

Building components and building elements — Thermal resistance and thermal transmittance — Calculation method (ISO 6946:2007)

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National foreword

This British Standard is the UK implementation of EN ISO 6946:2007. It supersedes BS EN ISO 6946:1997 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/540, Energy performance of materials components and buildings.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Foreword

This document (EN ISO 6946:2007) has been prepared by Technical Committee ISO/TC 163 "Thermal performance and energy use in the built environment" in collaboration with Technical Committee CEN/TC 89 "Thermal performance of buildings and building components", the secretariat of which is held by SIS.

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of an identical text or by endorsement, at the latest by June 2008, and conflicting national standards shall be withdrawn at the latest by June 2008.

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Endorsement notice

The text of ISO 6946:2007 has been approved by CEN as a EN ISO 6946:2007 without any modification.

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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.

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ISO 6946 was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 2, *Calculation methods*.

This second edition cancels and replaces the first edition (ISO 6946:1996), which has been technically revised. It also incorporates the Amendment ISO 6946:1996/Amd.1:2003.

The following changes have been made to the first edition:

- information on the calculation of heat flow rates has been transferred from the Introduction to the note in Clause 4;
- 5.3.3 provides an amended basis for slightly ventilated air layers;
- 5.4.2 provides clarification of the applicability of Table 3;
- 5.4.3 has been completely revised;
- 6.2.1 provides a new text to allow calculation of a component that is part of a complete element; it also clarifies exceptions and the limit of applicability;
- Annex B provides additional data for other temperature differences across cavities; it also provides a correction to the formula for radiation transfer in divided airspaces;
- Annex C contains an additional shape;
- D.2 has been completely rewritten to clarify the intentions, the former Annex E having been deleted (national annexes can be attached to this International Standard giving examples in accordance with local building traditions);
- D.3 provides a revised procedure for mechanical fasteners, including recessed fasteners;
- D.4 does not apply in cooling situations.

Introduction

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

Building components and building elements — Thermal resistance and thermal transmittance — Calculation method

1 Scope

This International Standard provides the method of calculation of the thermal resistance and thermal transmittance of building components and building elements, excluding doors, windows and other glazed units, curtain walling, components which involve heat transfer to the ground, and components through which air is designed to permeate.

The calculation method is based on the appropriate design thermal conductivities or design thermal resistances of the materials and products for the application concerned.

The method applies to components and elements consisting of thermally homogeneous layers (which can include air layers).

This International Standard also provides an approximate method that can be used for elements containing inhomogeneous layers, including the effect of metal fasteners, by means of a correction term given in Annex D. Other cases where insulation is bridged by metal are outside the scope of this International Standard.

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

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

3 Terms, definitions, symbols and units

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7345 and ISO 10456 and the following apply.

3.1.1

building element

major part of a building such as a wall, floor or roof

3.1.2

building component

building element or a part of it

NOTE In this International Standard, the word “component” is used to indicate both element and component.

3.1.3

thermally homogeneous layer

layer of constant thickness having thermal properties which may be regarded as being uniform

3.2 Symbols and units

Symbol	Quantity	Unit
A	area	m^2
d	thickness	m
h	surface heat transfer coefficient	$\text{W}/(\text{m}^2 \cdot \text{K})$
R	design thermal resistance (surface to surface)	$\text{m}^2 \cdot \text{K}/\text{W}$
R_g	thermal resistance of airspace	$\text{m}^2 \cdot \text{K}/\text{W}$
R_{se}	external surface resistance	$\text{m}^2 \cdot \text{K}/\text{W}$
R_{si}	internal surface resistance	$\text{m}^2 \cdot \text{K}/\text{W}$
R_T	total thermal resistance (environment to environment)	$\text{m}^2 \cdot \text{K}/\text{W}$
R'_T	upper limit of total thermal resistance	$\text{m}^2 \cdot \text{K}/\text{W}$
R''_T	lower limit of total thermal resistance	$\text{m}^2 \cdot \text{K}/\text{W}$
R_u	thermal resistance of unheated space	$\text{m}^2 \cdot \text{K}/\text{W}$
U	thermal transmittance	$\text{W}/(\text{m}^2 \cdot \text{K})$
λ	design thermal conductivity	$\text{W}/(\text{m} \cdot \text{K})$

4 Principles

The principle of the calculation method is as follows:

- to obtain the thermal resistance of each thermally homogeneous part of the component;
- to combine these individual resistances so as to obtain the total thermal resistance of the component, including (where appropriate) the effect of surface resistances.

Thermal resistances of individual parts are obtained in accordance with 5.1.

The values of surface resistance given in 5.2 are appropriate in most cases. Annex A gives detailed procedures for low emissivity surfaces, specific external wind speeds and non-planar surfaces.

Air layers may be regarded as thermally homogeneous for the purposes of this International Standard. Values of the thermal resistance of large air layers with high emissivity surfaces are given in 5.3. Annex B provides procedures for other cases.

The resistances of the layers are combined as follows:

- a) for components consisting of thermally homogeneous layers, obtain the total thermal resistance in accordance with 6.1 and the thermal transmittance in accordance with Clause 7;

- b) for components having one or more thermally inhomogeneous layers, obtain the total thermal resistance in accordance with 6.2 and the thermal transmittance in accordance with Clause 7;
- c) for components containing a tapered layer, obtain the thermal transmittance and/or the total thermal resistance in accordance with Annex C.

Finally, corrections are applied to the thermal transmittance, if appropriate, in accordance with Annex D, in order to allow for the effects of air voids in insulation, mechanical fasteners penetrating an insulation layer and precipitation on inverted roofs.

The thermal transmittance calculated in this way applies between the environments on either side of the component concerned, e.g. internal and external environments, two internal environments in the case of an internal partition, an internal environment and an unheated space. Simplified procedures are given in 5.4 for treating an unheated space as a thermal resistance.

NOTE Calculation of heat flow rates are commonly undertaken using operative temperature (usually approximated to the arithmetic mean of air temperature and mean radiant temperature) to represent the environment inside buildings, and air temperature to represent the external environment. Other definitions of the temperature of an environment are also used when appropriate to the purpose of the calculation. See also Annex A.

5 Thermal resistances

5.1 Thermal resistance of homogeneous layers

Design thermal values can be given as either design thermal conductivity or design thermal resistance. If thermal conductivity is given, obtain the thermal resistance of the layer from

$$R = \frac{d}{\lambda} \quad (1)$$

where

d is the thickness of the material layer in the component;

λ is the design thermal conductivity of the material, either calculated in accordance with ISO 10456 or obtained from tabulated values.

NOTE The thickness, d , can be different from the nominal thickness (e.g. when a compressible product is installed in a compressed state, d is less than the nominal thickness). If relevant, it is advisable that d also make appropriate allowance for thickness tolerances (e.g. when they are negative).

Thermal resistance values used in intermediate calculations shall be calculated to at least three decimal places.

5.2 Surface resistances

Use the values in Table 1 for plane surfaces in the absence of specific information on the boundary conditions. The values under "horizontal" apply to heat flow directions $\pm 30^\circ$ from the horizontal plane. For non-planar surfaces or for specific boundary conditions, use the procedures in Annex A.

Table 1 — Conventional surface resistances

Surface resistance $\text{m}^2\cdot\text{K}/\text{W}$	Direction of heat flow		
	Upwards	Horizontal	Downwards
R_{si}	0,10	0,13	0,17
R_{se}	0,04	0,04	0,04
NOTE 1 The values given are design values. For the purposes of declaration of the thermal transmittance of components and other cases where values independent of heat flow direction are required, or when the heat flow direction is liable to vary, it is advisable that the values for horizontal heat flow be used. NOTE 2 The surface resistances apply to surfaces in contact with air. No surface resistance applies to surfaces in contact with another material.			

5.3 Thermal resistance of air layers

5.3.1 Applicability

The values given in 5.3.1 to 5.3.3 apply to an air layer which

- is bounded by two faces that are effectively parallel and perpendicular to the direction of heat flow and that have emissivities not less than 0,8,
- has a thickness (in the direction of heat flow) of less than 0,1 times each one of the other two dimensions, and not greater than 0,3 m,
- has no air interchange with the internal environment.

If the above conditions do not apply, use the procedures in Annex B.

NOTE Most building materials have an emissivity greater than 0,8.

A single thermal transmittance should not be calculated for components containing air layers thicker than 0,3 m. Instead, heat flows should be calculated by performing a heat balance (see ISO 13789).

5.3.2 Unventilated air layer

An unventilated air layer is one in which there is no express provision for air flow through it. Design values of thermal resistance are given in Table 2. The values under “horizontal” apply to heat flow directions $\pm 30^\circ$ from the horizontal plane.

An air layer having no insulation between it and the external environment, but with small openings to the external environment, shall also be considered as an unventilated air layer if these openings are not arranged so as to permit air flow through the layer and they do not exceed

- 500 mm^2 per metre of length (in the horizontal direction) for vertical air layers,
- 500 mm^2 per square metre of surface area for horizontal air layers.

NOTE Drain openings (weep holes) in the form of open vertical joints in the outer leaf of a masonry cavity wall usually conform with the above criteria and so are not regarded as ventilation openings.