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Building environment design — Design, test methods and control of hydronic radiant heating and cooling panel systems —

Part 6: Input parameters for the energy calculation

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Contents

Page

Foreword

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

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

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

A list of all parts in the ISO 18566 series can be found on the ISO website.

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

Introduction

The radiant heating and cooling system consists of heat emitting/absorbing, heat supply, distribution and control systems. Typical applications are low temperature radiant heating and high temperature radiant cooling. They are classified as embedded radiant heating and cooling systems and prefabricated radiant heating and cooling panel systems.

While the ISO 11855 series is for embedded radiant heating and cooling systems without an open-air gap, the ISO 18566 series is for radiant heating and cooling panel systems with an open air gap. Because the system specifications for ISO 18566 are different from those of ISO 11855, it was necessary to develop separate ISO standards regarding the design and test methods of the cooling and heating capacity and control.

ISO 18566-1 specifies the comfort criteria, technical specifications and requirements which should be considered in the manufacturing and installation of radiant heating and cooling systems. ISO 18566-2 provides the test facility and test method for heating and cooling capacity of ceiling mounted radiant panels. ISO 18566-3 specifies the design considerations and design processes of ceiling mounted radiant panels. ISO 18566-4 addresses the control of ceiling mounted radiant heating and cooling panels to ensure the maximum performance which was intended in the design stage when the system is actually being operated in a building. This document presents a determination method of input parameters for the energy efficiency of heating and cooling products in relation to ISO 52031.[1)]

ISO 18566 does not cover the panels that are embedded into the ceiling, wall or floor structure. This document is partly based on EN 14240, EN 14037 and ASNI/ASHRAE Standard 138.

1) Under preparation. Stage at the time of publication: ISO/DIS 52031:—.

Building environment design — Design, test methods and control of hydronic radiant heating and cooling panel systems —

Part 6: Input parameters for the energy calculation

1 Scope

This document establishes guidelines for the determination of input parameters for ceiling mounted radiant heating and cooling panels in relation to ISO 52031. The requirements specified by this document are applicable only to the components of the heating/cooling systems and the elements which are part of the heating/cooling panels and which are installed to provide heating and/or cooling.

This document is applicable to water-based ceiling mounted radiant heating and cooling panels in residential, commercial and industrial buildings. The methods apply to systems mounted under the ceiling with an open air gap between the panels and the ceiling.

This document also applies, as appropriate, to the use of fluids other than water as a heating or cooling medium. This document is also applicable for testing of systems. The methods do not apply to heated or chilled ceiling beams.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 18566-1, *Building environment design — Design, test methods and control of hydronic radiant heating and cooling panel systems — Part 1: Vocabulary, symbols, technical specifications and requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 18566-1 apply.

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

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

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

4 Symbols and subscripts

4.1 Symbols

NOTE Additional symbols are given in ISO 52000 (all parts).

Symbol	Quantity	Unit
$\Delta\theta_{ctr}$	temperature variation based on room control system	K
$\Delta\theta_{ctr,1}$	temperature variation based on room control system, not certified products	K

Symbol	Quantity	Unit
$\Delta\theta_{ctr,2}$	temperature variation based on room control system, certified products	K
$\Delta\theta_{hydr}$	temperature variation based on not balanced hydraulic systems	K
$\Delta\theta_{im,crt}$	temperature variation based on intermittent room controls operation system	K
$\Delta\theta_{im,emt}$	temperature variation based on intermittent operation of the emission system	K
$\Delta\theta_{rad}$	temperature variation based on radiation by type of the emission system	K
$\Delta\theta_{str}$	temperature variation based on the stratification	K
$\Delta\theta_{str,1}$	temperature variation based on the stratification - part of influence due to "over-temperature"	K
$\Delta\theta_{str,2}$	temperature variation based on the stratification - part of influence due to "specific heat losses via external components"	K
$\Delta\theta_{emb}$	temperature variation based on an additional heating/cooling loss by emitters embedded in the envelope	K
$\Delta\theta_{roomout}$	temperature variation based on room automation	K
c_i	heat capacity of the heating surface covering	kJ/(kg K)
c_1	specific heat capacity construction material	kJ/(kg K)
c_W	specific heat capacity of water	kJ/(kg K)
$C_{sys,1}$	specific heat capacity of the system	kJ/(m^2·K)
$C_{sys,2}$	specific heat capacity of the system	kJ/(kW·K)
ρ_i	density of the heating surface covering	kg/m^3
ρ_W	density of water	kg/m^3
d_i	thickness of the heating surface covering	m
V_W	volume of the water	m^3
Φ_{50}	thermal output based on an over temperature of $\Delta\vartheta$ = 50K ($\Delta\vartheta = (\vartheta_s + \vartheta_R)/2 - \vartheta_i$; ϑ_s – supply temperature, ϑ_R – return temperature; ϑ_i – internal temperature)	kW
m_1	mass of the construction material	kg
A_1	coefficient of the calculation	(K^2 m^2)/kJ
A_2	coefficient of the calculation	(K^2 kW)/kJ
B	coefficient of the calculation	K

4.2 Subscripts

emb	embedded
fan	fan
emt	emitter
hydr	hydraulic balancing

im	intermittent
ini	initial
inc	increased
roomaut	room automation

pmp	pump
rad	radiant
str	stratification
conv	convective

5 Basic formula

ISO 52031 presents an overall calculation method for the additional heat losses and energy efficiency. The calculation procedure in ISO 52031 is based on temperature differences (temperature variations), calculated using Formulae (1) to (5).

The equivalent internal temperature, $\theta_{int,inc}$, taking into account the emitter, is calculated by Formula (1).

$$\theta_{int,inc} = \theta_{int,ini} + \Delta\theta_{int,inc} \quad (1)$$

$$\Delta\theta_{\text{int,inc}} = \Delta\theta_{\text{str}} + \Delta\theta_{\text{ctr}} + \Delta\theta_{\text{emb}} + \Delta\theta_{\text{rad}} + \Delta\theta_{\text{im}} + \Delta\theta_{\text{hydr}} + \Delta\theta_{\text{roomaut}} \quad (2)$$

With temperature variations based on an emission system:

$$\Delta\theta_{\text{emt,syst}} = \Delta\theta_{\text{str}} + \Delta\theta_{\text{emb}} + \Delta\theta_{\text{rad}} + \Delta\theta_{\text{im,emt}} \quad (3)$$

In Formula (3) $\Delta\theta_{\text{rad}}$ is calculated for radiators, and $\Delta\theta_{\text{im,emt}}$ is calculated for embedded systems (see Clause 6).

With temperature variation based on a control system:

$$\Delta\theta_{\text{ctr,syst}} = \Delta\theta_{\text{ctr}} + \Delta\theta_{\text{im,ctr}} + \Delta\theta_{\text{roomaut}} \quad (4)$$

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

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

$$\Delta\theta_{\text{int,inc}} = \Delta\theta_{\text{hydr}} + \Delta\theta_{\text{emt,syst}} + \Delta\theta_{\text{ctr,syst}} \quad (5)$$

Based on these formulae, Clause 6 describes some calculation methods for the input parameters[2].

6 Determination of input parameters for the energy efficiency of heating and cooling emission products

6.1 Heating and cooling systems with more than one covering layer above the pipes (Type 1)

This subclause describes the determination procedure for the different products. The calculation procedure is valid for heating and cooling systems with an open air gap and more than one covering layer above the pipes. For a calculation example, see Annex A.

The correction of the default values, given in ISO 52031, is based on the specific heat capacity of the system. The specific heat capacity can be calculated using Formula (6):

$$C_{\text{sys,1}} = \sum_{i=1}^{n} c_i \cdot \rho_i \cdot d_i \quad (6)$$

With C_{sys} the correction coefficient can be calculated depend on the orientation of the embedded heating surface using Formula (7):

$$\Delta\theta_{\text{im,emt}} = A_1 \cdot C_{\text{sys}} + B \quad (7)$$

For the heating and cooling case the different values for the coefficients A_1 and B can be selected from Table 1.

Table 1 — Coefficient *A* and *B* (heating and cooling case)

Installation of the system	Heating case		Cooling case	
	A_1 in $(K^2m^2)/kJ$	B in K	A_1 in $(K^2m^2)/kJ$	B in K
Ceiling	0,037	−1,45	−0,037	1,45
NOTE The coefficient A_1 and B are based on numerical simulations. Detailed information is given in Formulae [6] and [7].				

2) Additional information can be found in the literature listed in the Bibliography (see [8] to [14]).

6.2 Ceiling mounted water-based radiator system (Type 2)

This subclause describes the determination procedure for the different products. The calculation procedure is for heating systems (ceiling mounted water-based radiator systems).

The correction of the default values, given in ISO 52031, is based on the specific heat capacity of the system. It can be calculated using Formula (8):

$$C_{\mathrm{sys},2} = \frac{m_1 \cdot c_1 + V_{\mathrm{W}} \cdot \rho_{\mathrm{W}} \cdot c_{\mathrm{W}}}{\Phi_{50}} \tag{8}$$

With $C_{\mathrm{sys},2}$ the correction coefficient can be calculated depend on the orientation of the embedded heating surface using Formula (9):

$$\Delta\theta_{\mathrm{im,emt}} = A_2 \cdot C_{\mathrm{sys},2} + B \tag{9}$$

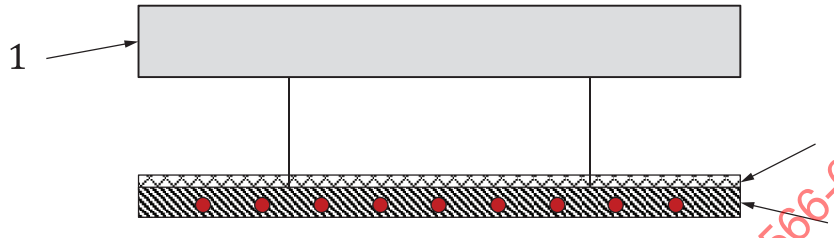
For the heating case the different values for the coefficients A_2 and B can be selected from Table 2.

Table 2 — Coefficient A_2 and B (heating case)

Installation of the system	Heating case	
	A_2 in $(\mathrm{K}^2\ \mathrm{kW})/\mathrm{kJ}$	B in K
Ceiling	0,003 4	−0,11
NOTE The coefficients A and B are based on numerical simulations. Detailed information is given in Formulae [6] and [7].		

Annex A
(informative)

Calculation example (Type 1)



Key

1 ceiling construction
2 thermal insulation
3 plasterboard construction with pipes (c_1/ ρ_1 / d_2)

Figure A.1 — Construction of heating and cooling system with more than one covering layer above the pipes (Type 1)

Table A.1 gives details of the systems.

Table A.1 — Construction of the ceiling system

c in kJ/(kg K); ρ in kg/m^3; d in m												$C_{sys,1}$
c_1	ρ_1	d_1	c_2	ρ_2	d_2	c_3	ρ_3	d_3	c_4	ρ_4	d_4	kJ/(kW K);
1,09	1 000	0,03	—	—	—	—	—	—	—	—	—	32,7

The thermal insulation of the system in Figure A.1 has no influence of the dynamic behaviour of the system. Therefore it should not be taken into account for the calculation of $\Delta\theta_{im,emt}$.

For the heating case, Formula (A.1) is based on the coefficient from Table 1:

$$\Delta\theta_{im,emt} = A_1 \cdot C_{sys,1} + B = 0,037 \cdot C_{sys} - 1,45 \quad \text{(A.1)}$$

With Formula (A.1), the following values can be calculated: $\Delta\theta_{im,emt}$ = −0,24 K.