BRITISH STANDARD

BS EN 1264-3:2009

Water based surface embedded heating and cooling systems

Part 3: Dimensioning

ICS 91.140.10

British Standards

National foreword

This British Standard is the UK implementation of EN 1264-3:2009. It supersedes BS EN 1264-3:1998 which is withdrawn. Together with BS EN 1264-4:2009, it also supersedes BS EN 15377-2:2008 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee RHE/6, Air or space heaters or coolers without combustion.

A list of organizations represented on this committee can be obtained on request to its secretary.

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 September 2009

ISBN 978 0 580 59452 6

Amendments/corrigenda issued since publication

Date	Comments

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 1264-3

September 2009

ICS 91.140.10

Supersedes EN 1264-3:1997, EN 15377-2:2008

English Version

Water based surface embedded heating and cooling systems - Part 3: Dimensioning

Systèmes de surfaces chauffantes et rafraîchissantes hydrauliques intégrées - Partie 3 : Dimensionnement

Raumflächenintegrierte Heiz- und Kühlsysteme mit Wasserdurchströmung - Teil 3: Auslegung

This European Standard was approved by CEN on 1 August 2009.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 1264-3:2009: E

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Foreword

This document (EN 1264-3:2009) has been prepared by Technical Committee CEN/TC 130 “Space heating appliances without heat sources”, the secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2010, and conflicting national standards shall be withdrawn at the latest by March 2010.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 1264-3:1997. Together with EN 1264-4, this document also supersedes EN 15377-2.

The series of European Standards EN 1264 "*Water based surface embedded heating and cooling systems*" consists of the following parts:

— Part 1: Definitions and symbols;

— Part 2: Floor heating : Prove methods for the determination of the thermal output using calculation and test methods

— Part 3: Dimensioning;

— Part 4: Installation;

— Part 5: Heating and cooling surfaces embedded in floors, ceilings and walls — Determination of the thermal output.

The main change with respect to EN 1264-3:1997 is the expansion of the scope beyond floor heating, with the addition of ceiling and wall heating as well as cooling surfaces in floors, ceilings and walls.

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

1 Scope

This European Standard applies to heating and cooling systems embedded into the enclosure surfaces of the room to be heated or to be cooled.

This document deals with the use in practical engineering of the results coming from part 2 and 5 and is applicable to floor-, ceiling- and wall heating systems, as well floor-, ceiling- and wall cooling systems.

For heating systems, physiological limitations are taken into account when specifying the surface temperatures. In the case of floor heating systems the limitations are realised by a design based on the characteristic curves and limit curves determined in accordance with part 2 of this Standard.

For cooling systems, only a limitation with respect to the dew point is taken into account. In predominating practice, this means that physiological limitations are included as well.

2 Normative References

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

EN 1264-1:1997, *Water based surface embedded heating and cooling systems - Part 1: Definitions and symbols*

EN 1264-2, *Water based surface embedded heating and cooling systems - Part 2: Floor heating: Prove methods for the determination of the thermal output using calculation and test methods*

EN 1264-4, *Water based surface embedded heating and cooling systems - Part 4: Installation*

EN 1264-5, *Water based surface embedded heating and cooling systems — Part 5: Heating and cooling surfaces embedded in floors, ceilings and walls — Determination of the thermal output*

EN 12831, *Heating systems in buildings — Method for calculation of the design heat load*

EN 15243, *Ventilation for buildings — Calculation of room temperatures and of load and energy for buildings with room conditioning systems*

EN ISO 7730, *Ergonomics of the thermal environment - Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria (ISO 7730:2005)*

3 Terms, definitions and symbols

For the purposes of this document, the definitions and symbols given in EN 1264-1:1997 apply.

4 Heating systems

4.1 Floor heating systems

4.1.1 Basic principles

4.1.1.1 Temperature difference between heating water and room

The temperature difference between the heating water and the room is calculated using equation (1), see EN 1264-2. In this equation, the effect of the temperature drop of the heating water is taken into account.

$$\Delta\vartheta_H = \frac{\vartheta_V - \vartheta_R}{\ln \frac{\vartheta_V - \vartheta_i}{\vartheta_R - \vartheta_i}} \qquad (1)$$

4.1.1.2 Characteristic curve

The characteristic curve describes the relationship between the specific thermal output q of a system and the required temperature difference between heating water and room $\Delta\vartheta_H$. For a simplification, the specific thermal output is taken directly proportional to the temperature difference:

$$q = K_H \cdot \Delta\vartheta_H \qquad (2)$$

where the gradient is $K_H = B \prod_i (a_i^{m_i})$, calculated in accordance with clause 6 of part 2 of this Standard, or the gradient K_H is experimentally determined in accordance with clause 9 of part 2 of this European Standard.

4.1.1.3 Field of characteristic curves

The field of characteristic curves of a floor heating system with a specific pipe spacing T shall at least contain the characteristic curves for values of the thermal resistance $R_{\lambda, B} = 0$, $R_{\lambda, B} = 0{,}05$, $R_{\lambda, B} = 0{,}10$ and $R_{\lambda, B} = 0{,}15$ (m² K)/W in accordance with part 2 of this European Standard (see Figure A.1). Values of $R_{\lambda, B} > 0{,}15$ (m² K)/W shall not be used if possible.

4.1.1.4 Limit curves

The limit curves in the field of characteristic curves describe in accordance with part 2 of this European Standard the relationship between the specific thermal output q and the temperature difference $\Delta\vartheta_H$ between the heating water and the room in the case where the physiologically agreed limit values of surface temperatures $\vartheta_{F,max}$ = 29 °C (occupied area) or $\vartheta_{F,max}$ = 35 °C (peripheral area) are reached[1]. For bathrooms (ϑ_i = 24 °C) the limit curve for ($\vartheta_{F,max} - \vartheta_i$) = 9 K also applies. For design purposes, i.e. the determination of design values of the specific thermal output and the associated temperature difference between heating water and room, the limit curves are valid for the temperature drop σ of the heating water in a range of

$$0 \text{ K} < \sigma \leq 5 \text{ K}.$$

The limit curves are used to specify the maximum permissible flow temperature (refer to clause 4.1.3.2 and Figure A.4).

[1]) National regulations may limit these temperatures to lower values.

4.1.1.5 Thermal inertia

The difference between the minimum and the maximum surface temperature of a floor heating system is low. This means for design purposes that no consideration of thermal inertia is required.

4.1.2 Boundary conditions

4.1.2.1 Flow pipes to adjacent rooms

The heat output of service pipes, not serving rooms through which they pass, must be limited by careful design, or by use of thermal insulation coverings, so that any room temperature should not be increased substantially. The heat output of service pipes passing through the room in question to adjacent rooms is taken into account if the same type of room usage can be assumed.

4.1.2.2 Downwards thermal insulation

To limit the heat flow through the floor to rooms below, the required thermal resistance of the insulating layer $R_{\lambda,ins}$ (see Figure A.5) shall be at minimum in accordance with Table 1 of EN 1264-4[2]. It is calculated according to equation (3).

$$R_{\lambda,ins} = \frac{s_{ins}}{\lambda_{ins}} \tag{3}$$

where

s_{ins} is the thickness of the insulating layer in m, and

λ_{ins} is the thermal conductivity of the insulating layer in W/(m•K).

Depending on the construction of the floor heating system, the effective thickness of the insulating layer s_{ins} is determined differently:

For floor heating systems with flat thermal insulating panels (see Figure A.2), s_{ins} is identical with the thickness of the thermal insulating panel.

For floor heating systems with profiled thermal insulating panels (see Figure A.3), a surface-related weighted calculation is made for the effective thickness of the insulating layer s_{ins}:

$$s_{ins} = \frac{s_h \cdot (T - D) + s_l \cdot D}{T} \tag{4}$$

For profiled thermal insulating panels shaped differently from that shown in Figure A.3, the average effective thickness of the insulating layer shall be mathematically verified with an accordant application of equation (4).

NOTE In cases where formula (4) is non-applicable, an accordant calculation method shall be applied. For instance, in the case of system plates with attachment studs, the accordant calculation is given through: s_{ins} = (Volume of plate with studs included, divided by A_F).

[2]) National regulations may vary the requirements given in Table 1 of EN 1264-4.

4.1.3 Design

4.1.3.1 Design value of specific thermal output

The design value q_{des} to design a floor heating system for a room is equal to the standard heat load $Q_{N,f}$ (see part 1 of this Standard) divided by the heating surface A_F:

$$q_{des} = \frac{Q_{N,f}}{A_F} \tag{5}$$

The standard heat load $Q_{N,f}$ shall be calculated in accordance with EN 12831. Normally, the heat output Q_F of the floor heating system shall be equivalent to the standard heat load $Q_{N,f}$. If this is not possible, additional heating surfaces shall be used, see equation (12).

The design thermal output Q_F of the entire heating surface A_F is calculated as follows:"

$$Q_F = q \cdot A_F \tag{6}$$

Where peripheral area is used, q shall be distributed between the peripheral area A_R and the occupied area A_A according to a surface weighted calculation (see also clause 4.1.4):

$$q = \frac{A_R}{A_F} \cdot q_R + \frac{A_A}{A_F} \cdot q_A \tag{7}$$

where:

q_A is the specific thermal output of the occupied area

q_R is the specific thermal output of the peripheral area

4.1.3.2 Determination of the design flow temperature

The design flow temperature is determined for the room (or the rooms respectively) with the highest value $q_{max} = q_{des}$ of the specific thermal output (bathrooms excepted). In the rooms being heated, it is assumed that floor coverings with an uniform thermal conduction resistance are used. Generally for the design of floor heating systems in residential rooms, uniform floor coverings with $R_{\lambda,B}$ = 0,10 ($m^2 \cdot K$)/W are assumed. In the case of using higher values $R_{\lambda,B}$, these values shall be taken.

For the room used for design, the temperature drop of the heating water is specified to $\sigma \leq 5$ K. If necessary, a subdivision of this room into heating circuits should be performed. Under these conditions, the maximum value q_{max} may reach until the limit value q_G of the specific thermal output (see Figure A.4)[3].

For the room with q_{max}, a pipe spacing is chosen with which q_{max} remains less or equal to the limit value q_G ($q_{max} \leq q_G$, see Figure A.4). For this, small pipe spacing is recommended. In case of $q_{max} \leq q_G$, design values of the temperature difference between flow heating water and room $\Delta\vartheta_{V,des} \leq \Delta\vartheta_{H,G}$+2,5 K are permitted (see Figure A.4). The maximum permissible temperature difference between flow and room comes to:

$$\Delta\vartheta_{V,des} = \Delta\vartheta_{H,des} + \sigma / 2 \quad \text{where } \Delta\vartheta_{H,des} \leq \Delta\vartheta_{H,G} \tag{8}$$

The temperature drop σ in equation (8) and in equation (9), in figure A.4 is designated σ_{des}.

Equation (8) is valid for $\sigma/\Delta\vartheta_H \leq 0,5$.

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3) This means that above the flow pipe the maximum floor temperature $\vartheta_{F,max}$ can be exceeded compared with the centre of the room, corresponding to the higher heating water temperature by σ/2.

For the relationship $\sigma/\Delta\vartheta_H > 0{,}5$ the following equation has to be used:

$$\Delta\vartheta_{V,des} = \Delta\vartheta_{H,des} + \frac{\sigma}{2} + \frac{\sigma^2}{12 \cdot \Delta\vartheta_{H,des}} \tag{9}$$

The result of Equation (8) or (9) provides the design flow temperature $\vartheta_{V,des} = \Delta\vartheta_{V,des} + \vartheta_i$.

For all other rooms operated at the same flow temperature $\vartheta_{V,des}$, for the ratio $\sigma/\Delta\vartheta_{H,j} \leq 0{,}5$ the associated values for the temperature drop σ_j of the heating water are taken from the field of characteristic curves (see Figure A.4) or calculated according to

$$\frac{\sigma_j}{2} = \Delta\vartheta_{V,des} - \Delta\vartheta_{H,j} \tag{10}$$

using the temperature differences $\Delta\vartheta_{H,j}$ corresponding to the respective values of the specific thermal output q_j (see Figure A.4).

For $\sigma/\vartheta_{H,j} > 0{,}5$ the temperature drop σ_j has to be calculated as follows:

$$\sigma_j = 3 \cdot \Delta\vartheta_{H,j} \cdot \left[\left(1 + \frac{4 \cdot \left(\Delta\vartheta_{V,des} - \Delta\vartheta_{H,j}\right)}{3 \cdot \Delta\vartheta_{H,j}} \right)^{\frac{1}{2}} - 1 \right] \tag{11}$$

Note: Equations (8) and (10) are the result of simplifications and therefore valid only under the specified condition $\sigma/\Delta\vartheta_H \leq 0{,}5$. Compared to this, equations (9) and (11) generally are applicable, i.e. for any relationship $\sigma/\Delta\vartheta_H$.

If the value q_{des} according to equation (5) for the room used for design (or for other rooms if the case arises) cannot be obtained under the aforementioned conditions by any pipe spacing, it is recommended to include a peripheral area or to provide supplementary heating surfaces. The supplementary heating surfaces shall be selected complying with the purpose and the location. The additional required thermal output Q_{out} is determined with the following equation:

$$Q_{out} = Q_{N,f} - Q_F \tag{12}$$

In this case, the maximum specific thermal output q_{max} now may occur in another room.

4.1.3.3 Heating Mode - Determination of Water Flow rate

The total thermal output of a floor heating system is composed of the specific thermal output q and the downward heat loss q_U, see clause 8 of part 2 of this Standard. These circumstances taking into account, the design water flow rate m_H of a heating circuit is calculated as follows:

$$m_H = \frac{A_F \cdot q}{\sigma \cdot c_W} \cdot \left(1 + \frac{R_o}{R_u} + \frac{\vartheta_i - \vartheta_u}{q \cdot R_u} \right) \tag{13}$$

where (also see Figure A.5):

c_W specific heat capacity of water; $c_W = 4190$ J/(kg·K)[4]

[4]) Using this value together with q in W/m² in equation (13), m_H is provided in kg/s.

R_o upwards partial heat transmission resistance of the floor structure (see equation (14))

R_u downwards partial heat transmission resistance of the floor structure (see equation (15))

ϑ_i standard indoor room temperature in accordance with EN1264-2

ϑ_u indoor temperature of a room under the floor heated room

With respect to the thermal resistances indicated in Figure A.5, the following equations are valid:

$$R_o = \frac{1}{\alpha} + R_{\lambda;B} + \frac{s_u}{\lambda_u} \tag{14}$$

$$R_u = R_{\lambda,ins} + R_{\lambda,ceiling} + R_{\lambda,plaster} + R_{\alpha,ceiling} \tag{15}$$

where:

$1/\alpha$ is the heat transfer resistance on the heating floor surface; $1/\alpha$ = 0,0093 $(m^2 \cdot K)/W$

$R_{\alpha;ceiling}$ is the heat transfer resistance on the ceiling under the floor heated room; $R_{\alpha;ceiling}$ = 0,17 $(m^2 \cdot K)/W$

NOTE The calculation procedure above described on the basis of Figure A.5 is to understand as a principle one. For other structures, an appropriate modification may be necessary.

4.1.4 Peripheral areas

Peripheral areas A_R, with an increased surface temperature (up to a maximum of 35 °C) are generally situated along the outer walls of a room with a maximum width of 1 m. As described in clause 4.1.3, design of peripheral areas is based on the higher limit curve ($\vartheta_{F,max}$ - ϑ_i) = 15 K (see Figure A.1). In case a series circuit is formed with a heating circuit in the occupied area, the temperature drop in the peripheral area shall be selected, so that the flow temperature, calculated from the lower limit curve, is not exceeded by entry of the heating water from the peripheral area into the occupied area.

4.2 Ceiling heating systems

4.2.1 Basic principles

4.2.1.1 Temperature difference between heating water and room

For ceiling heating systems, the specifications and equation (1) given in clause 4.1.1.1 unchanged apply.

4.2.1.2 Characteristic curve

For ceiling heating systems, equation (2) and the respective specifications given in clause 4.1.1.2, apply. The gradient K_H is provided as a combined result coming from part 2 and part 5 of this Standard. Detailed information about the procedure, see part 5 of this Standard.

4.2.1.3 Field of characteristic curves

In principle, the specifications given in clause 4.1.1.3 also apply. With respect to the calculation method (see part 5 of this Standard), the field of characteristic curves should contain the values of $R_{\lambda,B}$ specified in clause 4.1.1.3, even though not all together are needed for practical application.

4.2.1.4 Limit curve

Physiological limitations concerning the surface temperatures of ceiling heating systems depend on geometrical conditions, i.e. in practice on the respective application. Therefore, in this Standard only average conditions can be taken into consideration. Consequently, it is emphasized, in practical engineering the real conditions shall be taken into account.

For geometrical conditions of usual flat rooms a maximum amount for the average temperature of the heating ceiling surface of $\vartheta_{F,m}$ = 29 °C is applicable, i.e. a difference between the heating surface and the room of ($\vartheta_{F,m} - \vartheta_i$) = 9 K[5]. As a result, the limit curve within the field of characteristic curves is a horizontal straight line in the distance q_G (see below).

Using the heat transfer coefficient α = 6,5 W/(m^2·K) coming from part 5 of this Standard, the limit of the specific output results to:

$$q_G = 59 \text{ W/m}^2 \text{ (rounded)}$$

If higher values $\vartheta_{F,m}$ > 29 °C are used, the compliance with physiological limitations shall be proved. In general, refer to EN ISO 7730.

4.2.2 Boundary conditions

4.2.2.1 Flow pipes to adjacent rooms

The same procedure described in clause 4.1.2.1 applies.

4.2.2.2 Upwards thermal insulation

To limit the heat flow through the ceiling to rooms above, the required thermal resistance of the insulating layer $R_{\lambda,ins}$ (in principle see Figure A.5) shall be at minimum in accordance with Table 1 of EN 1264-4.

As for the rest, the content of clause 4.1.2.2 applies accordingly.

4.2.3 Design

4.2.3.1 Design value of specific thermal output

It is recommended to apply the procedure described in clause 4.1.3.1 accordingly.

4.2.3.2 Determination of the design flow temperature

It is recommended to apply the procedure described in clause 4.1.3.2 accordingly. In the case of operating with floor heating connected in parallel and using uniform flow temperature, the flow temperature of the floor heating system shall be used.

4.2.3.3 Heating mode – Determination of water flow rate

It is recommended to apply the procedure described in clause 4.1.3.3 accordingly taking into account the reversed position of the structure shown in Figure A.5 and the changes of the transfer resistances on the surfaces as follows:

1/α is the heat transfer resistance on the heating ceiling surface; 1/α = 0,154 (m^2·K)/W

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5) Standard indoor temperature ϑ_i = 20 °C, see EN1264-2.

$R_{\alpha;ceiling}$ is replaced by $R_{\alpha;floor}$, the heat transfer resistance on the floor above the ceiling heated room; $R_{\alpha;floor}$ = 0,10 (m^2·K)/W

4.3 Wall heating systems

4.3.1 Basic principles

NOTE The prove results coming from part 2 and part 5 of this Standard are valid for wall heating systems where the respective wall is fully covered with the heating surface. But the accuracy is also sufficient for cases where the wall is partially covered.

The descriptions given for ceiling heating systems (see clause 4.2.1.1 thru clause 4.2.1.3) also applies for wall heating systems (in the respective wordings replace "ceiling heating" by "wall heating").

Concerning the limit curve depending on physiological considerations, refer in principle to the first statement in clause 4.2.1.4. For wall heating systems, in this Standard only a recommendation for the limitation of the average surface temperature is given. This temperature should not exceed $\vartheta_{F,m}$ = 40 °C, i.e. a difference between the heating surface and the room of ($\vartheta_{F,m}$ - ϑ_i) = 20 K. As a result, the limit curve within the field of characteristic curves is a horizontal straight line in the distance q_G (see below).

Using the heat transfer coefficient α = 8 W/(m^2·K) coming from part 5 of this Standard, the limit of the specific output results to:

$$q_G = 160 \text{ W/m}^2$$

If higher values $\vartheta_{F,m}$ > 40 °C are used, the compliance with physiological limitations shall be proved. In general, refer to EN ISO 7730.

4.3.2 Boundary conditions

4.3.2.1 Flow pipes to adjacent rooms

The same procedure described in clause 4.1.2.1 applies.

4.3.2.2 Backing thermal insulation

To limit the heat flow through the wall to rooms adjacent or to the external environs, the required thermal resistance of the insulating layer $R_{\lambda,ins}$ (in principle see Figure A.5) shall be at least in accordance with Table 1 of EN 1264-4.

As for the rest, the contents of clause 4.1.2.2 apply accordingly.

4.3.3 Design

4.3.3.1 Design value of specific thermal output

It is recommended to apply the procedure described in clause 4.1.3.1 accordingly.

4.3.3.2 Heating mode – Determination of water flow temperature

It is recommended to apply the procedure described in clause 4.1.3.2 accordingly. In the case of operating with floor heating connected in parallel and using uniform flow temperature, the flow temperature of the floor heating system shall be used.

4.3.3.3 Determination of the design flow rate

It is recommended to apply the procedure described in clause 4.1.3.3 accordingly taking into account the changed position of the structure shown in Figure A.5 and the changes of the transfer resistances on the surfaces as follows:

$1/\alpha$ is the heat transfer resistance on the heating wall surface; $1/\alpha = 0{,}125\ (m^2 \cdot K)/W$

$R_{\alpha;ceiling}$ is replaced by $R_{\alpha;back}$, the heat transfer resistance on the surface of the back side of the wall;

$R_{\alpha;back} = 0{,}13\ (m^2 \cdot K)/W$, in case of adjacent rooms

$R_{\alpha;back} = 0{,}04\ (m^2 \cdot K)/W$, in case of outside environments

5 Cooling systems

5.1 General

5.1.1 Basic principles

The content of the following clauses, for cooling systems embedded in floors, ceilings and walls apply.

5.1.2 Temperature differences

Temperature differences are formulated in such a manner that the thermal output gets positive sign; i. e. cooling output and heating output are not distinguished by sign.

5.1.3 Regional dew point and standard indoor room temperature

Cooling systems shall operate within a temperature range above the dew point ϑ_{Dp}. In this Standard a regional dew point $\vartheta_{Dp,R}$ shall be specified depending on the respective climatic conditions. In this standard for example is set $\vartheta_{Dp,R0}$ = 18 °C, corresponding with an air moisture content of x = 13 g/kg. If for design other regional values $\vartheta_{Dp,R}$ are applicable or design values $\vartheta_{Dp,des}$ are set (for instance if air is dehumidified), these values shall be used (see clause 5.2.2.2).

In this standard for cooling systems the standard indoor room temperature is specified to ϑ_i = 26 °C. If other values are designed, these shall be taken into consideration.

5.1.4 Temperature difference between room and cooling water

The temperature difference $\Delta\vartheta_C$ between room and cooling water is calculated using equation (16), corresponding with the procedure for heating systems, i.e. the effect of the temperature increase of the cooling water is taken into account as well.

$$\Delta\vartheta_C = \frac{\vartheta_{C,out} - \vartheta_{C,in}}{\ln \dfrac{\vartheta_{C,in} - \vartheta_i}{\vartheta_{C,out} - \vartheta_i}} \tag{16}$$

where:

$\vartheta_{C,out}$ is the outlet (return) temperature of the cooling water

$\vartheta_{C,in}$ is the inlet (flow) temperature of the cooling water

ϑ_i is the standard indoor room temperature, ϑ_i = 26 °C

5.1.5 Characteristic curves

The characteristic curve describes the relationship between the specific thermal output q_C of cooling systems and the required temperature difference $\Delta\vartheta_C$ between room and cooling water. For simplification, the specific thermal output is taken directly proportional to the temperature difference:

$$q = K_H \cdot \Delta\vartheta_C \tag{17}$$

where the gradient K_H (same designation as for heating systems) is provided as a combined result coming from part 2 and part 5 of this Standard. Detailed information about the procedure, see part 5 of this standard.

5.1.6 Field of characteristic curves

In principle, the specifications given in clause 4.1.1.3 for floor heating systems also apply accordingly. With respect to the calculation method (see part 5 of this Standard), the field of characteristic curves should contain the values of $R_{\lambda,B}$ specified in clause 4.1.1.3, even though not all together are needed for practical application.

5.1.7 Limit curve

For cooling systems the dew point limits the temperature of the cooling water on the regional value $\vartheta_{C,des} = \vartheta_{Dp,R}$ or on other design values $\vartheta_{Dp,des}$. As a result, the limit curve within the field of characteristic curves is a vertical straight line in a distance of $\Delta\vartheta_{C,des}$ from the ordinate, depending on the set dew point.

Note: The above description is a principle one. In practice, the inlet temperature $\vartheta_{C,in}$ of the cooling water, that is the lowest system temperature, has to be limited. Depending on the design, therefore the real limit curves result a little bit lower (see clause 5.2.2).

It can be assumed that fulfilling of the dew point limitation satisfies physiological limitations as well. This shall be proved in special cases.

5.1.8 Thermal insulation

For basic information, see clause 4.1.2.2. The thermal resistance $R_{\lambda,ins}$ of the insulation layer is recommended in accordance with Table 1 of EN1264-4.

5.2 Design

5.2.1 Design value of specific cooling load

In principle, the procedure described in clause 4.1.3.1 applies, where $Q_{N,f}$ has to be replaced by the standard cooling load $Q_{C,f}$. The standard cooling load shall be calculated in accordance with EN 15243. The result according to equation (5) is denominated as designed specific cooling load $q_{C,Ld,des}$.

5.2.2 Determination of the design flow (inlet) temperature and the design specific thermal output

5.2.2.1 General

For the following descriptions it is presumed, a dew point sensor is installed on a suitable place in order to limit the inlet water temperature $\vartheta_{C,in}$. This means, operation only takes place in the range $\vartheta_{C,in} > \vartheta_{Dp,des}$.,

where

$\vartheta_{C,in}$ is the cooling water inlet temperature

$\vartheta_{Dp,des}$ is the design dew point.

The procedure described in clause 5.2.2.2 is worked out for the case where design dew point is equal regional dew point, i.e $\vartheta_{Dp,des} = \vartheta_{Dp,R0}$, where $\vartheta_{Dp,R0}$ is set equal 18 °C (see clause 5.1.3). But for other values $\vartheta_{Dp,R}$ or $\vartheta_{Dp,des}$ respectively, the procedure also applies if the following modification is carried out:

Modification for $\vartheta_{Dp,des} \neq \vartheta_{Dp,R0}$ or $\vartheta_{Dp,R} \neq \vartheta_{Dp,R0}$:

Calculate the difference $\Delta\vartheta_{Dp} = \vartheta_{Dp,des} - \vartheta_{Dp,R0}$ or $\Delta\vartheta_{Dp} = \vartheta_{Dp,R} - \vartheta_{Dp,R0}$ respectively, and in clause 5.2.2.2 replace the term $\Delta\vartheta_{C,N}$ by $\Delta\vartheta_{C,N} - \Delta\vartheta_{Dp}$.

5.2.2.2 Design based on standard water temperature difference $\Delta\vartheta_{C,N}$ and calculation of the general design flow (inlet) temperature $\vartheta_{C,in,des}$

In accordance with part 5 of this Standard, the standard temperature difference between the room and the average cooling water temperature is $\Delta\vartheta_{C,N}$ = 8 K. It should be noticed that this value is set with regard to the regional dew point $\vartheta_{Dp,R0}$. Design based on standard water temperature difference means, $\Delta\vartheta_{C,N}$ is used with the characteristic curve of the respective cooling system to get the design specific thermal output $q_{C,des}$.

It shall be allowed to use this value $\Delta\vartheta_{C,N}$ for design if the design temperature increase $\sigma_C = (\vartheta_{C,out} - \vartheta_{C,in})$ does not exceed 2 K ($\sigma_C \leq 2$ K). Including for design the range $\Delta\vartheta_{C,des} \leq \Delta\vartheta_{C,N}$, this leads to the following equation:

$$\Delta\vartheta_{C,in,des} = \Delta\vartheta_{C,des} + \frac{\sigma_C}{2} \quad \text{where } \Delta\vartheta_{C,des} \leq \Delta\vartheta_{C,N} \tag{18}$$

where

$\Delta\vartheta_{C,des}$ is the design value of the temperature difference between room temperature and average temperature of the cooling water.

Equation (18) specifies the range

$$\Delta\vartheta_{C,in,des} \leq \Delta\vartheta_{C,N} + \frac{\sigma_C}{2} \tag{18a}$$

where

$\Delta\vartheta_{C,in,des}$ is the design value of the temperature difference between room temperature and inlet temperature of the cooling water.

Equations (18/18a) are valid for $\sigma_C/\Delta\vartheta_C \leq 0{,}5$.

For the design inlet temperature, the following equation applies:

$$\vartheta_{C,in,des} = \vartheta_i - \Delta\vartheta_{C,in,des} \tag{19}$$

which results in the following final expression for the possible range of the design inlet temperature:

$$\vartheta_{C,in,des} \geq \vartheta_i - (\Delta\vartheta_{C,N} + \frac{\sigma_C}{2}) \tag{19a}$$

where ϑ_i = 26 °C.

As a result, for cooling systems limited by a dew point for example $\vartheta_{Dp,des,}$ = 18 °C, the possible range for the design inlet temperature is given by for example 1: $\vartheta_{C,in,des} \geq 17$ °C.

As a result, for cooling systems limited by a dew point for example $\vartheta_{Dp,des,}$ = 17 °C, the possible range for the design inlet temperature is given by:

for example 2: $\vartheta_{C,in,des} \geq 16$ °C.

The procedure above allows designing the inlet temperature to remain up to 1 K below the design dew point. In case the design dew point really is reached, the dew point sensor prevents to reach this lower temperature. In this case it means only a lower maximum average value $\Delta\vartheta_C < \Delta\vartheta_{C,des}$ can be reached, i. e. $\Delta\vartheta_C = \Delta\vartheta_{C,des} - \sigma_C/2$. Under these conditions, a restricted decrease of the respective thermal output occurs which shall be tolerated.

It shall be noticed that a lower inlet temperature range than calculated with the procedure above cannot be reached. Therefore a result obtained above for the design inlet temperature $\vartheta_{C,in,des}$ is a general one and shall unchanged be used for design with values $\sigma_C > 2$ K, see below.

5.2.2.3 General design, especially design with higher values σ_C

The results of clause 5.2.2.2 are presumed.

For higher values $\sigma_C > 2$ K the result of equations (19/19a) for the inlet temperature remains valid. The design inlet temperature $\vartheta_{C,in,des}$ presumed, the further calculation concerns the determination of the average temperature difference $\Delta\vartheta_{C,des}$. But in the case $\sigma_C > 2$ K for design, the standard temperature difference $\Delta\vartheta_{C,N}$ cannot longer be used. In this case and generally, if in the range of equation (19/19a) any value for the design inlet temperature $\vartheta_{C,in,des}$ is set, the design value of the average cooling water temperature difference $\Delta\vartheta_{C,des}$ is calculated with the following equation:

$$\Delta\vartheta_{C,des} = \Delta\vartheta_{C,in,des} - \left(\frac{\sigma_C}{2} + \frac{\sigma_C^{\,2}}{12 \cdot (\Delta\vartheta_{C,in,des} - \sigma_C / 2)}\right) \tag{20}$$

which is valid for any relation $\sigma_C/\Delta\vartheta_C$.

Using the characteristic curve, from $\Delta\vartheta_{C,des}$ results the corresponding design specific thermal output $q_{C,des}$. Comparison with the specific cooling load $q_{C,Ld,des}$ (see 5.2.1) clarifies the degree of load accomplishment.

The procedure above described shall be carried out for all room circuits which are operated at the same design inlet temperature $\vartheta_{C,in,des}$.

5.2.3 Determination of design cooling water flow rate

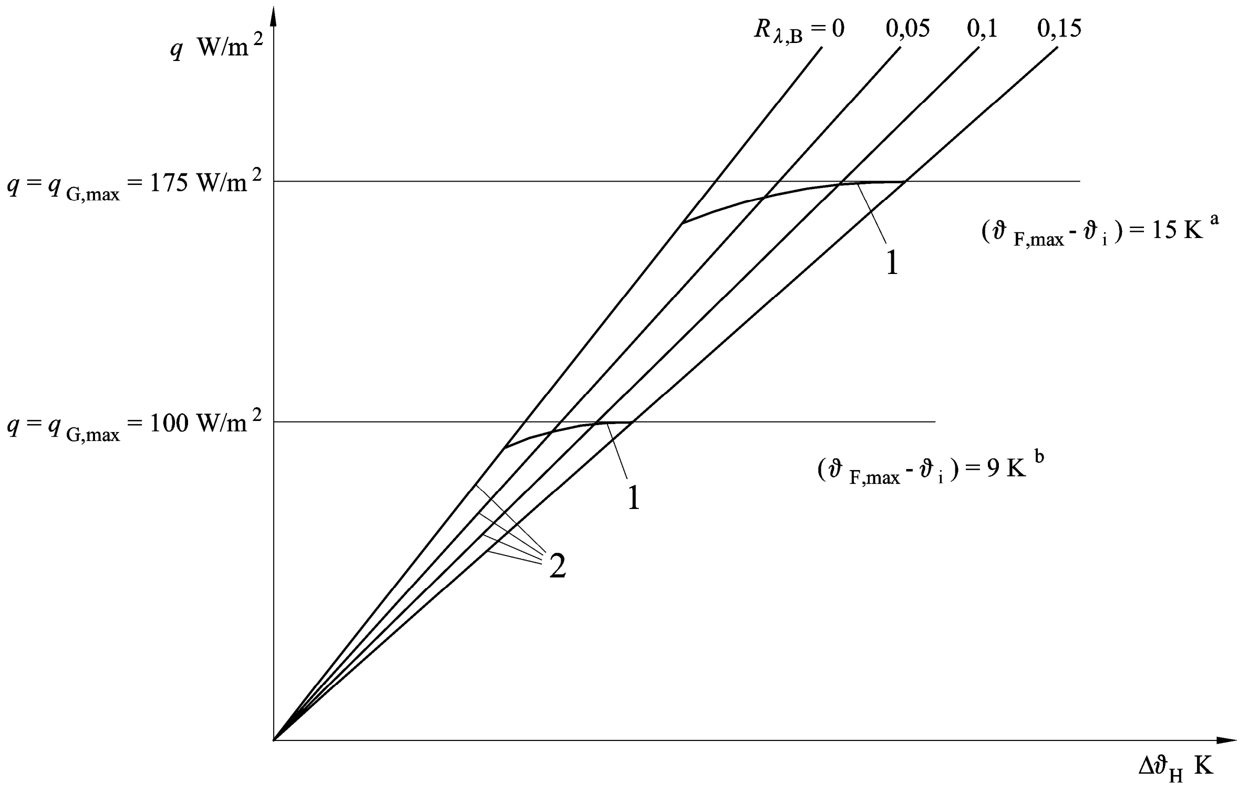
The respective equation (13) of clause 4.1.3.3 is changed in

$$m_C = \frac{A_F \cdot q_{C,des}}{\sigma_C \cdot c_W} \cdot \left(1 + \frac{R_o}{R_u} + \frac{\vartheta_u - \vartheta_i}{q \cdot R_u}\right) \tag{21}$$

For the rest, the procedure of clause 4.1.3.3 should be used accordingly.

Annex A
(normative)

Figures



Key

q: specific thermal output

$\Delta\vartheta_H$: Temperature difference between heating water and room K

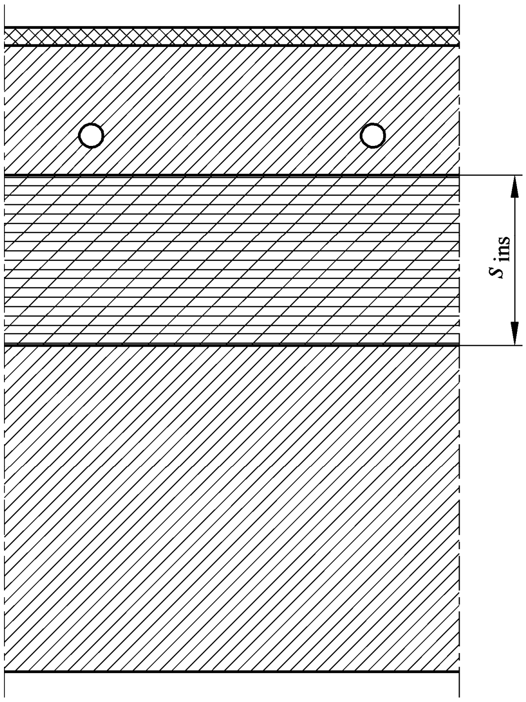
1: Limit curves

a: peripheral area

b: occupied area

2: Characteristic curves

Figure A.1 — Field of characteristic curves for T = constant with limit curves included



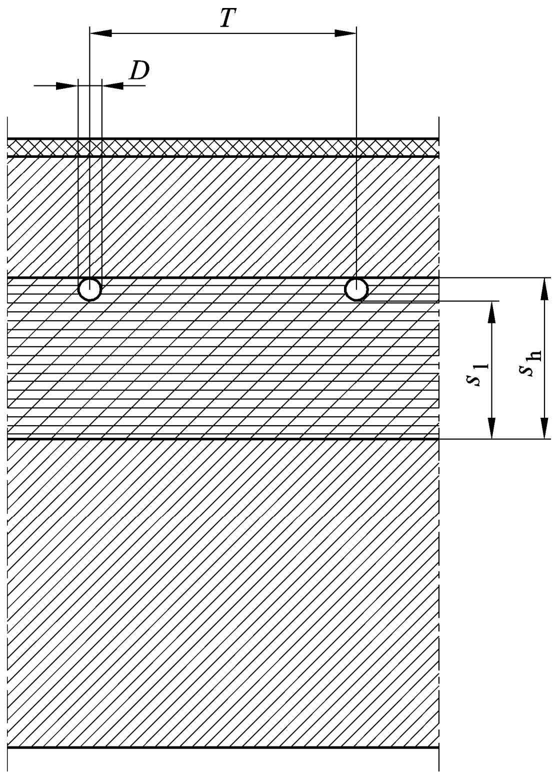


Figure A.2: Average thickness of insulating layer flat insulating panels

Figure A.3: Average thickness of insulating for layer for profiled insulating panels

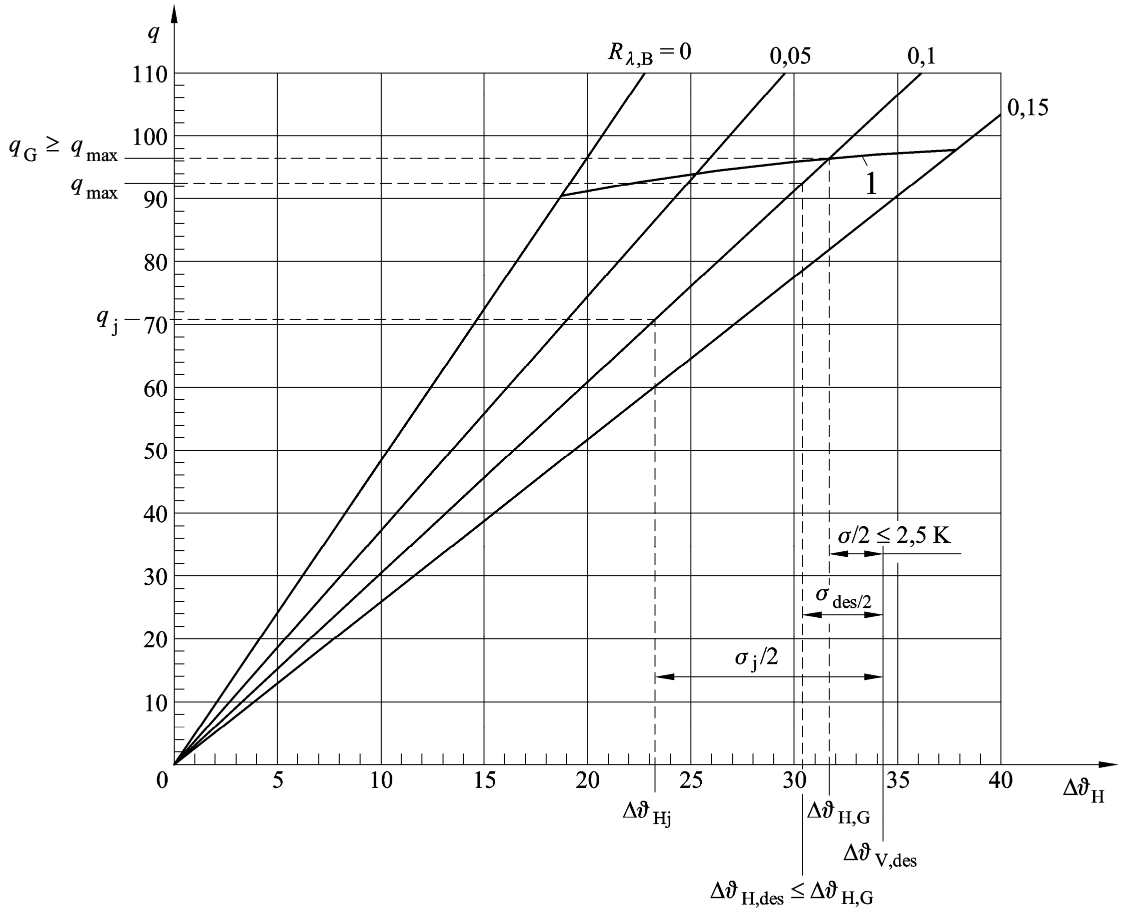


Figure A.4 — Determination of the design temperature difference $\Delta\vartheta_{V,des}$ between flow and room, and temperature drop σ_j for the other rooms

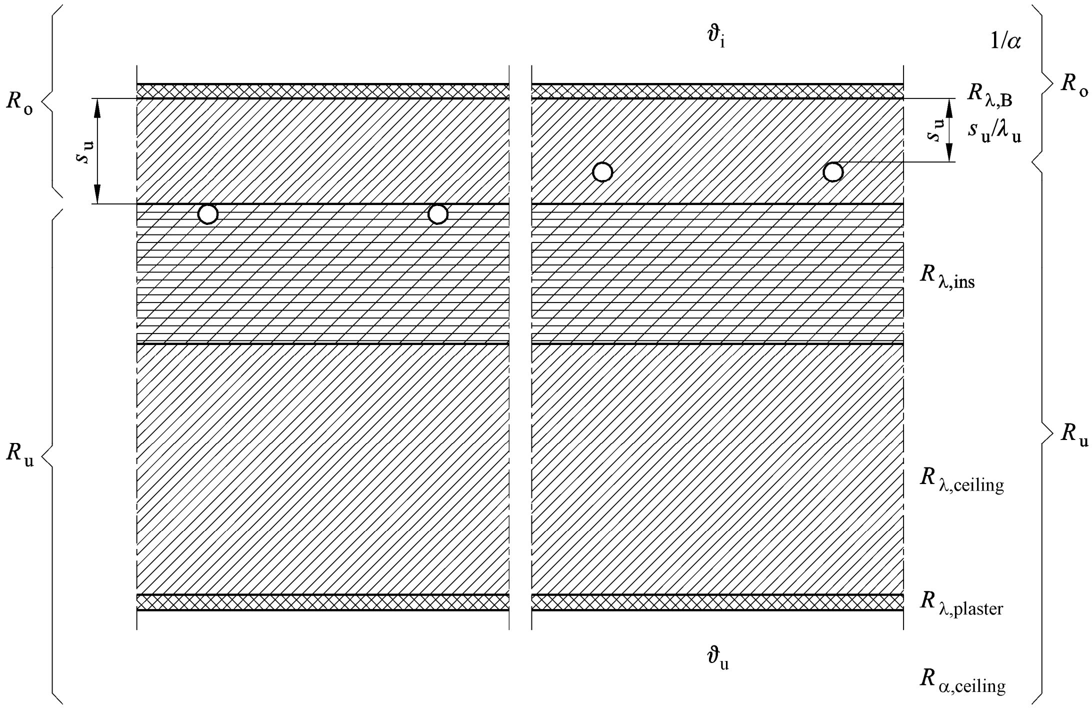


Figure A.5 — Model of a floor construction with floor heating system installed

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