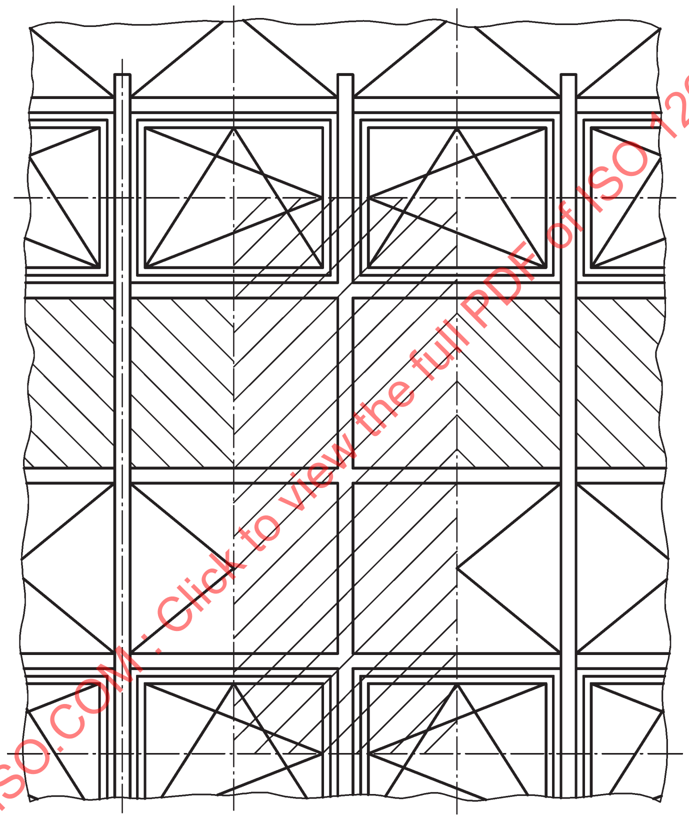
— the single assessment method, and

— the component assessment method.

The single assessment method (see Clause 7) is based on detailed computer calculations of the heat transfer through a complete construction including mullions, transoms, and filling elements (e.g. glazing unit, opaque panel). The heat flow rate (between two adiabatic boundaries) is calculated by modelling each thermal joint between two filling elements (opaque panel and/or glazing unit) using two-dimensional or three-dimensional finite element analysis software. By area weighting the *U*-values of thermal joints and filling elements, the overall façade *U*-value can be calculated. This method can be used for any curtain walling system (i.e. unitised systems, stick systems, patent glazing, structural sealant glazing, rain screens, structural glazing).

The component assessment method (see Clause 8) divides the representative element into areas of different thermal properties, e.g. glazing units, opaque panels and frames. By area weighting the *U*-values of these elements with additional correction terms describing the thermal interaction between these elements (Ψ-values), the overall façade *U*-value can be calculated. This method can be used for curtain walling systems such as unitised systems, stick systems and patent glazing. Structural silicone glazing, rain screens and structural glazing are excluded from the component assessment method.

For the purposes of this document, the term “filling element” is any façade component that has a one-dimensional heat flow in the absence of edge effects (the flat surface being perpendicular to the heat flow direction). Examples are glazing units and spandrel panels.



Key

— · — · — adiabatic boundary

Figure 6 — Thermal section representing the full curtain wall

Table 2 — Summary of the two different methodologies for determining U_{cw} of curtain walling

Single assessment method	Component assessment method
Frames (joints)	**Frames**
Definition and evaluation of areas according to 5.3 **Evaluation of U_{TJ} or Ψ_{TJ} according to 7.3.2.2**	**Definition and evaluation of areas according to 5.3** **Evaluation of U_f, U_m und U_t values according to** ISO 10077-2 **(see 6.3.4) or** EN 12412–2
	Evaluation of $\Psi_{m,f}$ / $\Psi_{t,f}$ according to Table D.6 of this document or ISO 10077-2
Glazing	**Glazing**

Table 2 *(continued)*

Single assessment method	Component assessment method
Definition and evaluation of areas according to this document **Evaluation of U_g according to** ISO 10077-1 **or** ISO 10291 **for measured value (GHP),** ISO 10292 **for calculation value,** ISO 10293 **for measured value (HFM), (or see Subjects 1, 2 and 3 in Table C.1)**	**Definition and evaluation of areas according to this document** **Evaluation of U_g according to** ISO 10077-1 **or** ISO 10291 **for measured value (GHP),** ISO 10292 **for measured value (HFM), (or see Subjects 1, 2 and 3 in Table C.1)** **Evaluation of $\Psi_{t,g}$ $\Psi_{m,g}$ and $\Psi_{f,g}$ according to Table D.1, D.2, D.3 or D.4 of this document or** ISO 10077-2
Panels	**Panels**
Definition and evaluation of areas according to 5.3 **Evaluation of U_p according to** ISO 6946	**Definition and evaluation of areas according to 4.2** **Evaluation of U_p according to** ISO 6946 **Evaluation of Ψ_p-values according to Table D.5 or** ISO 10077-2
Complete elements	**Complete elements**
Calculation of complete elements according to Formula (5) or (6)	**Calculation of complete elements according to Formula (12)**
Complete curtain walling	**Complete curtain walling**
Calculation of a façade built of different elements according to Formula (7)	**Calculation of a façade built of different elements according to Formula (14)**

7 Single assessment method

7.1 Output data

The output of the single assessment method according to this document is the transmission heat transfer coefficient of a curtain walling shown in Table 3.

Table 3 — Output data

Description	Symbol	Unit	Destination module	Validity interval	Varying
Thermal transmittance	U_{CW}	W/(m²·K)	M2–2, M2–3, M2–4	0 to ∞	No

7.2 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.

7.3 Input data

7.3.1 Geometrical characteristics

Table 4 identifies the geometrical characteristics of the individual components necessary for the calculation of the thermal transmittance of the curtain walling using the area related thermal transmittance U_{TJ}.

Table 4 — Identifiers for geometric characteristics using the area related thermal transmittance, U_{TJ}

Name	Symbol	Unit	Range	Origin	Varying
Geometrical data					
Glazed area	A_g	m^2	0 to ∞	Curtain wall construction	No
Thermal joint area	A_{TJ}	m^2	0 to ∞	Curtain wall construction	No
Opaque panel area	A_p	m^2	0 to ∞	Curtain wall construction	No
Total perimeter of the glazing	l_g	m	0 to ∞	Curtain wall construction	No
Total perimeter of the panel	l_p	m	0 to ∞	Curtain wall construction	No

Table 5 identifies the geometrical characteristics of the individual components necessary for the calculation of the thermal transmittance of the curtain walling using the length related linear thermal transmittance Ψ_{TJ}.

Table 5 — Identifiers for geometric characteristics using the length related linear thermal transmittance, Ψ_{TJ}

Name	Symbol	Unit	Range	Origin	Varying
Geometrical data					
Glazed area	A^*_g	m^2	0 to ∞	Curtain wall construction	No
Opaque panel area	A^*_p	m^2	0 to ∞	Curtain wall construction	No
Length of the thermal joint	l_g	m	0 to ∞	Curtain wall construction	No

7.3.1.1 Definition of the areas using the area related thermal transmittance, U_{TJ}

The glazed area, A_g, or the opaque panel area, A_p, of a component is the smaller of the visible areas that can be seen from both sides. Any overlapping of the glazed area by the gaskets is ignored.

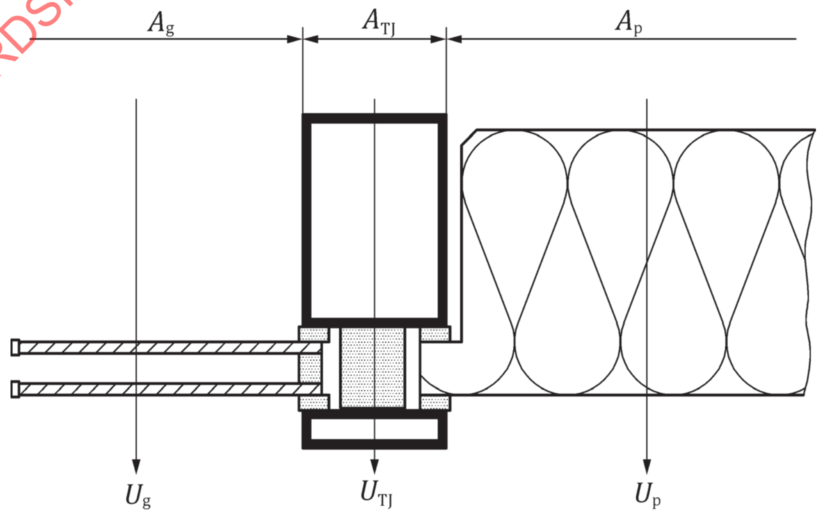


Figure 7 — Definition of the areas when using U_{TJ} (e.g. glazing, mullion, panel)

7.3.1.2 Definition of the areas using the length related linear thermal transmittance, Ψ_{TJ}

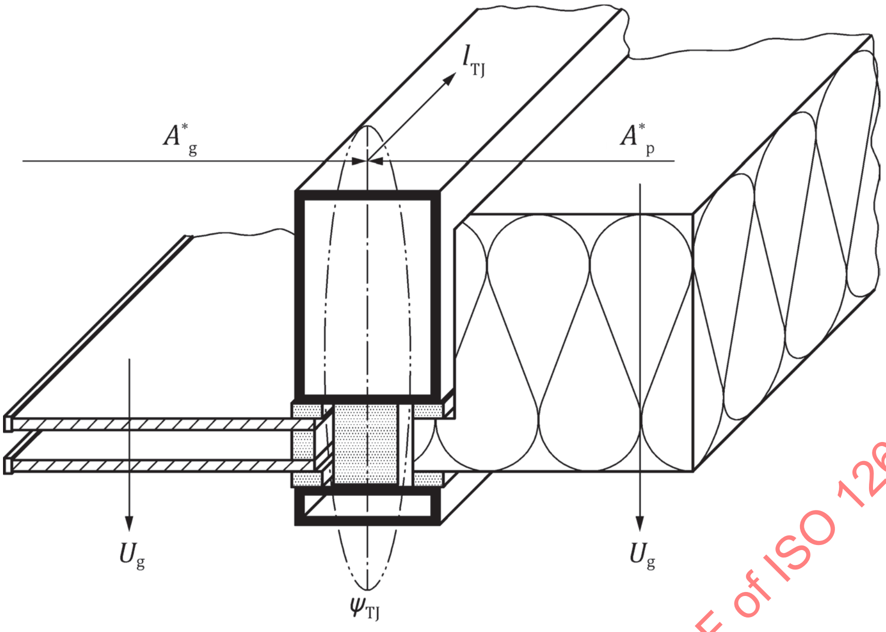
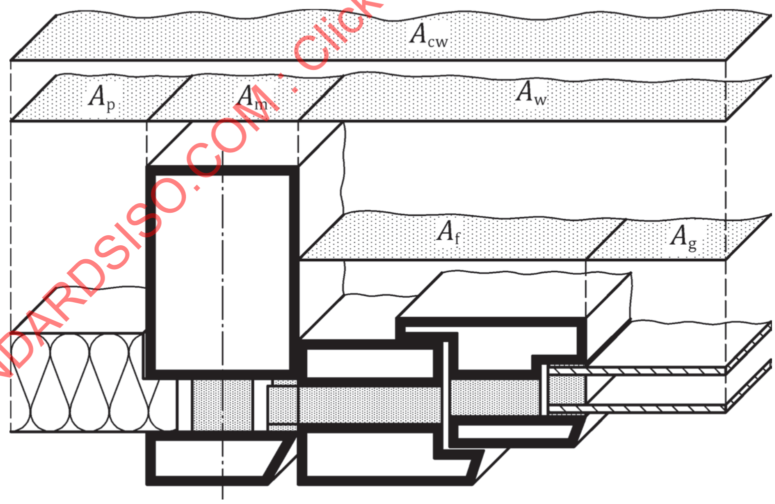


Figure 8 — Definition of the areas when using Ψ_{TJ} (e.g. glazing, mullion, panel)

7.3.1.3 Definitions of areas for other combinations

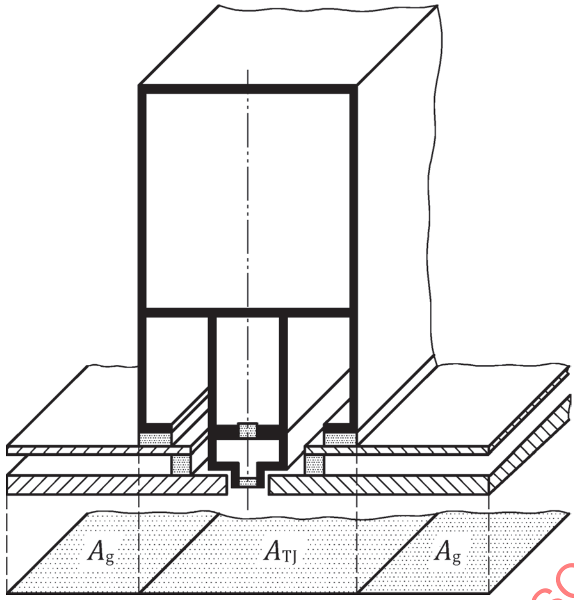
Figures 9 to 12 give further examples of how the curtain wall can be decomposed into parts for analysis by the single assessment method. The area of the joint A_{TJ} is the largest of the projected areas between the two filling elements. The length l_{TJ} is the length of the thermal joint connecting the filling elements.



Key

A_m	mullion
A_{cw}	curtain walling
A_p	panel area
A_w	window area
A_f	frame area
A_g	glazing area

Figure 9 — Example 1: Framed curtain wall

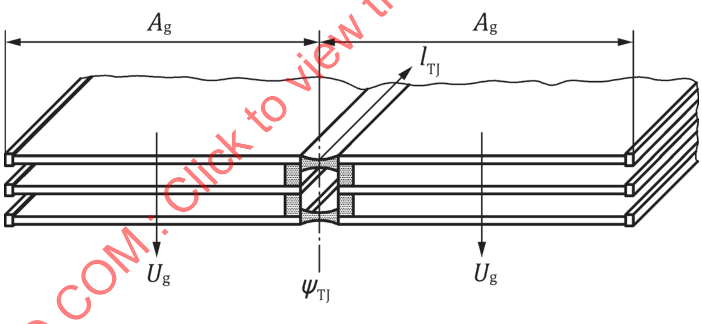


Key

A_{TJ} area of thermal joint

A_g glazing area

Figure 10 — Example 2: Structural silicone glazing



Key

TJ thermal joint

Figure 11 — Example 3: Structural glazing

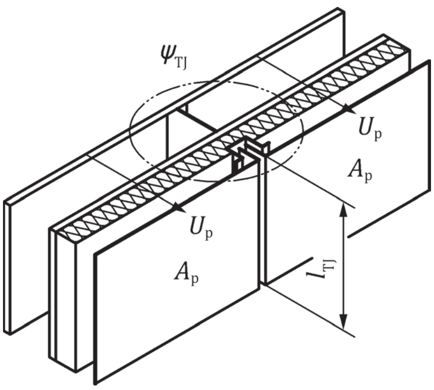


Figure 12 — Example 4: Rain screen

7.3.2 Thermal characteristics

The thermal property data required to evaluate the thermal transmittance of curtain walling, using the single assessment method, shall be obtained from Tables 5 or 6.

Table 6 — Identifiers for thermal characteristics using the area related thermal transmittance U_{TJ}

Name	Symbol	Unit	Range	Origin	Varying
Thermal transmittance of the thermal joint	U_{TJ}	W/(m²·K)	0 to ∞	EN 12412–2, ISO 10077-2 (and Annex E)	No
Thermal transmittance of glazing	U_g	W/(m²·K)	0 to ∞	ISO 10291 for measured value (GHP), ISO 10292 for calculation value, ISO 10293 for measured value (HFM), (or see Subjects 1, 2 and 3 in Table C.1)	No
Thermal transmittance of opaque panel	U_p	W/(m²·K)	0 to ∞	ISO 6946	No

7.3.2.1 Thermal transmittance of glazing units and panels (filling elements)

The thermal transmittance of opaque panels U_p shall be evaluated according to ISO 6946. The thermal transmittance of glazing units U_g shall be evaluated according to ISO 10291 for measured value (GHP), ISO 10292 for calculation value, ISO 10293 for measured value (HFM), (or see Subjects 1, 2 and 3 in Table C.1). In some cases, there is a different filling element at each side of the thermal joint (mullion, transom), so that two thermal transmittances shall be determined.

7.3.2.2 Determination of the heat flow through filling element/mullion or transom/filling element connection

7.3.2.2.1 General

The total heat flow rate Φ_{tot} of the complete connection shall be calculated using computer software that conforms to ISO 10211 and ISO 10077-2 or measured according to ISO 12567-1 with the filling elements positioned between the adiabatic lines. The modelling of screws (if present) in the two dimensional calculation shall be performed according to Annex E.

Since the heat flow rate is determined between the two adiabatic boundaries, it represents the heat flow through the filling elements, the thermal joint (e.g. mullion/transom) and also the lateral heat flow (edge effects) of the interaction between the two filling elements.

Therefore, Φ_{tot} represents the total heat flow rate that results from making a thermal joint between two filling elements and includes:

— heat flow rate straight through filling element 1 and filling element 2 (one-dimensional heat flow perpendicular to the surface of the filling element);

— heat flow rate through the thermal joint that is used to connect the two filling elements together (e.g. a frame in a framed curtain wall, a silicone joint in case of structural glazing);

— lateral and edge heat-flows due to the thermal interaction between the filling elements and the thermal joint and due to the edge constructions of the two individual filling elements (e.g. glass spacer).

As in most cases these different heat flows are difficult to separate, and to assign to a specific sub-component of the thermal joint, it is appropriate to split the overall heat flow through a thermal joint into only three parts (see Figure 8):

a) the heat flow rate Φ_{FE1} through filling element 1 without the presence of the thermal joint (i.e. the heat flow derived from the centre U-value of filling element 1);

b) the heat flow rate Φ_{FE2} through filling element 2 without the presence of the thermal joint (i.e. the heat flow derived from the centre U-value of filling element 2);

c) the heat flow rate Φ_{TJ} which is the additional heat flow rate due to making a thermal joint (which includes direct and lateral heat flows of all joint edges and the thermal joint itself excluding the one dimensional heat flow through the filling elements).

There are two ways of allowing for the additional heat flow rate Φ_{TJ}, which are equivalent and either approach will yield the same result for the thermal transmittance of the curtain wall. The possibilities are:

— to consider the heat flow rate Φ_{TJ} in terms of an area-related joint thermal transmittance U_{TJ}, or

— to consider the heat flow rate Φ_{TJ} in terms of a length-related linear joint thermal transmittance Ψ_{TJ}.

The thermal transmittance of the joint U_{TJ} or the linear thermal transmittance of the joint Ψ_{TJ} includes, in one single parameter, all thermal bridging effects resulting from making a thermal joint between the filling elements. This definition should not be compared with the frame thermal transmittance U_f (e.g. as defined in ISO 10077-2 or in the alternative method described in Clause 8), which is solely the heat flow rate through the frame excluding the lateral heat flow effects of panels and interaction with the frame. U_{TJ} should not be used to assess condensation risk.

7.3.2.2.2 Determination of the area-related joint thermal transmittance U_{TJ}

The heat flow rate Φ_{TJ}, which represents the additional heat flow rate due to making a thermal joint between two filling elements, can be calculated as:

$$\Phi_{TJ} = \Phi_{tot} - (U_{FE1}\,A_{FE1} + U_{FE2}\,A_{FE2})\,\Delta T \tag{1}$$

where ΔT is the temperature difference between internal and external environments used to simulate the heat transfer.

The thermal transmittance of the joint U_{TJ} (see Figure 7) is calculated as:

$$U_{TJ} = \Phi_{TJ}/(A_{TJ}\cdot\Delta T) \tag{2}$$

where

A_{TJ} is the projected area of the thermal joint;

ΔT is the temperature difference between the internal and external environment used for the simulation.

NOTE For the example in Figure 9, the areas and U-values of the filling elements are defined as follows:

$A_g = A_{FE1}$, $A_p = A_{FE2}$, $U_g = U_{FE1}$, $U_p = U_{FE2}$

7.3.2.2.3 Determination of the linear joint thermal transmittance Ψ_{TJ}

The definition of the filling element areas is different from the definition in Figure 8 and is as specified in Figure 9. The calculation of Φ_{TJ} is according to Formula (3).

The heat flow rate Φ_{TJ} can be calculated as:

$$\Phi_{TJ} = \Phi_{tot} - (U_{FE1}\, A^*_{FE1} + U_{FE2}\, A^*_{FE2})\, \Delta T \tag{3}$$

where ΔT is the temperature difference between inside and outside air used to simulate the heat transfer.

The linear thermal transmittance of the joint Ψ_{TJ} is calculated as:

$$\Psi_{TJ} = \Phi_{TJ} / (l_{TJ}\, \Delta T) \tag{4}$$

where ΔT is the temperature difference between the internal and external environments used for the simulation.

7.4 Calculation procedure

7.4.1 Applicable time interval

The thermal transmittance of a curtain walling to this document is a steady-state property which can also be used as input for dynamic (e.g. hourly) building calculations, because the time constant of these types of building elements are negligible compared to many opaque elements.

However, depending on the type of product or assembly, some properties and consequently the calculated thermal transmittance, may be affected by the boundary conditions. The procedure whether and how this should be taken into account is given in the standards that use the output from this document as input.

Also, some products or assemblies may be used in different modes of operation: parts that are opened, moved or removed as function of time or conditions. The output may be different per mode of operation.

NOTE ISO 52016-1 contains procedures for the handling of building elements with different modes of operation (dynamic transparent building elements) in the calculation of the energy needs for heating and cooling and the internal temperature in a building.

7.4.2 Calculation of thermal transmittance

7.4.2.1 Single Element

7.4.2.1.1 Using the area-related thermal transmittance U_{TJ}

The thermal transmittance of the curtain wall element, U_{cw}, is calculated as the area-weighted average of all the thermal transmittances of the joints, glazing units and panels.

$$U_{cw} = \frac{\sum A_g U_g + \sum A_p U_p + \sum A_{TJ} U_{TJ}}{\sum A_g + A_p + \sum A_{TJ}} \tag{1}$$

where the areas A_g and A_p are defined according to Figure 7.

7.4.2.1.2 Using the length-related linear thermal transmittance Ψ_{TJ}

The thermal transmittance of the curtain wall element, U_{cw}, is calculated as the area-weighted average of all the thermal transmittances of glazing units and panels and the linear thermal transmittances of the joints.

$$U_{cw} = \frac{\sum A_g^* U_g + \sum A_p^* U_p + \sum l_{TJ} \Psi_{TJ}}{A_g^* + A_p^*} \quad (2)$$

using the areas $\sum A^*_g$ and $\sum A^*_p$ as defined according to Figure 8.

7.4.2.2 Thermal transmittance of a curtain wall built of different elements

The calculation of $U_{cw,tot}$ of the overall curtain wall built with different sizes or design of elements shall be calculated as the area-weighted average thermal transmittance of all modules according to Formula (7).

$$U_{cw,tot} = \frac{\sum (U_{cw,j} A_{cw,j})}{\sum A_{cw,j}} \quad (7)$$

where

$\Sigma U_{cw,j}\ A_{cw,j}$ is the sum of the products of thermal transmittances and corresponding areas of the different modules;

$\Sigma A_{cw,j}$ is the sum of the areas of the different modules.

8 Component assessment method

8.1 Output data

The output of the component assessment method according to this document is the transmission heat transfer coefficient of a curtain walling shown in Table 7.

Table 7 — Output data

Description	Symbol	Unit	Destination module	Validity interval	Varying
Thermal transmittance	U_{CW}	W/(m²·K)	M2–2, M2–3, M2–4	0 to ∞	No

8.2 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.

8.3 Input data

8.3.1 Geometrical characteristics

Table 8 is showing the necessary geometrical characteristics.

Table 8 — – Identifiers for geometric characteristics

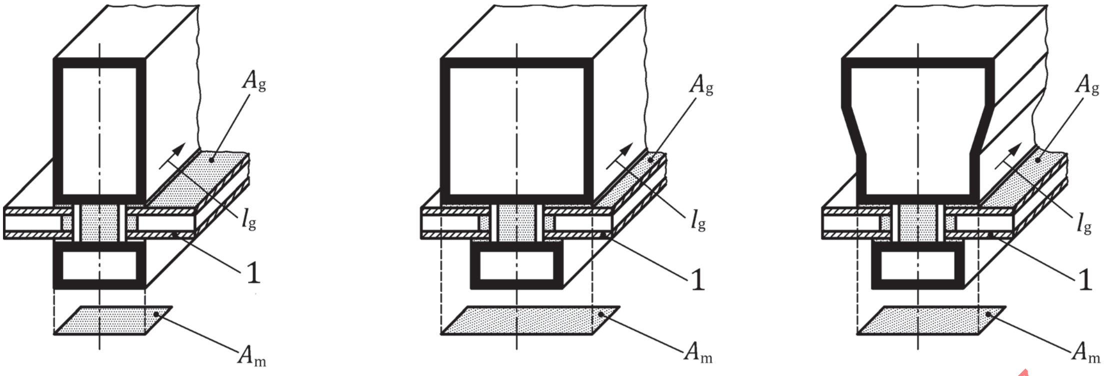
Name	Symbol	Unit	Range	Origin	Varying
Geometrical data					
Glazed area	A_g	m^2	0 to ∞	Curtain wall construction	No
Frame area	A_f	m^2	0 to ∞	Curtain wall construction	No
Mullion area	A_m	m^2	0 to ∞	Curtain wall construction	No
Transom area	A_t	m^2	0 to ∞	Curtain wall construction	No
Opaque panel area	A_p	m^2	0 to ∞	Curtain wall construction	No
Total length of the interface frame/glazing	$l_{f,g}$	m	0 to ∞	Curtain wall construction	No
Total length of the interface mullion/glazing	$l_{m,g}$	m	0 to ∞	Curtain wall construction	No
Total length of the interface transom/glazing	$l_{t,g}$	m	0 to ∞	Curtain wall construction	No
Total length of the interface mullion/frame	$l_{t,f}$	m	0 to ∞	Curtain wall construction	No
Total length of the interface transom/frame	$l_{t,f}$	m	0 to ∞	Curtain wall construction	No
Total length of the interface mullion/panel	$l_{t,p}$	m	0 to ∞	Curtain wall construction	No
Total length of the interface transom/panel	$l_{t,p}$	m	0 to ∞	Curtain wall construction	No

8.3.1.1 Glazed area, opaque panel area

The glazed area A_g, or the opaque panel area A_p, of a component is the smaller of the visible areas that can be seen from both sides (see Figures 14 and 15). Any overlapping of the glazed area by the gaskets is ignored.

8.3.1.2 Total visible perimeter of the glazing

The total perimeter of glazing, l_g, or of an opaque panel, $l_{p,}$ is the sum of the visible perimeter of the glass panes (or opaque panels). If different perimeters are seen from each side, the perimeter is defined by the interface of the area of the glazing or panel and the frame or mullion or transom Figure 13 gives an example for the interface glazing and mullion.



Key

1 glazing

Figure 13 — Illustration of the glazed area and perimeter

8.3.1.3 Areas of frames, mullions and transoms

For the definition of the areas see also Figures 14 and 15.

$A_{m,i}/A_{t,i}$ is the internal projected mullion/transom area at the interface glazing/mullion/transom, equal to the area of the projection of the internal mullion/transom on a plane parallel to the wall;

$A_{m,e}/A_{t,e}$ is the external projected mullion/transom area at the interface glazing/mullion/transom, equal to the area of the projection of the external mullion/transom on a plane parallel to the wall;

A_m/A_t is the mullion/transom area, equal to the larger of the two projected areas seen from either side;

$A_{f,i}$ is the internal projected frame area at the interface glazing/frame, equal to the area of the projection of the internal frame on a plane parallel to the wall;

$A_{f,e}$ is the external projected frame area at the interface glazing/frame, equal to the area of the projection of the external frame on a plane parallel to the wall;

A_f is the frame area, equal to the larger of the two projected areas seen from either side.

$A_m = \max\left(A_{m,i}\,;\,A_{m,e}\right)$

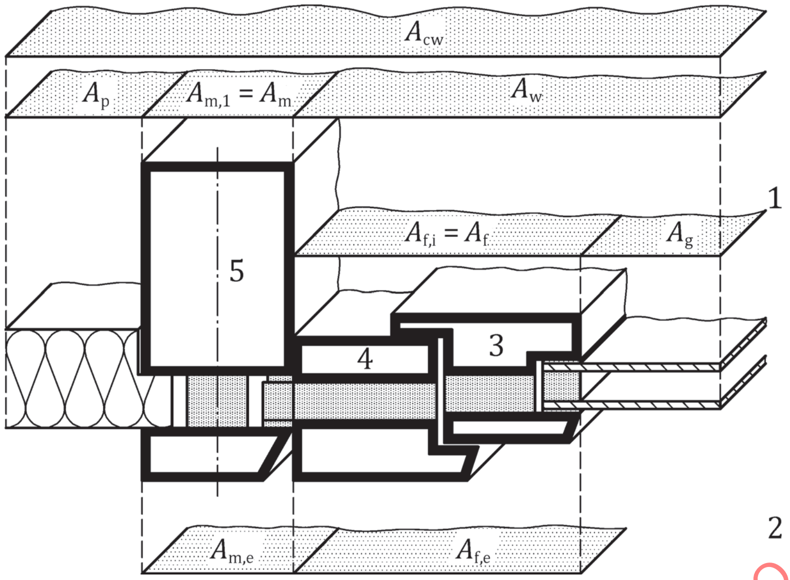
$A_t = \max\left(A_{t,i}\,;\,A_{t,e}\right)$

$A_f = \max\left(A_{f,i}\,;\,A_{f,e}\right)$

$A_w = A_f + A_g$

$A_{cw} = A_t + A_m + A_f + A_g + A_p$

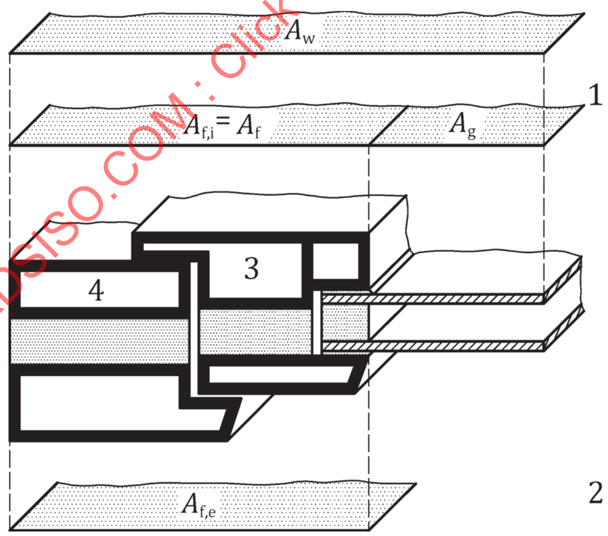
In Figure 15 only a mullion is shown. The general principle is also applicable for transoms.



Key

1	internal	A_{cw}	curtain walling	A_f	frame area
2	external	A_p	panel area	A_g	glazing area
3	sash (movable)	$A_{m,i}$	internal mullion area	$A_{m,e}$	external mullion area
4	frame (fixed)	A_m	mullion		
5	mullion/transom	$A_{f,e}$	external frame area		

Figure 14 — Illustration of the various areas on mullion or transom sections, panels and glazing



Key

1 internal
2 external
3 sash (movable)
4 frame (fixed)

Figure 15 — Illustration of the various areas on frame-sash sections and glazing

8.3.1.4 Area of a module of curtain walling

If the internal or external frame has a complex geometrical shape, the frame section A_f is determined according to Figure 15, and the mullion and transom section A_m and A_t are determined according to Figure 15. The total area A_{cw}, of an element of curtain walling is the sum of the mullion/transom area, A_m/A_t, the frame area, A_f, the glazing area, A_g, and the panel area, A_p (see also Figure 14).

8.3.2 Thermal characteristics

The thermal property data required to evaluate the thermal transmittance of curtain walling, using the component assessment method, shall be obtained from Table 9.

Table 9 — Identifiers for thermal characteristics of the window/door component

Name	Symbol	Unit	Range	Origin	Varying
Thermal transmittance of mullion	U_m	W/(m²·K)	0 to ∞	EN 12412–2, ISO 10077-2 (and Annex E)	No
Thermal transmittance of transom	U_t	W/(m²·K)	0 to ∞	EN 12412–2, ISO 10077-2 (and Annex E)	No
Thermal transmittance of frame	U_f	W/(m²·K)	0 to ∞	EN 12412–2, ISO 10077-1, ISO 10077-2	No
Thermal transmittance of glazing	U_g	W/(m²·K)	0 to ∞	ISO 10291 for measured value (GHP), ISO 10292 for calculation value, ISO 10293 for measured value (HFM), (or see Subjects 1, 2 and 3 in Table C.1)	No
Thermal transmittance of opaque panel	U_p	W/(m²·K)	0 to ∞	ISO 6946	No
Linear thermal transmittance due to combined effect of glazing, spacer and frame	$\Psi_{f,g}$	W/(m·K)	0 to ∞	Annex D, ISO 10077-2	No
Linear thermal transmittance due to combined effect of glazing, spacer and mullion	$\Psi_{m,g}$	W/(m·K)	0 to ∞	Annex D, ISO 10077-2	No
Linear thermal transmittance due to combined effect of glazing, spacer and transom	$\Psi_{t,g}$	W/(m·K)	0 to ∞	Annex D, ISO 10077-2	No
Linear thermal transmittance due to combined effect of panel, spacer and mullion	$\Psi_{m,p}$	W/(m·K)	0 to ∞	Annex D, ISO 10077-2	No
Linear thermal transmittance due to combined effect of panel, spacer and transom	$\Psi_{t,p}$	W/(m·K)	0 to ∞	Annex D, ISO 10077-2	No
Linear thermal transmittance due to combined effect of frame and mullion	$\Psi_{m,f}$	W/(m·K)	0 to ∞	Annex D, ISO 10077-2	No
Linear thermal transmittance due to combined effect of frame and transom	$\Psi_{t,f}$	W/(m·K)	0 to ∞	Annex D, ISO 10077-2	No

The sources of all data shall be stated unambiguously. Ensure that numerical values used relate exactly to the areas as defined in 5.3.

If the results are to be used for comparison of the performance of different curtain walling, the sources of the numerical values of each parameter shall be the same for each type of curtain walling included in the comparison.

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

Design values should be determined for the actual position and boundary conditions, by including the effect of the inclination of the curtain wall in the determination of U_g. However, the U_m, U_t, U_f and Ψ as determined for the curtain wall in the vertical position are used for all inclinations of the curtain wall.

Values for the surface thermal resistance can be obtained from ISO 10077-1:2017, Annex A.

8.3.2.1 Thermal transmittance of glazing units and panels (filling elements)

The thermal transmittance of opaque panels U_p shall be evaluated according to ISO 6946. The thermal transmittance of glazing units U_g shall be evaluated according to ISO 10291 for measured value (GHP), ISO 10292 for calculation value, ISO 10293 for measured value (HFM), (or see Subjects 1, 2 and 3 in Table C.1). In some cases, there is a different filling element at each side of the thermal joint (mullion, transom), so that two thermal transmittances shall be calculated.

8.3.2.2 Thermal transmittance of frames, mullions and transoms

The U_f values of the sash and frame sections can be evaluated according to EN 12412-2, ISO 10077-1 or ISO 10077-2. See also Annex D concerning the boundary conditions for the calculation of U_f for frames which are integrated in the façade.

The U_t and U_m values for the transom and mullion sections can be evaluated according to EN 12412-2 or ISO 10077-2.

The U-value calculated according to ISO 10077-2 does not take into account the effect of screws connecting the internal to the external sections of mullions and transoms. The effect of screws shall be included using Formulae (8) and (9):

$$U_m = U_0 + \Delta U \tag{8}$$

$$U_t = U_0 + \Delta U \tag{9}$$

where

U_m/U_t	is the thermal transmittance of the mullion/transom;
U_0	is the thermal transmittance of the mullion/transom calculated according to ISO 10077-2 excluding the effect of metal connectors (screws);
ΔU	is the difference in the thermal transmittance of mullion/transom with and without screws.

Values for ΔU are given in Table 10.

Table 10 — Values of ΔU for mullion and transom sections for stainless steel connectors

Diameter of stainless steel connectors mm	**Distance between stainless steel connectors** mm	ΔU W/(m^2·K)
≤6	200 to 300	0,3

ΔU depends on the distance between the connectors, the diameter and the materials used.

An alternative to using the values given in Table 10 is to measure ΔU using the procedures specified in EN 12412-2. In this case, ΔU is derived from the difference between measured values for specimens with metal screws and those on the same specimen but using plastic screws (which are assumed to have a negligible effect). ΔU can also be evaluated by a three dimensional calculation according to ISO 10211 obeying the specific rules for cavities given in ISO 10077-2.

A second alternative is to calculate the influence of the screws according to Annex E.

It is common practice to produce "profile systems" comprising a large number of different frames, having a wide range of geometric shapes but having similar thermal properties. This is because in these groups of frames, the important parameters such as the size, material and design of the thermal break, are the same. The thermal transmittance of a profile or profile combination of a "profile system" can be evaluated by

— using the highest value of U_f or U_m/U_t of the profiles or profile combinations within the profile system, or

— using trend lines that show the relationship between U_f or U_m/U_t and defined geometrical characteristics.

In the latter case, the data points for the trend line are evaluated on selected profile cross-sections, taken from the profile system in question. Detailed procedures are described in References [5] - [8].

Values for the linear thermal transmittance of glazing units, $\Psi_{m,g}$ $\Psi_{t,g}$ $\Psi_{f,g}$, are given in Tables D.1, D.2, D.3 and D.4 or can be calculated using ISO 10077-2 In the case of single glazing, Ψ_{fmg} $\Psi_{t,g}$ $\Psi_{f,g}$ in Formula (12) shall be taken as zero (no spacer effect) because any correction is negligible.

Values for the linear thermal transmittance $\Psi_{m,p}$ $\Psi_{t,p}$ of panels are given in Table D.5 or can be calculated using ISO 10077-2.

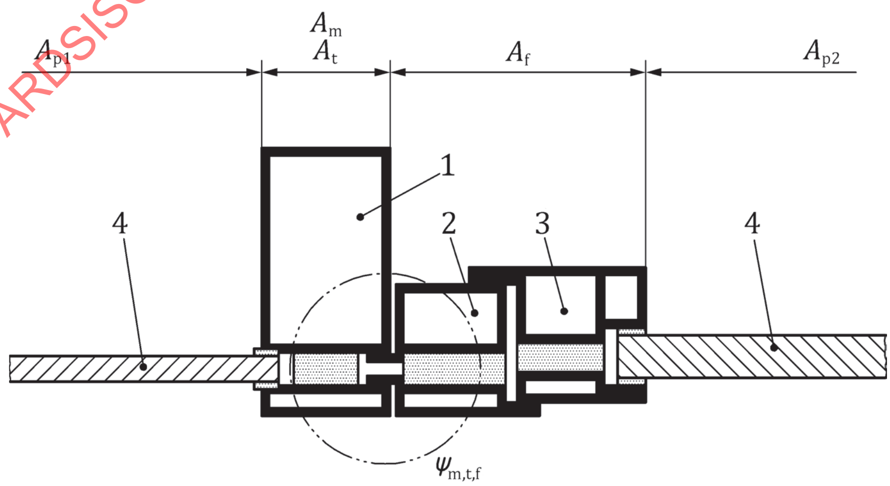
The interaction between the frame and the mullion or transom caused by the installation of the frame into the rebate of the mullion or transom (Figure 16) is accounted for with the linear thermal transmittances $\Psi_{m,f}$ and $\Psi_{t,f}$.

Values for the linear thermal transmittances $\Psi_{m,f}$ and $\Psi_{t,f}$ describing the thermal heat flow due to the installation of a window in the façade are given in Tables D.6 or D.7 or can be calculated using ISO 10077-2:

$$\Psi_{m,f} = L_{\Psi}^{2D} - U_m A_m - U_f A_f - U_{p1} A_{p1} - U_{p2} A_{p2} \tag{10}$$

$$\Psi_{t,f} = L_{\Psi}^{2D} - U_t A_t - U_f A_f - U_{p1} A_{p1} - U_{p2} A_{p2} \tag{11}$$

where



L_{Ψ}^{2D} is the thermal conductance of the section shown in Figure 16, in W/(m·K), calculated using ISO 10077-2;

U_f is the thermal transmittance of the frame, in W/(m²·K), calculated using ISO 10077-2;

U_m is the thermal transmittance of the mullion, in W/(m²·K), calculated using ISO 10077-2;

U_t is the thermal transmittance of the transom, in W/(m²·K), calculated using ISO 10077-2;

U_{p1} is the thermal transmittance of panel 1, in W/(m²·K);

U_{p2} is the thermal transmittance of panel 2, in W/(m²·K).

Key

1 transom or mullion

2 frame (fixed)

3 sash (movable)

4 infill, panel

Figure 16 — Illustration of a window integrated in a transom or mullion section

8.4 Calculation procedure

8.4.1 Applicable time interval

The thermal transmittance of a curtain walling to this document is a steady-state property which can also be used as input for dynamic (e.g. hourly) building calculations, because the time constant of these types of building elements are negligible compared to many opaque elements.

However, depending on the type of product or assembly, some properties and consequently the calculated thermal transmittance, may be affected by the boundary conditions. The procedure whether and how this should be taken into account is given in the standards that use the output from this document as input.

Also, some products or assemblies may be used in different modes of operation: parts that are opened, moved or removed as function of time or conditions. The output may be different per mode of operation.

8.4.2 Calculation of thermal transmittance

8.4.2.1 Single element

The thermal transmittance of a single element of a curtain walling, U_{cw}, shall be calculated using Formula (12).

$$U_{cw} = \frac{\sum A_g U_g + \sum A_p U_p + \sum A_f U_f + \sum A_m U_m + \sum A_t U_t + \sum l_{f,g} \Psi_{f,g} + \sum l_{m,g} \Psi_{m,g}}{A_{cw}} + \frac{\sum l_{t,g} \Psi_{t,g} + \sum l_{m,p} \Psi_{m,p} + \sum l_{m,f} \Psi_{m,f} + \sum l_{t,f} \Psi_{t,f}}{A_{cw}} \tag{12}$$

where

U_g, U_p	are the thermal transmittances of glazing and panels;
U_f, U_m, U_t	are the thermal transmittances of frames, mullions and transoms;
$\Psi_{f,g}$, $\Psi_{m,g}$, $\Psi_{t,g}$	are the linear thermal transmittances due to the combined thermal effects of glazing unit and frame or mullion or transom;
$\Psi_{m,p}$, $\Psi_{t,p}$	are the linear thermal transmittances due to the combined thermal effects of panel and mullion or transom;
$\Psi_{m,f}$, $\Psi_{t,f}$	are the linear thermal transmittances due to the combined thermal effects of frame-mullion and frame-transom;

and the other symbols are defined in Clause 4.

The area of the curtain walling shall be calculated according to Formula (13):

$$A_{cw} = \Sigma A_g + \Sigma A_p + \Sigma A_f + \Sigma A_m + \Sigma A_t \tag{13}$$

where

A_{cw}	is the area of curtain walling;
ΣA_g	is the total area of glazing;
ΣA_p	is the total area of panels;
ΣA_f	is the total area of frames;
ΣA_m	is the total area of mullions;
ΣA_t	is the total area of transoms.

8.4.2.2 Thermal transmittance of a curtain wall built of different elements

The calculation of $U_{cw,tot}$ of the overall curtain wall built with different sizes or design of elements shall be calculated as the area-weighted average thermal transmittance of all modules according to Formula (14):

$$U_{cw,tot} = \frac{\sum (U_{cw,j} A_{cw,j})}{\sum A_{cw,j}} \tag{14}$$

where

$\Sigma U_{cw,j}\ A_{cw,j}$	is the sum of the products of thermal transmittances and corresponding areas of the different modules;
$\Sigma A_{cw,j}$	is the sum of the areas of the different modules.

9 Report

9.1 Contents of report

The calculation report shall include the following:

— reference to this document, i.e. ISO 12631:2017;

— identification of the organization making the calculation;

— date of calculation;

— items listed in 9.2 and 9.3.

9.2 Drawings

9.2.1 Section drawings

A technical drawing shall be available (preferably scale 1:1) giving the sections of the curtain walling with sufficient details to permit the verification of the following:

— thickness, position type and number of thermal breaks;

— number and thickness of air chambers (for plastic frame sections);

— presence and position of metal stiffening (for plastic frame sections);

— thickness of frames;

— thickness of the gas-spaces and the identification of the gas;

— type of glass, its thickness, its thermal properties and emissivity of its surfaces;

— thickness and description of any opaque panels in the frame;

— position of the glazing and panel unit spacer bars or of the edge stiffening for opaque panels.

The distance between the connections of external and internal frame sections having thermal bridge effects shall be clearly indicated.

9.2.2 Overview drawing of the whole curtain wall element

A drawing of the front view of the whole curtain wall element (seen from outside the building) with the following information shall be available:

— glazed area, A_g and/or opaque panel area, A_p;

— frame area, A_f;

— perimeter length of the glazing, l_g and/or of the opaque panels, l_p.

9.3 Values used in the calculation

If the values in Annex D are used, this shall be stated and reference made to the identifiers of the tables and Annexes used.

If measured or calculated values are used, the measurement or calculation methods shall be indicated precisely (e.g. indicate the standard) and it shall be stated that the values obtained correspond to the definitions of the areas given in this document.

9.4 Presentation of results

The thermal transmittance of the curtain walling, calculated according to this document, shall be given to two significant figures.

Annex A
(normative)

Input and method selection data sheet — Template

A.1 General

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

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

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

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

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

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

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

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

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

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

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

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

A.2 References

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

Table A.1 — References

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

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

A.3 Calculation of thermal transmittance

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

Annex B
(informative)

Input and method selection data sheet — default choices

B.1 General

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

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

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

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

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

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

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

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

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

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

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

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

B.2 References

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

Table B.1 — References

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

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

B.3 Calculation of thermal transmittance

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

Annex C
(normative)

Regional references in line with ISO Global Relevance Policy

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

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

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

	Subject	Global	Regional: CEN area[a]
Thermal transmission: glazing			
1	Calculated value	ISO 10292	EN 673
2	Measured value (GHP apparatus)	ISO 10291	EN 674
3	Measured value (HFM apparatus)	ISO 10293	EN 675

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

Annex D
(normative)

Linear thermal transmittance of junctions

D.1 Overview

The thermal transmittance of glazing units, U_g, and panels, U_p, are applicable to the central area of the glazing unit or panel and do not include the effect of the spacers at the edge of the glazing unit or the panel. The thermal transmittance of frame, mullions and transoms (U_f, U_m, U_t), however, has been defined without the presence of the glazing or panel. The linear thermal transmittance Ψ describes the additional heat conduction due to the interaction between frame, glazing unit or panel and spacer. The linear thermal transmittance, Ψ, is mainly determined by the thermal conductivity of the spacer material and the design of the frame or mullion/transom.

Values of linear thermal transmittance can be established by numerical calculation according to ISO 10077-2:2012. If detailed results are not available, the values in this Annex may be used.

Tables D.1 and D.2 give the $\Psi_{m,g}$,$\Psi_{t,g}$ values for spacers used in glazing units installed in mullions/transoms used for stick constructions.

Tables D.3 and D.4 give the $\Psi_{f,g}$ values for spacers used in glazing units installed in frames.

Table D.5 gives the Ψ_p values for spacers used in opaque panels.

Tables D.6 and D.7 give the $\Psi_{m,f}$ / $\Psi_{t,f}$ values for mullion/transom-frame junctions.

Table D.1 — Values of the linear thermal transmittance $\Psi_{m,g}$ and $\Psi_{t,g}$ in W/(m·K) for normal types of glazing spacer bars (e.g. aluminium and steel – desiccant-filled) used in glazing units installed in transoms/mullions

Mullion or transom type	**Glazing type**	
	Double or triple glazing — uncoated glass — air or gas filled W/(m·K)	Double or triple glazing — low emissivity glass * 1 pane coated for double glazed * 2 panes coated for triple glazed - air or gas filled W/(m·K)
Wood-Metal	0,08	0,11
Metal with a thermal break	$d_i \leq 100$ mm: 0,13 $d_i \leq 200$ mm: 0,15	$d_i \leq 100$ mm: 0,17 $d_i \leq 200$ mm: 0,19
d_i is the internal depth of the mullion or transom (see also Figure 3).		

Table D.2 — Values of the linear thermal transmittance $\Psi_{m,g}$ and $\Psi_{t,g}$ in W/(m·K) for thermally improved types of glazing spacer bars used in glazing units installed in transoms/mullions

Mullion or transom type	Glazing type	
Mullion or transom type	Double or triple glazing — uncoated glass — air or gas filled W/(m·K)	Double or triple glazing — low emissivity glass * 1 pane coated for double glazed * 2 panes coated for triple glazed — air or gas filled W/(m·K)
Wood-Metal	0,06	0,08
Metal with a thermal break	$d_i \leq 100$ mm: 0,09 $d_i \leq 200$ mm: 0,10	$d_i \leq 100$ mm: 0,12 $d_i \leq 200$ mm: 0,13
d_i is the internal depth of the mullion or transom (see also Figure 3).		

Table D.3 — Values of the linear thermal transmittance $\Psi_{f,g}$ in W/(m·K) for normal types of glazing spacer bars (e.g. aluminium and steel – desiccant-filled) used in glazing units installed in frames

Frame type	Glazing type	
	Double or triple glazing — uncoated glass — air or gas filled W/(m·K)	Double or triple glazing — low emissivity glass * 1 pane coated for double glazed * 2 panes coated for triple glazed — air or gas filled W/(m·K)
Wood or PVC	0,06	0,08
Metal with a thermal break	0,08	0,11
Metal without a thermal break	0,02	0,05
NOTE This Table is based on ISO 10077-1.		

Table D.4 — Values of the linear thermal transmittance $\Psi_{f,g}$ in W/(m·K) for thermally improved types of glazing spacer bars used in glazing units installed in frames

Frame type	Glazing type	
	Double or triple glazing — uncoated glass — air or gas filled W/(m·K)	Double or triple glazing — low emissivity glass * 1 pane coated for double glazed * 2 panes coated for triple glazed — air or gas filled W/(m·K)
Wood or PVC	0,05	0,06
Metal with a thermal break	0,06	0,08
Metal without a thermal break	0,01	0,04
NOTE This Table is based on ISO 10077-1.		

Values for spacers not covered by the tables can be determined by numerical calculation in accordance with ISO 10077-2.

D.2 Definition of glazing spacer bars with improved thermal performance

For the purpose of this Annex, a thermally improved spacer is defined by the following criteria:

$$\Sigma(d \cdot \lambda) \leq 0{,}007 \text{ W/K}$$

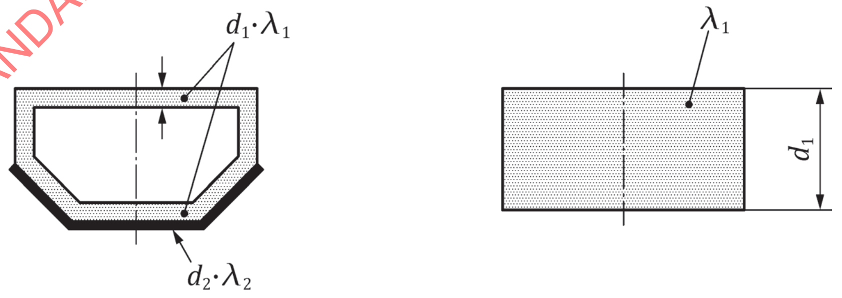
This criterion is based on the thickness of the materials of the spacer where

d is the thickness of the spacer wall, in m;

λ is the thermal conductivity of the spacer material, in W/(m·K).

The products of the spacer wall thickness and the thermal conductivity should be summed.

The summation applies to all heat flow paths parallel to the principal heat flow direction, the thickness d being measured perpendicular to the principal heat flow direction (see Figure D.1). Values of thermal conductivity for spacer materials should be taken from ISO 10456 or ISO 10077-2.



$\Sigma(d \cdot \lambda) = 2(d_1 \cdot \lambda_1) + d_2 \cdot \lambda_2$ $\Sigma(d \cdot \lambda) = d_1 \cdot \lambda_1$

Figure D.1 — Definition of glazing unit spacer bars with improved thermal performance

Representative Ψ-values of thermally improved spacers can be established on the basis of representative profile sections and representative glazing units. Detailed procedures are given in Bibliography.

