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

Matériaux et produits pour le bâtiment — Propriétés hygrothermiques — Valeurs utiles tabulées et procédures pour la détermination des valeurs thermiques déclarées et utiles

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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 10456 was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 2, *Calculation methods*.

This third edition cancels and replaces the second edition (ISO 10456:1999), which has been technically revised.

The following changes have been made to the second edition:

— the Scope has been extended to include tabulated design values of thermal and moisture properties of materials, and the title has been modified accordingly;

— an Introduction has been added;

— the Scope specifies that moisture coefficients are valid only between 0 °C and 30 °C;

— 4.2 has been added as a new subclause on tests for moisture properties;

— 7.2 has been extended to contain general information about climates;

— 7.4 contains clarification that ageing factors are not applied if taken into account in declared values;

— 7.5 has been added as a new subclause dealing with convection in insulating materials;

— Clause 8 has been added, giving tabulated design values (in Tables 3, 4 and 5); the data, taken from EN 12524, have been reviewed and updated.

— Annex A contains data reviewed for extruded polystyrene (XPS) and polyurethane (PU).

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.

Heat and moisture transfer calculations require design values of thermal and moisture properties for materials used in building applications.

Design values can be derived from declared values that are based on measured data on the product concerned, which is usually the case for thermal insulation materials. Where the design conditions differ from those of the declared value, the data needs to be converted to the applicable conditions. This International Standard provides the methods and data for making this conversion.

For materials for which measured values are not available, design values can be obtained from tables. This International Standard provides such tabulated information based on the compilation of existing data (see reference documents listed in the Bibliography).

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

1 Scope

This International Standard specifies methods for the determination of declared and design thermal values for thermally homogeneous building materials and products, together with procedures to convert values obtained under one set of conditions to those valid for another set of conditions. These procedures are valid for design ambient temperatures between –30 °C and +60 °C.

This International Standard provides conversion coefficients for temperature and for moisture. These coefficients are valid for mean temperatures between 0 °C and 30 °C.

This International Standard also provides design data in tabular form for use in heat and moisture transfer calculations, for thermally homogeneous materials and products commonly used in building construction.

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 8990, *Thermal insulation — Determination of steady-state thermal transmission properties — Calibrated and guarded hot box*

ISO 12572, *Hygrothermal performance of building materials and products — Determination of water vapour transmission properties*

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 the following apply.

3.1.1
declared thermal value
expected value of a thermal property of a building material or product assessed from measured data at reference conditions of temperature and humidity, given for a stated fraction and confidence level, and corresponding to a reasonable expected service lifetime under normal conditions

3.1.2
design thermal value
design thermal conductivity or design thermal resistance

NOTE A given product can have more than one design value, for different applications or environmental conditions.

3.1.3
design thermal conductivity
value of thermal conductivity of a building material or product under specific external and internal conditions, which can be considered as typical of the performance of that material or product when incorporated in a building component

3.1.4
design thermal resistance
value of thermal resistance of a building product under specific external and internal conditions, which can be considered as typical of the performance of that product when incorporated in a building component

3.1.5
material
piece of a product irrespective of its delivery form, shape and dimensions, without any facing or coating

3.1.6
product
final form of a material ready for use, of given shape and dimensions and including any facings or coatings

3.2 Symbols and units

Symbol	Quantity	Unit
c_p	specific heat capacity at constant pressure	J/(kg·K)
F_a	ageing conversion factor	—
F_m	moisture conversion factor	—
F_T	temperature conversion factor	—
f_T	temperature conversion coefficient	K^{-1}
f_u	moisture conversion coefficient mass by mass [a]	kg/kg
f_ψ	moisture conversion coefficient volume by volume [a]	m^3/m^3
R	thermal resistance	$m^2 \cdot K/W$
s_d	water vapour diffusion-equivalent air layer thickness	m
T	thermodynamic temperature	K
u	moisture content mass by mass	kg/kg
λ	thermal conductivity	W/(m·K)
μ	water vapour resistance factor	—
ρ	density	kg/m^3
ψ	moisture content volume by volume	m^3/m^3

[a] For conversion of thermal properties.

4 Test methods and test conditions

4.1 Tests for thermal properties

4.1.1 Test methods

Measured values of thermal conductivity or thermal resistance shall be obtained using the following methods:

— guarded hot plate, in accordance with ISO 8302 or equivalent national method;

— heat flow meter, in accordance with ISO 8301 or equivalent national method;

— calibrated and guarded hot box, in accordance with ISO 8990.

4.1.2 Test conditions

To avoid conversions, it is recommended that measurements be conducted under conditions corresponding to the selected set of conditions given in Table 1.

The mean test temperature should be chosen so that the application of the temperature coefficients does not introduce a change of more than 2 % from the measured value.

The following testing conditions are required:

— measured thickness and density for identification;

— mean test temperature;

— moisture content of the specimen during test;

— (for aged materials) age of the specimen and conditioning procedures before testing.

4.2 Tests for moisture properties

Measured values of water vapour resistance factor or water vapour diffusion-equivalent air layer thickness shall be obtained using ISO 12572.

5 Determination of declared thermal values

A declared thermal value shall be given under one of the sets of conditions a) or b) in Table 1, with reference temperature I (10 °C) or II (23 °C).

Table 1 — Declared value conditions

Property	Sets of conditions			
	I (10 °C)		II (23 °C)	
	a)	b)	a)	b)
Reference temperature	10 °C	10 °C	23 °C	23 °C
Moisture	u_{dry} [a]	$u_{23,50}$ [b]	u_{dry} [a]	$u_{23,50}$ [b]
Ageing	aged	aged	aged	aged

[a] u_{dry} is a low moisture content reached by drying according to specifications or standards for the material concerned.

[b] $u_{23,50}$ is the moisture content when in equilibrium with air at 23 °C and relative humidity of 50 %.

Either the declared value shall be determined at a thickness large enough to neglect the thickness effect, or the declared values for smaller thicknesses shall be based on measurements at those thicknesses.

The data used shall be either

— directly measured values according to the test methods given in Clause 4, or

— obtained indirectly by making use of an established correlation with a related property such as density.

When all data have not been measured under the same set of conditions, they shall first be brought to one set of conditions (see Clause 7). A statistical single value estimate shall then be calculated. Annex C refers to International Standards on statistics that may be used.

During calculations, no value shall be rounded to less than three significant figures.

The declared value is the estimated value of the statistical single value, rounded according to either or both of the following rules:

a) for thermal conductivity, λ, expressed in W/(m·K):

   — if $\lambda \leqslant 0{,}08$: rounding to nearest higher 0,001 W/(m·K);

   — if $0{,}08 < \lambda \leqslant 0{,}20$: rounding to nearest higher 0,005 W/(m·K);

   — if $0{,}20 < \lambda \leqslant 2{,}00$: rounding to nearest higher 0,01 W/(m·K);

   — if $2{,}00 < \lambda$: rounding to nearest higher 0,1 W/(m·K);

b) for thermal resistance, R, expressed in m^2·K/W, as the nearest lower value rounded to not more than two decimals or three significant figures.

Rules for determining declared values for specific products may be specified in applicable product standards.

6 Determination of design thermal values

6.1 General

Design values can be obtained from declared values, measured values or tabulated values (see Clause 8).

Measured data shall be either

— directly measured values in accordance with the test methods given in Clause 4, or

— obtained indirectly by making use of an established correlation with a related property, such as density.

If the set of conditions for declared, measured or tabulated values can be considered relevant for the actual application, those values can be used directly as design values. Otherwise, conversion of data shall be undertaken according to the procedure given in Clause 7.

6.2 Rounding of design values

The design value shall be rounded in accordance with the rules given in Clause 5:

— for thermal conductivity, as the nearest higher value, in W/(m·K);

— for thermal resistance, as the nearest lower value, in m^2·K/W.

6.3 Design values derived from declared values

When the design value is calculated from the declared value and is based on the same statistical evaluation, the declared value shall be converted to the design conditions.

Information is given in Annex C on how to derive design values based on another statistical evaluation different from the one applicable to the declared value.

6.4 Design values derived from measured values

When necessary, all data shall first be converted to the design conditions. A statistical single value estimate shall then be calculated. Annex C refers to International Standards on statistics that can be used.

7 Conversion of thermal values

7.1 General

Conversions of thermal values from one set of conditions (λ_1, R_1) to another set of conditions (λ_2, R_2) are carried out according to the following equations:

$$\lambda_2 = \lambda_1 F_T F_m F_a \tag{1}$$

$$R_2 = \frac{R_1}{F_T F_m F_a} \tag{2}$$

Conversion coefficients may be taken from the applicable tables in this International Standard. Alternatively, they may be derived from measured data obtained in accordance with the test methods referred to in 4.1, provided that the procedure for determining conversion coefficients other than those in Table 4 are validated by independent test institutes.

7.2 Conversion for temperature

The factor F_T for temperature is determined by

$$F_T = e^{f_T(T_2 - T_1)} \tag{3}$$

where

f_T is the temperature conversion coefficient;

T_1 is the temperature of the first set of conditions;

T_2 is the temperature of the second set of conditions.

Values of the temperature conversion coefficient for insulation materials and masonry materials are given in Annex A.

NOTE The effect of temperature on the thermal properties of other materials is generally not significant for heat transfer calculations, and can usually be neglected.

Design thermal values should be obtained for the expected mean temperature of the material as installed in the component in the applicable climate.

7.3 Conversion for moisture

The factor F_m for moisture content is determined as follows:

a) conversion of moisture content given as mass by mass:

$$F_m = e^{f_u(u_2-u_1)} \quad (4)$$

where

f_u is the moisture conversion coefficient mass by mass;

u_1 is the moisture content mass by mass of the first set of conditions;

u_2 is the moisture content mass by mass of the second set of conditions;

b) conversion of moisture content given as volume by volume:

$$F_m = e^{f_\psi(\psi_2-\psi_1)} \quad (5)$$

where

f_ψ is the moisture conversion coefficient volume by volume;

ψ_1 is the moisture content volume by volume of the first set of conditions;

ψ_2 is the moisture content volume by volume of the second set of conditions.

Values of the moisture conversion coefficient for insulation and masonry materials are given in Table 4.

7.4 Age conversion

The ageing depends upon the material type, facings, structures, the blowing agent, the temperature and the thickness of the material. For a given material, the ageing effect can be obtained from theoretical models validated by experimental data. There are no simple rules to correlate ageing over time for a given material.

If the declared thermal value takes account of ageing, no further ageing conversions shall be applied for design thermal values.

If a conversion factor F_a is used, it shall allow the calculation of the aged value of the thermal property corresponding to a time not less than half the working lifetime of the product in the application concerned.

NOTE 1 The working lifetime is often taken as 50 years.

NOTE 2 No conversion coefficients are given in this International Standard to derive the ageing conversion factor F_a. Procedures for establishing aged values or ageing factors are given in some product standards.

7.5 Natural convection

The onset of natural convection in an insulating material with an open structure depends on permeability, thickness and temperature difference. The driving force for natural convection is described by the modified Rayleigh number, Ra_m, which is a dimensionless number defined for the purposes of this International Standard by

$$Ra_m = 3 \times 10^6 \frac{dk\Delta T}{\lambda} \quad (6)$$