INTERNATIONAL STANDARD

ISO 13792

Second edition
2012-03-15

Thermal performance of buildings — Calculation of internal temperatures of a room in summer without mechanical cooling — Simplified methods

Performance thermique des bâtiments — Calcul des températures intérieures en été d'un local sans dispositif de refroidissement mécanique — Méthodes simplifiées

Reference number
ISO 13792:2012(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

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 13792 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 13792:2005), which has been technically revised. The main changes compared to the previous edition are given in the following table.

Clause/subclause	Changes
2	Added ISO 9050, ISO 10292, and ISO 15927-2
3.2 and 3.3	Deleted g and m Added subscript sl
4.2.1.2	Added first and second list items, descriptions of the reference
4.2.3	Replaced U^* by U Replaced g by S_f as the solar heat gain factor Deleted Equation (1) and replaced old Equations (2) to (6) by Equations (1) to (5) Amended Equations (2) to (4)
4.2.3.2	Third list item, replaced g by S_{f1}
6.2.5	Added the descriptions of the latitudes in Tables 7, 8 and 9
A.2.1	Amended the descriptions of symbols S_f and n
A.2.2	Amended Equation (A.1)
A.2.3	Added the equation to define A_t Amended Equation (A.24)
A.3.1	Amended Equations (A.28), (A.31), (A.32), (A.33) and (A.34)
A.3.2.1	Amended Equation (A.35) Amended the unit for c
A.3.2.2.1	Amended Equations (A.38), (A.39), (A.40), (A.45) and (A.47) Changed the description of H_T
A.3.2.2.2	Amended Equation (A.49)
A.3.2.3	Amended Equation (A.52)
A.3.3	Amended Equation (A.53)
C.2	Added a title to Table C.1
E.1	Amended the description of S_f in Table E.5
E.3	Replaced U^*_m by U_m

Introduction

Knowledge of the internal temperature of a room in warm periods 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 warm periods can be determined using detailed calculation methods. ISO 13791 lays down the assumptions and the criteria 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 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 International Standard 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 International 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 International Standard.

The use of these simplified calculation methods does not imply that other calculation methods are excluded from standardization, nor does it hamper future developments. Clause 6 gives the criteria to be satisfied in order for a method to comply with this International Standard.

Thermal performance of buildings — Calculation of internal temperatures of a room in summer without mechanical cooling — Simplified methods

1 Scope

This International Standard 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 warm periods:

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

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 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 6946, *Building components and building elements — Thermal resistance and thermal transmittance — Calculation method*

ISO 7345, *Thermal insulation — Physical quantities and definitions*

ISO 9050, *Glass in building — Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors*

ISO 10077-1, *Thermal performance of windows, doors and shutters — Calculation of thermal transmittance — Part 1: General*

ISO 10292, *Glass in building — Calculation of steady-state U values (thermal transmittance) of multiple glazing*

ISO 13370, *Thermal performance of buildings — Heat transfer via the ground — Calculation methods*

ISO 13791, *Thermal performance of buildings — Calculation of internal temperatures of a room in summer without mechanical cooling — General criteria and validation procedures*

ISO 15927-2, *Hygrothermal performance of buildings — Calculation and presentation of climatic data — Part 2: Hourly data for design cooling load*

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*

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
internal environment
closed space delimited from the external environment or adjacent spaces by the building fabric

3.1.2
room element
wall, ceiling, roof, floor, door or window that separates the internal environment from the external environment or an adjacent space

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 a building element

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 environment

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	Definition	Unit
A	area	m^2
A_c	cavity area	m^2
A_m	thermal mass area	m^2
A_s	sunlit area	m^2
A_t	exposed area	m^2
A_w	wall area	m^2
C	heat capacity	J/K
C_i	internal heat capacity	J/K

C_m	heat capacity of the enclosure elements	J/K
c	specific heat capacity	J/(kg·K)
c_a	specific heat capacity of air at constant pressure	J/(kg·K)
d	thickness	m
F_a	decrement factor	—
F_s	surface factor	—
F_{sm}	surface factor of the envelope	—
f_c	correction factor for transmission thermal load	—
f_{ex}	exposure factor	—
f_r	correction factor for solar thermal load	—
f_s	sunlit factor	—
f_{sa}	solar-to-air factor	—
f_{sl}	solar loss factor	—
f_t	frame factor	—
f_v	ventilation factor	—
H_{ei}	heat transfer coefficient due to the air ventilation	W/K
H_{em}	conventional heat transfer coefficient between the external environment and the internal surface of the heavy components	W/K
H_{es}	global heat transfer coefficient between the internal and external environment	W/K
H_{is}	heat transfer coefficient due to internal exchanges by convection and radiation	W/K
H_{ms}	conventional internal heat transfer coefficient	W/K
H_T	heat transfer coefficient of the envelope	W/K
h	surface coefficient of heat transfer	W/(m²·K)
h_c	convective heat transfer coefficient	W/(m²·K)
h_r	radiative heat transfer coefficient	W/(m²·K)
I	intensity of solar radiation	W/m²
I_r	reflected component of the solar radiation reaching the surface	W/m²
l	length	m
N_c	number of components facing the indoor environment	—
N_e	number of external components	—
N_h	number of heavy opaque components	—
N_l	number of light opaque components	—
N_p	number of opaque components	—
N_s	number of internal sources	—
N_w	number of glazing components	—
n	air changes per hour	l/h
q	density of heat flow rate	W/m²
R	thermal resistance	m²·K/W

R_{ei}	thermal resistance due to air ventilation	$m^2 \cdot K/W$
S_f	solar heat gain factor	—
S_{fc}	solar heat gain factor for the closed cavity	—
S_{f1}	solar direct transmittance	—
S_{f2}	secondary heat transfer factor	—
S_{f3}	tertiary heat transfer factor	—
S_{fv}	solar heat gain factor for the ventilated cavity	—
T	thermodynamic temperature	K
t	time	s
U	thermal transmittance	$W/(m^2 \cdot K)$
U_e	thermal transmittance between the external environment and the air cavity	$W/(m^2 \cdot K)$
U_i	thermal transmittance between the internal environment and the air cavity	$W/(m^2 \cdot K)$
U_w	thermal transmittance of the glazing component	$W/(m^2 \cdot K)$
V	volume	m^3
v	velocity	m/s
x_v	vertical shaded distance	—
Y	admittance	$W/(m^2 \cdot K)$
Y_T	total admittance	$W/(m^2 \cdot K)$
α_{sr}	solar absorptance	—
β	solar altitude angle	degrees
ε	long-wave emissivity of the surface	—
θ	Celsius temperature	°C
θ_{ae}	external air temperature	°C
θ_{ei}	outdoor air temperature	°C
θ_{em}	outdoor air temperature of the heavy external components	°C
θ_{es}	outdoor air temperature of the light external components	°C
θ_m	mass temperature	°C
$\theta_{op,av}$	daily average value of the operative temperature	°C
$\theta_{op,min}$	daily minimum value of the operative temperature	°C
$\theta_{op,max}$	daily maximum value of the operative temperature	°C
θ_s	star temperature	°C
λ	thermal conductivity	$W/(m \cdot K)$
ρ	density	kg/m^3
ρ_a	density of air	kg/m^3
ρ_{sr}	solar reflectance	—
τ_{sr}	solar direct transmittance	—
Φ	heat flow rate	W

Φ_{co}	transmission thermal load contribution	W
Φ_{er}	heat flow rate due to the solar radiation through the glazing components	W
Φ_{erm}	mean daily value of the heat flux due to the solar radiation through the glazing components	W
Φ_{i}	heat flow to air node	W
Φ_{intc}	convective heat flow of each internal source	W
Φ_{intr}	radiative heat flow of each internal source	W
Φ_{is}	internal source thermal load	W
Φ_{m}	heat flow to mass node	W
Φ_{s}	heat flow to star node	W
Φ_{sr}	solar thermal load	W
Φ_{sv}	thermal load due to the ventilation solar factor	W
Φ_{T}	thermal load	W
Φ_{V}	ventilation thermal load	W
φ	time lag of the density of heat flow rate	h
ω	solar wall azimuth angle	degrees

3.3 Subscripts

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

4 Input data and results

4.1 Assumptions

For the scope of this International Standard 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 International Standard 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;
- thermal inertia characteristics (see ISO 13786);
- building elements in contact with the external air (see ISO 6946);
- building elements in contact with the ground (see ISO 13370).

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

The sunlit factor, f_s, is given by Equation (1):

$$f_s = \frac{A_s}{A} \quad (1)$$

where

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

A is the total area of the wall.

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

The solar heat gain factor, S_f, 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 Equation (2):

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

$$S_f = \frac{\alpha_{sr} U}{h_e} \quad (2)$$

where

α_{sr} is the direct solar absorptance of the external surface;

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

— element with open air cavity (external air):

$$S_f = f_v S_{fc} + (1 - f_v) S_{fv} \quad (3)$$

where

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

S_{fc} is the solar heat gain factor for the closed cavity;

S_{fv} is the solar heat gain factor for the ventilated cavity, given by:

$$S_{fv} = \frac{\alpha_{sr}}{h_e} \left(\frac{U_e U_i}{U_e + U_i + h'} \right) \quad (4)$$

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);

with

$$h' = h_c \frac{(h_c + 2h_r)}{h_r} \quad (5)$$

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_{sr}	0,3	0,6	0,9

4.2.3.2 Glazed elements

For each glazed element the following data are required:

— area calculated, including the frame;

— thermal transmittance (U value);

— total solar direct transmittance, S_{f1} (τ_v in ISO 9050 and EN 410);

— secondary heat transfer factor, S_{f2}, 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 thermal transmittance, U, is determined according to EN 673 and ISO 10077-1.