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BSI Standards Publication

Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies

Part 6-2: Explanation and justification of EN 15316-2, Module M3-5, M4-5

National foreword

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Energetische Bewertung von Gebäuden - Verfahren zur Berechnung der Energieanforderungen und Nutzungsgrade der Anlagen - Teil 6-2: Begleitende TR zur EN 15316-2 (Raumluftsysteme (Heizen und Kühlen))

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COMITÉ EUROPÉEN DE NORMALISATION
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European foreword

This document (CEN/TR 15316-6-2:2017) has been prepared by Technical Committee CEN/TC 228 "Heating systems and water based cooling systems in buildings", the secretariat of which is held by DIN.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

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Introduction

This standard is part of a set of standards developed to support EPBD directive implementation, hereafter called “EPB standards”.

EPB standards deal with energy performance calculation and other related aspects (like system sizing) to provide the building services considered in the EPBD directive.

CEN/TC 228 deals with heating systems in buildings. Subjects covered by CEN/TC 228 are:

a) energy performance calculation for heating systems;

b) inspection of heating systems;

c) design of heating systems;

d) installation and commissioning of heating systems.

The set of EPB standards, technical reports and supporting tools

In order to facilitate the necessary overall consistency and coherence, in terminology, approach, input/output relations and formats, for the whole set of EPB-standards, the following documents and tools are available:

a) a document with basic principles to be followed in drafting EPB-standards: CEN/TS 16628:2014, Energy Performance of Buildings - Basic Principles for the set of EPB standards [14];

b) a document with detailed technical rules to be followed in drafting EPB-standards; CEN/TS 16629:2014, Energy Performance of Buildings - Detailed Technical Rules for the set of EPB-standards [15];

c) the detailed technical rules are the basis for the following tools:

   1) a common template for each EPB-standard, including specific drafting instructions for the relevant clauses;

   2) a common template for each technical report that accompanies an EPB standard or a cluster of EPB standards, including specific drafting instructions for the relevant clauses;

   3) a common template for the spreadsheet that accompanies each EPB standard, to demonstrate the correctness of the EPB calculation procedures.

Each EPB-standards follows the basic principles and the detailed technical rules and relates to the overarching EPB-standard, EN ISO 52000-1 [16].

One of the main purposes of the revision of the EPB-standards is to enable that laws and regulations directly refer to the EPB-standards and make compliance with them compulsory. This requires that the set of EPB-standards consists of a systematic, clear, comprehensive and unambiguous set of energy performance procedures. The number of options provided is kept as low as possible, taking into account national and regional differences in climate, culture and building tradition, policy and legal frameworks (subsidiarity principle). For each option, an informative default option is provided (Annex B).

Rationale behind the EPB technical reports

There is a risk that the purpose and limitations of the EPB standards will be misunderstood, unless the background and context to their contents – and the thinking behind them – is explained in some detail to readers of the standards. Consequently, various types of informative contents are recorded and made available for users to properly understand, apply and nationally or regionally implement the EPB standards.

If this explanation would have been attempted in the standards themselves, the result is likely to be confusing and cumbersome, especially if the standards are implemented or referenced in national or regional building codes.

Therefore each EPB standard is accompanied by an informative technical report, like this one, where all informative content is collected, to ensure a clear separation between normative and informative contents (see CEN/TS 16629 [15]):

— to avoid flooding and confusing the actual normative part with informative content;

— to reduce the page count of the actual standard; and

— to facilitate understanding of the set of EPB standards.

This was also one of the main recommendations from the European CENSE project [18] that laid the foundation for the preparation of the set of EPB standards.

1 Scope

This Technical Report refers to standard EN 15316-2.

It contains information to support the correct understanding and use of EN 15316-2.

The scope of this specific part is to standardize the required inputs, the outputs and the links (structure) of the calculation method in order to achieve a common European calculation method.

This standard covers energy performance calculation of heating systems and water based cooling space emission sub-systems.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 215, *Thermostatic radiator valves - Requirements and test methods*

EN 416-2, *Single burner gas-fired overhead radiant tube heaters for non-domestic use - Part 2: Rational use of energy*

EN 419-2, *Non-domestic gas-fired overhead luminous radiant heaters - Part 2: Rational use of energy*

EN 442 (all parts), *Radiators and convectors – Part 2: Test methods and rating*

EN 1264 (all parts), *Water based surface embedded heating and cooling systems*

EN 14037 (all parts), *Free hanging heating and cooling surfaces for water with a temperature below 120°C*

EN 14337, *Heating Systems in buildings - Design and installation of direct electrical room heating systems*

EN 15316-1, *Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 1: General and Energy performance expression, Module M3-1, M3-4, M3-9, M8-1, M8-4*

EN 15316–2, *Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 2: Space emission systems (heating and cooling), Module M3-5, M4-5*

EN 15500, *Control for heating, ventilating and air-conditioning applications - Electronic individual zone control equipment*

EN 16430 (all parts), *Fan assisted radiators, convectors and trench convectors - Part 1: Technical specifications and requirements*

EN 60240–1, *Characteristics of electric infra-red emitters for industrial heating - Part 1: Short wave infra-red emitters (IEC 60240-1)*

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

EN ISO 13790, *Energy performance of buildings - Calculation of energy use for space heating and cooling (ISO 13790)*

EN ISO 52000-1:2017, *Energy performance of buildings - Overarching EPB assessment - Part 1: General framework and procedures (ISO 52000-1:2017)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 7345:1995, EN ISO 52000-1:2017, and the following apply.

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

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

3.3
total heat losses
sum of the heat losses within the heating system from the system, including recoverable heat loss

3.4
total cooling losses
sum of the cooling losses within the cooling system from the system, including recoverable cooling loss

3.5
control
self-acting device with and without auxiliary energy to keep a physical condition as temperature, humidity, etc. close to set-point

3.6
room automatisation controls
BMS
room temperature controls in combination with:

— timer function;

— timer function and self-adoption / self-optimization;

timer function and self-adoption / self-optimization and interaction with other components of heating / cooling system like further controls, circulator or heat- / cool-generator (net work operation)

4 Symbols and abbreviations

4.1 Symbols

For the purposes of this document, the following symbols (see Table 1) apply:

Table 1 — Symbols and units

Symbol	Quantity	Unit
RF	Radiant factor	-

4.2 Subscripts

For the purposes of this document, the following subscripts (see Table 2) apply:

Table 2 — Subscripts

emb	embedded	*im*	*intermittent*	*pmp*	*pump*
fan	*fan*	*ini*	initial	*rad*	*radiant*
emt	*emitter*	*inc*	increased	*str*	stratification
hydr	*hydraulic balancing*	*roomaut*	room automation	*Δ*	additional
out	*output*	*sol*	*solar*		

5 Description of the method

5.1 Output of the method

The method described in this standard calculate

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

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

— room temperature $\theta_{\text{int},inc}$ in Centigrade (°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

5.2.1 General

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.

The calculation factors for conversion of energy requirements to primary energy shall be decided on a national level.

5.2.2 non-uniform space temperature distribution

The additional energy loss, based on non- uniform space temperature distribution can be caused by:

— a temperature stratification, resulting in an increased internal temperature under the ceiling and upper parts of the room;

— an increased internal temperature and heat transfer coefficient near windows;

— convection and radiation from the heating system through other outside surfaces.

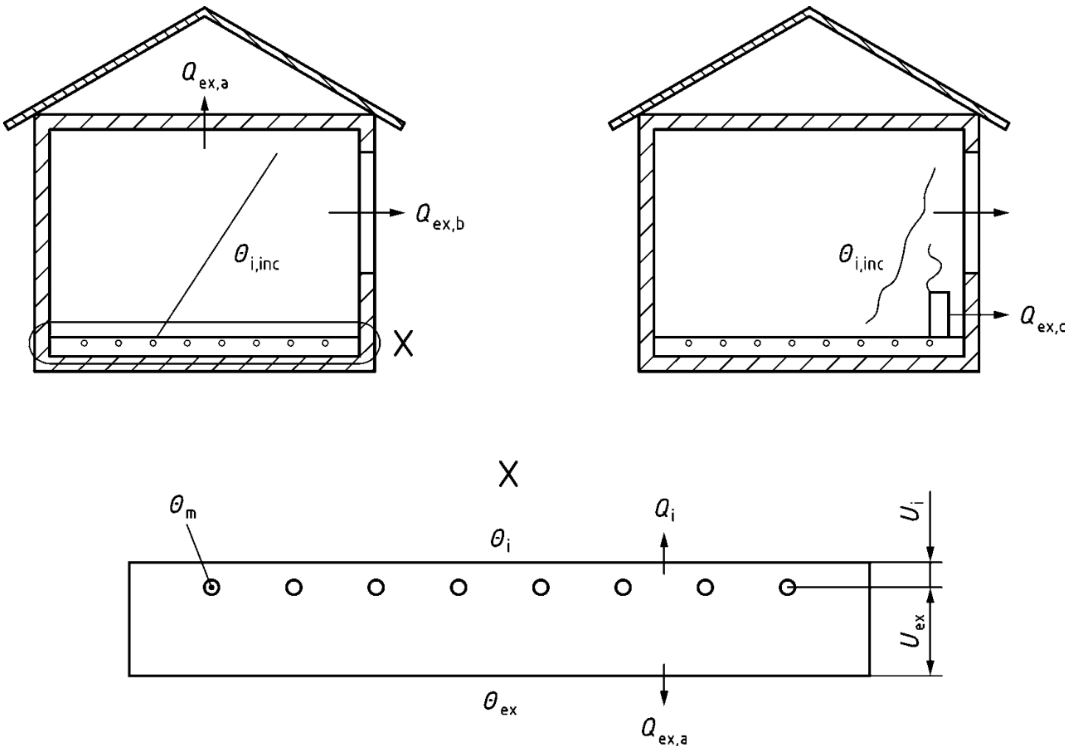

Figure 1 — Effects due to non-uniform temperature distribution and position of heat and cooling emitter

Figure 1 shows some examples for the non-uniform temperature distribution.

5.2.3 Heat loss of embedded surface heating devices due to additional transmission to the outside

This applies to floor heating, ceiling heating and wall heating systems and similar.

This is only considered as a loss when one side of the building part containing the embedded heating device is facing the outside, the ground, an unheated space or a space belonging to another building unit.

If embedded heat emitters with different characteristics (e.g. insulation) are used in the heating installation, it is necessary to take this into account by separate calculations.

If the increased temperature in the building element has been taken into account in the calculations according to EN ISO 13790, this shall not be done again.

5.2.4 Control of the indoor temperature

This method covers only control of the heat emission system and does not take into account the influences, which the control (central or local) may have on efficiency of the heat generation system and on heat losses from the heat distribution system.

A non-ideal control may cause temperature variations and drifts around the prefixed set point temperature, due to the physical characteristics of the control system, sensor locations and characteristics of the heating system itself. This may result in increased or decreased heat losses through the building envelope compared to heat losses calculated with the assumption of constant internal temperature. The ability to utilize internal gains (from people, equipment, solar radiation) depends on the type of heat emission system and control method (Figure 2). The calculation of the energy use according to EN ISO 13790 are based on a constant internal temperature, while the real room temperature (as indicated in Figure 2) will vary according to control concept and variations in internal loads.

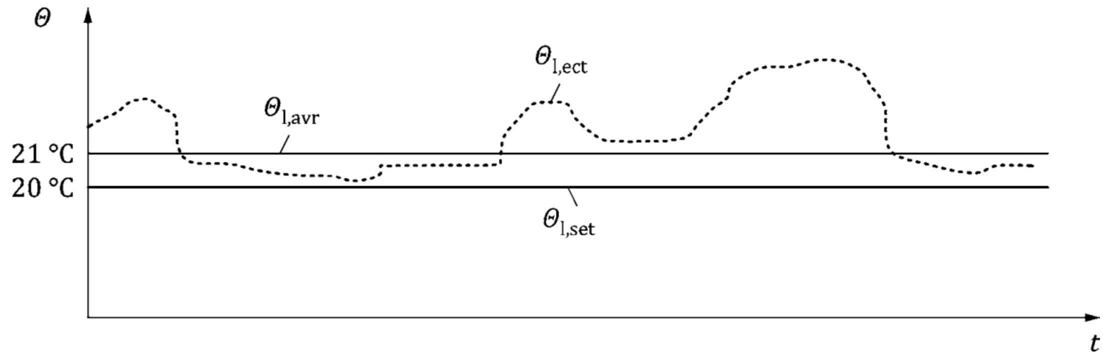

Figure 2 — Effect of control accuracy as efficiency or equivalent increase in space temperature

5.2.5 Effects of room automatisation

Heating or cooling systems in residential and non-residential buildings can demand-oriented operated intermittently. The reduction in room temperature with intermittent operation of heating systems depends essentially on the reduction- or off time, the transmission and ventilation heat loss, the outside temperature as well as the effectual thermal mass of the room. With room automatisation systems the potential reduction of room temperature can be utilized better. Because the above mentioned influencing factors are often unknown a global temperature variation caused by room automatisation is assumed. Regarding the functionality of the room automatisation system it is differentiated into 3 levels as follows with increasing temperature variation.

1. stand alone room automatisation

This covers systems without networked operation and fixed heating-up times.

2. stand alone room automatisation with self-adoption start / stop

This covers systems without networked operation and optimized heating-up times.

3. networked room automatisation with self-adoption and interaction

This covers systems with networked operation and optimized heating-up times.

5.2.6 Combined outside temperature for cool emission systems

In addition to the difference between room and outside temperature the cooling load is influenced essentially by solar and internal gains. To account for this, the outside temperature is corrected by a temperature difference to ensure adequate temperature differences between room and outside temperature as reference value for the calculation of additional emission losses.

6 Calculation Method

6.1 Output data

The output data of this method are listed in Table 3.

Table 3 — 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 steps

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 standard shall be the data supplied by the manufacturer if they are declared according to relevant EN 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 certified measurements performed according to the relevant product standards. If values declared by the manufacturer are not available, then default values are given in informative Annex B.

Required technical data for this calculation procedure are listed in Table 4.

Table 4 — 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
affect of supply water temperature on 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
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

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 – 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	$\Delta\theta_{roomout}$	K	K	−5…+5	6.4.2	No
radiant factor of radiant heaters for room heights ≥ 4m	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 5 — 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 6.

Table 6 — 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…8760	M1–9	Yes
total time of generator(s) operation	t_{gnr}	h	0…8760	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
operation time of the fans in the calculation period	$t_{h,rl}$	h	0…8760	M1–6	Yes
analytical running time (monthly or other period)	t_h	h	0…8760	M1–6	Yes

6.4 Monthly and yearly calculation procedure

6.4.1 Applicable calculation interval

This calculation procedure can be used with the following calculation interval:

— monthly;

— yearly.

6.4.2 Operating conditions calculation

Not relevant.

6.4.3 Energy calculation (additional heating / cooling losses)

This section gives a detail method for 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 using equivalent internal temperature.

The present standard will present an overall method to calculate the additional heat / cooling losses and energy efficiency. In Annex A only the structure of the tables are included. Default values for the calculation are given in Annex B. The internal temperature is affected by:

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

— the control variation depending on the capacity of the control device to ensure an homogeneous and constant temperature;

— the temperature variation based on an 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 not balanced hydraulic systems;

— the temperature variation based on space automation system;

— the temperature variation based on controls system stand alone or networked operation of the system;

— the temperature variation based on type of emitter.

The equivalent internal temperature, $\theta_{int;inc}$ taking into account the emitter, is calculated by:

$$\theta_{H;int;inc} = \theta_{H;int;ini} + \Delta\theta_{int;inc} \ [°C] \quad (1a)$$

$$\theta_{C;int;inc} = \theta_{C;int;ini} - \Delta\theta_{int;inc} \ [°C] \quad (1b)$$

where

$\theta_{H;int,ini}$	is the initial internal heating temperature (°C);
$\theta_{C;int,ini}$	is the initial internal cooling temperature (°C);
$\Delta\theta_{str}$	is the spatial variation of temperature due to stratification (K);
$\Delta\theta_{ctr}$	is the control variation (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 are available. $\Delta\theta_{ctr,2}$ should be used for calculation with certified products. Alternatively product specific values can be used if proved by certification.);
$\Delta\theta_{emb}$	is the 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);
$\Delta\theta$	is the temperature variation e.g. $\Delta\theta = \Delta\theta_{ctr} + \Delta\theta_{str} + \Delta\theta_{emb}$ (K);
$\Delta\theta_{rad}$	is the temperature variation based on radiation by type of the emission system (K);
$\Delta\theta_{im}$	is the temperature variation based on intermittent operation and based on the type of the emission system (K), $\Delta\theta_{im} = \Delta\theta_{im,emt} + \Delta\theta_{im,ctr}$
$\Delta\theta_{im,ctr}$	is the temperature variation based on intermittent operation of control (K);
$\Delta\theta_{im,emt}$	is the temperature variation based on intermittent operation on the type of the emission system (K);
$\Delta\theta_{hydr}$	is the temperature variation based on not balanced hydraulic systems (K);
$\Delta\theta_{roomaut}$	is the temperature variation based on stand alone or networked operation/ space automation of the system (K);
$\Delta\theta_{int;inc}$	is the temperature variation based on all losses (K);

NOTE Room/space automation system covers room wide temperature controls including an individual timer function, timer function with self-adoption of start / stop or timer function with self-adoption of start / stop and interaction with other controls or heating / cooling system devices.

$$\Delta\theta_{int;inc} = \Delta\theta_{str} + \Delta\theta_{ctr} + \Delta\theta_{emb} + \Delta\theta_{rad} + \Delta\theta_{im} + \Delta\theta_{hydr} + \Delta\theta_{roomaut} \ [K] \quad (2)$$

In case of using product data for control systems $\Delta\theta_{ctr}$ = CA-value.

Electronic controllers: CA – based on EN 15500 (see Table 7).

TRV: based on EN 215 (see Table 7).

with temperature variation based on emission system

$$\Delta\theta_{emt,syst} = \Delta\theta_{str} + \Delta\theta_{emb} + \Delta\theta_{rad} + \Delta\theta_{im,emt} \quad [K] \tag{3}$$

where

$\Delta\theta_{rad}$ is calculated for radiators in EN 442 (see Table 7).

$\Delta\theta_{im,emt}$ is calculated for embedded systems in EN 1264 (see Table 7).

and with temperature variation based on control system

$$\Delta\theta_{ctr,syst} = \Delta\theta_{ctr} + \Delta\theta_{im,ctr} + \Delta\theta_{roomout} \quad [K] \tag{4}$$

The equivalent internal temperature difference, $\Delta\theta_{int;inc}$ taking into account the emitter, is calculated by:

$$\Delta\theta_{\text{int},inc} = \Delta\theta_{hyd} + \Delta\theta_{emt,syst} + \Delta\theta_{ctr,syst} \quad [K] \tag{5}$$

In case of rooms with ceiling heights ≥ 4 m the temperature variation $\Delta\theta_{str}$ is calculated as specific value for different emitter systems as:

$$\Delta\theta_{str} = 10 \cdot \frac{\theta'_{str}}{a} \cdot \left(0,5 \cdot h_R - b\right) \quad [K] \tag{6}$$

With $a = 16K$ and $b = 1,1m$

h_R is the the room height (m),

θ'_{str} is the air temperature gradient (K/m) taken from following Table A.8 or B.8.

In case of rooms with ceiling heights ≥ 4 m the temperature variation $\Delta\theta_{rad}$ is calculated as specific value for different ceiling heights and emitter systems of radiant luminous and tube heaters as:

$$\Delta\theta_{rad} = 10 \cdot \left[\frac{0,36}{RF + 0,2} + 0,354 \cdot \left(\frac{70}{p_h}\right)^{0,12} \cdot \left(\frac{10}{h_R}\right)^{0,15} - 0,9\right] \quad [K] \tag{7}$$

where

RF is the Radiant Factor of radiant heaters according to EN 416–2 resp. EN 419–2 (product value)

p_h is the specific heat power in W/m² based on product values;

Formulas for $\Delta\theta_{rad}$ for radiant panels may be written in national annexes. The accordant values are determined on basis of radiant heat transfer according to EN 14037–3 (see Table 7).

NOTE Values for radiant heat transfer of radiant panels according to EN 14037–2 cannot be compared directly with values of radiant factors of radiant heaters according to EN 416–2 resp. EN 419–2 (see Table 7).

In case of using standard designs of radiant luminous or radiant tube heaters for ceiling heights ≥ 4m standard product values of RF are taken from Tables A.9 and B.9.

Table 7 — Interaction between product values and terms in EN 15316–2

Product	relevant standard	term
free heating surface (radiators)	EN 442	$\Delta\theta_{rad}$, $\Delta\theta_{im,emt}$
embedded heating and cooling systems	EN 1264	$\Delta\theta_{im,emt}$
not embedded radiant heating and cooling systems (open air gap)	EN 14037	$\Delta\theta_{im,emt}$
thermostatic controllers (TRV)	EN 215	$\Delta\theta_{ctr}$ = CA
electronic controllers	EN 15500	$\Delta\theta_{ctr}$ = CA
radiant luminous and tube heaters	EN 416–2 resp. EN 419–2	RF
Fan assisted radiators	EN 16430	$\Delta\theta_{rad}$
Electrical radiators	EN 14337	$\Delta\theta_{rad}$
electric infrared emitters for industrial heating	EN 60240–1	RF

The additional heat / cooling losses of emission in kWh are calculated as:

$$Q_{em,ls} = Q_{em,out} \cdot \left(\frac{\Delta\theta_{\text{int},inc}}{\theta_{\text{int},inc} - \theta_{e,comb}} \right) \text{ [kWh]} \quad (8)$$

Where for heating emission:

$$\theta_{e,comb} = \theta_{e,avg} \text{ [°C°]} \quad (9a)$$

and for cooling emission:

$$\theta_{e,comb} = \theta_{e,avg} + \Delta\theta_{e,sol} \text{ [°C]} \quad (9b)$$

The values $\theta_{e,avg}$ is an input value from EN 15316-1. Default values for $\Delta\theta_{e,sol}$ are given in B.7.

In individual application cases this breakdown is not required. The annual losses for the heating and cooling emission in the room space is calculated as

$$Q_{em,ls,an} = \sum Q_{em,ls} \text{ [kWh]} \quad (10)$$

where

$Q_{em,ls,an}$ is the annual loss of the heating / cooling emission, in kWh;

$Q_{em,ls}$ is the loss of the heating / cooling emission (in the time period), in kWh.

The annual thermal output of the heating/cooling emission in the room space is calculated as

$$Q_{em,out,an} = \sum Q_{em,out} \text{ [kWh]} \quad (11)$$

A heating / cooling system may, as required, be split up in zones with different heating / cooling emission systems, and the heating / cooling loss calculations can be applied individually for each zone. The considerations given in EN 15316-1 regarding splitting up or branching of the heating / cooling system shall be followed. If the principle of adding up the heating / cooling losses is respected, it is always possible to combine zones with different heating / cooling emission systems.

Based on the result of the calculation a characteristic value (annual expenditure factor) for heat and cooling emission can be calculated.

$$\varepsilon_{em,ls,an} = \frac{Q_{em,out,an} + Q_{em,ls,an}}{Q_{em,out,an}} \quad [-] \tag{12}$$

6.4.4 Auxiliary energy calculation

With Formula (13) the auxiliary energy is balanced that serves to improve the heating / cooling emission processes in the room space and is not recorded in the above calculations.

$$W_{em,ls,aux} = W_{fan} \quad [\text{kWh}] \tag{13}$$

where

$W_{em,ls,aux}$ is the auxiliary energy (in the period), in kWh;

W_{fan} is the auxiliary energy of fans in the calculation period, in kWh;

The individual component W_{fan} is to be determined from Formulae (14).

$$W_{fan} = \sum \frac{P_{\text{fan}} \cdot n_{fan} \cdot t_{h,rL}}{1000} \quad [\text{kWh}] \tag{14}$$

where

n_{fan} is the number of ventilator/fan units;

$t_{h,rL}$ is the operation time of the system in the calculation period, in h

P_{fan} is the electrical rated power consumption of the ventilators/fans (from Table A13/B13 or product data), in W;

Auxiliary energy calculation in large indoor space buildings (h > 4 m) – systems with direct heating

In large indoor space buildings in particular, heating equipment is used, the method of working of which cannot logically be differentiated into sub-systems of heat generation and heat emission, and which at the same time is installed in the room space in which it is used (e.g. gas and infrared radiators).

The total auxiliary energy of these systems is credited to the heat and cooling demand of the installation room space (see Table A13/B13, upper section).

$$W_{em,ls,aux} = \sum \frac{P_{\text{H,aux}} \cdot n_{H,aux} \cdot t_{h}}{1000} \quad [\text{kWh}] \tag{15}$$

where

$W_{em,ls,aux}$ is the monthly or other period auxiliary energy (heat emission and, if necessary heat generation), in kWh;

$P_{H,aux}$ is the rated power consumption of the equipment from Table A12/B12 or manufacturer data (heat generation and heat emission), in W;

$n_{H,aux}$ is the number of equipment

t_h is the monthly or other period analytical running time, in h.

The operating duration of the ventilator/fan including control system is set equal to the operating time of the heating system. In Table A13/B13 are prescribed the standard values for the auxiliary energy of fans and for the control system in room spaces h > 4 m in height (large indoor space buildings).

6.5 Hourly calculation procedure

6.5.1 Applicable calculation interval

This calculation procedure can be used with the following calculation interval:

— hourly.

6.5.2 Operating conditions calculation

Not relevant !

6.5.3 Energy calculation (additional heating / cooling losses)

This section gives a detail method for 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 using equivalent internal temperature.

The present standard will present an overall method to calculate the additional heat / cooling losses and energy efficiency. In Annex A only the structure of the tables are included. Default values for the calculation are given in Annex B. The internal temperature is affected by:

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

— the control variation depending on the capacity of the control device to ensure an homogeneous and constant temperature;

— the temperature variation based on an 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 not balanced hydraulic systems;

— the temperature variation based on space automation system;

— the temperature variation based on controls system stand alone or networked operation of the system;

— the temperature variation based on type of emitter.

There are two types of temperature variations. The first one is used to modify the set point temperature by $\Delta\theta_{int;inc}$

The equivalent internal temperature, $\theta_{int;inc}$ taking into account the emitter, is calculated by:

$$\theta_{int,inc} = \theta_{int,ini} + \Delta\theta_{int,inc} \quad [°C] \tag{16}$$

$$\Delta\theta_{int;inc} = \Delta\theta_{str} + \Delta\theta_{ctr} + \Delta\theta_{rad} + \Delta\theta_{hydr} + \Delta\theta_{roomaut} \quad [K] \tag{17}$$

where

$\theta_{int,ini}$	is the initial internal temperature (°C);
$\Delta\theta_{str}$	is the spatial variation of temperature due to stratification (K);
$\Delta\theta_{ctr}$	is the control variation (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 are available. $\Delta\theta_{ctr,2}$ should be used for calculation with certified products. Alternatively product specific values can be used if proved by certification.);
$\Delta\theta_{rad}$	is the temperature variation based on radiation by type of the emission system (K);
$\Delta\theta_{hydr}$	is the temperature variation based on not balanced hydraulic systems (K);
$\Delta\theta_{roomaut}$	temperature variation based on stand alone or networked operation/ space automation of the system (K);

In case of using product data for control systems $\Delta\theta_{ctr}$ = CA-value.

Electronic controllers:	CA – based on EN 15500 (see Table 7).
TRV:	based on EN 215 (see Table 7).

$\Delta\theta_{rad}$ is calculated for radiators in EN 442 (see Table 7).

In case of rooms with ceiling heights ≥ 4 m the temperature variation $\Delta\theta_{str}$ is calculated as specific value for different emitter systems as:

$$\Delta\theta_{str} = 10 \cdot \frac{\theta'_{str}}{a} \cdot \left(0,5 \cdot h_R - b\right) \text{ [K]} \tag{18}$$

With $a = 16K$ and $b = 1,1m$

h_R	is the the room height (m),
θ'_{str}	is the air temperature gradient (K/m) taken from following Table A8/B8.

In case of rooms with ceiling heights ≥ 4 m the temperature variation $\Delta\theta_{rad}$ is calculated as specific value for different ceiling heights and emitter systems of radiant luminous and tube heaters as:

$$\Delta\theta_{rad} = 10 \cdot \left[\frac{0,36}{RF + 0,2} + 0,354 \cdot \left(\frac{70}{p_h}\right)^{0,12} \cdot \left(\frac{10}{h_R}\right)^{0,15} - 0,9\right] \text{ [K]} \tag{19}$$

where

RF	is the Radiant Factor of radiant heaters according to EN 416–2 resp. EN 419–2 (product value)
p_h	is the specific heat power in W/m² based on product values;

In case of using standard designs of radiant luminous or radiant tube heaters for ceiling heights ≥ 4m standard product values of RF are taken from Table A.9 and B.9.

Formulas for $\Delta\theta_{rad}$ for radiant panels may be written in national annexes. The accordant values are determined on basis of radiant heat transfer according to EN 14037-3 (see Table 7).

NOTE 1 Values for radiant heat transfer of radiant panels according to EN 14037–2 cannot be compared directly with values of radiant factors of radiant heaters according to EN 416–2 resp. EN 419–2 (see Table 7).

NOTE 2 $\Delta\theta_{rad}$ is not based on the convective (or radiative) part of the emission system.

Table 8 — Interaction between product values and terms in EN 15316–2

Product	relevant standard	term
free heating surface (radiators)	EN 442	$\Delta\theta_{rad}$, $\Delta\theta_{im,emt}$
embedded heating and cooling systems	EN 1264	$\Delta\theta_{im,emt}$
not embedded radiant heating and cooling systems (open air gap)	EN 14037	$\Delta\theta_{im,emt}$
thermostatic controllers (TRV)	EN 215	$\Delta\theta_{ctr}$ = CA
electronic controllers	EN 15500	$\Delta\theta_{ctr}$ = CA
radiant luminous and tube heaters	EN 416–2 resp. EN 419–2	RF
Fan assisted radiators	EN 16430	$\Delta\theta_{rad}$
Electrical radiators	EN 14337	$\Delta\theta_{rad}$
electric infrared emitters for industrial heating	EN 60240–1	RF

The total useful output of the emission system $Q_{em,out,inc}$ is the minimum of the calculated emission output according to M2.2 with the modified set point temperature by $\Delta\theta_{\text{int};inc}$ and the design useful nominal power Φ_{Hemn}x1h.

The embedded losses are calculated to the following formula:

$$Q_{emb,ls} = Q_{em,out,inc} \cdot \left(\frac{\Delta\theta_{emb}}{\theta_{\text{int},inc} - \theta_{e,comb}} \right) \text{ [kWh]} \quad (20)$$

where

$\Delta\theta_{emb}$ is the 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);

And where for heating emission:

$$\theta_{e,comb} = \theta_{e,avg} \text{ [°C]} \quad (21a)$$

and for cooling emission:

$$\theta_{e,comb} = \theta_{e,avg} + \Delta\theta_{e,sol} \text{ [°C]} \quad (21b)$$

The values $\theta_{e,avg}$ is an input value from EN 15316-1. Default values for $\Delta\theta_{e,sol}$ are given in B.7.

The convective fraction of the heating/cooling emitter, which is useful for the calculation in M2.2 is defined by $f_{em,conv}$. Product values are given in Tables A.17or B.17.

The total heat / cooling losses of emission in kWh are calculated as:

$$Q_{em,ls} = Q_{em,out,inc} - Q_{em,out} + Q_{emb,ls} \text{ [kWh]} \quad (22)$$

The required energy input to the emission system is calculated by

$$Q_{em,in} = Q_{em,out} + Q_{em,ls} \text{ [kWh]} \quad (23)$$

The annual losses for the heating and cooling emission in the room space is calculated as

$$Q_{em,ls,an} = \sum Q_{em,ls} \text{ [kWh]} \quad (24)$$

where

$Q_{em,ls,a}$ is the annual loss of the heating / cooling emission, in kWh;

$Q_{em,ls}$ is the loss of the heating / cooling emission (in the time period), in kWh.

The annual thermal output of the heating/cooling emission in the room space is calculated as

$$Q_{em,out,an} = \sum Q_{em,out} \text{ [kWh]} \quad (25)$$

A heating / cooling system may, as required, be split up in zones with different heating / cooling emission systems, and the heating / cooling loss calculations can be applied individually for each zone. The considerations given in EN 15316-1 regarding splitting up or branching of the heating / cooling system shall be followed. If the principle of adding up the heating / cooling losses is respected, it is always possible to combine zones with different heating / cooling emission systems.

Based on the result of the calculation a characteristic value (annual expenditure factor) for heat and cooling emission can be calculated.

$$\varepsilon_{em,ls,an} = \frac{Q_{em,out,an} + Q_{em,ls,an}}{Q_{em,out,an}} \text{ [-]} \quad (26)$$

Auxiliary energy calculation

With Formula (27) the auxiliary energy is balanced that serves to improve the heating / cooling emission processes in the room space and is not recorded in the above calculations.

$$W_{em,ls,aux} = W_{fan} \text{ [kWh]} \quad (27)$$

where

$W_{em,ls,aux}$ is the auxiliary energy (in the period), in kWh;

W_{fan} is the auxiliary energy of fans in the calculation period, in kWh;

The individual component W_{fan} is to be determined from Formulae (14).

$$W_{fan} = \sum \frac{P_{fan} \cdot n_{fan}}{1000} \text{ [kWh]} \quad (28)$$

where

n_{fan} is the number of ventilator/fan units;

P_{fan} is the electrical rated power consumption of the ventilators/fans (from Table A12/B12 or product data), in W;

Auxiliary energy calculation in large indoor space buildings (h > 4 m) – systems with direct heating

In large indoor space buildings in particular, heating equipment is used, the method of working of which cannot logically be differentiated into sub-systems of heat generation and heat emission, and which at the same time is installed in the room space in which it is used (e.g. gas and infrared radiators).

The total auxiliary energy of these systems is credited to the heat and cooling demand of the installation room space (see Table A.13 or B.13 upper section).

$$W_{em,ls,aux} = \sum \frac{P_{\mathrm{H,aux}} \cdot n_{H,aux}}{1000} \quad [\mathrm{kWh}] \tag{29}$$

where

$W_{\mathrm{em,ls,aux}}$ is the hourly or other period auxiliary energy (heat emission and, if necessary heat generation), in kWh;

$P_{\mathrm{H,aux}}$ is the rated power consumption of the equipment from Table A12/B12 or manufacturer data (heat generation and heat emission), in W;

$n_{\mathrm{H,aux}}$ is the number of equipment

The operating duration of the ventilator/fan including control system is set equal to the operating time of the heating system. In Table A.13 or B.13 are prescribed the standard values for the auxiliary energy of fans and for the control system in room spaces h > 4 m in height (large indoor space buildings).

7 Quality control

not relevant

8 Compliance check

To check if the calculation procedure is applicable/was applied correctly to the installed system, check the following items for heating and cooling application:

— type of room controller;

— type of room automation system;

— type of room emission system;

— height of the room.

Annex A
(informative)

Template for choices, input data and references (Additional heating and cooling losses / auxiliary energy)

A.1 Introduction

For the correct use of this Technical Report, the template given in this Annex shall be used to specify the choices between methods, the required input data and references to other standards.

NOTE 1 A complete set of informative default choices, input data and references are provided in Annex B.

NOTE 2 Following this template is necessary but not enough to guarantee consistency of data.

NOTE 3 In particular for the application within the context of EU Directives transposed into national legal requirements, the values and choices can be imposed by national / regional regulations. If the values and default choice of Annex B are not adopted because of the regulations, policies or national traditions, it is expected that:

— national or regional authorities prepare data sheets containing the choices, national or regional input data and references, according to the template in Annex A. In this case the National Annex (e.g. Annex NA, NB, ..) should provide a reference to these specifications;

— or, by default, the national standardization body will consider the possibility to prepare a National Annex (e.g. Annex NA, NB, ..)complying with the template of Annex A, that provides choices, national or regional input data and references specified in the legal documents.

NOTE 4 Where necessary for certain input values to be acquired by the user, a datasheet according to the template of Annex A may contain a reference to national procedures for assessing the needed input data. For instance to a national assessment protocol comprising decision trees, tables and pre-calculations.

NOTE 5 Drafting an application document according to the template in Annex A is open for different situations e.g. design of new building, certification of new building, renovation of existing building and certification of existing building and for different types of buildings e.g. small or simple buildings and large or complex buildings.. This can be done by developing different versions this application document. In such application document it is possible to add information about, e.g. applicable national or regional regulations.

If product specific values are available these may be used instead of the values in following Tables A.1 to A.13, compare normative Annex: C.

The temperature variation for hydraulic balancing is described in Table A.1

Table A.1 — Default values for temperature variation for hydronic balancing in K

Influence parameters (Performed hydronic balancing with manufacturer's declaration on the balance and in coordination with EN 14336)				
One pipe heating	$\Delta\theta_{hydr}$	**Two pipe heating**	$*n \le 10$ $\Delta\theta_{hydr}$	$*n > 10$ $\Delta\theta_{hydr}$
No hydronic balancing		No hydraulic balancing		
Balanced statically per circuit		Balanced statically per free heating surface (radiator) or embedded heating surface, without group balance		
Balanced dynamically per circuit (e.g. with automatic flow limiters)		Balanced statically per free heating surface (radiator) or embedded heating surface, with group balance (e.g. with balancing valve)		
Balanced dynamically per circuit (e.g. with automatic flow limiters) and dynamically controlled depending on its load (e.g. return temperature limitation)		Balanced statically per free heating surface (radiator) or embedded heating surface (radiator) and dynamic group balance (e.g. with differential pressure controller)		
Balanced dynamically per circuit (e.g. with automatic flow limiters) and dynamically controlled depending on its load (supply-return temperature difference)		Balanced dynamically per free heating surface (radiator) or embedded heating surface (e.g. with automatic flow limiters / differential pressure controllers)		
n – number of heat and cooling emission systems (e.g. number of radiators…)				

A.2 Temperature variation for free heating surfaces (radiators), room heights ≤ 4 m (heating case)

In Table A.2 the temperature variation for free heating surfaces are described.

Table A.2 — Temperature variation free heating surfaces (radiators), room heights ≤ 4 m (heating case)

Influence parameters		Variation				
		$\Delta\theta_{str}$		$\Delta\theta_{ctr\ 0,1}$[b]	$\Delta\theta_{ctr,2}$[c]	$\Delta\theta_{emb}$
Room space temperature regulation	Unregulated, with central supply temperature regulation Master room space or one-pipe heating Room temperature control (electromechanical / electronic) P-controller (before 1988) P-controller PI-controller PI-controller (with optimization function, e.g. presence management, adaptive controller)					
Over-temperature (reference Θ_i = 20 °C)	Two-pipe heating and one-pipe heating renovated [d]	$\Delta\theta_{str,1}$	$\Delta\theta_{str,2}$			
	60 K (e.g. 90/70) 42,5 K (e.g. 70/55) 30 K (e.g. 55/45) 20 K (e.g. 45/35) One-pipe heating (not renoveted) 60 K (e.g. 90/70) 42,5 K (e.g. 70/55) Heating systems combined with mechanical ventilation [e] Fan assisted radiators / fan coil units [e]					
Specific heat losses via external components (GF = glass surface area)	Radiator location internal wall Radiator location external wall - GF without radiation protection - GF with radiation protection [a] - external wall					

[a] The radiation protection shall prevent 80 % of the radiation losses from the heating body to the glass surface area by means of insulation and/or reflection.

[b] use $\Delta\theta_{ctr\ ;1}$ for not certified products

[c] use $\Delta\theta_{ctr\ ;2}$ for certified products

[d] one-pipe heating is assumed as renovated, if the flow rate is dynamically controlled depending on the load and the distribution pipes are insulated

[e] When heating systems are installed in rooms equipped with mechanical ventilation systems the temperature stratification is influenced

For $\Delta\theta_{str}$ an average value is to be formed from the data for the main influence parameters “over-temperature” and “specific heat losses via external components”.

$$\Delta\theta_{str} = (\Delta\theta_{str,1} + \Delta\theta_{str,2})/2 \text{ [K]} \quad (A.1)$$

Temperature variation for intermittent operation

controls $\Delta\theta_{im,ctr}$ = ...

emitters $\Delta\theta_{im,emt}$ = ...

Temperature variation for radiation effect: $\Delta\theta_{rad}$ = ...

Alternatively product specific values for $\Delta\theta_{rad}$ in accordance to product standards can be used.

Temperature variation for room automation $\Delta\theta_{roomaut}$ = ...

stand alone

stand alone with self-adoption start / stop

networked with self-adoption and interaction

(Interaction in the form of individual room control system includes the connection of the individual room control system with additional controls and / or the heat source - for example, supply temperature adaptation)

A.3 Temperature Variation for component integrated heating surfaces (panel heaters) (room heights ≤ 4 m, heating case)

In Table A.3 the temperature variation for component integrated heating surfaces (panel heaters) (room heights ≤ 4 m) are prescribed.

Table A.3 — Temperature variation for component integrated heating surfaces (panel heaters); room heights ≤ 4 m (heating case)

influence parameters		Variation				
		$\Delta\theta_{str}$	$\Delta\theta_{ctr,1}$ [a]	$\Delta\theta_{ctr,2}$ [b]	$\Delta\theta_{emb}$	
Room space temperature regulation	unregulated, with central supply temperature regulation					
	Master room space					
	Room temperature control (e.g. 2-step controller)					
	P-controller (before 1988)					
	P-controller / 2-step controller (hysteresis ≤ ± 0,5 K)					
	PI-controller					
	PI-controller (with optimization function, e.g. presence management, adaptive controller)					
System	Floor heating			□	$\Delta\theta_{emb,1}$	$\Delta\theta_{emb,2}$
	- screed system					
	- dry system					
	- system with low cover					
	Wall heating					
	Ceiling heating					
	Heating systems combined with mechanical ventilation[c]					
Specific heat losses via laying surfaces	Integrated heating surface without minimum insulation in accordance with EN 1264					
	Integrated heating surface with minimum insulation in accordance with EN 1264					
	Integrated heating surface with 100 % better insulation than required by EN 1264					

[a] use $\Delta\theta_{ctr\,;1}$ for not certified products

[b] use $\Delta\theta_{ctr\,;2}$ for certified products

[c] When heating systems are installed in room equipped with mechanical ventilation systems the temperature stratification is influenced

For $\Delta\theta_{emb}$ an average value is to be formed from the data for the main influence parameters “system” and “specific heat losses via laying surfaces”.

$$\Delta\theta_{emb} = (\Delta\theta_{emb,1} + \Delta\theta_{emb,2})/2 \text{ [K]} \quad \text{(A.2)}$$

In Table A.4 the overall temperature variation ($\Delta\theta = \Delta\theta_{ctr} + \Delta\theta_{str} + \Delta\theta_{emb}$) for thermally activated building systems (room heights ≤ 4 m) are prescribed.

Table A.4 — Default values for temperature variation for component integrated heating surfaces (thermally activated building systems); room heights ≤ 4 m; heating case

Influence parameters		Variation $\Delta\vartheta$
Control	Constant supply temperature	
	Central supply temperature regulation	

Temperature variation for radiation effect: $\Delta\theta_{rad}$ =

Alternatively product specific values for $\Delta\theta_{rad}$ in accordance to product standards can be used.

Temperature variation for intermittent operation

controls $\Delta\theta_{im,ctr}$ = …

emitters $\Delta\theta_{im,emt}$ = …

Temperature variation for room / space automation $\Delta\theta_{roomaut}$ = …

stand alone

stand alone with self-adoption start / stop

networked with self-adoption and interaction

(Interaction in the form of individual room control system includes the connection of the individual room control system with additional controls and / or the heat source - for example, supply temperature adaptation)

A.4 Temperature variation for air heating systems; room heights ≤ 4 m (heating case)

For air heating systems the calculation has to be done with the following values:

Air heating system (mixing case) $\Delta\theta_{str}$ =

$\Delta\theta_{ctr;1}$ =

$\Delta\theta_{ctr;2}$ =

$\Delta\theta_{emb}$ =

Temperature variation for intermittent operation

controls$\Delta\theta_{im,ctr}$ =

emitters $\Delta\theta_{im,emt}$ =

Temperature variation for radiation effect: $\Delta\theta_{rad}$ =

Temperature variation for room automation

stand alone $\Delta\theta_{roomaut}$ =

stand alone with self-adoption start / stop $\Delta\theta_{roomaut}$ =

networked with self-adoption and interaction $\Delta\theta_{roomaut}$ =

(Interaction in the form of individual room control system includes the connection of the individual room control system with additional controls and / or the heat source - for example, supply temperature adaptation.)

A.5 Temperature Variation for electrical heating (room heights ≤ 4 m, heating case)

In Table A.5 the temperature variation for electrical heating (room heights ≤ 4 m) are prescribed.

Table A.5 — Temperature variation for electrical heating and air heating systems in K (room heights ≤ 4 m, heating case)

<table>
<tr><th colspan="2">Influence parameters</th><th>Variation
$\Delta\theta$</th></tr>
<tr><td rowspan="7">External wall region</td><td>Air heating with zone control P-controller (1 K)</td><td></td></tr>
<tr><td>Air heating with central master control and pilot room control including supplementary heating with single-room control P-controller (1K)</td><td></td></tr>
<tr><td>E- direct heating P-controller (1 K) or air heating with single-room control P-controller (1 K)</td><td></td></tr>
<tr><td>E- direct heating PI-controller (with optimization) or air heating with single-room control PI-controller (with optimization)</td><td></td></tr>
<tr><td>Storage heating unregulated without external temperature dependent charging</td><td></td></tr>
<tr><td>Storage heating P-controller (1 K) with external temperature dependent charging</td><td></td></tr>
<tr><td>Storage heating PID-controller with optimization with external temperature dependent charging</td><td></td></tr>
<tr><td rowspan="7">Internal wall region</td><td>Air heating with zone control P-controller (1 K)</td><td></td></tr>
<tr><td>Air heating with central master control and pilot room control including supplementary heating with single-room control P-controller (1K)</td><td></td></tr>
<tr><td>E- direct heating P-controller (1 K) or air heating with single-room control P-controller (1 K)</td><td></td></tr>
<tr><td>E- direct heating PI-controller (with optimization) or air heating with single-room control PI-controller (with optimization)</td><td></td></tr>
<tr><td>Storage heating unregulated without external temperature dependent charging</td><td></td></tr>
<tr><td>Storage heating P-controller (1 K) with external temperature dependent charging</td><td></td></tr>
<tr><td>Storage heating PID-controller with optimization with external temperature dependent charging</td><td></td></tr>
<tr><td colspan="2">Ventilation Systems with supply air temperature below the room temperature</td><td></td></tr>
</table>

Temperature variation for intermittent operation: $\Delta\theta_{im}$ = … (to be used for electrical heating systems with an integrated feedback control system)

Temperature variation for radiation effect: $\Delta\theta_{rad}$ =

Alternatively product specific values for $\Delta\theta_{rad}$ in accordance to product standards can be used.

A.6 Temperature Variation air heating (ventilation systems, room heights ≤ 4 m, heating case)

In Table A.6 the temperature variation $\Delta\theta_{em,ls}$ for air heating (non-domestic ventilation systems, room heights ≤ 4 m) are prescribed.

Table A.6 — Temperature variation for air heating (non-domestic ventilation systems, room heights ≤ 4 m, heating case)

System configuration	**Control parameter**	$\Delta\theta$	
		Low quality of control	**High quality of control**
Additional heating in the incoming air (additional heater)	Room space temperature		
	Room space temperature (cascade control of incoming air temperature)		
	Exhaust air temperature		
Recirculation air heating (induction equipment, ventilator convectors, fan coil units)	Room space temperature		

NOTE The auxiliary energy for the recirculation air heating is to be taken from Table B.2.

A.7 Temperature variation for room spaces with heights > 4 m (large indoor space buildings, heating case)

In Table A.7 the temperature variation for room spaces with heights ≥ 4 m are prescribed.

Table A.7 — temperature variation for room spaces with heights > 4 m (heating case) reference case: ceiling height 10 m, standard product values radiant factors of luminous and tube heaters and tube heaters)

Influence parameters			variation		
			$\Delta\theta_{ctr,1}$[a]	$\Delta\theta_{ctr,2}$ [b]	$\Delta\theta_{emb}$
Room space temp. regulation	Unregulated Two-step controller P-controller PI-controller PI-controller with optimization				
	Warm air <u>without</u> additional vertical recirculation	Outlet horizontal (wall unit)			
		Outlet horizontal (wall unit) low temperature system[c] (valid only up to ceiling heights of 6 m)			
		Outlet from above (ceiling unit)			
		Outlet from vertical (ceiling unit) low temperature system[d] (valid only up to ceiling heights of 6 m)			
	Warm air <u>with</u> additional vertical recirculation or adjustable induction outlet	Recirculation controlled by two-step controller			
		Recirculation controlled by PI-controller			
	Radiant tube heaters	standard Design			
		improved Design			
	Luminous heaters	standard Design			
		improved Design			
	Radiant ceiling panels	standard Design			
		improved Design			
		improved design and keeping distances to the wall			
	Floor heating	Without isolation (coverage ≤ 10cm)			
		Without isolation (coverage > 10cm)			
		Integrated into the component (minimum insulation in accordance with EN 1264 (coverage ≤ 10cm),			
		Integrated into the component (minimum insulation in accordance with EN 1264 (coverage > 10cm),			
		Thermally decoupled ($U_{bottom\ plate}$ ≤ 0,35 W/(m²K)) and coverage ≤ 10cm			

[a] use $\Delta\theta_{ctr;1}$ for not certified products.

[b] use $\Delta\theta_{ctr;2}$ for certified products, alternative $\Delta\theta_{ctr;2}$ can be calculated for TRV-systems based on EN 215.

[c] the outcoming temperature has to be max. 15 K higher than the required internal temperature; the value $\Delta\theta_{str}$ = 1,03 may only be used for ceiling heights ≤ 6m. For larger ceiling heights the value $\Delta\theta_{str}$ = 2,93 has to be used.

[d] the outcoming temperature has to be max. 15 K higher than the required internal temperature; the value $\Delta\theta_{str}$ = 1,03 may only be used for ceiling heights ≤ 6m. For larger ceiling heights the value $\Delta\theta_{str}$ = 1,76 has to be used.

Table A.8 — Air temperature gradient for rooms with ceilings heights > 4 m

Emitter System		**Air temperature gradient θ'_{str} [K/m]**
Warm air heaters Without additional vertical recirculation	Outlet horizontal (wall unit)	
	Outlet horizontal (wall unit) low temperature system[c] (valid only up to ceiling heights of 6 m)	
	Outlet from above (ceiling unit)	
	Outlet from above (ceiling unit) low temperature system[d] (valid only up to ceiling heights of 6 m)	
Warm air heaters With additional vertical recirculation	Recirculation controlled by two-step controller	
	Recirculation controlled by PI-controller	
Radiant tube heaters	standard Design	
	improved Design[1]	
Luminous heaters	standard Design	
	improved Design[2]	
Radiant ceiling panels	standard Design	
	improved Design	
	improved design and keeping distances to the wall	
Floor heating	Without isolation (coverage ≤ 10cm)	
	Without isolation (coverage > 10cm)	
	Integrated into the component (minimum insulation in accordance with EN 1264 (coverage ≤ 10cm),	
	Integrated into the component (minimum insulation in accordance with EN 1264 (coverage > 10cm),	
	Thermally decoupled ($U_{bottom\ plate}$ ≤ 0,35 W/(m²K)) and coverage ≤ 10cm	

Table A.9 — Standard product values of Radiant Factors for radiant luminous and radiant tube heaters in rooms with ceiling heights > 4 m

Heater	Classification	RF
Radiant tube heater	standard	
	improved design[a]	
Radiant luminous heaters	standard	
	improved design[b]	

[a] Improved design radiant tube heaters: feature construction with completely insulated reflector; in case value for "improved design" is used for heat demand calculation, the product value for radiant factor RF acc. EN 416–2 has to be minimum 0,69.

[b] Improved design radiant luminous heaters: feature construction with reflector overstreamed by flue gases; in case value for "improved design" is used for heat demand calculation, the product value for radiant factor RF acc. EN 419–2 has to be minimum 0,69.

A.8 Temperature variation for room heaters fired by solid fuel

In Table A.10 the temperature variation for room heaters fired by solid fuel are prescribed.

Table A.10 — temperature variation for room heaters fired by solid fuel

Influence parameters		Variation		
		$\Delta\Theta_{str}$	$\Delta\Theta_{ctrl,1}$	$\Delta\Theta_{ctrl,2}$
System	Used on one single floor			
	Used for 2 floors			
Control	Manual thermostat			
	Room thermostat			

A.9 Temperature variation for water based cooling systems; room heights ≤ 4 m (cooling case)

Table A.11 — temperature variation for cooling systems; room heights ≤ 4 m (cooling case)

influence parameters		Variation			
		$\Delta\theta_{str}$	$\Delta\theta_{ctr\ 0,1}$[a]	$\Delta\theta_{ctr,2}$ [b]	$\Delta\theta_{emb}$
Room space temperature regulation	unregulated, with central supply temperature regulation Master room space or one-pipe heating Room temperature control (electromechanical / electronic) P-controller (before 1988) P-controller PI-controller PI-controller (with optimization function, e.g. presence management, adaptive controller)				
System	Floor cooling system Wall cooling Ceiling cooling Radiators assisted with fan / fan coil unit - located on the ceiling - located on external wall			□	

[a] use $\Delta\theta_{ctr\ ;1}$ for not certified products

[b] use $\Delta\theta_{ctr\ ;2}$ for certified products

For $\Delta\theta_{emb}$ an average value is to be formed from the data for the main influence parameters “system” and “specific heat losses via laying surfaces”.

Temperature variation for consideration of solar and internal gains

average proportion of window area or internal loads (e.g. residential buildings) $\Delta\theta_{e,sol}$ =

high proportion of window area or internal loads (e.g. office buildings) $\Delta\theta_{e,sol}$ =

Temperature variation for intermittent operation

controls $\Delta\theta_{im,ctr}$ =

emitters $\Delta\theta_{im,emt}$ =

Temperature variation for radiation effect: $\Delta\theta_{rad}$ =

Alternatively product specific values for $\Delta\theta_{rad}$ in accordance to product standards can be used.

Temperature variation for room automation

stand alone $\Delta\theta_{roomaut}$ =

stand alone with self-adoption start / stop $\Delta\theta_{roomaut}$ =

networked with self-adoption and interaction $\Delta\theta_{roomaut}$ =

(Interaction in the form of individual room control system includes the connection of the individual room control system with additional controls and / or the heat source - for example, supply temperature adaptation.)

A.10 Auxiliary Energy

In Table A.12- 15 the default values for auxiliary energy components are prescribed.

Table A.12 — default values for electrical power for the control system

Influence parameters		Power W
Control system with auxiliary energy P_{ctr}	Electrical control system with electrical motor actuation	
	Electrical control system with electro thermal actuation	
	Electrical control system with electromagnetic actuation	

Table A.13 — default values for electrical power of fans for air supply in room spaces h ≤ 4 m

Influence parameters		**Power** W
Ventilator/ fan P_{fan}	Fan coils unit	
	E- direct heating fan coils unit	
	Storage heating with dynamic discharge	
	Storage heating with continuous dynamic discharge	

For heating systems in room spaces with a high h > 4 m and decentralized heat generator the system is a part of heat generation and heat emission (Luminous heaters). The complete auxiliary energy is for such a system a part of heat emission. Default values are given in Table A.14.

Table A.14 — Standard values for electrical power of fans and for the control system in room spaces h > 4 m in height (large indoor space buildings) – decentralized system

Influence parameters		Power W
Directly heated heat generator (installed in the working space) $P_{H,aux}$	Luminous heaters (control and regulation)	
	Radiant tube heaters up to 50 kW (control, regulation and fan for combustion air supply)	
	Radiant tube heaters above 50 kW (control, regulation and fan for combustion air supply)	
	Warm air generator with atmospheric burner and recirculation air axial fan (control, regulation and fan for combustion air supply)	
	Warm air generator with fan-assisted burner and recirculation air radial ventilator (control, regulation and fan for combustion air supply, fan for warm air supply)	

$Q_{h;b}$ is determined from EN 12831

For heating systems in room spaces with a high h > 4 m and central heat generator and a separate unit for heat emission in the rooms auxiliary energy is needed (indirect air heater). This additional energy is a part of the heat emission in the room. For such systems Table A.15 gives some default values.

Table A.15 — default values for electrical power of fans and for the control system in room spaces with central heat generator – air heating systems

Influence parameters			Power W
indirect space heating with a room height ≤ 8 m	with warm-air return	with asynchronous motor	
		with a regulated EC motor	
	without warm-air return	with asynchronous motor	
		with a regulated EC motor	
indirect space heating with a room height > 8 m	without warm-air return	with asynchronous motor	
		with a regulated EC motor	
	with warm-air return	with asynchronous motor	
		with a regulated EC motor	

A.11 Additional Information

Table A.16 shows a classification of the controllers in relation to the EN 15232.

Table A.16 — Classification of the controllers in relation to the EN 15232

EN 15316–2	EN 15232 - **BACS function**	**Identifier**
unregulated, with central supply temperature regulation Master room space or one-pipe heating Room temperature control (electromechanical / electronic) P-controller (before 1988) P-controller PI-controller PI-controller (with optimization function, e.g. presence management, adaptive controller)		

In Table A.17 the default values for convective fraction $f_{em,conv}$ of the heating/cooling emitter are prescribed.

Table A.17 — default values for convective fraction of heating/cooling emitters

System		$f_{em,conv}$
Heating	Air heating (convectors, fan coils…)	
	Free heating surface (radiators, radiant panels…)	
	Floor heating, low temperature radiant tube heaters, luminous heaters, wood stoves	
	Wall heating, radiant ceiling panels, accumulation stoves	
	Ceiling heating, radiant ceiling electric heating	
Cooling	Cold air blowing systems (fan coils…)	
	Chilled beams	
	Ceiling cooling	
	Wall cooling	
	Floor cooling	

Annex B
(informative)

Default choices, input data and references (additional heating and cooling losses / auxiliary energy)

B.1 Introduction

All tables in this Annex have the same lay-out as the corresponding tables in the template in Annex A. But in this Annex B these are filled with a complete set of informative default choices, input data and references.

NOTE 1 In future versions of this standard some of the informative default values and choices may become normative.

NOTE 2 Using the default values will not guarantee consistency of data.

NOTE 3 In particular for the application within the context of EU Directives transposed into national legal requirements, the values and choices can be imposed by national / regional regulations. If the values and default choice of Annex B are not adopted because of the regulations, policies or national traditions, it is expected that:

— national or regional authorities prepare data sheets containing the choices, national or regional input data and references, according to the template in Annex A. In this case the National Annex (e.g. Annex NA, NB, ..) should provide a reference to these specifications;

— or, by default, the national standardization body will consider the possibility to prepare a National Annex (e.g. Annex NA, NB, ..)complying with the template of Annex A, that provides choices, national or regional input data and references specified in the legal documents.

NOTE 4 Where necessary for certain input values to be acquired by the user, a datasheet according to the template of Annex A may contain a reference to national procedures for assessing the needed input data. For instance to a national assessment protocol comprising decision trees, tables and pre-calculations.

NOTE 5 Drafting an application document according to the template in Annex A is open for different situations e.g. design of new building, certification of new building, renovation of existing building and certification of existing building and for different types of buildings e.g. small or simple buildings and large or complex buildings.. This can be done by developing different versions this application document. In such application document it is possible to add information about, e.g. applicable national or regional regulations.

If product specific values are available these may be used instead of the values in following Tables B1 – B13, compare normative Annex: C.

The default values for temperature variation for hydronic balancing are prescribed in Table B.1.

Table B.1 — Default values for temperature variation for hydronic balancing in K

Influence parameters (Performed hydronic balancing with manufacturer's declaration on the balance and in coordination with EN 14336)				
One pipe heating	$\Delta\theta_{hydr}$	**Two pipe heating**	*$n \leq 10$ $\Delta\theta_{hydr}$	*$n > 10$ $\Delta\theta_{hydr}$
No hydronic balancing	0,7	No hydraulic balancing	0,6	
Balanced statically per circuit	0,4	Balanced statically per free heating surface (radiator) or embedded heating surface, without group balance	0,3	0,4
Balanced dynamically per circuit (e.g. with automatic flow limiters)	0,3	Balanced statically per free heating surface (radiator) or embedded heating surface, with group balance (e.g. with balancing valve)	0,2	0,3
Balanced dynamically per circuit (e.g. with automatic flow limiters) and dynamically controlled depending on its load (e.g. return temperature limitation)	0,2	Balanced statically per free heating surface (radiator) or embedded heating surface (radiator) and dynamic group balance (e.g. with differential pressure controller)	0,1	0,2
Balanced dynamically per circuit (e.g. with automatic flow limiters) and dynamically controlled depending on its load (supply-return temperature difference)	0,1	Balanced dynamically per free heating surface (radiator) or embedded heating surface (e.g. with automatic flow limiters / differential pressure controllers)	0,0	
n – number of heat and cooling emission systems (e.g. number of radiators…)				

B.2 Temperature variation for free heating surfaces (radiators); room heights ≤ 4 m (heating case)

In Table B.2 the temperature variation for free heating surfaces are described.

Table B.2 — Default values for temperature variation for free heating surfaces (radiators) in K; room heights ≤ 4 m, heating case

Influence parameters		Variation				
		$\Delta\theta_{str}$		$\Delta\theta_{ctr,1}$[b]	$\Delta\theta_{ctr,2}$[c]	$\Delta\theta_{emb}$
Room space temperature regulation	Unregulated, with central supply temperature regulation Master room space or one-pipe heating Room temperature control (electromechanical / electronic) P-controller (before 1988) P-controller PI-controller PI-controller (with optimization function, e.g. presence management, adaptive controller)			2,5 2 1,8 1,4 1,2 1,2 0,9	2,5 1,8 1,6 1,4 0,7 0,7 0,5	
Over-temperature (reference Θ_i = 20 °C)		$\Delta\theta_{str;1}$	$\Delta\theta_{str;2}$			
	Two-pipe heating and one-pipe heating renovated[d] 60 K (e.g. 90/70) 42,5 K (e.g. 70/55) 30 K (e.g. 55/45) 20 K (e.g. 45/35) One-pipe heating (not renoveted) 60 K (e.g. 90/70) 42,5 K (e.g. 70/55) Heating systems combined with mechanical ventilation Fan assisted radiators / fan coil units[e]	1,2 0,7 0,5 0,4 1,6 1,2 0,2 0				
Specific heat losses via external components (GF = glass surface area)	Radiator location internal wall Radiator location external wall - GF without radiation protection - GF with radiation protection [a] - external wall		1,3 1,7 1,2 0,3			0 0 0 0

[a] The radiation protection shall prevent 80 % of the radiation losses from the heating body to the glass surface area by means of insulation and/or reflection.

[b] use $\Delta\theta_{ctr;1}$ for not certified products

[c] use $\Delta\theta_{ctr;2}$ for certified products, alternative $\Delta\theta_{ctr;2}$ can be calculated for TRV-systems based on EN 215

[d] one-pipe heating is assumed as renovated, if the flow rate is dynamically controlled depending on the load and the distribution pipes are insulated

[e] When heating systems are installed in rooms equipped with mechanical ventilation systems the temperature stratification is influenced

For $\Delta\theta_{str}$ an average value is to be formed from the data for the main influence parameters "over-temperature" and "specific heat losses via external components".

$$\Delta\theta_{str} = (\Delta\theta_{str,1} + \Delta\theta_{str,2})/2 \text{ [K]} \quad \text{(B.1)}$$

Temperature variation for intermittent operation

controls $\Delta\theta_{im,ctr}$ = 0,0 K

emitters $\Delta\theta_{im,emt}$ = −0,3 K

Temperature variation for radiation effect: $\Delta\theta_{rad}$ = 0 K

Alternatively product specific values for $\Delta\theta_{rad}$ in accordance to product standards can be used.

Temperature variation for room automation

stand alone $\Delta\theta_{roomaut}$ = - 0,5 K

stand alone with self-adoption start / stop $\Delta\theta_{roomaut}$ = −1,0 K

networked with self-adoption and interaction $\Delta\theta_{roomaut}$ = −1,2 K

(Interaction in the form of individual room control system includes the connection of the individual room control system with additional controls and / or the heat source - for example, supply temperature adaptation)

B.3 Temperature Variation for component integrated heating surfaces (panel heaters) (room heights ≤ 4 m, heating case)

In Table B.3 the temperature variation for component integrated heating surfaces (panel heaters) (room heights ≤ 4 m) are prescribed.

Table B.3 — Default values for temperature variation for component integrated heating surfaces (panel heaters) in K; room heights ≤ 4 m; heating case

influence parameters		Variation				
		$\Delta\theta_{str}$	$\Delta\theta_{ctr,1}$[a]	$\Delta\theta_{ctr,2}$[b]	$\Delta\theta_{emb}$	
Room space temperature regulation	Unregulated, with central supply temperature regulation		2,5	2,5		
	Master room space		2	1,8		
	Room temperature control (e.g. 2-step controller)		1,8	1,6		
	P-controller (before 1988)		1,4	1,4		
	P-controller / 2-step controller (hysteresis ≤ ± 0,5 K)		1,2	0,7		
	PI-controller		1,2	0,7		
	PI-controller (with optimization function, e.g. presence management, adaptive controller)		0,9	0,5		
System	Floor heating	0			$\Delta\theta_{emb,1}$	$\Delta\theta_{emb,2}$
	- screed system	0			0,7	
	- dry system	0			0,4	
	- system with low cover	0,4			0,2	
	Wall heating	0,7			0,7	
	Ceiling heating	0			0,7	
	Heating systems combined with mechanical ventilation[c]					
Specific heat losses via laying surfaces	Integrated heating surface without minimum insulation in accordance with EN 1264					1,4
	Integrated heating surface with minimum insulation in accordance with EN 1264					0,5
	Integrated heating surface with 100 % better insulation than required by EN 1264					0,1

[a] use $\Delta\theta_{ctr;1}$ for not certified products

[b] use $\Delta\theta_{ctr;2}$ for certified products, alternative $\Delta\theta_{ctr;2}$ can be calculated for TRV-systems based on EN 215

[c] When heating systems are installed in rooms equipped with mechanical ventilation systems the temperature stratification is influenced

For $\Delta\theta_{emb}$ an average value is to be formed from the data for the main influence parameters “system” and “specific heat losses via laying surfaces”.

$$\Delta\theta_{emb} = (\Delta\theta_{emb,1} + \Delta\theta_{emb,2})/2 \quad \text{(B.2)}$$

In Table B.4 the default values for overall temperature variation for thermally activated building systems (room heights ≤ 4 m) are prescribed.

Table B.4 — Default values for temperature variation for component integrated heating surfaces (thermally activated building systems) in K; room heights ≤ 4 m; heating case

Influence parameters		**Variation $\Delta\vartheta$**
Control	Constant supply temperature	3
	Central supply temperature regulation	2,7

Temperature variation for intermittent operation

controls $\Delta\theta_{im,ctr}$ = 0,0 K

emitters $\Delta\theta_{im,emt}$ = −0,2K

Temperature variation for radiation effect: $\Delta\theta_{rad}$ = 0 K

Alternatively product specific values for $\Delta\theta_{rad}$ in accordance to product standards can be used.

Temperature variation for room / space automation

stand alone $\Delta\theta_{roomaut}$ = - 0,5 K

stand alone with self-adoption start / stop $\Delta\theta_{roomaut}$ = −1,0 K

networked with self-adoption and interaction $\Delta\theta_{roomaut}$ = −1,2 K

(Interaction in the form of individual room control system includes the connection of the individual room control system with additional controls and / or the heat source - for example, supply temperature adaptation)

B.4 Temperature variation for air heating systems; room heights ≤ 4 m (heating case)

For air heating systems the calculation has to be done with the following values:

Air heating system (mixing case) $\Delta\theta_{str}$ = 0,0 K.

$\Delta\theta_{ctr,1}$ = according to Table B2

$\Delta\theta_{ctr,2}$ = according to Table B2

$\Delta\theta_{emb}$ = 0K

Temperature variation for intermittent operation

controls $\Delta\theta_{im,ctr}$ = 0,0 K

emitters $\Delta\theta_{im,emt}$ = 0,0 K

Temperature variation for radiation effect: $\Delta\theta_{rad}$ = 0 K

Temperature variation for room automation

stand alone $\Delta\theta_{roomaut}$ = - 0,5 K

stand alone with self-adoption start / stop $\Delta\theta_{roomaut}$ = −1,0 K

networked with self-adoption and interaction $\Delta\theta_{roomaut}$ = −1,2 K

(Interaction in the form of individual room control system includes the connection of the individual room control system with additional controls and / or the heat source - for example, supply temperature adaptation)

B.5 Temperature Variation for electrical heating (room heights ≤ 4 m, heating case)

In Table B.5 the default values for temperature variation for electrical heating (room heights ≤ 4 m) are prescribed.

Table B.5 — Temperature variation for electrical heating and air heating systems in K (room heights ≤ 4 m, heating case)

Influence parameters		Variation $\Delta\theta$
External wall region	Air heating with zone control P-controller (1 K)	1,2
	Air heating with central master control and pilot room control including supplementary heating with single-room control P-controller (1K)	1,1
	E- direct heating P-controller (1 K) or air heating with single-room control P-controller (1 K)	1,1
	E- direct heating PI-controller (with optimization) or air heating with single-room control PI-controller (with optimization)	0,7
	Storage heating unregulated without external temperature dependent charging	2,7
	Storage heating P-controller (1 K) with external temperature dependent charging	1,5
	Storage heating PID-controller with optimization with external temperature dependent charging	1,1
Internal wall region	Air heating with zone control P-controller (1 K)	1,6
	Air heating with central master control and pilot room control including supplementary heating with single-room control P-controller (1K)	1,5
	E- direct heating P-controller (1 K) or air heating with single-room control P-controller (1 K)	1,5
	E- direct heating PI-controller (with optimization) or air heating with single-room control PI-controller (with optimization)	1,1
	Storage heating unregulated without external temperature dependent charging	3,1
	Storage heating P-controller (1 K) with external temperature dependent charging	1,9
	Storage heating PID-controller with optimization with external temperature dependent charging	1,5
Ventilation Systems with supply air temperature below the room temperature		0,0

Temperature variation for intermittent operation: $\Delta\theta_{im} = -0,3$ K (to be used for electrical heating systems with an integrated feedback control system)

Temperature variation for radiation effect: $\Delta\theta_{rad} = 0$ K

Alternatively product specific values for $\Delta\theta_{rad}$ in accordance to product standards can be used.

B.6 Temperature Variation air heating (ventilation systems, room heights ≤ 4 m, heating case)

In Table B.6 the default values for temperature variation *Δθ* for air heating (non-domestic ventilation systems) (room heights ≤ 4 m) are prescribed.

Table B.6 — Default values for temperature variation for air heating (ventilation systems) in K; room heights ≤ 4 m; heating case

System configuration	**Control parameter**	*Δθ*	
		Low quality of control	**High quality of control**
Additional heating in the incoming air (additional heater)	Room space temperature	1,8	1,3
	Room space temperature (cascade control of incoming air temperature)	1,2	1,0
	Exhaust air temperature	1,9	1,5
Recirculation air heating (induction equipment, ventilator convectors, fan coil units)	Room space temperature	1,1	0,7

Temperature variation intermittent operation: $\Delta\theta_{im}$ = 0 K

Temperature variation for radiation effect: $\Delta\theta_{rad}$ = 0 K

B.7 Temperature variation for room spaces with heights > 4 m (large indoor space buildings, heating case)

In Table B.7 the default values for temperature variation for room spaces with heights ≥ 4 m are prescribed.

Table B.7 — Default values for temperature variation for room spaces with heights > 4 m in K; heating case (Reference case: ceiling height 10 m, standard product values radiant factors of luminous and tube heaters)

Influence parameters			variation		
			$\Delta\theta_{ctr,1}$[a]	$\Delta\theta_{ctr,2}$[b]	$\Delta\theta_{emb}$
Room space temp. regulation	Unregulated		2,5	2,5	
	Two-step controller		1,8	1,6	
	P-controller		1,2	0,7	
	PI-controller		1,2	0,7	
	PI-controller with optimization		0,9	0,5	
	Warm air without additional vertical recirculation	Outlet horizontal (wall unit)			0
		Outlet horizontal (wall unit) low temperature system[c] (valid only up to ceiling heights of 6 m)			0
		Outlet from above (ceiling unit)			0
		Outlet from vertical (ceiling unit) low temperature system[d] (valid only up to ceiling heights of 6 m)			0
	Warm air with additional vertical recirculation or adjustable induction outlet[g]	Recirculation controlled by two-step controller			0
		Recirculation controlled by PI-controller			0
	Radiant tube heaters	standard Design			0
		improved Design[h]			0
	Luminous heaters	standard Design			0
		improved Design[i]			0
	Radiant ceiling panels	standard Design			0,5
		improved Design			0,3
		improved design and keeping distances to the wall			0
	Floor heating	Without isolation (coverage ≤ 10cm)			1,4
		Without isolation (coverage > 10cm)			1,9
		Integrated into the component (minimum insulation in accordance with EN 1264 (coverage ≤ 10cm),			0,5
		Integrated into the component (minimum insulation in accordance with EN 1264 (coverage > 10cm),			1,0
		Thermally decoupled ($U_{bottom\ plate}$ ≤ 0,35 W/(m²K)) and coverage ≤ 10cm			0

[a] use $\Delta\theta_{ctr;1}$ for not certified products

[b] use $\Delta\theta_{ctr;2}$ for certified products, alternative $\Delta\theta_{ctr;2}$ can be calculated for TRV-systems based on EN 215

[c] the outcoming temperature has to be max. 15 K higher than the required internal temperature; the value $\Delta\theta_{str}$ = 1,03 may only be used for ceiling heights ≤ 6m. For larger ceiling heights the value $\Delta\theta_{str}$ = 2,93 has to be used.

[d] the outcoming temperature has to be max. 15 K higher than the required internal temperature; the value $\Delta\theta_{str}$ = 1,03 may only be used for ceiling heights ≤ 6m. For larger ceiling heights the value $\Delta\theta_{str}$ = 1,76 has to be used.

Table B.8 — Air temperature gradient for rooms with ceilings heights > 4 m

Emitter System		Air temperature gradient θ'_{str} [K/m]
Warm air heaters Without additional vertical recirculation	Outlet horizontal (wall unit)	1,0
	Outlet horizontal (wall unit) low temperature system[c] (valid only up to ceiling heights of 6 m)	0,35
	Outlet from above (ceiling unit)	0,60
	Outlet from above (ceiling unit) low temperature system[d] (valid only up to ceiling heights of 6 m)	0,35
Warm air heaters With additional vertical recirculation	Recirculation controlled by two-step controller	0,35
	Recirculation controlled by PI-controller	0,25
Radiant tube heaters	standard Design	0,2
	improved Design[1]	0,2
Luminous heaters	standard Design	0,2
	improved Design[2]	0,2
Radiant ceiling panels	standard Design	0,4
	improved Design	0,3
	improved design and keeping distances to the wall	0,3
Floor heating	Without isolation (coverage ≤ 10cm)	0,1
	Without isolation (coverage > 10cm)	0,1
	Integrated into the component (minimum insulation in accordance with the EN 1264 series (coverage ≤ 10cm),	0,1
	Integrated into the component (minimum insulation in accordance with the EN 1264 series (coverage > 10cm),	0,1
	Thermally decoupled ($U_{bottom\ plate}$ ≤ 0,35 W/(m²K)) and coverage ≤ 10cm	0,1

Table B.9 — Standard product values of Radiant Factors for radiant luminous and radiant tube heaters in rooms with ceiling heights > 4 m

Heater	Classification	RF
Radiant tube heater	standard	0,55
	improved design[a]	0,69
Radiant luminous heaters	standard	0,55
	improved design[b]	0,69

[a] Improved design radiant tube heaters: feature construction with completely insulated reflector; in case value for "improved design" is used for heat demand calculation, the product value for radiant factor RF acc. EN 416–2 has to be minimum 0,69

[b] Improved design radiant luminous heaters: feature construction with reflector overstreamed by flue gases; in case value for "improved design" is used for heat demand calculation, the product value for radiant factor RF acc. EN 419–2 has to be minimum 0,69

B.8 Temperature variation for room heaters fired by solid fuel

In Table B.10 the temperature variation for room heaters fired by solid fuel are prescribed.

Table B.10 — temperature variation for room heaters fired by solid fuel

Influence parameters		Variation		
		$\Delta\Theta_{str}$	$\Delta\Theta_{ctrl,1}$	$\Delta\Theta_{ctrl,2}$
System	Used on one single floor	0,9		
	Used for 2 floors	1,4		
Control	Manual thermostat		2,5	2,5
	Room thermostat		2	2

B.9 Temperature variation for water based cooling systems; room heights ≤ 4 m (cooling case)

Table B.11 — temperature variation for cooling systems; room heights ≤ 4 m (cooling case)

influence parameters		Variation			
		$\Delta\theta_{str}$	$\Delta\theta_{ctr\ 0,1}$ [a]	$\Delta\theta_{ctr,2}$ [b]	$\Delta\theta_{emb}$
Room space temperature regulation	unregulated, with central supply temperature regulation		−2,5	−2,5	
	Master room space or one-pipe heating		−2	−1,8	
	Room temperature control (electromechanical / electronic)		−1,8	−1,6	
	P-controller (before 1988)		−1,4	−1,4	
	P-controller		−1,2	−0,7	
	PI-controller		−1,2	−0,7	
	PI-controller (with optimization function, e.g. presence management, adaptive controller)		−0,9	−0,5	
System	Floor cooling system	−0,7		□	−0,7
	Wall cooling	−0,4			−0,7
	Ceiling cooling	0			−0,2
	Radiators assisted with fan / fan coil unit	0			0
	- located on the ceiling	−0,4			0
	- located on external wall				
	a use $\Delta\theta_{ctr\ ;1}$ for not certified products b use $\Delta\theta_{ctr\ ;2}$ for certified products				

Temperature variation for consideration of solar and internal gains

average proportion of window area or internal loads (e.g. residential buildings) $\Delta\theta_{e,sol}$ = 8 K

high proportion of window area or internal loads (e.g. office buildings) $\Delta\theta_{e,sol}$ = 12 K

Temperature variation for intermittent operation

controls $\Delta\theta_{im,ctr}$ = - 0,3 K

emitters $\Delta\theta_{im,emt}$ = 0 K

Temperature variation for radiation effect: $\Delta\theta_{rad}$ = 0 K

Alternatively product specific values for $\Delta\theta_{rad}$ in accordance to product standards can be used.

Temperature variation for room automation

stand alone $\Delta\theta_{roomaut}$ = - 0,5 K

stand alone with self-adoption start / stop $\Delta\theta_{roomaut}$ = −1,0 K

networked with self-adoption and interaction $\Delta\theta_{roomaut}$ = −1,2 K

(Interaction in the form of individual room control system includes the connection of the individual room control system with additional controls and / or the heat source - for example, supply temperature adaptation)

B.10 Auxiliary Energy

In Tables B.12 to B.15 the default values for auxiliary energy components are prescribed.

Table B.12 — default values for electrical power for the control system

Influence parameters		Power W
Control system with auxiliary energy P_{ctr}	Electrical control system with electrical motor actuation	0,1 (per actuator)
	Electrical control system with electro thermal actuation	1,0 (per actuator)
	Electrical control system with electromagnetic actuation	1,0 (per actuator)

Table B.13 — default values for electrical power of fans for air supply in room spaces h ≤ 4 m

Influence parameters		**Power** W
Ventilator/ fan P_{fan}	Fan coils unit	10
	E- direct heating fan coils unit	10
	Storage heating with dynamic discharge	12
	Storage heating with continuous dynamic discharge	12

For heating systems in room spaces with a high h > 4 m and decentralized heat generator the system is a part of heat generation and heat emission (Luminous heaters). The complete auxiliary energy is for such a system a part of heat emission. Default values are given in Table B.14.

Table B.14 — Standard values for electrical power of fans and for the control system in room spaces h > 4 m in height (large indoor space buildings) – decentralized system

Influence parameters		Power W
$P_{H,aux}$ Directly heated heat generator (installed in the working space)	Luminous heaters (control and regulation)	25 (per unit)
	Radiant tube heaters up to 50 kW (control, regulation and fan for combustion air supply)	80 (per unit)
	Radiant tube heaters above 50 kW (control, regulation and fan for combustion air supply)	100 (per unit)
	Warm air generator with atmospheric burner and recirculation air axial fan (control, regulation and fan for combustion air supply)	$0{,}014 \cdot Q_{h,b}$
	Warm air generator with fan-assisted burner and recirculation air radial ventilator (control, regulation and fan for combustion air supply, fan for warm air supply)	$0{,}022 \cdot Q_{h,b}$

$Q_{h;b}$ is determined from EN 12831

For heating systems in room spaces with a high h > 4 m and central heat generator and a separate unit for heat emission in the rooms auxiliary energy is needed (indirect air heater). This additional energy is a part of the heat emission in the room. For such systems Table B.15 gives some default values.

Table B.15 — default values for electrical power of fans and for the control system in room spaces with central heat generator – air heating systems

Influence parameters			Power W
indirect space heating with a room height ≤ 8 m	with warm-air return	with asynchronous motor	$0{,}008 \cdot Q_{h,b}$
		with a regulated EC motor	$0{,}004 \cdot Q_{h,b}$
	without warm-air return	with asynchronous motor	$0{,}009 \cdot Q_{h,b}$
		with a regulated EC motor	$0{,}005 \cdot Q_{h,b}$
indirect space heating with a room height > 8 m	without warm-air return	with asynchronous motor	$0{,}012 \cdot Q_{h,b}$
		with a regulated EC motor	$0{,}006 \cdot Q_{h,b}$
	with warm-air return	with asynchronous motor	$0{,}013 \cdot Q_{h,b}$
		with a regulated EC motor	$0{,}007 \cdot Q_{h,b}$

B.11 Additional Information

Table B.16 shows a classification of the controllers in relation to the EN 15232.

Table B.16 — Classification of the controllers in relation to the EN 15232

EN 15316–2	EN 15232 - **BACS function**	**Identifier**
unregulated, with central supply temperature regulation Master room space or one-pipe heating Room temperature control (electromechanical / electronic) P-controller (before 1988) P-controller PI-controller PI-controller (with optimization function, e.g. presence management, adaptive controller)	0 1 1 1 1 2–3 4	HEAT_EMIS_CTRL_DEF

In Table B.17 the default values for convective fraction $f_{em,conv}$ of the heating/cooling emitter are prescribed.

Table B.17 — default values for convective fraction of heating/cooling emitters

System		$f_{em,conv}$
Heating	Air heating (convectors, fan coils…)	0,95
	Free heating surface (radiators, radiant panels…)	0,70
	Floor heating, low temperature radiant tube heaters, luminous heaters, wood stoves	0,50
	Wall heating, radiant ceiling panels, accumulation stoves	0,35
	Ceiling heating, radiant ceiling electric heating	0,20
Cooling	Cold air blowing systems (fan coils…)	0,95
	Chilled beams	0,80
	Ceiling cooling	0,50
	Wall cooling	0,35
	Floor cooling	0,20

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