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Ploskovni sistemi za gretje in hlajenje z vodo - 3. del: Dimenzioniranje

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

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

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

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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of an identical text or by endorsement, at the latest by March 2010, and conflicting national standards shall be withdrawn at the latest by March 2010.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 $R_{\lambda,B} = 0{,}15$ (m^2 K)/W in accordance with part 2 of this European Standard (see Figure A.1). Values of $R_{\lambda,B} > 0{,}15$ (m^2 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).

$$R_{\lambda,ins} = \frac{s_{ins}}{\lambda_{ins}} \quad (3)$$

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}:

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

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:

$$q_{des} = \frac{Q_{N,f}}{A_F} \quad (5)$$

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:"

$$Q_F = q \cdot A_F \quad (6)$$

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):

$$q = \frac{A_R}{A_F} \cdot q_R + \frac{A_A}{A_F} \cdot q_A \quad (7)$$

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·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:

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

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

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

[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:

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

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

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

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:

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

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:

$$Q_{out} = Q_{N,f} - Q_F \qquad (12)$$

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:

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

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·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·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 ($\vartheta_{F,max} - \vartheta_i$) = 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.