**SLOVENSKI STANDARD**
# SIST EN ISO 13788:2002

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**Higrotermalno obnaģanje sestavnih delov stavb in elementov stavb ï Notranja površinska temperatura za prepreļ evanje kritiļ ne vlage ob površini in kondenzacije v konstrukciji ï Raļ unska metoda (ISO 13788:2001)**

Hygrothermal performance of building components and building elements - Internal surface temperature to avoid critical surface humidity and interstitial condensation - Calculation methods (ISO 13788:2001)



Wärme- und feuchtetechnisches Verhalten von Bauteilen und Bauelementen - Raumseitige Oberflächentemperatur zur Vermeidung kritischer Oberflächenfeuchte und Tauwasserbildung im Bauteilinneren - Berechnungsverfahren (ISO 13788:2001)



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 (ISO 13788:2001)

**Ta slovenski standard je istoveten z:** **EN ISO 13788:2001**

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|---|---|---|
| 91.120.10 | Toplotna izolacija stavb | Thermal insulation |
| 91.120.30 | Zaģļ ita pred vlago | Waterproofing |

**SIST EN ISO 13788:2002** **en**

EUROPEAN STANDARD

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# EN ISO 13788

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ICS

English version

# Hygrothermal performance of building components and building elements - Internal surface temperature to avoid critical surface humidity and interstitial condensation - Calculation methods (ISO 13788:2001)

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This European Standard was approved by CEN on 18 October 2000.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.



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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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## Contents

## 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 European publications to be used instead of the International Standards listed in clause 2 are given in normative annex ZA, which is an integral part of this European Standard.

The annexes A, B, C, D, E, F and ZB are informative. Annex ZA is normative.

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.



## Introduction

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.

## 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.



## 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.



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*

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.



### 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:

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

[1] To be published

**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 | $kg/m^3$ |
| $\delta_p$ | water vapour permeability of material with respect to partial vapour pressure | $kg/(m \cdot s \cdot Pa)$ |
| $\delta_0$ | water vapour permeability of air with respect to partial vapour pressure | $kg/(m \cdot s \cdot Pa)$ |
| $v$ | humidity of air by volume | $kg/m^3$ |
| $\Delta v$ | internal moisture excess, $v_i - v_e$ | $kg/m^3$ |
| $\Delta p$ | internal vapour pressure excess, $p_i - p_e$ | Pa |
| $\varphi$ | relative humidity of air | - |
| $\lambda$ | thermal conductivity | $W/(m \cdot K)$ |
| $\mu$ | water vapour resistance factor | - |
| $\theta$ | Celsius temperature | °C |
| $\theta_{si,min}$ | minimum acceptable surface temperature | °C |

### 3.3 Subscripts

c condensation
cr critical value
e external air
ev evaporation
i internal air
min minimum value
n interface
s surface
sat value at saturation
se external surface
si internal surface
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<br>thermal resistance | $\lambda$<br>$R$ | Obtained from EN 12524 or determined in accordance with ISO 10456. |
| Water vapour resistance factor<br>water vapour diffusion-equivalent air layer thickness | $\mu$<br>$s_d$ | Obtained from EN 12524 or determined in accordance with ISO 12572. |



Thermal conductivity, $\lambda$, and water vapour resistance factor, $\mu$, 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).



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



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

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

$$p_i = p_e + \Delta p \quad (8)$$

$$v_i = v_e + \Delta v \quad (9)$$

Take values of $\Delta p$ and $\Delta v$ 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 $\varphi_i$ 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** m$^2$·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.

# 5 Calculation of surface temperature to avoid critical surface humidity

## 5.1 General

This clause specifies a method to design the building envelope to prevent the adverse effects of critical surface humidity, e.g. mould growth.

NOTE Surface condensation can cause damage to unprotected building materials that are sensitive to moisture. It can be accepted temporarily and in small amounts, e.g. on windows and tiles in bathrooms, if the surface does not absorb the moisture and adequate measures are taken to prevent its contact with adjacent sensitive materials.

There is a risk for mould growth at surface relative humidities above 0,8 for several days.

## 5.2 Determining parameters

Besides the external climate (air temperature and humidity) three parameters govern surface condensation and mould growth:

a) the "thermal quality" of each building envelope element, represented by thermal resistance, thermal bridges, geometry and internal surface resistance. The thermal quality can be characterised by the temperature factor at the internal surface, $f_{Rsi}$ ;



NOTE ISO 10211-1 gives a method for calculating weighting factors, when there is more than one inside boundary temperature.



b) the internal moisture supply, see 4.2.4;

c) internal air temperature and heating system.

NOTE A lower room temperature is in general more critical. This is especially the case for rooms with reduced, intermittent or no heating where water vapour may enter from adjacent warmer rooms. The heating system will influence air movement and temperature distribution in the rooms and therefore locally cooler areas of the building envelope may become more critical.

## 5.3 Design for avoidance of mould growth

To avoid mould growth the relative humidity at the surface should not exceed 0,8 for several days. The principal steps in the design procedure are to determine the internal air humidity and then, based on the required relative humidity at the surface, to calculate the acceptable saturation humidity, by volume, $v_{sat}$, or vapour pressure, $p_{sat}$, at the surface. From this value, a minimum surface temperature and hence a required "thermal quality" of the building envelope (for a given internal air temperature and expressed by $f_{Rsi}$ ) is established.