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Energy performance of buildings — Method for calculation of system energy requirements and system efficiencies — Space emission systems (heating and cooling)

Performance énergétique des bâtiments — Méthode de calcul des besoins énergétiques et des rendements des systèmes — Systèmes d'émission (de chaleur et de froid) dans les locaux

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 205, *Building environment design*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document is part of a series aimed at international harmonization of the methodology for assessing the energy performance of buildings. Throughout, this series is referred to as a 'set of EPB standards'.

All EPB standards follow specific rules to ensure overall consistency, unambiguity and transparency.

All EPB standards provide a certain flexibility with regard to the methods, the required input data and references to other EPB standards, by the introduction of a normative template in Annex A and Annex B with informative default choices.

For the correct use of this document, a normative template is given in Annex A to specify these choices. Informative default choices are provided in Annex B.

The framework for overall EPB includes:

a) common terms, definitions and symbols;

b) building and assessment boundaries;

c) building partitioning into space categories;

d) methodology for calculating the EPB (formulae on energy used, delivered, produced and/or exported at the building site and nearby);

e) a set of overall formulae and input-output relations, linking the various elements relevant for the assessment of the overall EPB;

f) general requirements for EPB dealing with partial calculations;

g) rules for the combination of different spaces into zones;

h) performance indicators;

i) methodology for measured energy performance assessment.

The EPB series covers:

a) energy performance calculation for heating systems;

b) inspection of heating systems;

c) design of heating systems;

d) installation and commissioning of heating systems.

This document constitutes the specific part related to space heating and cooling emission, determining methods for calculation of energy losses/requirements of space heating and cooling systems, space cooling systems and domestic hot water systems in buildings.

This document specifies the structure for calculation of the additional heat and cooling losses and energy requirements of a heat and cooling emission systems for meeting the building net energy demand.

The calculation method is used for the following applications:

— calculation of the additional energy losses in the heat emission system or cooling system;

— optimisation of the energy performance of a planned heat emission system or cooling system, by applying the method to several possible options.

Table 1 shows the relative position of this document within the set of EPB standards in the context of the modular structure as set out in ISO 52000-1.

NOTE 1 In ISO/TR 52000-2 the same table can be found, with, for each module, the numbers of the relevant EPB standards and accompanying technical reports that are published or in preparation.

NOTE 2 The modules represent EPB standards, although one EPB standard can cover more than one module and one module can be covered by more than one EPB standard, for instance a simplified and a detailed method respectively. See Tables A.1 and B.1.

Table 1 — Position of this document (in casu M1-1–M1-3, M1-5, M1-7–M1-10), within the modular structure of the set of EPB standards

Overarching			Building (as such)		Technical building systems										
Sub-module	Descriptions			Descriptions		Descriptions	Heating	Cooling	Ventilation	Humidification	Dehumidification	Domestic hot water	Lighting	Building automation and control	PV, wind...
sub1		M1	sub1	M2	sub1		M3	M4	M5	M6	M7	M8	M9	M10	M11
1	General		1	General	1	General	EN 15316-1					EN 15316-1			
2	Common terms and definitions; symbols, units and subscripts		2	Building energy needs	2	Needs						EN 12831-3			
3	Applications		3	(Free) Indoor conditions without systems	3	Maximum load and power	EN 12831-1					EN 12831-3			
4	Ways to express energy performance		4	Ways to express energy performance	4	Ways to express energy performance	EN 15316-1					EN 15316-1			
5	Building categories and building boundaries		5	Heat transfer by transmission	5	Emission and control	EN 15316-2	EN 15316-2							
6	Building occupancy and operating conditions		6	Heat transfer by infiltration and ventilation	6	Distribution and control	EN 15316-3	EN 15316-3				EN 15316-3			
7	Aggregation of energy services and energy carriers		7	Internal heat gains	7	Storage and control	EN 15316-5					EN 15316-5 EN 15316-4-3			
8	Building zoning		8	Solar heat gains	8	Generation									
					8-1	Combustion boilers	EN 15316-4-1					EN 15316-4-1			
					8-2	Heat pumps	EN 15316-4-2	EN 15316-4-2				EN 15316-4-2			
					8-3	Thermal solar Photovoltaics	EN 15316-4-3					EN 15316-4-3			EN 15316-4-3
					8-4	On-site cogeneration	EN 15316-4-4					EN 15316-4-4			EN 15316-4-4
					8-5	District heating and cooling	EN 15316-4-5	EN 15316-4-5							EN 15316-4-5

Table 1 *(continued)*

Overarching			Building (as such)		Technical building systems										
Sub-module	Descriptions			Descriptions		Descriptions	Heating	Cooling	Ventilation	Humidification	Dehumidification	Domestic hot water	Lighting	Building automation and control	PV, wind…
sub1		M1	sub1	M2	sub1		M3	M4	M5	M6	M7	M8	M9	M10	M11
					8-6	Direct electrical heater	EN 15316-4-6					EN 15316-4-6			
					8-7	Wind turbines									EN 15316-4-7
					8-8	Radiant heating, stoves	EN 15316-4-8								
9	Calculated energy performance		9	Building dynamics (thermal mass)	9	Load dispatching and operating conditions									
10	Measured energy performance		10	Measured energy performance	10	Measured energy performance	EN 15378-3					EN 15378-3			
11	Inspection		11	Inspection	11	Inspection	EN 15378-1					EN 15378-1			
12	Ways to express indoor comfort		12	—	12	BMS									
13	External environment conditions														
14	Economic calculation	15459-1													

Energy performance of buildings — Method for calculation of system energy requirements and system efficiencies — Space emission systems (heating and cooling)

1 Scope

This document establishes the required inputs, outputs and links (structure) of the calculation method for heating and cooling space emission systems.

This document is applicable to the energy performance calculation of heating systems and water-based cooling space emission sub-systems.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 performance of buildings and building components — Physical quantities and definitions*

ISO 52000-1, *Energy performance of buildings — Overarching EPB assessment — Part 1: General framework and procedures*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
heat loss
emissions within the heating system as losses through the building envelope due to non-uniform temperature distribution, *control* (3.3) inefficiencies and losses of emitters embedded in the building structure

3.2
cooling loss
emissions within the cooling system as losses through the building envelope due to non-uniform temperature distribution, *control* (3.3) inefficiencies and losses of emitters embedded in the building structure

3.3
control
self-acting devices with and without auxiliary energy to keep a physical condition such as temperature, humidity, etc. close to set-point

3.4
emission system
system which transmits heat or cold into the room

Note 1 to entry: In different countries the word emission system is replaced by the word distribution systems.

4 Symbols and subscripts

4.1 Symbols

For the purposes of this document, the symbols given in ISO 52000-1 and the following apply.

RF radiant factor

4.2 Subscripts

For the purposes of this document, the subscripts given in ISO 52000-1 and the following apply.

emb	embedded
fan	fan
emt	emitter
hydr	hydraulic balancing
im	intermittent
ini	initial
inc	increased
roomaut	room automation
pmp	pump
rad	radiant
str	stratification
conv	convective

5 Description of the method

5.1 Output of the method

The method described in this document calculates:

— energy losses (heating and cooling) $Q_{em,ls}$ in kWh;

— auxiliary energy: heat/cooling emission W_{em} in kWh;

— room temperature $\theta_{int,inc}$ in °C.

The time step of the output can be:

— hourly;

— monthly;

— yearly;

according to the time step of the input.

5.2 General description of the method

The energy performance is assessed by values of the increased space temperatures due to heat and cooling emission system inefficiencies.

The method is based on an analysis of the following characteristics of a space heating emission system or cooling system including control:

— non-uniform space temperature distribution;

— emitters;

— emitters embedded in the building structure;

— control accuracy of the indoor temperature;

— operation of controls/controls systems and emitters.

The energy required by the emission system is calculated separately for thermal energy and electrical energy in order to determine the final energy, and subsequently the corresponding primary energy is calculated.

For the calculation of the different characteristics within combined systems it is assumed that the system is designed under the aspect of energy optimisation.

6 Calculation method

6.1 Output data

The output data of this method are listed in Table 2.

Table 2 — Output data of this method

Description	Symbol	Unit	Validity interval	Intended	Varying
auxiliary energy — heating/cooling emission	$W_{em,ls,aux}$	kWh	0…∞	M3-1	Yes
additional energy losses of heat emission	$Q_{em,ls}$	kWh	0…∞	M3-1	Yes
equivalent internal heating temperature	$\theta_{H;int;inc}$	°C	−5…40	M3-1	Yes
equivalent internal cooling temperature	$\theta_{C;int;inc}$	°C	−5…40	M4-1	Yes
temperature variation based on losses	$\Delta\theta_{int;inc}$	°C	−5…40	M3-1	Yes
annual expenditure factor for the heat and cooling emission	$\varepsilon_{em,ls,an}$	—	1…2	M3-1	No
convective fraction of the heating/ cooling emitter	$f_{em,conv}$	—	0…1	M3-1/M2-2	No

6.2 Calculation time interval

The objective of the calculation is to determine the annual energy demand or the energy demand of a time period of the space heating/cooling emission system. This may be done in one of the following two different ways:

— by using annual data for the system operation period and perform the calculations using annual average values;

— by dividing the year into a number of calculation periods (e.g. year, month, week, day, hour, boosted sub-period) and perform the calculations for each period using period dependent values and adding up the results for all the periods over the year.

6.3 Input data

6.3.1 Source of data

Input data about products that are required for the calculation described in this document shall be the data supplied by the manufacturer if they are declared according to relevant product standards.

If no such data from the manufacturer is available, or if the required data are not product data, default values are given in Annex B.

6.3.2 Product data (technical data)

The product data shall be the value declared by the manufacturer according to measurements performed meeting the requirements of the relevant product standards. If values declared by the manufacturer are not available, then default values are given in informative Annex B. New values can be definite based on the boundary condition from Annex C.

Required technical data for this calculation procedure are listed in Table 3.

Table 3 — Product technical input data list

Characteristics	Symbol	Catalogue unit	Computed unit	Validity interval	Ref.	Varying
control variation of temperature	$\Delta\theta_{ctr}$	K	K	−5…5	6.4.2	No
temperature variation based on control, not certified products	$\Delta\theta_{ctr,1}$	K	K	−5…+5	6.4.2	No
temperature variation based on control, certified products	$\Delta\theta_{ctr,2}$	K	K	−5…+5	6.4.2	No
hysteresis of thermostatic valve	θ_H	K	K	0…1	6.4.2	No
effect of supply water temperature on thermostatic controllers (TRV) head sensing element	θ_W	K	K	0…1	6.4.2	No
temperature variation based on not balanced hydraulic systems	$\Delta\theta_{hydr}$	K	K	0…1	6.4.2	No
temperature variation based on intermittent controls operation system	$\Delta\theta_{im,crt}$	K	K	−5…+5	6.4.2	No
temperature variation based on intermittent operation of the emission system	$\Delta\theta_{im,emt}$	K	K	−5…+5	6.4.2	No
temperature variation based on radiation by type of the emission system	$\Delta\theta_{rad}$	K	K	−5…+5	6.4.2	No
temperature variation based on the stratification	$\Delta\theta_{str}$	K	K	−5…+5	6.4.2	No
temperature variation based on the stratification — part of influence due to “over-temperature”	$\Delta\theta_{str,1}$	K	K	−5…+5	6.4.2	No
temperature variation based on the stratification — part of influence due to “specific heat losses via external components”	$\Delta\theta_{str,2}$	K	K	−5…+5	6.4.2	No

Table 3 *(continued)*

Characteristics	Symbol	Catalogue unit	Computed unit	Validity interval	Ref.	Varying
temperature variation based on an additional heating/cooling loss by emitters embedded in the envelope	$\Delta\theta_{emb}$	K	K	−5...+5	6.4.2	No
temperature variation based on an additional heating/cooling loss by emitters embedded in the envelope — part of influence due to the "system"	$\Delta\theta_{emb,1}$	K	K	−5...+5	6.4.2	No
temperature variation for consideration of solar and internal gains	$\Delta\theta_{e,sol}$	K	K	−15...+15	6.4.2	No
temperature variation based on an additional heating/cooling loss by emitters embedded in the envelope — part of influence due to "specific heat losses via laying surfaces"	$\Delta\theta_{emb,2}$	K	K	−5...+5	6.4.2	No
temperature variation based on room automation	$\Delta\theta_{roomaut}$	K	K	−5...+5	6.4.2	No
radiant factor of radiant heaters for room heights ≥4 m	RF			0...1	6.4.2	No
room height	h_R	m	m	2...50	6.4.2	No
electrical rated power consumption of the control	P_{ctr}	W	W	0...500	6.4.4	No
electrical rated power consumption of the equipment	$P_{H,aux}$	W	W	0...500	6.4.4	No
electrical rated power consumption of the fan	P_{fan}	W	W	0...500	6.4.4	No
design nominal useful emitter power	Φ_{Hemn}	kW	W	0...		No

6.3.3 Configuration and system design data

Table 4 — Configuration and system design data

Name	Symbol	Unit	Range	Origin module	Varying
design over-temperature		K	5...60	M3-1	Yes

6.3.4 Operating or boundary conditions

Required operating conditions data for this calculation procedure are listed in Table 5.

Table 5 — Operating conditions data list

Name	Symbol	Unit	Range	Origin module	Varying
Operating conditions					
initial internal temperature	$\theta_{int,ini}$	°C	0...50	M3-2	Yes
calculation interval	t_{ci}	h	1...8 760	M1-9	Yes
total time of generator(s) operation	t_{gnr}	h	0...8 760	M1-6	Yes
external temperature of the calculation interval	$\theta_{e,avg}$	°C	−50...+50	M1-13	Yes
thermal output of the heating/cooling emission system	$Q_{em;out}$	kWh	0...	M3-3/M4-3	Yes

Table 5 *(continued)*

Name	Symbol	Unit	Range	Origin module	Varying
Operating conditions					
operation time of the fans in the calculation period	$t_{h,rl}$	h	0…8 760	M1-6	Yes
analytical running time (monthly or other period)	t_h	h	0…8 760	M1-6	Yes

6.4 Calculation procedure

6.4.1 Applicable calculation interval

This calculation procedure can be used with the following calculation interval: hourly, monthly or yearly.

6.4.2 Energy calculation (additional heating/cooling losses)

This subclause gives a detailed method for the calculation of losses in the heating/cooling emission systems or in the cooling system (for the cooling case the loss is a heat loss with a negative sign). The concept uses the equivalent internal temperature.

This document presents an overall method to calculate the additional heat/cooling losses and energy efficiency. In Annex A only the structure of the tables is included. Default values for the calculation are given in Annex B. The internal temperature is affected by the following (see Figure 1):

— the spatial temperature variation due to the stratification, depending on the emitter;

— the control variation depending on the capacity of the control device to assure a homogeneous and constant temperature;

— the temperature variation based on additional heating/cooling losses by emitters embedded in the envelope;

— the temperature variation based on radiation heat transfer of the emitter;

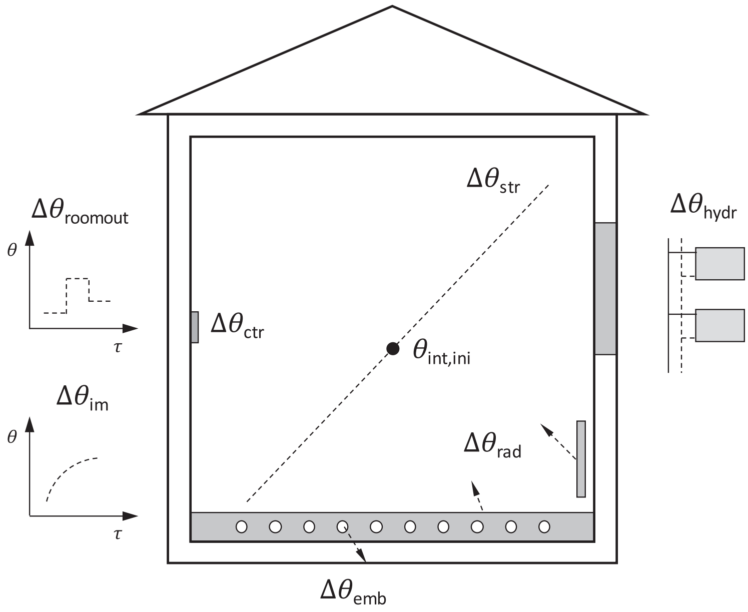
— the temperature variation based on intermittent operation of controls and emitters;

— the temperature variation based on imbalanced hydraulic systems;

— the temperature variation based on a space automation system;

— the temperature variation based on a controls system with standalone or networked operation of the system;

— the temperature variation based on type of emitter.



Key

$\Delta\theta_{im}$	temperature variation based on intermittent operation and based on the type of emission system (K),
$\Delta\theta_{roomaut}$	temperature variation based on standalone or networked operation/ space automation of the system (K)
$\Delta\theta_{ctr}$	control variation (K)
$\Delta\theta_{emb}$	temperature variation based on an additional heating/cooling losses of embedded emitters or by undirected (flat) radiant emitters like radiant panels installed in the upper area of the room (K)
$\theta_{int;inc}$	equivalent internal temperature (K)
$\Delta\theta_{rad}$	temperature variation based on radiation by the type of emission system (K)
$\Delta\theta_{str}$	spatial variation of temperature due to stratification (K)
$\Delta\theta_{hydr}$	temperature variation based on not balanced hydraulic systems (K)

The control variation $\Delta\theta_{ctr}$ is divided into $\Delta\theta_{ctr,1}$ and $\Delta\theta_{ctr,2}$. $\Delta\theta_{ctr,1}$ should be used for standard calculation if no information is available. $\Delta\theta_{ctr,2}$ should be used for calculation with certified products. Alternatively, product specific values can be used if proved by certification.

Figure 1 — Temperature differences in the room based on different sources

The temperature variation based on intermittent operation and based on the type of emission system shown in Figure 1 is calculated by Formula (1):

$$\Delta\theta_{im} = \Delta\theta_{im,emt} + \Delta\theta_{im,ctr} \qquad (1)$$

where

$\Delta\theta_{im,emt}$	is the temperature variation based on intermittent operation on the type of the emission system (K);
$\Delta\theta_{im,ctr}$	is the temperature variation based on intermittent operation of control (K).

The equivalent internal temperature, $\theta_{int;inc}$ taking into account the emitter, is calculated by Formulae (2) and (3):

$$\theta_{H;int;inc} = \theta_{H;int;ini} + \Delta\theta_{int;inc} \qquad (2)$$

