INTERNATIONAL STANDARD

ISO 10077-2

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

Part 2: Numerical method for frames

Performance thermique des fenêtres, portes et fermetures — Calcul du coefficient de transmission thermique —

Partie 2: Méthode numérique pour les encadrements

Reference number
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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 10077-2 was prepared by 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 International Standard is one of a series of standards on methods for the design and evaluation of the thermal performance of building equipment and industrial installations.

This second edition cancels and replaces the first edition (ISO 10077-2:2003), which has been technically revised. The main changes compared to the previous edition are given in the following table:

Clause	Changes
5.1	Clarified use of measured data.
5.4	Added calculation rules for roller shutter boxes and added new figure.
5.5	Added calculation rules for extensions of window frame profiles and new added figure.
Annex A	Added Table A.2 — Thermal conductivity of timber species.
Annex A	Added Table A.3 — Typical emissivities of metallic surfaces.
Annex B	Added Table B.2 for roller shutter boxes.
C.2	Added calculation rules for the combination of frame constructions with insulating glazing units (IGU) and Figure C.3 showing a representative metal spacer incorporated in an IGU.
Annex D	Updated Figures D.1 to D.10 for frame sections.

ISO 10077 consists of the following parts, under the general title *Thermal performance of windows, doors and shutters — Calculation of thermal transmittance*:

— *Part 1: General*

— *Part 2: Numerical method for frames*

Introduction

ISO 10077 consists of two parts. The method in this part of ISO 10077 is intended to provide calculated values of the thermal characteristics of frame profiles, suitable to be used as input data in the calculation method of the thermal transmittance of windows, doors and shutters given in ISO 10077-1. It is an alternative to the test method specified in EN 12412-2. In some cases, the hot box method is preferred, especially if physical and geometrical data are not available or if the profile is a complicated geometrical shape.

Although the method in this part of ISO 10077 basically applies to vertical frame profiles, it is an acceptable approximation for horizontal frame profiles (e.g. sill and head sections) and for products used in sloped positions (e.g. roof windows). For calculations made with the glazing units in place, the heat flow pattern and the temperature field within the frame are useful by-products of this calculation.

This part of ISO 10077 does not cover building façades and curtain walling. These are covered in ISO 12631[1)] or EN 13947.

1) To be published.

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

Part 2:
Numerical method for frames

1 Scope

This part of ISO 10077 specifies a method and gives reference input data for the calculation of the thermal transmittance of frame profiles and of the linear thermal transmittance of their junction with glazing or opaque panels.

The method can also be used to evaluate the thermal resistance of shutter profiles and the thermal characteristics of roller shutter boxes and similar components (e.g. blinds).

This part of ISO 10077 also gives criteria for the validation of numerical methods used for the calculation.

This part of ISO 10077 does not include effects of solar radiation, heat transfer caused by air leakage or three-dimensional heat transfer such as pin point metallic connections. Thermal bridge effects between the frame and the building structure are not included.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

ISO 10456: 2007, *Building materials and products — Hygrothermal properties — Tabulated design values and procedures for determining declared and design thermal values*

ISO 12567-2:2005, *Thermal performance of windows and doors — Determination of thermal transmittance by hot box method — Part 2: Roof windows and other projecting windows*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

EN 673, *Glass in building — Determination of thermal transmittance (U-value) — Calculation method*

EN 12519, *Windows and pedestrian doors — Terminology*

3 Terms, definitions and symbols

For the purposes of this document, the terms and definitions given in ISO 7345 and EN 12519 apply.

Symbol	Definition	Unit
A	area	m^2
b	width, i.e. perpendicular to the direction of heat flow	m
d	depth, i.e. parallel to the direction of heat flow	m
E	intersurface emittance	—
F	view factor	—
h	heat transfer coefficient	$W/(m^2 \cdot K)$
L^{2D}	two-dimensional thermal conductance or thermal coupling coefficient	$W/(m \cdot K)$
l	length	m
q	density of heat flow rate	W/m^2
R	thermal resistance	$m^2 \cdot K/W$
T	thermodynamic temperature	K
U	thermal transmittance	$W/(m^2 \cdot K)$
σ	Stefan-Boltzmann constant	$W/(m^2 \cdot K^4)$
ε	emissivity	—
λ	thermal conductivity	$W/(m \cdot K)$
Ψ	linear thermal transmittance	$W/(m \cdot K)$

Subscripts	
a	convective (surface to surface)
e	external (outdoor)
g	glazing
eq	equivalent
f	frame
fr	frame adjacent to roller shutter box
i	internal (indoor)
p	panel
r	radiative
s	space (air or gas space)
sb	shutter box
se	external surface
si	internal surface

4 Calculation method

4.1 General principle

The calculation shall be carried out using a two-dimensional numerical method conforming to ISO 10211. The elements shall be divided such that any further division does not change the calculated result significantly. ISO 10211 gives criteria for judging whether sufficient sub-divisions have been used.

Vertical orientation of frame sections and air cavities is assumed for calculations using this part of ISO 10077 for the purposes of assigning equivalent thermal conductivity values (see 7.3); this applies irrespective of the intended orientation of the actual window, including roof windows.

4.2 Validation of the calculation programme

To ensure the suitability of the calculation programme used, calculations shall be carried out on the examples described in Annex D. The calculated two-dimensional thermal conductance L^{2D} shall not differ from the corresponding values given in Table D.3 by more than ±3 %. This will lead to an accuracy of the thermal transmittance, U, and the linear thermal transmittance Ψ, of about 5 %.

NOTE The ± deviations in Tables D.3 and D.4 are standard deviations from a round-robin and are not to be confused with ±3 % specified above.

4.3 Determination of the thermal transmittance

The thermal transmittance of a frame section shall be determined with the glazing replaced by an insulating panel according to Annex C, with the external and internal surface resistances taken from Annex B. The linear thermal transmittance of the interaction of frame and glazing shall be determined from calculations with the glazing in place and with the glazing replaced by an insulated panel.

NOTE 1 The interaction of the frame and the building structure is considered separately for the building as a whole. It is not part of the thermal transmittance of the frame section.

NOTE 2 In the case of an overlap between the frame section and part of the wall, the linear thermal transmittance could be negative.

5 Treatment of solid sections and boundaries

5.1 Solid materials

For the purpose of this part of ISO 10077, thermal conductivity values used for solid materials shall be obtained according to one of the following:

— Table A.1 of this part of ISO 10077;

— tabulated values given in ISO 10456;

— product standards;

— technical approvals by a recognized national body;

— measurements according to an appropriate International Standard.

Measurements shall be used only if there is no tabulated data or data according to relevant product standards or a technical approval. Measurements shall be performed at a mean temperature of 10 °C using the appropriate method by an institute accredited (as specified in ISO/IEC 17025) to carry out those measurements, on samples that have been conditioned at 23 °C and 50 % RH to constant mass (change in mass not more than 0,1 % over 24 h). To ensure that the thermal conductivity values are representative of the material (that is, that the value incorporates likely variability of the material and the measurement uncertainty), one of the following methods shall be used for obtaining the thermal conductivity value from measured data used in the calculations:

— The thermal conductivity is the declared value obtained from the measured data (at least three different samples from different lots representing the usual product variation, with ageing taken into consideration) according to a statistical evaluation as defined in ISO 10456: 2007, Annex C, 90 % fractile.

— If less than three samples, use the mean value multiplied by a factor of 1,25.

5.2 Emissivity of surfaces

Normally, the emissivity of surfaces bounding an air cavity shall have an emissivity of 0,9. Metallic surfaces such as aluminium alloy frame, steel reinforcement and other metals/alloys have lower emissivity. Typical values of the emissivity for metallic surfaces are given in Table A.3. Values less than 0,9 may be used only if taken from Table A.3 or measured in accordance with an appropriate standard by an institute accredited (as specified in ISO/IEC 17025) to carry out those measurements. Where based on measured values there shall be at least three samples and the results shall be evaluated according to the statistical treatment in ISO 10456.

5.3 Boundaries

The external and internal surface resistances depend on the convective and radiative heat transfer to the external and internal environments. If an external surface is not exposed to normal wind conditions, the convective part may be reduced in edges or junctions between two surfaces. The surface resistances for horizontal heat flow are given in Annex B. These values shall be used for calculations by this part of ISO 10077 irrespective of the intended orientation of the actual window, including roof windows. Surface condensation shall be assessed on the basis of the lowest internal surface temperature calculated using the surface resistances in Annex B.

The cutting plane of the infill and the cutting plane to neighbouring material shall be taken as adiabatic (see Figure 3 and Annex D)

The reference temperature conditions shall be 20 °C internal and 0 °C external.

5.4 Roller shutter boxes

Calculation of the thermal transmittance of a roller shutter box shall be done with the following boundary conditions:

— the top of the roller shutter box: adiabatic;

— the bottom of the roller shutter box where it adjoins the window frame: adiabatic for a distance of 60 mm;

— surfaces adjacent to the internal environment: surface resistance of 0,13 m^2·K/W;

— surfaces adjacent to the external environment: surface resistance of 0,04 m^2·K/W.

The cavity within the roller shutter box shall be treated as (see Figure 1):

— if $e_1 + e_3 \leq 2$ mm: unventilated. The equivalent thermal conductivity of an unventilated air cavity is calculated according to 6.3. Additional hardware, e.g. brushes, gaskets etc., can be taken into account for determination of e_1 and e_3;

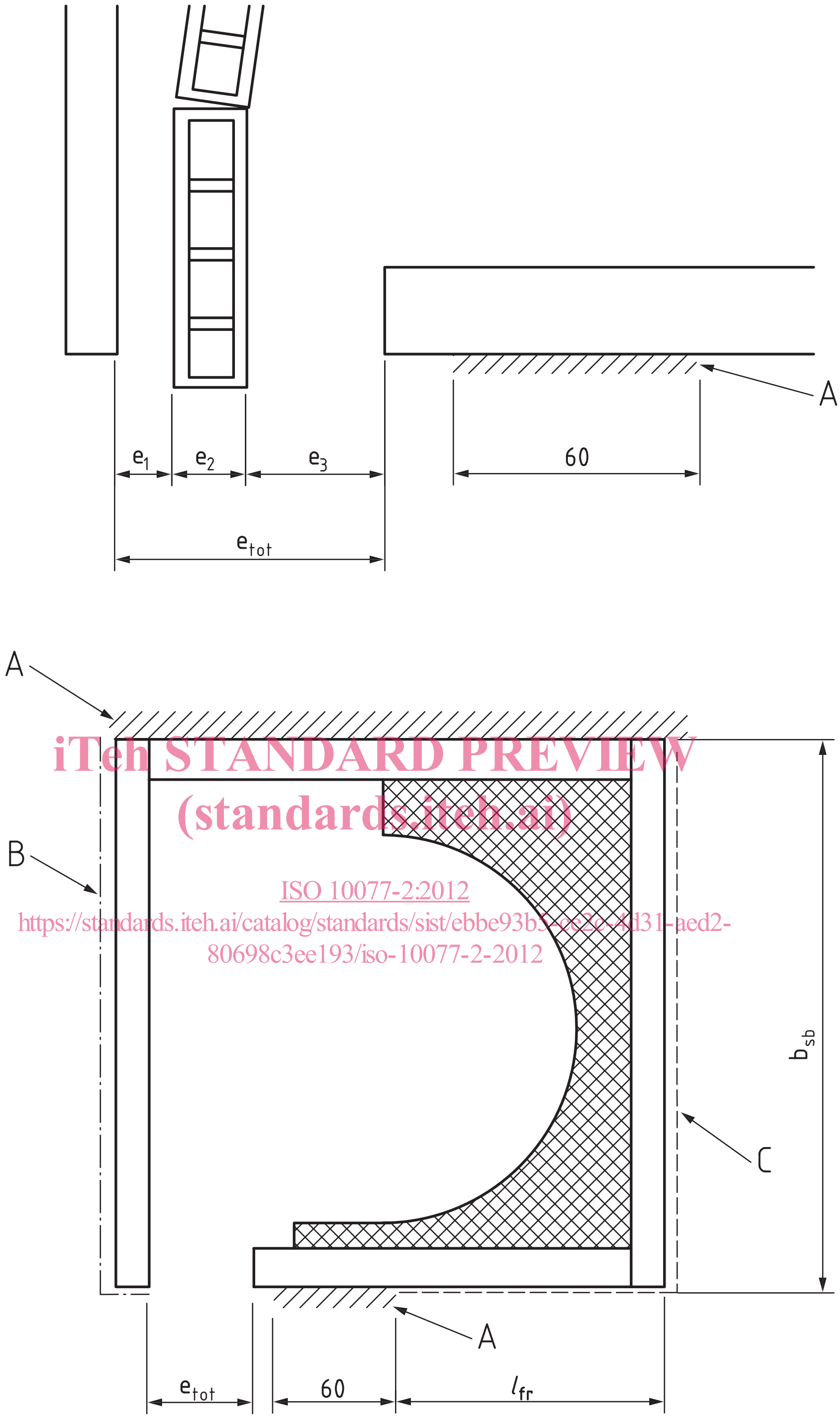
— if $e_{tot} \leq 35$ mm: slightly ventilated. The equivalent thermal conductivity is twice that of an unventilated cavity of the same size;

— if $e_{tot} > 35$ mm: well ventilated taking the air temperature within the cavity equal to the external air temperature but with a surface resistance of 0,13 m^2·K/W.

The relevant height of the roller shutter box, b_{sb}, used for the calculation is the projected distance between the upper and lower adiabatic boundary (see Figure 1).

The assessment may be done with insulation on either or both of the boundaries B and C indicated in Figure 1. If that is the case, the thickness and thermal conductivity of the insulation shall be stated in the calculation report.

Dimensions in millimetres



Key

Boundaries (see Annex B):

A adiabatic boundary

B external surface resistance

C internal surface resistance

b_{sb} height of the roller shutter box

e_1, e_3 widths of air gaps on either side of the shutter where it exits from the shutter box

e_2 thickness of shutter

e_{tot} $e_1 + e_2 + e_3$

l_{fr} frame length

NOTE The window frame (boundary A) is 60 mm wide but located with respect to the roller shutter box according to the actual situation.

Figure 1 — Schematic example for the treatment of the boundaries for roller shutter boxes

5.5 Extensions of window frame profiles

For frames with special extensions overlapping the wall or other building elements, such as Z-shaped profiles, the extensions shall be disregarded as illustrated in Figure 2. This applies to all profiles with special extensions (e.g. H-shape) where the extensions overlap the wall or other building elements. Other boundaries shall be treated as defined in Figure 3.

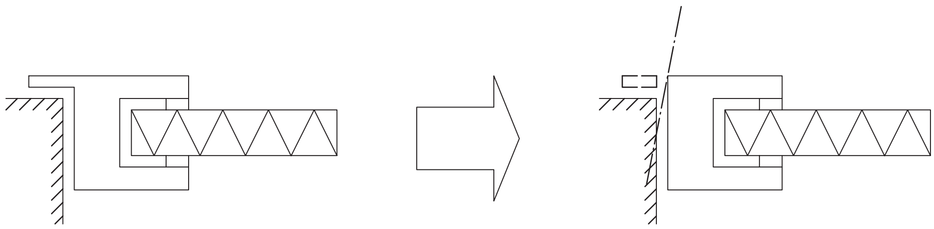


Figure 2 — Treatment of profiles with extensions (Z-shape)

NOTE 1 This approximation is for assessment of thermal transmittance. It is not appropriate for assessment of condensation risk.

NOTE 2 The extension of the frame profile is disregarded in the calculation of the thermal transmittance of the window (see ISO 10077-1).

6 Treatment of cavities

6.1 General

The heat flow rate in cavities shall be represented by an equivalent thermal conductivity λ_{eq}. This equivalent thermal conductivity includes the heat flow by conduction, by convection and by radiation, and depends on the geometry of the cavity and on the adjacent materials.

6.2 Cavities in glazing

The equivalent thermal conductivity of an unventilated space between glass panes in glazing shall be determined according to EN 673. The resulting equivalent conductivity shall be used in the whole cavity, up to the edge.

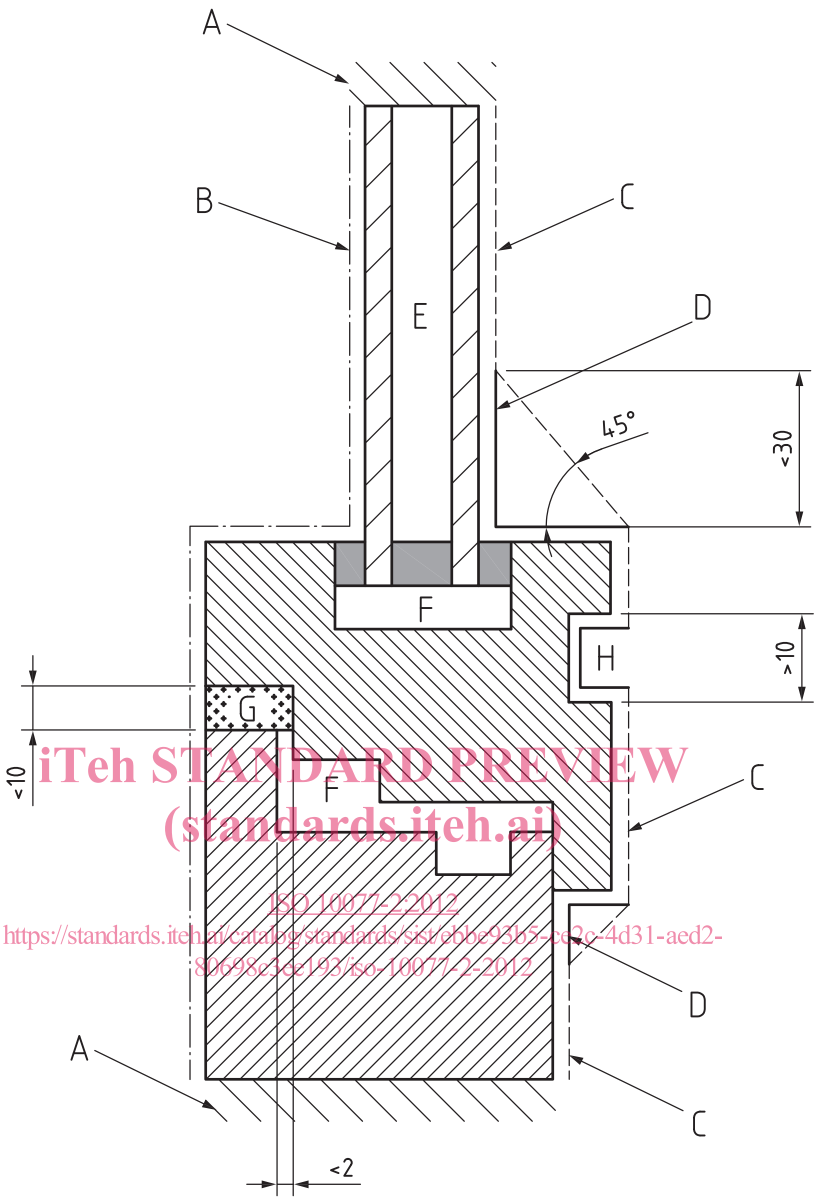
NOTE The correlations for high aspect ratio cavities used in EN 673 tend to give low values for the equivalent thermal conductivity. More accurate correlations are given in ISO 15099.

6.3 Unventilated air cavities in frames and roller shutter boxes

6.3.1 Definition

Air cavities are unventilated if they are completely closed or connected either to the exterior or to the interior by a slit with a width not exceeding 2 mm (see Figure 3). Otherwise, the cavity shall be treated as ventilated.

Dimensions in millimetres



Key

Boundaries (see Annex B): Cavities and grooves:

A adiabatic boundary

B external surface resistance

C internal surface resistance

D increased surface resistance

E glazing (see 6.2)

F unventilated cavity (see 6.3)

G slightly ventilated cavity or groove (see 6.4.1)

H well ventilated cavity or groove (see 6.4.2)

Figure 3 — Schematic example for the treatment of cavities and grooves of a frame section and the treatment of the boundaries

NOTE Figure 3 illustrates a window. The same principles are applicable to roof windows, but the adiabatic part of the boundary is different; an example of a roof window is shown in Figure D.5.