INTERNATIONAL STANDARD

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Hygrothermal performance of building components and building elements — Internal surface temperature to avoid critical surface humidity and interstitial condensation — Calculation methods

iTeh S*Performance hygrothermique des composants et parois de bâtiments —*
Température superficielle intérieure permettant d'éviter l'humidité
superficielle critique et la condensation dans la masse — Méthodes de
calcul

Reference number
ISO 13788:2001(E)

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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 3.

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 member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 13788 was prepared by the European Committee for Standardization (CEN) in collaboration with ISO Technical Committee TC 163, *Thermal insulation*, Subcommittee SC 2, *Calculation methods*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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

Annexes A to F of this International Standard are for information only.

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Foreword

The text of EN ISO 13788:2001 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 insulation".

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of an identical text or by endorsement, at the latest by January 2002, and conflicting national standards shall be withdrawn at the latest by January 2002.

This standard is one of a series of standards, which specify test methods for the thermal and moisture related properties of building materials and products.

The annexes A, B, C, D, E and F are informative.

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, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

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Introduction

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Moisture transfer is a very complex process and the knowledge of moisture transfer mechanisms, material properties, initial conditions and boundary conditions is often insufficient, inadequate and still under development. Therefore this standard lays down simplified calculation methods, based on experience and commonly accepted knowledge. The standardisation of these calculation methods does not exclude use of more advanced methods. The calculations will normally lead to designs well on the safe side and if a construction fails a specified design criterion according to this procedure, more accurate methods may be used to show that the design will pass.

This standard deals with critical surface humidity and interstitial condensation, and does not cover other aspects of moisture, e.g. ground water, precipitation, built-in moisture and moisture convection, which can be considered in the design of a building component.

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1   Scope

This standard gives calculation methods for:

a) The internal surface temperature of a building component or building element below which mould growth is likely, given the internal temperature and relative humidity – the method can also be used to assess the risk of other surface condensation problems.

b) The assessment of the risk of interstitial condensation due to water vapour diffusion. The method used assumes built-in water has dried out and does not take account of a number of important physical phenomena including:

- the dependence of thermal conductivity on moisture content;

- the release and absorption of latent heat;

- the variation of material properties with moisture content;

- capillary suction and liquid moisture transfer within materials;

- air movement through cracks or within air spaces;

- the hygroscopic moisture capacity of materials.

Consequently the method is applicable only to structures where these effects are negligible.

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2   Normative references (standards.iteh.ai)

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.

EN 12524   *Building materials and products – Hygrothermal properties - Tabulated design values*

ISO 6946   *Building components and building elements – Thermal resistance and thermal transmittance - Calculation method*

ISO 9346   *Thermal insulation - Mass transfer - Physical quantities and definitions*

ISO 10211-1   *Thermal bridges in building construction – Calculation of heat flows and surface temperatures - Part 1: General methods*

ISO 10456   *Building materials and products – Procedures for determining declared and design thermal values*

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

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ISO 15927-1[1] *Hygrothermal performance of buildings – Calculation and presentation of climatic data - Part 1: Monthly means of single meteorological elements*

3 Definitions, symbols and units

3.1 Terms and definitions

For the purposes of this standard, the terms and definitions given in ISO 9346 and the following apply.

3.1.1

temperature factor at the internal surface
difference between the temperature of the internal surface and the external air temperature, divided by the difference between the internal air temperature and the external air temperature, calculated with a surface resistance at the internal surface R_{si}:

$$f_{Rsi} = \frac{\theta_{si} - \theta_e}{\theta_i - \theta_e} \qquad (1)$$

Methods of calculating the temperature factor in complex constructions are given in ISO 10211-1.

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3.1.2
design temperature factor at the internal surface
minimum acceptable temperature factor at the internal surface:

$$f_{Rsi,min} = \frac{\theta_{si,min} - \theta_e}{\theta_i - \theta_e} \qquad (2)$$

3.1.3
minimum acceptable temperature
lowest internal surface temperature before mould growth starts

3.1.4
internal moisture excess
rate of moisture production in a space divided by the air change rate and the volume of the space:

$$\Delta v = v_i - v_e = G/(n\,V) \qquad (3)$$

3.1.5
water vapour diffusion-equivalent air layer thickness
thickness of a motionless air layer which has the same water vapour resistance as the material layer in question:

$$s_d = \mu\,d \qquad (4)$$

3.1.6
relative humidity
ratio of the vapour pressure to the saturated vapour pressure at the same temperature:

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[1] To be published

$$\varphi = \frac{p}{p_{sat}}$$ (5)

3.1.7
critical surface humidity
relative humidity at the surface that leads to deterioration of the surface, specifically mould growth

3.2 Symbols and units

Symbol	Quantity	Unit
D	water vapour diffusion coefficient in a material	m^2/s
D_0	water vapour diffusion coefficient in air	m^2/s
G	internal moisture production rate	kg/h
M_a	accumulated moisture content per area at an interface	kg/m^2
R	thermal resistance	$m^2 \cdot K/W$
R_v	gas constant for water vapour = 462	$Pa \cdot m^3/(K \cdot kg)$
T	temperature	K
U	thermal transmittance of component or element	$W/(m^2 \cdot K)$
V	internal volume of building	m^3
Z_p	water vapour resistance with respect to partial vapour pressure	$m^2 \cdot s \cdot Pa/kg$
Z_v	water vapour resistance with respect to humidity by volume	s/m^2
d	material layer thickness	m
f_{Rsi}	temperature factor at the internal surface	-
$f_{Rsi,min}$	design temperature factor at the internal surface	-
g	density of water vapour flow rate	$kg/(m^2 \cdot s)$
n	air change rate	h^{-1}
p	water vapour pressure	Pa
q	density of heat flow rate	W/m^2
s_d	water vapour diffusion-equivalent air layer thickness	m
t	time	s
w	moisture content mass by volume	kg/m^3
δ_p	water vapour permeability of material with respect to partial vapour pressure	$kg/(m \cdot s \cdot Pa)$
δ_0	water vapour permeability of air with respect to partial vapour pressure	$kg/(m \cdot s \cdot Pa)$
v	humidity of air by volume	kg/m^3
Δv	internal moisture excess, $v_i - v_e$	kg/m^3
Δp	internal vapour pressure excess, $p_i - p_e$	Pa
φ	relative humidity of air	-
λ	thermal conductivity	$W/(m \cdot K)$
μ	water vapour resistance factor	-
θ	Celsius temperature	°C
$\theta_{si,min}$	minimum acceptable surface temperature	°C

3.3   Subscripts

c	condensation	n	interface
cr	critical value	s	surface
e	external air	sat	value at saturation
ev	evaporation	se	external surface
i	internal air	si	internal surface
min	minimum value	T	total over whole component or element

4   Input data for the calculations

4.1   Material and product properties

For the calculations, design values shall be used. Design values in product or material specifications or the tabulated design values given in the standards referred to in Table 1 may be used.

Table 1 - Material and product properties

Property	Symbol	Design values
Thermal conductivity thermal resistance	λ R	Obtained from EN 12524 or determined in accordance with ISO 10456.
Water vapour resistance factor water vapour diffusion-equivalent air layer thickness	μ s_d	Obtained from EN 12524 or determined in accordance with ISO 12572.

Thermal conductivity, λ, and water vapour resistance factor, μ, are applicable to homogenous materials and thermal resistance, R, and water vapour diffusion-equivalent air layer thickness, s_d, primarily to composite products or products without well-defined thickness.

For air layers, R is taken from ISO 6946; s_d is assumed to be 0,01 m, independent of air layer thickness and inclination.

4.2   Climatic conditions

4.2.1   Location

Unless otherwise specified, the external conditions used shall be representative of the location of the building.

4.2.2   Time period

For the calculation of the risk of surface mould growth or the assessment of structures for the risk of interstitial condensation, monthly mean values, derived using the methods described in ISO 15927-1, shall be used.

For calculations of the risk of surface condensation on low thermal inertia elements such as, for example, windows and their frames, the mean annual minimum temperature on a daily basis and corresponding relative humidity shall be used.

NOTE   This implies that there will be some condensation on one day in half the years.

4.2.3   Temperatures

The following temperatures shall be used for the calculations.

a) External air temperature as specified in 4.2.2.

b) Ground temperature adjacent to building components.
   The annual mean value of the external air temperature shall be used.

c) Internal air temperature.
   Use values according to the expected use of the building. Internal air temperatures to be used in this standard may be specified nationally.

4.2.4   Humidity conditions

a) To define the external air humidity conditions, use humidity by volume, v_e, or vapour pressure, p_e.

Monthly mean vapour pressure or humidity by volume may be calculated from the mean temperature and relative humidity using equations (6) or (7).

$$\overline{p_e} = \overline{\varphi_e} \; p_{sat}(\overline{\theta_e}) \tag{6}$$

$$\overline{v_e} = \overline{\varphi_e} \; v_{sat}(\overline{\theta_e}) \tag{7}$$

Due to the non-linear relationship between temperature and saturation humidity, these equations become inaccurate in hot climates.

For calculations of the risk of surface condensation on low thermal inertia elements such as, for example windows and their frames, the external relative humidity corresponding to the mean annual minimum temperature on a daily basis shall be used.

b) Humidity conditions in the ground

Assume saturation ($\varphi = 1$).

c) Internal air humidity

The internal air humidity can be derived:

1) by either of the expressions

$$p_i = p_e + \Delta p \tag{8}$$

$$v_i = v_e + \Delta v \tag{9}$$

Take values of Δp and Δv according to the expected use of the building and multiply them by 1,10 to provide a safety margin. Values to be used in this standard may be specified nationally.

or

2) given as a constant φ_i when the internal relative humidity is known and kept constant e.g. by air-conditioning. To provide a safety margin add 0,05 to the relative humidity.

NOTE 1   The introduction of a factor 1,10 (or a margin of 0,05 RH) is intended to allow for inaccuracies in the method. The calculation method as described in this standard is a steady state calculation. In reality, however, external air temperature variations, changing solar radiation, hygroscopic inertia and intermittent heating can influence surface humidity conditions. This is especially the case for a thermal bridge area consisting of building materials with high thermal inertia. The factor does not include the behaviour of the occupants, which can have a significant effect on ventilation.

NOTE 2   Internal humidities can be classified in five humidity classes, see annex A.

4.3   Surface resistances

4.3.1   Heat transfer

The values of R_{se} and R_{si} given in Table 2 shall be used for the assessment of mould growth and interstitial condensation.

Table 2 - **Surface thermal resistances**

	Resistance m²·K/W
External surface resistance R_{se}	0,04
Internal surface resistance R_{si}	
On glazing and frames	0,13
All other internal surfaces	0,25

NOTE   An internal surface resistance of 0,25 is taken to represent the worst case of condensation risk in a corner.

4.3.2   Water vapour transfer

The surface water vapour resistance is assumed to be negligible in the calculations in accordance with this standard.