SLOVENSKI STANDARD
SIST EN ISO 13792:2005

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Toplotne znaļ ilnosti stavb - Izraļ un notranje temperature prostorov poleti brez mehanskega hlajenja ï Poenostavljena metoda (ISO 13792:2005)

Thermal performance of buildings - Calculation of internal temperatures of a room in summer without mechanical cooling - Simplified methods (ISO 13792:2005)

Wärmetechnisches Verhalten von Gebäuden - Berechnung von sommerliche Raumtemperaturen bei Gebäuden ohne Anlagentechnik - Vereinfachtes Berechnungsverfahren (ISO 13792:2005)

Performance thermique des bâtiments - Température intérieure en été d'un local non climatisé - Méthodes de calcul simplifiées (ISO 13792:2005)

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Thermal performance of buildings - Calculation of internal temperatures of a room in summer without mechanical cooling - Simplified methods (ISO 13792:2005)

Performances thermiques des bâtiments - Calcul de la température interne d'une pièce sans climatisation mécanique en été - Méthodes simplifiées (ISO 13792:2005)

Wärmetechnisches Verhalten von Gebäuden - Sommerliche Raumtemperaturen bei Gebäuden ohne Anlagentechnik - Vereinfachtes Berechnungsverfahren (ISO 13792:2005)

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Foreword

This document (EN ISO 13792:2005) 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”, Subcommittee SC 2, "Calculation methods".

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of an identical text or by endorsement, at the latest by August 2005, and conflicting national standards shall be withdrawn at the latest by August 2005.

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 elements.

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

Introduction

Knowledge of the internal temperature of a room in the warm period is needed for several purposes such as:

a) defining the characteristics of a room at the design stage, in order to prevent or limit overheating in summer;

b) assessing the need for a cooling installation.

The internal temperature is influenced by many parameters such as climatic data, envelope characteristics, ventilation and internal gains. The internal temperature of a room in the warm period can be determined using detailed calculation methods. EN ISO 13791 lays down the assumptions and the criteria which have to be satisfied for assessment of internal conditions in the summer with no mechanical cooling. However, for a number of applications the calculation methods based on EN ISO 13791 are too detailed. Simplified methods are derived from more or less the same description of the heat transfer processes in a building. Each calculation method has its own simplification, assumptions, fixed values, special boundary conditions and validity area. A simplified method can be implemented in many ways. In general the maximum allowed simplification of the calculation method and the input data is determined by the required amount and accuracy of the output data.

This document defines the level, the amount and the accuracy of the output data and the allowed simplification of the input data.

No particular calculation methods are included in the normative part of this standard. As examples, two calculation methods are given in Annex A. They are based on the simplification of the heat transfer processes that guarantees the amount and the accuracy of the output data and the simplification of the input data required by this standard.

The use of these simplified calculation methods does not imply that other calculation methods are excluded from standardisation, nor does it hamper future developments. Clause 6 gives the criteria which have to be satisfied in order that a method complies with this document.

1 Scope

This document specifies the required input data for simplified calculation methods for determining the maximum, average and minimum daily values of the operative temperature of a room in the warm period:

a) to define the characteristics of a room in order to avoid overheating in summer at the design stage;

b) to define whether the installation of a cooling system is necessary or not.

Clause 6 gives the criteria to be met by a calculation method in order to satisfy this document.

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.

EN 410, *Glass in building – Determination of luminous and solar characteristics of glazing.*

EN 673, *Glass in building – Determination of thermal transmittance (U value) – Calculation method.*

EN 13363-1, *Solar protection devices combined with glazing – Calculation of solar and light transmittance – Part 1: Simplified method.*

EN ISO 6946, *Building components and building elements – Thermal resistance and thermal transmittance – Calculation method (ISO 6946:1996).*

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

EN ISO 10077-1, *Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 1: Simplified method (ISO 10077-1:2000).*

EN ISO 13370, *Thermal performance of buildings – Heat transfer via the ground – Calculation methods (ISO 13370:1998).*

EN ISO 13786,*Thermal performance of building components – Dynamic thermal characteristics – Calculation methods (ISO 13786:1999).*

EN ISO 13791:2004, *Thermal performance of buildings – Calculation of internal temperatures of a room in summer without mechanical cooling – General criteria and calculation procedures (ISO 13791:2004).*

3 Terms, definitions, symbols and units

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 7345:1995 and the following apply.

3.1.1
internal environment
closed space delimited from the external environment or adjacent spaces by an envelope element

3.1.2
room element
wall, ceiling, roof, floor, door or window which separates the room from the adjacent spaces or external environment

3.1.3
room air
air in the room

3.1.4
internal air temperature
temperature of the room air

3.1.5
internal surface temperature
temperature of the internal surface of each element of the envelope

3.1.6
mean radiant temperature
uniform surface temperature of an enclosure in which an occupant would exchange the same amount of radiant heat as in the actual non-uniform enclosure

3.1.7
operative temperature
uniform temperature of an enclosure in which an occupant would exchange the same amount of heat by radiation plus convection as in the actual non-uniform enclosure

NOTE For simplification the mean value of the air temperature and the mean radiant temperature of the room can be used.

3.2 Symbols and units

For the purposes of this document, the following symbols and units apply.

Symbol	Quantity	Unit
A	area	m^2
C	heat capacity	J/K
I	intensity of solar radiation	$W/\ m^2$
m	mass	Kg
R	thermal resistance	$m^2 \cdot K/W$
T	thermodynamic temperature	K
U	thermal transmittance under steady state conditions	$W/(m^2 \cdot K)$
V	volume	m^3
c_p	specific heat capacity of air at constant pressure	$J/(kg \cdot K)$
d	thickness	m
f_{sl}	solar loss factor	-
f_s	sunlit factor	-
f_v	ventilation factor	-
g	total solar energy transmittance	-
h	surface coefficient of heat transfer	$W/(m^2 \cdot K)$
l	length	m
q_a	mass air flow rate	kg/s
q	density of heat flow rate	W/m^2
q^*	heat flow rate per volume	W/m^3
t	time	s
v	velocity	m/s
Λ	thermal conductance	$W/(m^2 \cdot K)$
Φ	heat flow rate	W
α	solar absorptance	-
ε	total hemispherical emissivity	-
θ	Celsius temperature	°C
λ	thermal conductivity	$W/(m \cdot K)$
ρ	density	kg/m^3
ρ	solar reflectance	-
τ	solar direct transmittance	-

Subscripts

a	air	cd	conduction
b	building	ec	external ceiling
c	convection	ef	external floor
D	direct solar radiation	eq	equivalent
d	diffuse solar radiation	ic	internal ceiling
e	external	if	internal floor
g	ground	il	inlet section
i	internal	lr	long-wave radiation
l	leaving the section	mr	mean radiant
n	normal to surface	op	operative
r	radiation	sa	solar to air
s	surface	sk	sky
t	time	sr	short wave radiation
v	ventilation	va	ventilation through air cavity

4 Input data and results

4.1 Assumptions

For the scope of this document the following basic assumptions are made:

— the room is considered a closed space delimited by enclosure elements;

— the air temperature is uniform throughout the room;

— the various surfaces of the enclosure elements are isothermal;

— the thermophysical properties of the material composing the enclosure elements are constant;

— the heat conduction through each enclosure element is one dimensional;

— air spaces within the envelope elements are considered as air layers bounded by two isothermal surfaces;

— the mean radiant temperature is calculated as an area-weighted average of the radiant temperature at each internal surface;

— the operative temperature is calculated as the arithmetic mean value of the internal air temperature and the mean radiant temperature;

— the distribution of the solar radiation on the internal surfaces of the room is time independent;

— the spatial distribution of the radiative part of the heat flow due to internal sources is uniform;

— the long-wave radiative and the convective heat transfers at each internal surface are treated separately;

— the dimensions of each component are measured at the internal side of the enclosure element;

— the effects of the thermal bridges on heat transfers are neglected.

4.2 Boundary conditions and input data

4.2.1 Boundary conditions

4.2.1.1 General

The elements of the envelope are divided into:

— external elements: these include the elements separating the internal environment from the outside and from other zones (i.e. attic, ground, crawl space);

— internal elements: these include the elements (vertical and horizontal) separating the internal environment from other rooms which can be considered to have the same thermal conditions.

4.2.1.2 External elements

External elements are those separating the room from the external environment and from zones at different thermal conditions (e.g. attic, ground, crawl space).

Boundary conditions consist of defined hourly values of:

— external air temperature;

— intensity of the solar radiation on each orientation;

— sky radiant temperature;

— air temperature for the adjacent zones which cannot be considered at the same thermal conditions as the examined room.

For elements in contact with the ground the external temperature is assumed to be the mean monthly value of the external air temperature.

4.2.1.3 Internal elements

Internal elements are those separating the room from other rooms which can be considered to have the same thermal conditions.

Internal elements are assumed to be adiabatic, which means that the values of the following quantities are considered to be the same on either side of the element:

— the air temperature;

— the mean radiant temperature;

— the solar radiation absorbed by the surface.

4.2.2 Heat transfer coefficients

For the purposes of this document the following values shall be used:

— internal convective heat transfer coefficient h_{ci} = 2,5 W/(m^2·K);

— internal long-wave radiative heat transfer coefficient h_{ri} = 5,5 W/(m^2·K);

— external convective heat transfer coefficient h_{ce} = 8,0 W/(m^2·K);

— external long-wave radiative heat transfer coefficient h_{re} = 5,5 W/(m^2·K);

— internal surface coefficient of heat transfer h_i = 8,0 W/(m^2·K);

— external surface coefficient of heat transfer h_e = 13,5 W/(m^2·K).

4.2.3 Geometrical and thermophysical parameters of the room envelope

4.2.3.1 Opaque elements

For each element the following data are required:

— area calculated using the internal dimensions;

— summertime thermal transmittance (U^*);

— thermal inertia characteristics [see EN ISO 13786];

— for external elements, sunlit factor and solar energy transmittance.

The summertime thermal transmittance, U^*, is given by:

$$U^* = \frac{1}{\frac{1}{U} - 0{,}17 + \frac{1}{h_i} + \frac{1}{h_e}} \qquad (1)$$

where

U is the conventional thermal transmittance with standard surface resistances defined below;

0,17 is the sum of the conventional internal and external surface resistances as defined in EN ISO 6946;

h_e is the external surface coefficient of heat transfer defined in 4.2.2;

h_i is the internal surface coefficient of heat transfer defined in 4.2.2.

The thermal transmittance, U, may be determined from:

— building elements in contact with the external air: EN ISO 6946;

— building elements in contact with the ground: EN ISO 13370.

The thermal inertia characteristics shall be determined according to EN ISO 13786.

NOTE The sunlit factor differs from the shading correction factor, defined in ISO 13790, which includes diffuse solar radiation.

The sunlit factor, f_s, is given by:

$$f_s = \frac{A_s}{A} \tag{2}$$

where

A_s is the area of the sunlit part of the wall (see 6.3);

A is the total area of the wall.

The solar energy transmittance, g, is the ratio of the heat flow through the element due to the absorbed solar radiation, to the incident solar radiation. It is given by:

— element with no air cavity (or closed air cavity):

$$g = \frac{\alpha\, U^*}{h_e} \tag{3}$$

where α is the direct solar absorptance of the external surface.

— element with open air cavity (external air):

$$g = f_v S_{fc} + (1 - f_v)\, S_{fv} \tag{4}$$

where

f_v is the ventilation coefficient derived from Table 1 as a function of ventilation in the cavity;

S_{fc} is the solar energy transmittance for the closed cavity;

S_{fv} is the solar energy transmittance for the ventilated cavity, given by:

$$S_{fv} = \frac{\alpha}{h_e}\left[\frac{U^*{}_e \cdot U^*{}_i}{U^*{}_e + U^*{}_i + h'}\right] \tag{5}$$

where

U^*_e is the thermal transmittance between the external environment and the air cavity defined as in Equation (1);

U^*_i is the thermal transmittance between the internal environment and the air cavity defined as in Equation (1);

h_e is the external surface coefficient of heat transfer (defined in 4.2.2);

α is the direct solar absorptance of the external surface of the element;

with

$$h' = h_c (h_c + 2\, h_r)/ h_r \quad (6)$$

where

h_c is the convective heat transfer coefficient between the surface of the ventilated air layer and the air in the cavity;

h_r is the radiative heat transfer coefficient between the two surfaces of the air layer.

Using the following values: $h_c = 5$ W/(m²·K) $h_r = 5$ W/(m²·K)

$h' = 15$ W/(m²·K),

Table 1 gives the ventilation coefficient f_v depending on the ratio between the cavity area (A_c) and the wall area (A_w).

The cavity area is the air flow area; the wall area is the conduction heat flow area.

Table 1 – Ventilation coefficient f_v

	$A_c/A_w \leq 0{,}005$	$0{,}005 < A_c/A_w \leq 0{,}10$	$0{,}10 < A_c/A_w$
f_v	0,8	0,5	0,2

In the absence of an actual measured value, the direct solar absorptance of the external surface may be derived from Table 2 as function of its colour.

Table 2 – Direct solar absorptance of external surface

	Light colour	**Medium colour**	**Dark colour**
α	0,3	0,6	0,9

4.2.3.2 Glazed elements

For each glazing element the following data are required:

— area calculated including the frame;

— summertime thermal transmittance (U^* value);

— total solar transmittance (g) (τ in EN 410);

— secondary solar heat gain (q_i) of the glazing by convection and long-wave radiation due to the absorbed solar radiation;

— tertiary heat transfer factor (S_{f3}) of the glazing by ventilation due to the absorbed solar radiation;

— the sunlit factor due to external obstruction f_s.

The summertime thermal transmittance, U^*, is determined by using Equation (1).

The thermal transmittance, U, is determined according to EN 673 and EN ISO 10077-1.

The solar direct transmittance, (τ), and the secondary and tertiary heat transfer factors S_{f2} and S_{f3} are determined from EN 13363-1.

a) Solar-to-air factor

The solar-to-air factor, f_{sa}, is the fraction of solar heat entering the room through the glazing which is immediately transferred to the internal air. This fraction depends on the presence of internal elements with very low heat capacity, such as carpets and furniture. It is assumed to be time independent and, unless otherwise specified, the values in informative Annex G of EN ISO ISO 13791:2004 may be used.

b) Solar loss factor

The solar loss factor, f_{sl}, is the fraction of the solar radiation entering the room which is reflected back outside. It depends on the solar position, solar properties, dimensions and exposure of the glazing system, the room geometry and the reflectivity of the internal room surfaces. It is assumed to be time independent. Unless otherwise specified, values of f_{sl} in informative Annex G of EN ISO 13791:2004 may be used.

NOTE The procedure for evaluating the sunlit factor due external obstruction f_s can be defined in national standards. Such a procedure is given in Annex C.

4.2.3.3 Special elements

a) Ceiling below attic

The element formed by the ceiling, the air space and the roof is considered as a single horizontal element with one-dimensional heat flow. The air space is considered as an air cavity and treated according to EN ISO 6946.

b) Floor on ground

The ground formed by the floor and the soil is considered as a single horizontal layer, which may include an air gap. The heat flow through the element is the sum of a monthly mean value and a variable term. The monthly mean value is calculated using the mean internal and external temperatures, and (taken as constant and equal to the mean monthly value) the thermal transmittance determined according to EN ISO 13370. The variable term is calculated assuming the mean temperature difference is zero. The depth of soil is taken to be 0,5 m.

c) Cellar

A cellar can be considered as an adjacent room with fixed air temperature.

d) Crawl space

A crawl space is treated as a floor on ground according to EN ISO 13370.

4.2.4 Air change rate

The air change rate depends on the tightness of the envelope and on the opening of any doors and windows.

At a design stage the air change rate is expressed as a function of the:

— location of the building;

— pattern of air ventilation;

— number of facades with windows.

The location may be categorised as:

— city centre area;

— suburban area;

— open area.

The pattern of air ventilation is related to the time schedule of the opening and closing of windows and whether windows are located on one or on more facades.

The following time schedules are considered:

— windows open day and night;

— windows closed day and night;

— window closed during the day and open during the night.

NOTE Data on the time of opening and closing of the windows and on hourly air change rates can be defined at a national level. Annex B gives examples of appropriate values of the air change rates.

4.2.5 Internal gain

Internal gains derive from lighting, equipment and occupant. The pattern of the heat flow due to internal gains is related to the occupants' behaviour and to the utilisation of the room.

NOTE Data on the time schedule of utilisation of the room, and the heat flow for each type of utilisation, can be defined at a national level. If information is not available the values included in Annex D can be used.

4.3 Output data

Results of the calculations are the maximum, average and minimum daily values of the operative temperature of the considered room under defined external and internal conditions.

5 Calculation procedure

The calculation procedure is based on the following steps:

a) definition of the climatic data of the location;

b) definition of the room for which the control is required;

c) definition of the elements of the envelope enclosing the room (area, exposure, boundary conditions);

d) calculation of the thermophysical parameters (steady state and transient conditions) and the solar energy transmittance of opaque and transparent elements;

e) definition of the ventilation pattern;

f) definition of the internal gains;

g) evaluation of the maximum, average and minimum daily values of the operative temperature.

The level of accuracy of a calculation procedure shall be checked using the validation procedure given in Clause 6, leading to a classification into one of three accuracy classes 1, 2 and 3 (see 6.2).