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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

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Foreword

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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.

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ISO 10077-2 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this document, read "...this European Standard..." to mean "...this International Standard...".

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

— *Part 1: Simplified method*

— *Part 2: Numerical method for frames*

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Foreword

This document EN ISO 10077-2:2003 has been prepared by Technical Committee CEN /TC 89, "Thermal performance of buildings and building components" the secretariat of which is held by SIS, in collaboration with Technical Committee ISO/TC 163 "Thermal performance and energy use in the built environment".

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2004, and conflicting national standards shall be withdrawn at the latest by April 2004.

This standard is one of a series of standards on calculation methods for the design and evaluation of the thermal performance of buildings and building components.

Annexes B, C, D and ZA are normative.

Annexes A and ZB are informative.

This document includes a Bibliography.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

The series of EN ISO 10077, *"Thermal performance of windows, doors and shutters – Calculation of thermal transmittance"*, consists of two parts. The method in Part 2: *"Numerical method for frames",* is intended to provide calculated values of the thermal characteristics of frame profiles, suitable to be used as input data in the simplified calculation method of the thermal transmittance of windows, doors and shutters given in Part 1: *"Simplified method*. It is an alternative to the test method specified in prEN 12412–2 (see Bibliography). In some cases, the hot box method can be preferred, especially if physical and geometrical data are not available or if the profile is of complicated geometrical shape.

Although the method in this Part 2 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). The heat flow pattern and the temperature field within the frame are useful by-products of this calculation.

1 Scope

This European Standard 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 glazings 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.

This European Standard also gives criteria for the validation of numerical methods used for the calculation.

This European Standard 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

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

prEN 12519:1996, *Windows and doors – Terminology.*

EN ISO 7345:1995, *Thermal insulation – Physical quantities and definitions (ISO 7345:1987).*

EN ISO 10211-1:1995, *Thermal bridges in building construction – Heat flows and surface temperatures – Part 1: General calculation methods (ISO 10211-1:1995).*

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

3 Terms, definitions, symbols and units

For the purposes of this European Standard, the terms and definitions given in EN ISO 7345:1995 and prEN 12519:1996 apply.

Symbol	Quantity	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
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 is carried out using a two-dimensional numerical method conforming to EN ISO 10211-1. The elements shall be divided such that any further division does not change the calculated result significantly. EN ISO 10211-1 gives criteria for judging whether sufficient sub-divisions have been used.

It is assumed that the principal heat flow in the section is perpendicular to a plane parallel to the external and internal surfaces. Vertical orientation of sections and air cavities is assumed. It is assumed that the emissivity of the surfaces adjoining the air cavities is 0,9 (it is assumed that the normal emissivity is 0,85). If other values are used they shall be clearly stated with references in the report.

4.2 Validation of the calculation program

To ensure the suitability of the calculation program 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 %.

4.3 Determination of the thermal transmittance

The thermal transmittance of a frame section and the linear thermal transmittance of the interaction of frame and glazing 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.

5 Treatment of solid sections and boundaries

5.1 Solid materials

Design values of thermal conductivity for common materials are given in annex A. Design values derived from measurements may be used instead of those in annex A, but this shall be clearly stated in the report. Further values can be obtained from EN 12524.

NOTE Design values derived in accordance with ISO 10456 (see Bibliography) is an alternative.

5.2 Boundaries

The external and internal surface resistances depend on the convective and radiative heat transfer to the external and internal environment. If an external surface is not exposed to normal wind conditions the convective part may be reduced in edges or junctions between two surfaces (see EN ISO 10211-1:1995, annex E). The surface resistances for horizontal heat flow are given in annex B. The cutting plane of the infill and the cutting plane to neighbouring material shall be taken as adiabatic (see Figure 1).

For the calculation of condensation risk see EN ISO 10211-1.

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 ISO 10292. The resulting equivalent conductivity shall be used in the whole cavity, up to the edge.

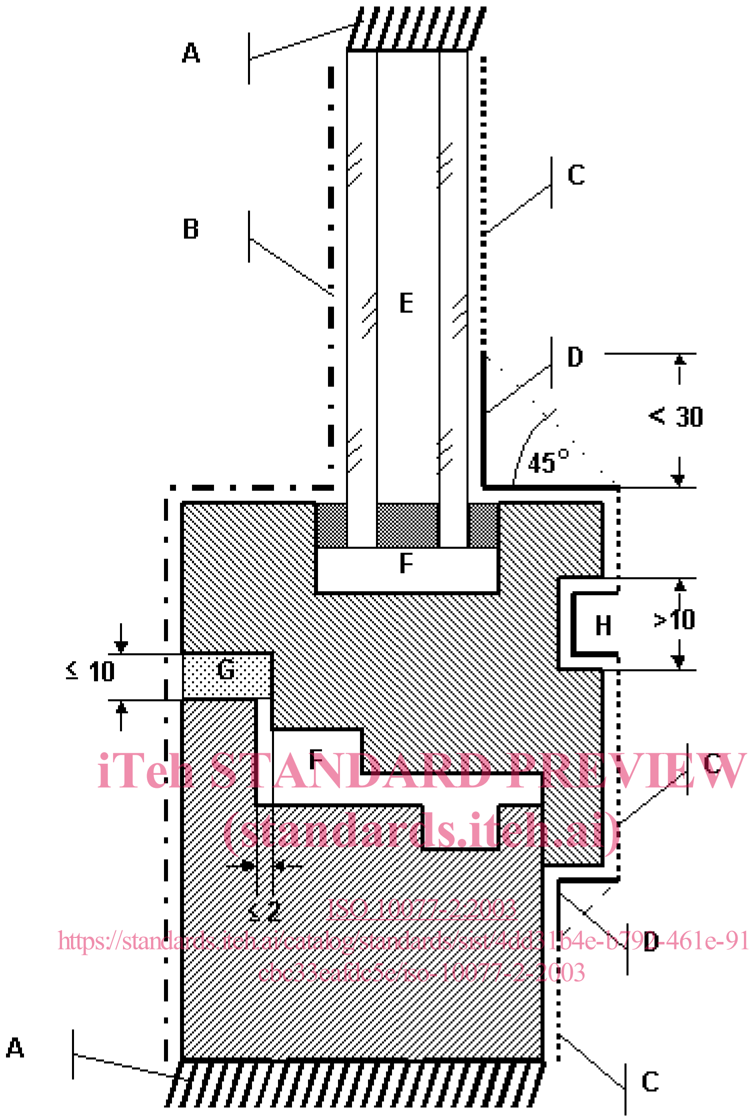
NOTE The correlations for high aspect ratio cavities used in EN 673 and ISO 10292 tend to give low values for the equivalent thermal conductivity. More accurate correlations are given in ISO 15099 (see Bibliography).

6.3 Unventilated air cavities in frames

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 1). Otherwise the cavity shall be treated as ventilated.

Dimensions in millimetres



Key

Boundaries (see annex B):

- A Adiabatic boundary
- B External surface resistance
- C Internal surface resistance
- D Increased surface resistance

Cavities and grooves:

- 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 1 — Schematic example for the treatment of cavities and grooves of a frame section and the treatment of the boundaries

6.3.2 Unventilated rectangular cavities

6.3.2.1 Equivalent thermal conductivity

The equivalent thermal conductivity of the cavity is given by Equation (1):

$$\lambda_{eq} = \frac{d}{R_s} \quad (1)$$

where

d is the dimension of the cavity in the direction of the heat flow, see Figure 2;

R_s is the thermal resistance of the cavity, given by Equation (2):

$$R_s = \frac{1}{h_a + h_r} \tag{2}$$

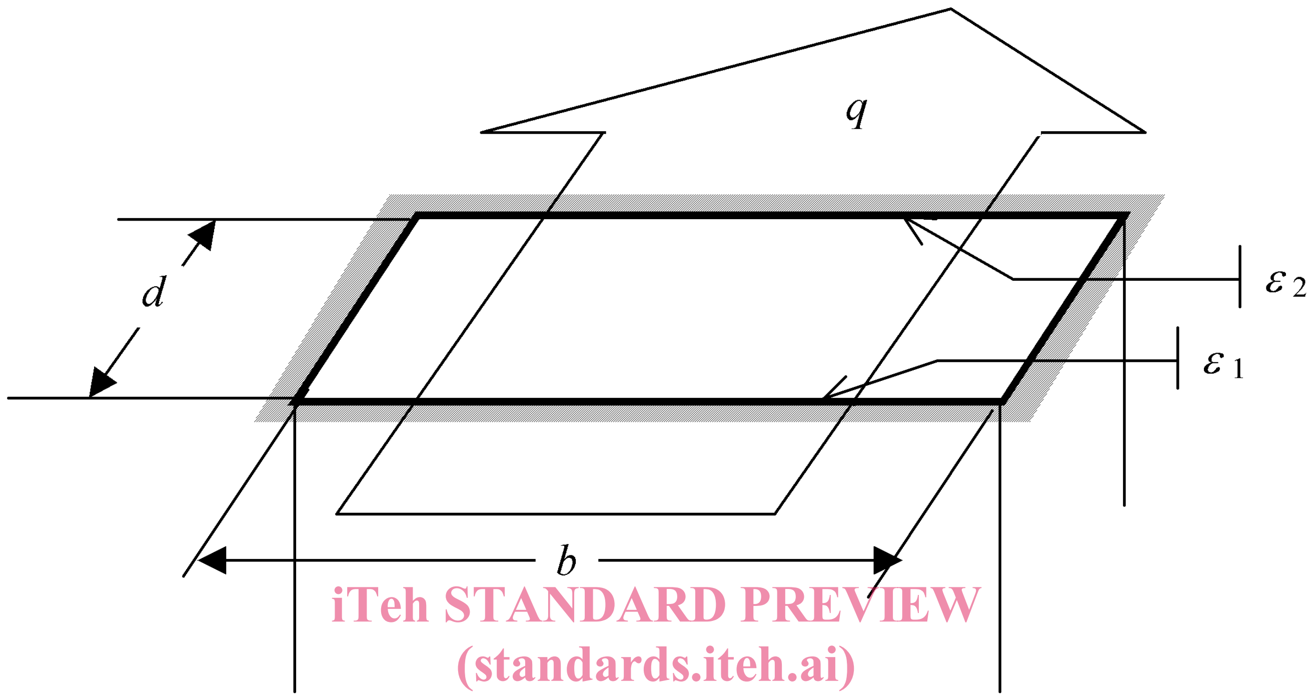


Figure 2 — Rectangular cavity and direction of heat flow

6.3.2.2 Convective heat transfer coefficient

The convective heat transfer coefficient, h_a, is:

In case of $b < 5$ mm

$$h_a = C_1 / d \tag{3}$$

where $C_1 = 0{,}025\ \mathrm{W/(m \cdot K)}$

otherwise

$$h_a = \max\left\{C_1 / d; \quad C_2\, \Delta T^{1/3}\right\} \tag{4}$$

where $C_1 = 0{,}025\ \mathrm{W/(m \cdot K)}$; $C_2 = 0{,}73\ \mathrm{W/(m^2 \cdot K^{4/3})}$

and ΔT is the maximum surface temperature difference in the cavity.

If no other information is available, use ΔT = 10 K for which

$$h_a = \max\left\{C_1 / d; \quad C_3\right\} \tag{5}$$

where

$$C_1 = 0{,}025\ \mathrm{W/(m \cdot K)}$$

$$C_3 = 1{,}57\ \mathrm{W/(m^2 \cdot K)}$$

6.3.2.3 Radiative heat transfer coefficient

$$h_r = 4\sigma T_m^3 EF \tag{6}$$

where

σ = 5,67×10^{-8} W/(m^2·K^4) is the Stefan–Boltzmann constant;

$E = \left(\dfrac{1}{\varepsilon_1} + \dfrac{1}{\varepsilon_2} - 1\right)^{-1}$ is the intersurface emittance;

$F = \dfrac{1}{2}\left(1 + \sqrt{1 + (d/b)^2} - d/b\right)$ is the view factor for a rectangular section;

ε_1 and ε_2 are the emissivities of the surfaces indicated in Figure 2.

The values of the emissivities should be given down to the second decimal place.

If no other information is available, use $\varepsilon_1 = \varepsilon_2 = 0{,}9$ and $T_m = 283\ \mathrm{K}$ for which

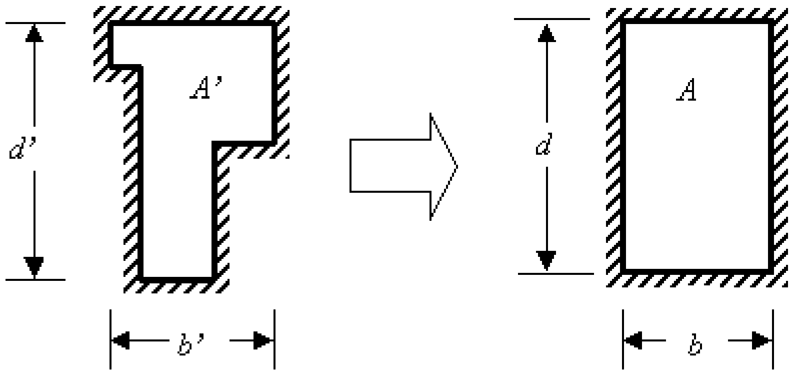
$$h_r = C_4 \cdot \left(1 + \sqrt{1 + (d/b)^2} - d/b\right) \tag{7}$$

where $C_4 = 2{,}11\ \mathrm{W/(m^2 \cdot K)}$.

6.3.3 Unventilated non-rectangular air cavities

Non-rectangular air cavities (T-shape, L-shape etc.) are transformed into rectangular air cavities with the same area ($A = A'$) and aspect ratio ($d/b = d'/b'$), see Figure 3 and after which 6.3.2 is applied.

Cavities with one dimension not exceeding 2 mm or cavities with an interconnection not exceeding 2 mm shall be considered as separate.



Key

A	area of the equivalent rectangular air cavity
d, b	depth and width of the equivalent air cavity
A'	area of the true cavity
d' b'	depth and width of the smallest circumscribing rectangle

Figure 3 — Transformation of non-rectangular air cavities