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Electric room heating, underfloor heating, characteristics of performance — Definitions, method of testing, sizing and formula symbols

National foreword

This British Standard is the UK implementation of EN 50559:2013.

The UK participation in its preparation was entrusted to Technical Committee CPL/59, Performance of household electrical appliances.

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

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Electric room heating, underfloor heating, characteristics of performance - Definitions, method of testing, sizing and formula symbols

Chauffage électrique de locaux - Chauffage par le sol - Caractéristiques de performance - Définitions, méthode d'essai, calibrage et symboles de formule

Elektrische Raumheizung, Fußbodenheizung, Charakteristika der Gebrauchstauglichkeit - Definitionen, Testmethoden, Dimensionierung und Formelsymbole

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

This document (EN 50559:2013) has been prepared by CLC/TC 59X "Performance of household and similar electrical appliances".

The following dates are fixed:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2013-12-24
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2015-12-24

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Introduction

No draft of this present preliminary standard has been published.

A preliminary standard is the result of standardisation work which, due to certain reservations about the contents or due to a compilation process deviating from a standard, has not yet been published by DIN.

The national working body UK 513.4 „Raumheizgeräte“ (Room Heating) of the DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE (http://www.dke.de) is responsible for this preliminary standard.

In cases of a dated reference in the normative text, the reference is always applied to the issue being referred to.

The correlation between the quoted standard and the relevant German Standard is given in so far as a correlation exists, fundamentally by means of the number of the relevant IEC-Publication.

Example: IEC 60068 has been taken over by CENELEC as EN 60068, and incorporated into the German Standards as DIN EN 60068.

1 Scope

This European Standard applies to electrical underfloor heating of dwellings and all other buildings whose use corresponds to dwellings or is at least similar, having a maximum load bearing in use of 4 kN/m².

This European Standard defines the main characteristics of electrical underfloor heating and establishes the method of testing of these characteristics as information for the user.

This European Standard does not deal with:

- installation and safety requirements;
- DIN VDE 0100-723.

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 1264-1, *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 1264-3, *Water based surface embedded heating and cooling systems — Part 3: Dimensioning*

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 60335-2-96, *Household and similar electrical appliances — Safety — Part 2-96: Particular requirements for flexible sheet heating elements for room heating (IEC 60335-2-96)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
electrical underfloor heating system
electrical underfloor heating, the switching, control and regulation appliances and the electrical installation

3.1.1
underfloor heating
in situ flooring constructed as a heating system

Note 1 to entry: It is generally laid on a dry, level, load-bearing substructure.

3.1.2
underfloor direct heating
underfloor direct heating, by which the heat generated from electrical energy is transferred with the least possible time lag to the room to be heated mainly via the surface of the floor

Note 1 to entry: There is no restriction on the amount of time electrical energy can be converted into heat.

3.1.3
underfloor warming
underfloor warming increases comfort by means of pleasant warmth on the feet

Note 1 to entry: It is not necessary to calculate the heat load of the room and the insulating layers as the underfloor warming is not considered when calculating the heat load of the room.

3.1.4
controlled underfloor heating
underfloor heating, by which the heat generated from electrical energy is transferred with the least possible time lag to the room to be heated mainly via the surface of the floor

Note 1 to entry: The conversion of electricity into heat may be interrupted - for no longer than 2 h continuously - no longer than 8 h total in a 24 h period. The period of use will be equivalent to at least the previous period of interruption.

3.1.5
underfloor storage heating
underfloor heating, by which the electrical energy is converted into heat and transferred with an intended time lag to the room to be heated mainly via the surface of the floor

Note 1 to entry: The charging takes place during the charging time period t_F and, as a rule, during an additional charging time t_{ZF} of minimum 2 h.

3.1.6
underfloor storage heating system
underfloor heating, auxiliary heating, the switching, control and regulation appliances and the electrical installation

3.1.7
electrical auxiliary heating
necessary heating equipment with a rating Q_Z in the room being heated, additional to, and different from, the underfloor heating (e.g. periphery heating, convector panels, etc.)

3.1.8
heating circuit
independently switched, regulated or controlled section of an underfloor heating system

3.2
duration of design charge
duration of the charge for which the storage heating system is designed and which is determined as the basis for testing

Note 1 to entry: It constitutes the largest continuous charging time within a period of 24 h.

3.3
auxiliary charge
sum of the auxiliary charging times occurring between two design charge times

3.4
designed rating of a heating element
manufacturer's stated power rating for the heating element in W at the design voltage

3.5
capacity of a room
capacity in W of underfloor heating in a room is the sum of the measured power ratings of the installed heating elements of an underfloor heating system in that room

3.6
design temperature ϑ_N
highest permissible heating cable nominal temperature in °C, taking into consideration the specific operating properties, such as heat resistance of heat and sound insulation materials

Note 1 to entry: The design limiting temperature is the highest permissible temperature which is allowed for by the manufacturer of the surface heating element.

3.7
maximum surface temperature
temperature which, for physiological purposes, cannot be exceeded on the uncovered upper surface of the flooring

Note 1 to entry: This temperature may be exceeded in peripheral areas.

3.8
standard internal temperature
value of the room temperature necessary for the calculation, ϑ_i in °C; is the resulting temperature, defined as the mean of the dry air temperature and the mean radiant temperature

3.9
standard heat load of an underfloor heated room
$\dot{Q}_N^*$ the standard heat load of an underfloor heated room, is used only to size the underfloor heating

Note 1 to entry: Its value (as with that of the standard heat load of an underfloor heated room $\dot{Q}_N^*$) in W, is calculated using EN 12831, taking into account the partially limited heating of the rooms in the dwelling. Areas of the room which are equipped with surface heating elements (Flooring, Ceiling) remain unconsidered. To differentiate between the standard heat load $\dot{Q}_N$ in W this value will be denoted as the standard heat load of an underfloor heated room, $\dot{Q}_N^*$ in W.

3.10
standard heat load per unit surface area $\dot{q}_N^*$

standard heat load $\dot{Q}_N$ related to the area of the flooring surface *A* of the room to be heated, in W/m^2

$$\dot{q}_N^* = \frac{\dot{Q}_N}{A}$$

3.11
design heating capacity of a room with an underfloor direct heating System $\dot{Q}_H^*$

design heating capacity of a room with underfloor direct heating $\dot{Q}_N^*$ in W in accordance with EN 12831, which is also valid for controlled underfloor heating

3.12
design heating capacity per unit area of a room with an underfloor direct heating system $\dot{q}_H^*$

design heating capacity of a room with underfloor direct heating $\dot{Q}_H^*$ in relation to its floor area *A* in m^2, in W/m^2

$$\dot{q}_H^* = \frac{\dot{Q}_H^*}{A}$$

3.13
maximum capacity per unit area P_F
largest possible capacity in W/m^{2}which can be installed, taking into account the maximum surface temperature, the construction of the underfloor heating system and the energy supply charging time

3.14
capacity per unit area
capacity P in W in relation to the floor area to be heated A_F

$$P_{IN} = \frac{P}{A_F}$$

3.15
mean heating capacity
average heating capacity in W of the heating floor area for a given time, taking into account the floor upper surface temperature, the standard room temperature and the mean temperature on the inside surfaces of walls and ceilings

3.16
mean heat flow density

$\dot{q}_F$
heat flow per surface area in W/m^2 from the floor to the heated room

3.17
localised hot spots
occur when the floor area is covered with a highly insulating material (such as cushions or mattresses) or by defective switching, regulation or control apparatus. This results in an undue thermal strain on the underfloor heating

3.18
effective heat storage capacity for underfloor storage heating
partial amount of the heat storage capacity of a building (room) in W/m^{3}K, having an influence on the heat load

Note 1 to entry: Evaluation, see EN 12831 and DIN V 4108-6:2003-06, 6.5.2.

3.19
storage mass of a heated room in relation to external surface
$m/\sum A_a$ in kg/m^2 is the Quotient of the storage mass of the room *m* in kg and the sum of the external surfaces of the room $\sum A_a$ in m^2

3.20
permanent fixture area
non-heating area of the floor surface which is designated for full-surface mounting or the installation of furnishings

Note 1 to entry: The floor areas in WC, shower or bathroom, on which bathroom fittings such as WC, shower or bathtub are to be installed, count as permanent fixture areas.

3.21
peripheral zone area A_R
floor area with a maximum width of 1 m which heats at a higher temperature, generally in front of glazed external walls or external doors

Note 1 to entry: This is not deemed to be an area of permanent dwelling; in m^2.

3.22
dwelling area A_V
area of permanent residing within the heating floor area

Note 1 to entry: It is the product of the heating floor area minus the border area, in m^2.

3.23
components of electric underfloor heating

- insulating layer (for heat- and soundproofing);
- damp proofing;
- heating element;
- heat and load distribution layer;
- floor covering

3.24
insulating layer
heat insulation below the flooring, which can also serve as sound proofing

3.25
damp proofing
layer of material that serves to prevent the insulating layer becoming damp from the water used to mix the flooring screed and also to prevent mortar pollution

Note 1 to entry: At the same time it prevents the heating cables from sinking into open joints in the insulation.

3.26
heating element
combination of a heating cable or laminar heating element and, if applicable, its cold tails which connect it to the terminals of the electrical installation

3.26.1
heating conductor
electrically conducting component of the heating cable in which electrical energy is directly converted into heat

3.26.2
heating cable
insulated heating conductor

3.26.3
laminar heating conductor
electrically conducting planar component of a laminar heating element serving the direct conversion of electrical energy into heat

3.26.4
laminar heating element
insulated laminar heating conductor. Contact strips provide power supply

3.26.5
heating loop
heating element comprising a heating cable and its connected cold tails, whose geometric fixing takes place during the installation of the system

3.26.6
heating mat
combination of one or more heating elements, geometrically fixed by the manufacturer using suitable equipment

3.26.7
cold tail
insulated conductor providing the connection between the heating cable and the terminals of the electrical installation, at the same time preventing an undue warming of the terminals on the supply side

3.26.8
point of connection
connection (e.g. coupling sleeve) between a heating cable or laminar heating element and its cold tail

3.27
load distribution layer in electric underfloor heating
for example heating screed

Note 1 to entry: See EN 1264-1.

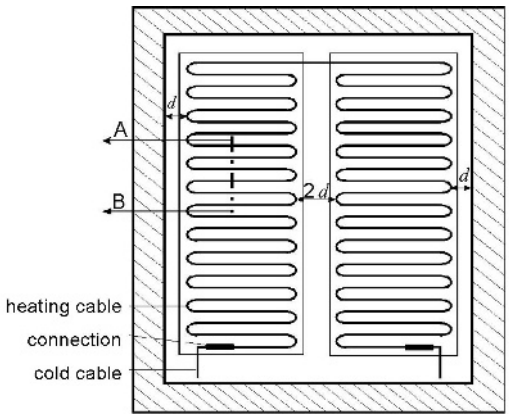
3.28
storage layer
comprises the heating screed, floor covering and all other construction elements above the heating layer which have heat conductivity values of $\lambda \geq 1{,}0$ W/(m · K)

3.29
floor covering
upper layer of the underfloor heating able to be walked upon

3.30 Laying methods

3.30.1
bedding in heating screed
the heating element is bedded directly in the freshly laid heating screed as shown in Figure 2 construction “A“ (corresponding to Type A in EN 1264)

3.30.2
bedding below heating screed
the heating element is bedded directly below, or only partially in the fresh heating screed as shown in Figure 3, construction “B“. The heating screed can have a separating layer (corresponding to Type C in EN 1264)



Key

d = depth of heating screed

Figure 1 — Layout diagram of an underfloor heating system

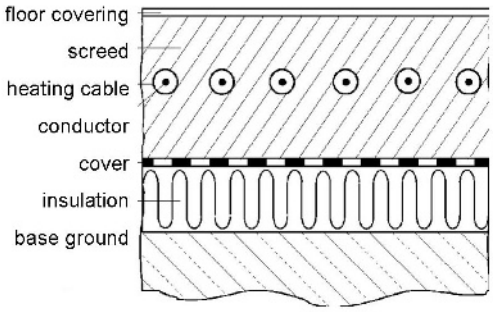


Figure 2 — Construction „A“, Cross-section A – B

3.30.3
dry laying of electrical heating elements
the heating element is laid in pre-fabricated, grooved slabs, tubes or canals below, or in the heating screed. The heating element does not come into contact with the heating screed

3.30.4
bedding directly below the floor covering
the heating element is laid on the existing sub-structure (e.g. screeding) as shown in Figure 4, construction “C“. It is normally fixed to the sub-structure with grouting

Note 1 to entry: It is normally fixed to the sub-structure with grouting.

3.31
pulsation factor $\Delta\vartheta_F$
maximum temperature difference in Kelvin which can occur on the upper surface of a flooring within the dwelling area, in K

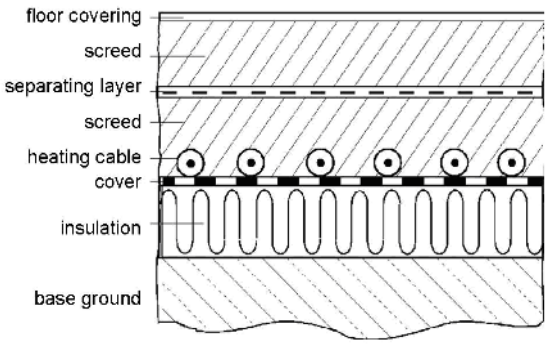


Figure 3 — Construction “B“, Cross-section A – B

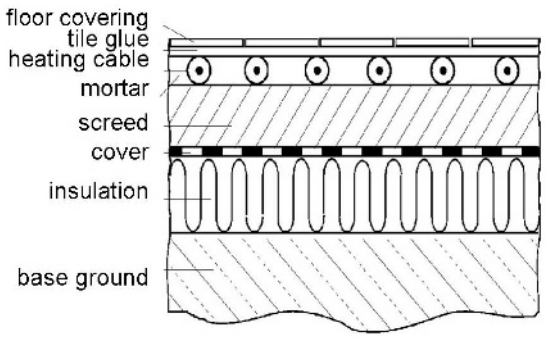


Figure 4 — Construction "C" Cross-section A – B

3.32 Control and regulation equipment

3.32.1
weather sensor
component which measures prevailing weather conditions (e.g. outside temperatures) and transmits these values as reference input to other components of the charge control

3.32.2
floor temperature sensor
floor temperature sensor is a component which measures the temperature of a fixed point in the heating floor surface and transmits this value as a reference input to other components of the charge control/regulator

3.32.3
floor temperature limiter
floor temperature limiter is an operating temperature limiter as defined in EN 60730-1

Note 1 to entry: It is a self-resetting component with which the temperature at a fixed point in the heating floor surface is kept below a set value by automatically controlling the heating system.

3.32.4
floor temperature regulator
floor temperature regulator is a component which maintains the temperature of the floor temperature sensor within settable limits by automatically controlling the heating system

3.32.5
room temperature regulator
room temperature regulator is a component which maintains the temperature of the room air within settable limits by automatically controlling the heating system

3.32.6
supply period
t_F
largest possible continuous period of time, in which during a time-period of 24 h electrical energy can be obtained for the underfloor heating at its point of installation

Note 1 to entry: In practical operation the supply period can either be continuous or, for reasons of load control in supply networks, divided into individual sectors.

3.32.7
auxiliary supply period
t_{ZF}
sum of the additional periods, between two supply periods, in which electrical energy is supplied for underfloor heating, in hours

3.32.8
period of room use
t_B
period for which the underfloor heating system is designed, in hours

4 Method of testing for the determination of characteristics of performance

4.1 General

Electrical underfloor heating systems are deemed to be a fixed component of the building to be heated. The testing of underfloor heating systems and their conformity to sizing standards shall be confirmed by calculation and if necessary by measurement. A confirmation by measurement of the installed system should only be carried out in justifiable cases.

4.2 Standard heating load per unit area

In consideration of functionality, efficiency and maintenance of hygienic conditions, the standard heating load per unit area of dwellings and buildings with similar use heated by underfloor heating should not exceed 70 W/m^2. The standard heating load per unit area of an individual room $\dot{q}^*_N$ in W/m^2 may in exceptional circumstances exceed this value when justified by the heat load calculation according to appendix A.

4.3 Maximum power rating per unit area

The maximum power rating per unit area shall be selected so that even at localised hot spots no damage can occur on the underside of the load distribution layer. An additional localised hot spot above the intended floor covering is assumed to exist due to covering by an additional insulating layer with a resistance to heat conductivity of

$$R_\lambda = 2\frac{\mathrm{m}^2 \times \mathrm{K}}{\mathrm{W}}$$

(Corresponds to e.g. 0,08 m of a material with λ = 0,04 W/(m K))

Limiting values of the maximum power rating based on surface are to be found in Appendix A of this European Standard, Tables A.1 to A.8.

The rating of the room shall be determined. The rating per unit area P'_{IN} in W/m^2 is:

$$P'_{IN} = \frac{P}{AF}$$

4.4 Maximum surface temperature

The temporal average temperature difference between floor surface and room air temperature during usage time in dwelling areas is

- not more than 6,5 K for underfloor storage heating,
- not more than 9,0 K for underfloor direct heating and controlled underfloor heating.

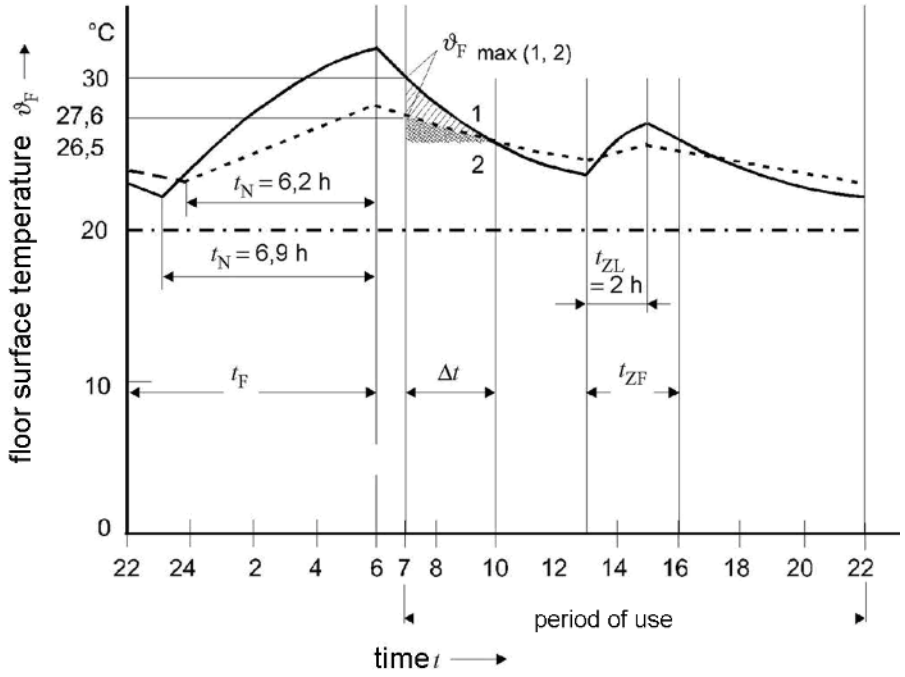
The value of the average heat flow density is based on this temperature difference.

The mean surface temperature shall be measured in the actual condition of the room (condition of use). It shall be determined whether the actual and designed conditions of the floor covering are correspondent. The surface temperature in shall be measured and recorded at a minimum of 5 random points in dwelling areas, in peripheral areas at a minimum of 3 random points, which are at least 0,4 m from lateral confinements of the heating area. Measurements shall not be carried out at points whose temperature can be influenced by outside sources, e.g. sun's rays.

The measurement of temperature should take place using a non-contact radiant thermometer, vertical to the area of measurement. The limit of error of the measuring instrument measured on a black radiator should be ± 0,5 K at a housing temperature of 15 °C to 35 °C.

The measurement area on the flooring shall have a diameter of 0,2 m ± 10 %.

The mean surface temperature ϑ_{FM} in °C during the period of use of the room shall be calculated and recorded from the values measured at 08:00, 13:00 and 19:00 hours for every point of measurement.



Key

1 storage Layer Depth e.g. δ = 0,06 m

2 storage Layer Depth e.g. δ = 0,12 m

floor covering: carpet 0,006 m, λ = 0,05 W/ (m · K)

Δt duration of exceeding 26,5 °C within the period of use

ϑ_{Fmax} maximum floor surface temperature within the period of use

hatched area = T_E

Figure 5 — Examples for the effect of floor excess temperature T_E

$$\vartheta_{Fm} = \frac{\vartheta_{F(8)} + \vartheta_{F(13)} + \vartheta_{F(19)}}{3}$$

The testing is only to be carried out when on two consecutive days immediately before the testing and on the day of testing itself the daily mean outside air temperature is $\vartheta_{am} \leq 10$ °C.

The outside air temperature ϑ_a in °C shall be measured with apparatus protected from radiation with a limit of error of 0,5 K, at a distance of 1 m from the external wall and at least 2 m above ground. Measurements are to be taken at 07:00, 14:00 and 21:00 hours and their daily mean ϑ_{am} in °C shall be recorded.

$$\vartheta_{am} = \frac{\vartheta_{a(7)} + \vartheta_{a(14)} + 2\vartheta_{a(21)}}{4}$$

4.5 Maximum floor surface temperature for underfloor storage heating

The effect of a floor temperature excess T_E in K compared with the maximum floor surface temperature for the designated use within the room use period is shown in Figure 5 and also in the approximation

$$T_E = \frac{(\vartheta F_{max} - \vartheta_{FZUL}) \cdot \Delta t}{2}$$

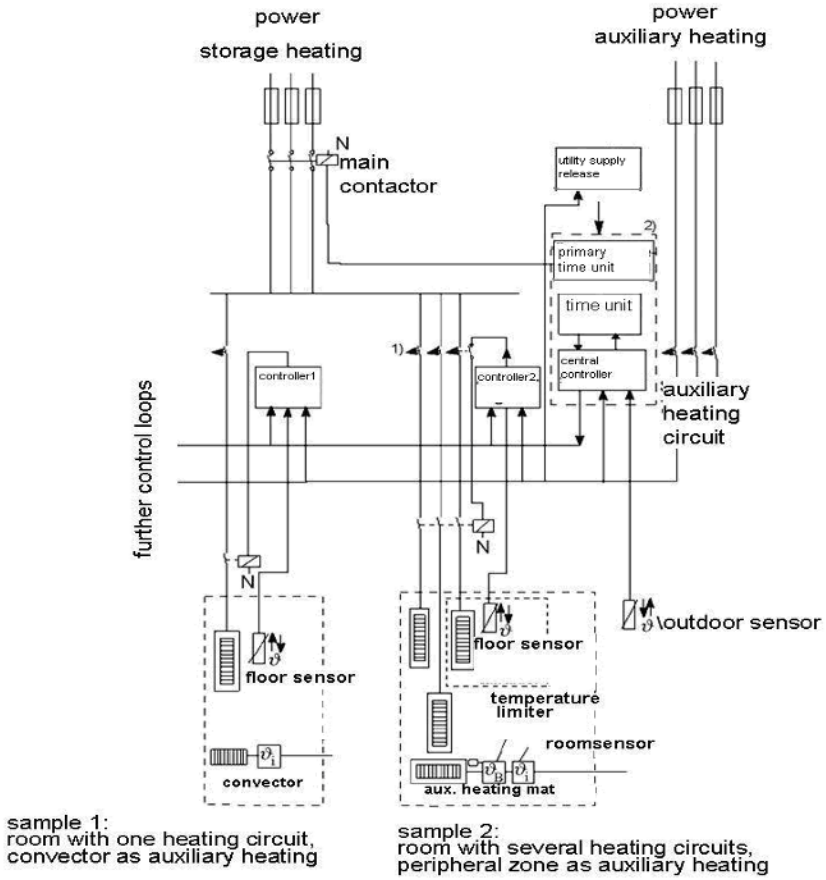
A value of 4 K shall not be exceeded.

Example of an unsuitable construction:

$$T_E = \frac{(\vartheta_{Fmax} - 26{,}5) \cdot \Delta t}{2} = \frac{(30 - 26{,}5) \cdot 3}{2} = 5{,}25\ \text{Kh}$$

Example of a suitable construction:

$$T_E = \frac{(\vartheta_{F\,max} - 26{,}5) \cdot \Delta t}{2} = \frac{(28 - 26{,}5) \cdot 3}{2} = 2{,}25\ \text{Kh}$$



Key

1) power switch with auxiliary switching of heating circuit by means of floor sensor

2) for monitoring supply charge periods

Figure 6 — Basic circuit diagram of underfloor storage heating

4.6 Room air temperature

During testing, the air temperature of the room being tested shall be continuously measured with a suitable measuring apparatus, limit of error 0,5 K, at 0,75 m above the point of intersection of the diagonals of the room floor surface. These measurements are to be recorded. The point of measurement shall be screened against heat radiation from the surrounding surfaces of the room.

If an auxiliary heater is used, this shall be ready for operation during the period of measurement within the duration of room use. The corresponding thermostat shall be set at the designed value for the measurement.

NOTE Explanations, see EN 12831.

4.7 Internal surface temperatures on the surrounding surfaces of the room

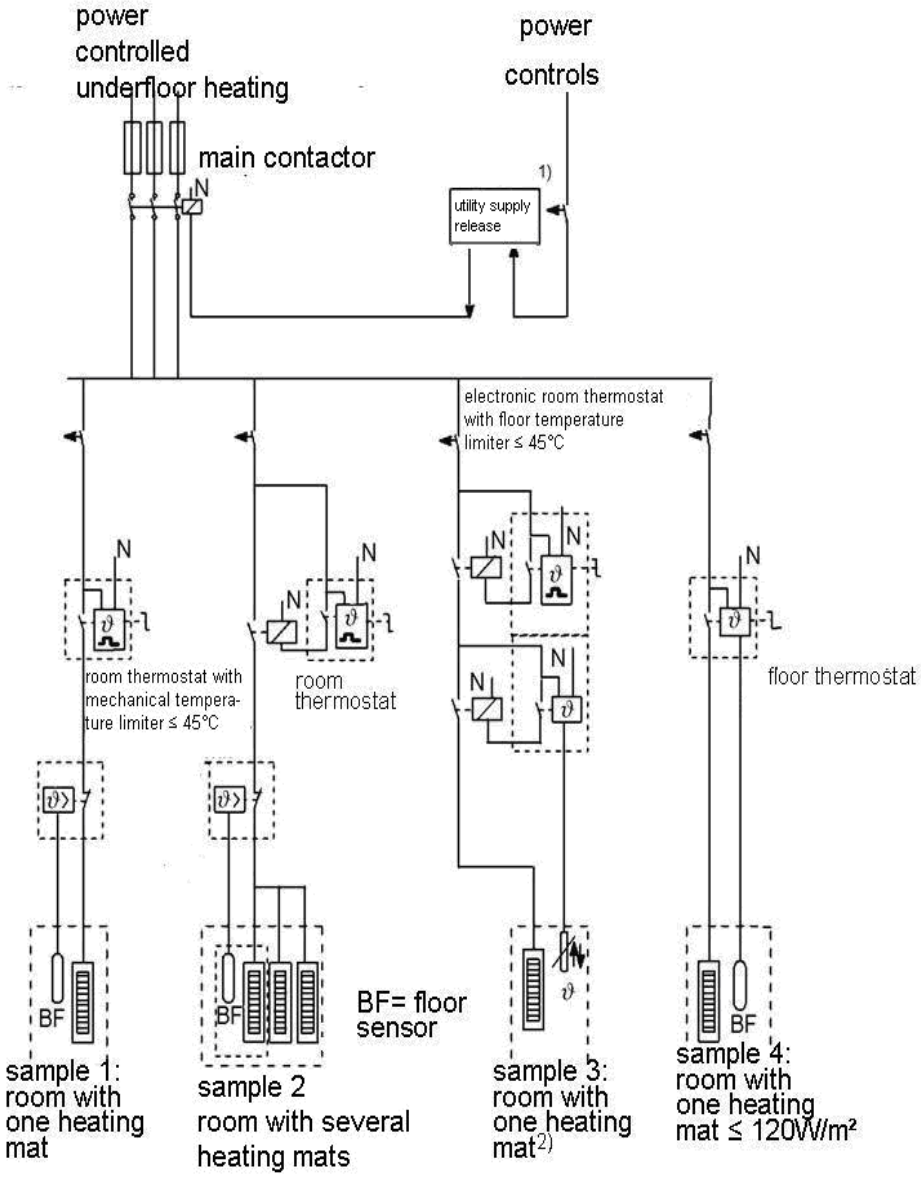
The mean surface temperature of surrounding surfaces of the room which are not heating surfaces shall be recorded in °C, using the method of testing described in 4.4. The points of measurement are at the points of intersection of each diagonal of the surrounding heat storing areas.

4.8 Thermal pre-conditioning of the room to be tested

In order to eliminate the influence of pre-heating, the thermal conditions in the room to be tested shall reach a state of equilibrium before floor temperatures are measured. After a three-day thermal pre-conditioning using the design supply charge and boost charge periods, the temperature of the damp-proofing of the insulating layer shall be measured at the points of intersection of each surface diagonal for a period of 24 h and the mean of the hourly measurements shall be recorded. A continuous power draw during the supply and boost charging shall be ensured. The temperature in the room to be tested is 20 °C $\pm$ 1 K.

In the process, the time intervals of supply and boost charging are to be measured and recorded.

If an auxiliary heater is used, this shall be ready for operation during the period of measurement within the duration of room use. The corresponding thermostat shall be set at the designed value.



Key

1) Only necessary for controlled underfloor direct heating

2) For power ratings > 120 W/m^2 additional temporal limiting equipment

Figure 7 — Underfloor direct heating, controlled underfloor heating and warming — Example of a circuit for individual room regulation. Rooms have one heating circuit each

4.9 Floor temperature in the case of continuous local hot spots

If heat dissipation is hindered continuously and over a large surface (hot spot) the temperature shall not exceed a mean value of 65 °C. The hot spot shall be simulated, using a separate insulating layer whose resistance to thermal conductivity is

$$R_\lambda = 2\,\frac{\mathrm{m}^2 \cdot \mathrm{K}}{\mathrm{W}}$$

with a surface area of ≥ 1 m^2.

Floor temperatures are to be measured on a construction model. The model of each underfloor heating construction with a minimum heated surface of 1 m x 2 m shall be covered over 50 % of its width by an insulating layer with an area of 1 m x 1 m whose resistance to thermal conductivity is

$$R_\lambda = 2 \frac{\mathrm{m}^2 \cdot \mathrm{K}}{\mathrm{W}}$$

For underfloor direct heating with $t_F + t_{ZF} \geq 16$ h a floor temperature limiter whose cut-off temperature set at 45 °C shall be placed at the point of intersection of the surface diagonals of the uncovered heating area at the level of the heating layer.

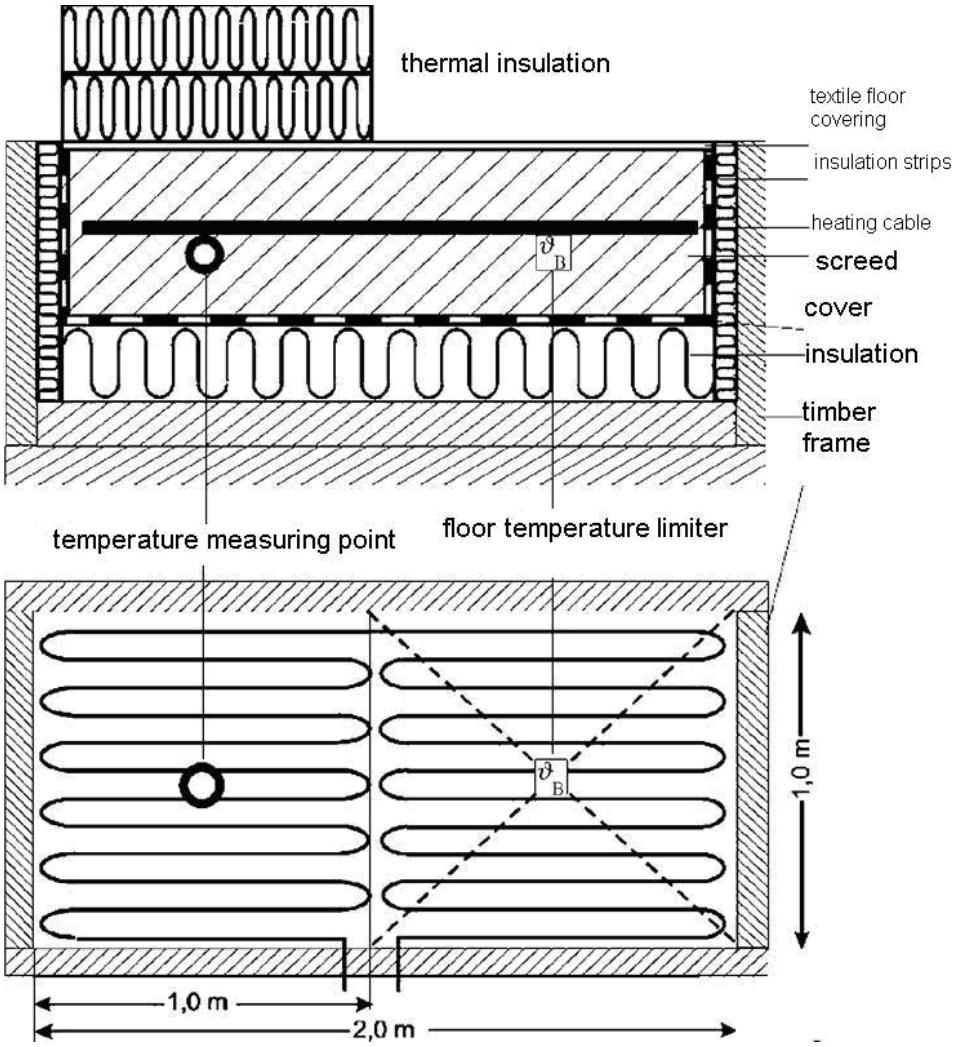


Figure 8 — Construction of model

The lateral confining materials for this model shall be so chosen as to have a resistance to thermal conductivity of:

$$R_\lambda = 1 \frac{\mathrm{m}^2 \cdot \mathrm{K}}{\mathrm{W}}$$

The insulating layer causing hot spots shall be placed on the floor surface after thermal pre-conditioning.

4.10 Floor temperature of underfloor storage heating through failure of a switching, controlling or regulation apparatus

If a switching, controlling or regulation apparatus fails, it shall be ensured that no damage occurs to the underfloor heating system. Individual automatic switching appliances for each heating circuit (heating circuit relay) shall be controlled by a separate charge control with floor temperature sensor.

Each individual heating circuit shall be protected by a circuit breaker.

If one charge control is used for multiple heating circuits, it shall be ensured, using appropriate switching (e.g. circuit breaker with auxiliary switching), that, when the heating element in which the floor temperature sensor is fixed is switched off, all accompanying switching appliances and heating circuits are switched off simultaneously.

Circuit breakers with auxiliary switching for heating elements in which floor temperature sensors are fixed are to be labelled as follows:

Heating element with floor temperature sensor

4.11 Floor temperature of controlled underfloor heating and underfloor direct heating through failure of a switching, controlling or regulation apparatus

If a switching, controlling or regulation apparatus fails, it shall be ensured that no damage occurs to the underfloor heating system. Each individual heating circuit shall be protected by a circuit breaker. Multiple heating circuits in one room can be controlled if it is ensured that, with appropriate switching, all switching appliances of both this regulation circuit and the controlled heating circuits are simultaneously switched off. Circuit breakers with auxiliary switching for heating elements with regulation appliances are to be labelled as follows:

Heating element with regulator

4.12 Regulation of room temperature using peripheral areas for underfloor storage heating

If a peripheral area heating is used as auxiliary heating, an additional switching apparatus which automatically limits the temperature in the load-bearing layer, e.g. a floor temperature limiter whose sensor is fixed in the load-bearing layer, shall be installed. Furthermore, this sensor shall be fixed in the point of intersection of the surface diagonals of each peripheral area, however at a minimum distance of 0,4 m from the edge of the peripheral area nearest to the external wall. A floor temperature limiter shall not be set at a temperature higher than 60 °C, the switching differential of the floor temperature limiter shall lie between 0 K and -5 K. The maximum rating per surface area of peripheral heating shall not exceed a value of 250 W/m^2.

If peripheral heating is installed such that it encroaches on the underfloor storage heating, both heating circuits shall be switched so as to be blocked against each other.

The operating instructions shall carry a clear notice that the areas of peripheral heating shall not be fully covered by furnishings (carpets or other large pieces of furniture).

4.13 Regulation of room temperature using controlled underfloor heating and underfloor direct heating

A switching apparatus which automatically limits the temperature in the heating layer e.g. a floor temperature limiter whose sensor is fixed in the heating layer shall be installed in addition to the room thermostat (see Figure 8).

The cut-out temperature of the floor temperature limiter shall be set at 45 °C $\pm$ 5 K.

Is the power per surface area of the heating elements > 120 W/m^2, the regulation equipment shall also allow a temporal limitation of the power draw, so that if a hot spot occurs outside the position of the floor temperature sensor or limiter, the permissible maximum temperature cannot be exceeded.

4.14 Regulation of room temperature using underfloor warming

No room temperature measurement is necessary to regulate the underfloor direct heating in this application. A floor temperature regulator with limiting function shall be installed.

Is the power per surface area of the heating elements > 120 W/m^2, the regulation equipment shall also allow a temporal limitation of the power draw, so that if a hot spot occurs outside the position of the floor temperature sensor or limiter, the permissible maximum temperature cannot be exceeded.

4.15 Relationship of coefficients of heat transfer

In order to limit the conduction of heat towards the sub-structure, it is necessary that the coefficients of heat transfer of the floor construction above the damp-proofing layer have the following minimum relationship to the coefficients of heat transfer of all layers below the load-bearing layer:

- Intermediate storey ceiling above heated rooms:

$U_o \geq 4{,}0\ U_u$ ($R_u \geq 4{,}0\ R_o$)

The coefficient of heat transfer U_u of construction layers between the heating screed and heated rooms below ($\vartheta_i \geq 15$ °C) should be ≤ 0,85 W/(m^2 · K).

- Flooring adjacent to unheated rooms:

$U_o \geq 6{,}0\ U_u$ ($R_u \geq 6{,}0\ R_o$)

- Flooring adjacent to outside air, e.g. above open passages and floor slabs directly on ground:

$U_o \geq 6{,}5\ U_u$ ($R_u \geq 6{,}5\ R_o$)

The coefficients of heat transfer of construction layers between heating screed and outside air, ground or parts of buildings with much lower inside temperatures shall conform to national regulations.

The relation between heat transfer resistances R_u und R_o is in parentheses.

4.16 Insulating layers

The insulating layers below the floor construction are to be selected using Table 1. The minimum coefficients of heat transfer or heat transfer resistance are to be adhered to.

Only standard insulating materials suitable for underfloor heating are to be used. Other insulating materials may be used if their adherence to building regulations can be correspondingly proved, e.g. with the general approval of a building authority.

The compressibility of the insulating layer shall not be more than 5 mm. When using multiple layers, the compressibility of the individual layers are to be aggregated.

If sound-proofing and thermal insulation are to be used in one insulating layer, the insulating material with the lowest compressibility should be laid on top.

Table 1 — Minimum coefficient of heat transfer and minimum resistance to thermal conductivity of construction elements

	Intermediate storey ceilings above heated rooms	Intermediate storey ceilings above partially heated rooms	Heating areas between outside air, ground or parts of building with much lower inside temperatures	Cellar ceilings, walls and ceilings below unheated rooms and ceilings and walls, adjacent to ground
Coefficient of heat transfer U_{max} W/(m^2 · K)	1,25	0,75	0,35	0,35
Minimum resistance to thermal conductivity R_λ m^2 · K/W	0,75	1,25	2,86	2,86

4.17 Edging insulation strips

Edging insulation strips are to be arranged on all walls and other upright construction elements such as door lintels, vertical pipework and columns before the heating screed is poured.

The edging insulation strips shall reach from the load-bearing sub-structure to the upper surface of the finished floor covering and are to allow a movement of the heating screed of at least 5 mm.

If multiple insulation layers are used, the edging insulation strips are to be laid before the uppermost insulation layer is put in place. The edging insulation strips are to be secured against movement when placing the heating screed. The protruding parts of the edging insulation strips and the damp-proofing are to be removed only after the upper floor surfacing has been completed or, with textile and elastic covering, when their adhesive has hardened.

4.18 Damp-proofing

The insulating layer shall be covered with a polyethylene sheeting of minimum 0,20 mm thickness before the heating screed is poured. The individual sheets shall overlap by a minimum of 80 mm and are to be fixed by adhesion if necessary.

Other materials or measures can be used for damp-proofing if an equivalent result can be proved.

The damp-proofing shall be laid up to the top edge of the edging insulation strips, in as far as the edging insulation strip does not fulfil the damp-proofing function.

This damp-proofing cannot be classified as a suitable measure for permanent protection of the insulating layer against water permeation.

4.19 Electrical auxiliary heating

The heating capacity of the electrical auxiliary heating shall be so designed that, with its help, the difference between the heat dissipation of the underfloor storage heating to the room to be heated and the room heating load is balanced over a 24 h period.

$$Q_Z = Q_H^* \quad Q_F$$

In order to balance out the uneven heat dissipation of the underfloor storage heating over a period of time, this heating system has a lower thermal inertia. It shall be regulated using a room thermostat. The draw of electrical energy should not be subject to time limitations during the period of room use and outside the supply charge and auxiliary charge periods.

Living rooms, children's rooms, bed and bathrooms can be equipped with electrical auxiliary heating.

4.20 Load distribution layer in electrical underfloor heating

The load distribution layer shall have a high temperature resistance, e.g. cement screeding.

If the screeding is separated horizontally, e.g. with laminar heating elements, each screeding layer shall be treated separately in relation to its bending strength.

4.21 Bedding in or under heating screed or directly below floor covering

The heating elements can be:

- bedded in the heating screed. The screed can be poured in one operation, or in two operations with a time interval.
- bedded under the heating screed. It shall be ensured that the heating cables do not penetrate into joints in the insulating layers.
- laid directly below the floor covering, e.g. on existing screeding, in grouting.

4.22 Dry laying of electrical heating elements

The heating elements are laid in pre-fabricated grooved slabs, tubes or canals. The finished flooring depends upon the individual methods of construction.

4.23 Heating element

The heating elements shall possess the necessary thermal and mechanical stability according to the respective method of installation.

4.24 Heating cable and laminar heating element

4.24.1 Heating cable for bedding in or under screeding or directly below floor covering

Heating cables used for bedding in or under heating screed or directly below floor covering shall have a design temperature of a minimum of 80 °C.

4.24.2 Heating cable for dry Laying

Heating cables used for dry laying shall have a design temperature of a minimum of 150 °C.

4.24.3 Laminar heating elements for installation below or in screeding

Laminar heating elements shall conform to EN 60335-2-96 and shall have a design temperature of a minimum of 80 °C.

4.25 Characteristics of heating cables

Heating cables shall not show any measured change in their properties compared to their condition as supplied after hot spots according to 4.9 or failure of switching and control apparatus according to 4.10 and 4.11.

4.26 Characteristics of laminar heating elements

Laminar heating elements shall not show any measured change in their properties compared to their condition as supplied over and above the values stated in IEC 61/1096/CD after hot spots according to 4.9 or failure of switching and control apparatus according to 4.10 and 4.11.

4.27 Cold tails

Cold tails are to be designed for a temperature of 70 °C.

The cable cross-section shall be designed for a surrounding temperature of 55 °C.

4.28 Point of connection

The points of connection between a heating cable or laminar heating element and its cold tails are to be so designed that they possess the thermal, electrical and mechanical resistance of the respective heating cable or laminar heating element. The point of connection shall be bedded in the flooring.

4.29 Bending radius of the heating cable

Heating cables are to be laid - with temporary tools if necessary - so that they shall be neither bent nor squeezed. The radius of bending shall not be less than five times the heating cable radius.

4.30 Heating element labelling

Each heating element shall be so labelled that the design data (supply voltage, design rating, dimensions) are clearly visible when supplied (e.g. by means of attached labels or package printing).

4.31 Pulsation factor

When using heating cables, the clearance between them shall be so designed that during the period of room use a temperature difference no greater than 1,5 K occurs on the floor surface within the heating area.

This follows also for the clearance between laminar heating elements, heating loops and heating mats within the area of dwelling.

The temperature distribution within the heated floor surface shall be measured during the period of room use, using a non-contact radiant thermometer. The area of measurement on the flooring shall have a diameter of 0,2 m $\pm$ 10 %. The maximum temperature differential in K shall be recorded.

4.32 Installation of heating elements for underfloor direct heating

In order to minimise thermal inertia, the heating elements should be installed as near as possible to the surface.

4.33 Adhesive and fixing material

Adhesive and fixing materials for floor coverings should continuously resist a temperature of 50 °C. They shall be physiologically harmless and emit no disturbing odours after an 8 week to 10 week period of correct use of the underfloor heating.

4.34 Permanent installation areas

Heating elements shall not be installed in permanent installation areas.

4.35 Pre-heating of screeding

Heating screed shall be pre-heated and cooled down ready for covering according to the instructions of the screed manufacturer before the floor covering is laid.

The pre-heating and measurement procedure shall be documented.

4.36 Floor coverings

Floor coverings shall be suitable for standard operation of underfloor heating.

The resistance to thermal conductivity of the floor coverings shall not be more than R_λ = 0,18 ($m^2 \cdot K$)/W.

If existing floor coverings are to be replaced or covered by other materials, the resistance to thermal conductivity of the new material shall be taken into consideration.

The residual humidity shall be monitored by the floor layer before the floor covering can be laid. A residual humidity measuring point for every regulating circuit/dwelling unit shall be indicated to the floor layer.

Manufacturer's instructions for laying the flooring are to be adhered to.

4.37 Control and regulation equipment

Every room such as living and bedroom, children's room, kitchen and bathroom shall be controlled by its individual regulating circuit. Small secondary rooms can be grouped together and placed on one regulating circuit.

4.38 Control and regulation equipment for underfloor storage heating

Underfloor storage heating systems are to be operated in conjunction with outside and floor temperature dependent charge controls. Auxiliary heating systems are to be regulated in individual rooms, dependent on the room inside temperature.

4.39 Control and regulation equipment for controlled underfloor heating and underfloor direct heating

Controlled underfloor heating and underfloor direct heating systems are to be operated in individual rooms in conjunction with control and regulation equipment using room air, floor and/or outside air temperature parameters.

4.40 Floor temperature measurement

The floor temperature sensor for each room or group of rooms shall be so placed in the load distribution layer that the measurement of its temperature ensures a control of the heating system according to the heat load requirements.

4.41 Auxiliary supply period

Auxiliary supply periods can only be considered in such a measure as that they start late enough within the period of room use that the boost charge can be absorbed by the storage heating system, and end early enough that the extra heat absorbed can also be dissipated into the room during the period of room use.

4.42 Period of room use

When designing the underfloor heating system the largest possible period of room use shall be assumed (e.g. living rooms, 06.00 to 22.00 h).

4.43 Insulation and dielectric resistance of the heating element

The values of insulation and dielectric resistance of the heating elements are to be measured during and after the installation of the heating system. These values are to be noted in the construction records.

4.44 Instructions for construction workers

4.44.1 Protective Measures when Pouring Flooring Screed.

The function of neither the insulation layer, nor the damp-proofing should be in anyway influenced during floor-pouring or installation of the heating elements e.g. by use of unsuitable knee boards. Planks or similar boards shall be laid on the insulation when transporting the screed over it in barrows. Short-term overloading of the insulation layer should also be avoided, so that its insulation properties are not reduced.

4.44.2 Pouring the Screed

Regulations for screeding are to be adhered to when pouring flooring-screed. The temperature of the screed should not fall below 5 °C and should be kept at a minimum of 5 °C for at least 3 d after pouring. Furthermore, the surface layer of the cement screeding shall be protected for at least 3 d (longer at lower temperatures or slow drying cement) from drying out or from other damaging influences such as heat and draught so as to prevent shrinkage. On small construction sites this is usually accomplished by closing the building.

After completion, the installer is to post a clear notice of the underfloor heating installation. Special notice shall be made that the architect or heating installer shall be consulted before drilling through ceilings or for screwplugs, etc.

4.45 Data for owner and user of the building

A description of the underfloor heating system is to given to the owner at the final handing over of the building. This shall include at least the following:

a) data on the heating system construction, especially the depth at which the heating elements are installed.

b) a plan of the installation with details of:

1) the distribution of the heating circuits in each room;

2) the positioning and direction of installation of the heating elements in each room;

3) the ratings of the heating circuits in each room;

4) special considerations whilst installing the heating elements such as unheated permanent installation and peripheral areas;

5) details of the control and regulatory equipment with their circuit diagrams and plans of the positions of weather and floor temperature sensors;

6) details of the type and thermal loading properties of the heating elements (with testing reports if necessary).

The installer is to instruct the owner that the description of the heating system shall be included in the building documents (such as construction plans, description of materials, installation plans etc.) so that relevant information is available for repairs or the like. This description is also to be handed to the building manager or administrator if necessary.

The underfloor heating installer is to hand over a suitable number of operating instructions to the owner or administrator of the building. The instructions shall be in a generally understandable form and contain at least the following:

c) details of:

1) construction of the underfloor heating;

2) mode of operation of the system;

3) floor temperature differences in the dwelling areas and peripheral zones;

4) operation of control and regulating equipment;

5) special precautions to be taken for underfloor heating systems when carpet laying or placing large pieces of furniture flush to floors such as settees and beds with pelmets etc.;

6) notice that on cold days, a satisfactory heating effect in new buildings can only be achieved when the auxiliary heating system is also switched on.

d) notices that:

1) peripheral areas should not be covered (neither fully nor partially) with large pieces of furniture flush to the floor such as carpets, settees and beds with pelmets;

2) door stoppers and other like furnishings are only allowed when they are fixed at a depth less than that of the heating elements as indicated by the installer of the system;

3) before installing fitted cupboards and the like, the construction plans and the heating installer are to be consulted;

4) the operating instructions, installation plans and details of the depth of installation of the heating elements are to be handed out from the landlord to each tenant in rented accommodation.

The user of the dwelling shall be specially instructed that an additional floor covering, for instance a layer of carpeting thicker than 10 mm, will lead to higher temperatures in the flooring and also that the designed room temperatures will not be reached.

4.46 Report of testing

A test report should at least include:

- results of individual tests;
- type and thickness of all floor coverings;
- sketch of the rooms including permanently installed furnishings flush to floor areas;
- dimensioned positioning of all measuring points.

Annex A
(informative)

Sizing Procedure — Range of application and purpose

A.1 General

This annex applies to electrical underfloor heating systems as described in Part 1 of this European Standard. It sets rules for the sizing of underfloor heating systems for room heating. The physiological requirements regarding floor surface temperatures shall be considered when sizing the systems. The associated definitions are explained in Clause 3 of this standard. Methods of testing are included in Clause 4.

A.2 Basic principles — Basic parameters of the room to be heated

A.2.1 General

In order to size an underfloor heating system, basic parameters of the room to be heated shall be known or determined.

The standard heat load of a room heated by underfloor heating Q_N^* in W and its effective storage capacity comprise the basic parameters of a room for sizing underfloor storage heating.

The standard heat load Q_N^* in W for underfloor direct and controlled heating shall be calculated.

A.2.2 Standard heat load of an underfloor heated room

The standard heat load of an underfloor heated room Q_N^* is used only to size this underfloor heating system. Its value, as with that of the standard heat load of an underfloor heated room Q_N^* in W, is calculated using EN 12831, taking into account the partially limited heating of the rooms in the dwelling. Areas of the room which are equipped with surface heating elements (flooring, ceiling) remain unconsidered.

To differentiate between the standard heat load $\dot{Q}_N$ in W this value will be denoted as the standard heating load of an underfloor heated room Q_N^* in W.

A.2.3 Standard heating load per unit area

The standard heating load per unit area $\dot{q}_N^*$ in W/m^2 is calculated as follows:

$$\dot{q}_N^* = \frac{Q_N^*}{A} \qquad \dot{q}_N^* \text{ in W/m}^2 \tag{A.1}$$

Definitions:

$\dot{Q}_N^*$ Standard heating load of an underfloor heated room in W

A Floor area of the room being heated in m^2

A.2.4 Effective heat storage capacity of the room to be heated

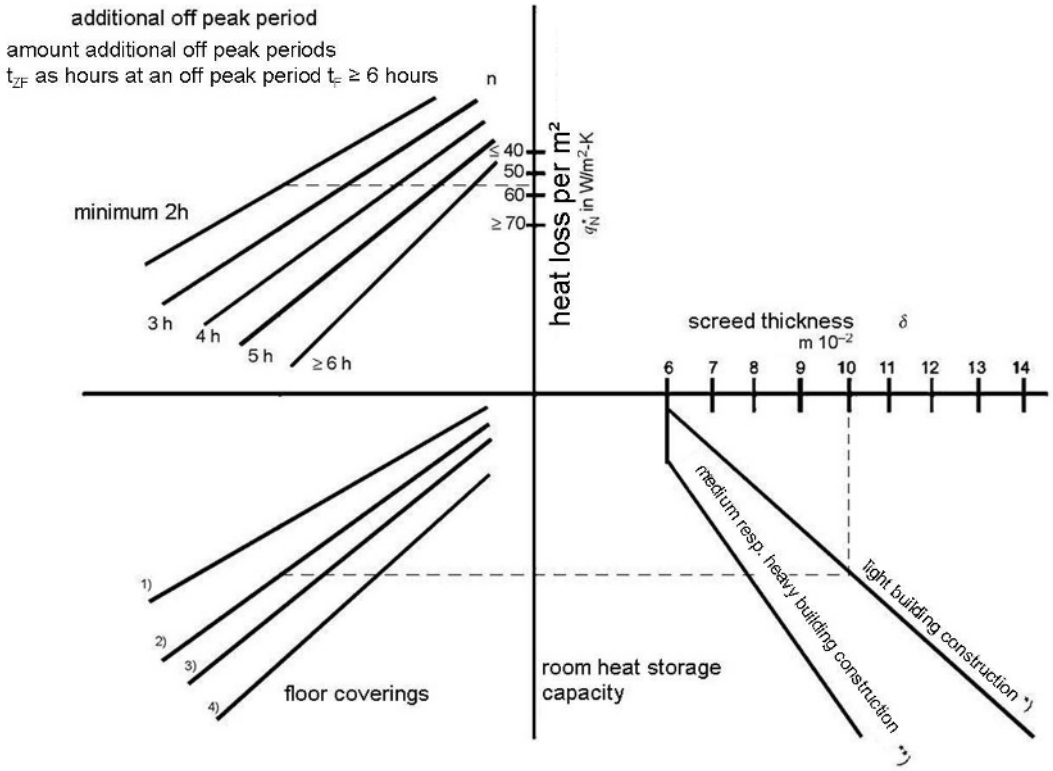
In order to achieve a substantially even pattern of the room temperature during its period of use, the heat storage capacity of the external construction elements, characterised by their effective heat storage capacity, are especially important for underfloor heating.

NOTE Calculation, see EN 12831.

A.2.5 Peripheral conditions and limiting values

The following peripheral conditions are to be verified when sizing electrical underfloor heating:

- maximum rating per surface area P'_F;
- relation of heat transfer coefficients U_o/U_u;
- supply time t_F and auxiliary supply time t_{ZF}.



Key

1) textile
2) parquet, PVC-felt, Ceramic-, Tile- or Stone flooring with 50 % carpet coverage
3) PVC
4) ceramic-, Tile- or Stone flooring

*) suspended ceilings and raised floors, lightweight walls

**) Concrete ceilings and floors with lightweight walls or bricks / concrete

Figure A.1 — Monogram for determining the storage layer depth

A.3 Sizing an underfloor heating system

A.3.1 Storage layer depth of an underfloor heating system

A.3.1.1 General

The storage layer depth δ is determined using Figure A.1. Parameters are:

- standard heat load per unit area $\dot{q}_{\mathrm{N}}^{*}$ in W/m^2 (determined in A.3.2);
- supply period t_{F} and auxiliary supply period t_{ZF} in hours in 3.32.6 and DIN V 4108-6:2003-06;
- type and thickness of the floor covering;
- effective heat storage capacity according to EN 12831 expressed in the classifications light, medium and massive construction.

The determination of the storage layer thickness in houses and similarly used dwellings shall be carried out for at least one room per floor which is used as a permanent dwelling area or can be classified as being characteristic for each specific story.

If the type of floor covering is not known at the planning stage, the thickness of the storage layer shall be determined assuming a carpet floor.

The depth of ceramic and stone floorings, including their grouting layers are to be included in the thickness of the storage layer

A.3.1.2 Depth of heating screed with underfloor direct and controlled heating

The depth of the heating screed for Underfloor direct and controlled heating shall be determined according to national regulations.

A.3.2 Heat Load Coverage for the underfloor heated room

A.3.2.1 Maximum rating per unit area

The requirements for maximum rating per unit area P'_{F} according to 4.3 are deemed to be fulfilled if the values of maximum rating per unit area in W/m² in Tables A.1 to A.8 are not exceeded. Intermediate values are to be determined by linear interpolation.

The parameters of Table A.1 to A.8 are:

- the sum of the values of supply period t_F and auxiliary supply period t_{ZF} in hours (first column)
- the value of the heat conductivity coefficients U_{u} in W/(m²·K) for the parts of the floor and ceiling construction which lie below the heating screed (second to eighth column)
- the difference in temperature (ϑ_{i} - ϑ'_{i}) above and below the heated floor. If the calculated difference ϑ_{i} - ϑ'_{i} does not appear in Tables A.1 to A.8, the next highest value shall be chosen

The values of the standard inside temperature and the temperature of neighbouring rooms using EN 12831 are to be used for ϑ_{i} and ϑ'_{i}.

The values of maximum rating per unit area P'_{F} in EN 12831 for underfloor storage heating are valid for a minimum storage layer depth of 6 cm.

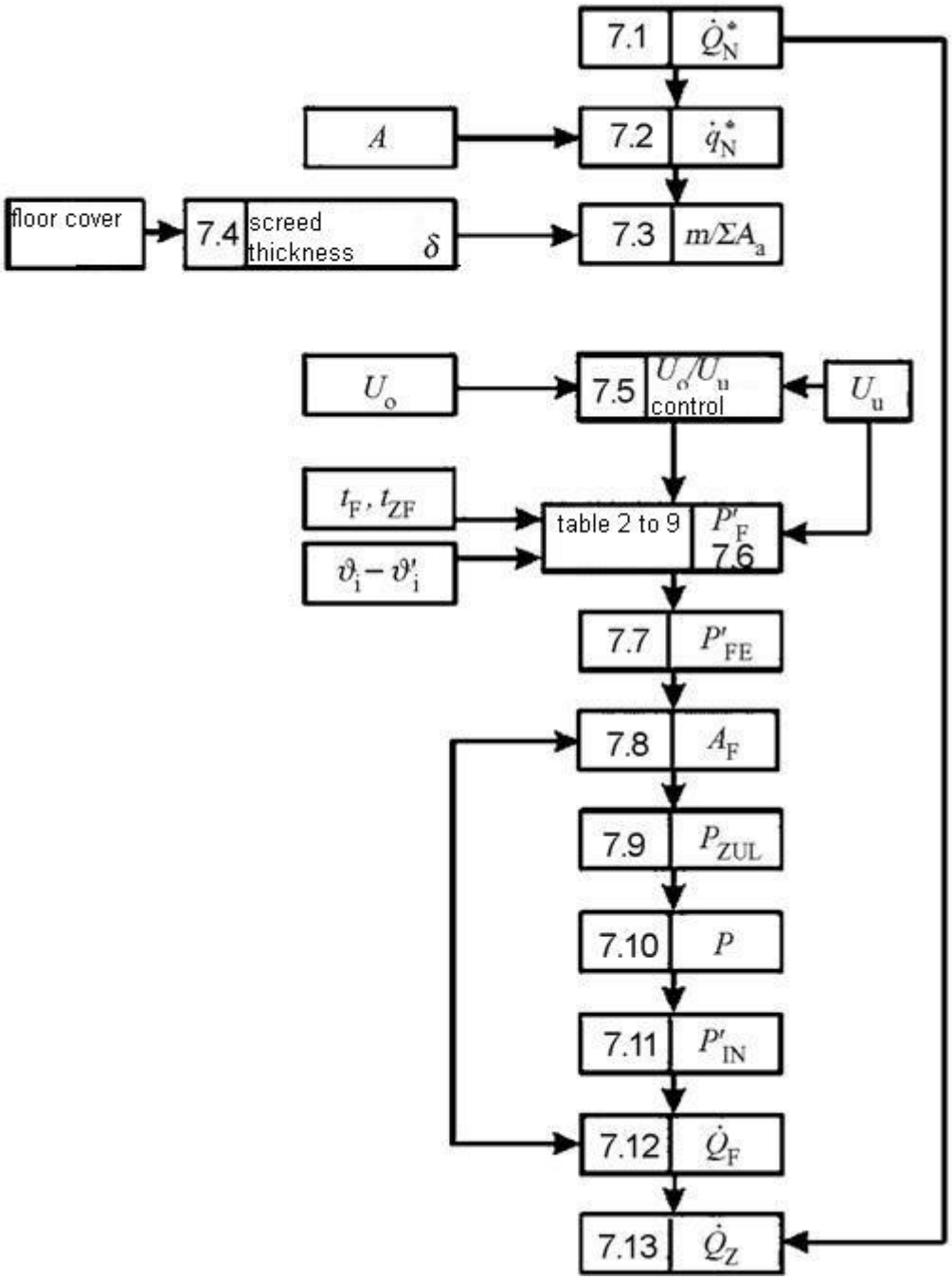


Figure A.2 — Electric underfloor storage heating, sizing chart

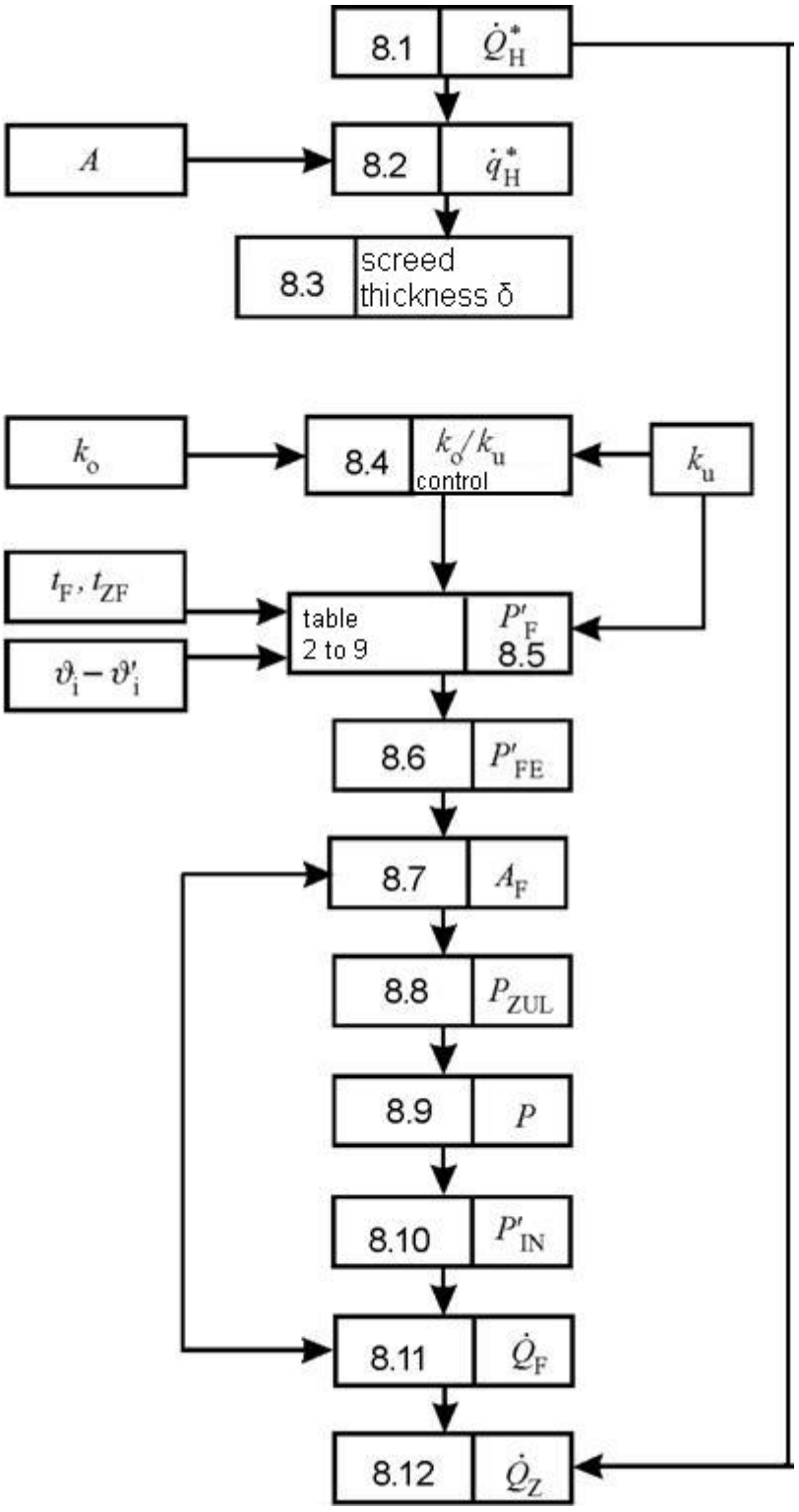


Figure A.3 — Electric underfloor direct and controlled heating, sizing chart

A.3.2.2 Determination of the maximum rating per unit area P'_F in W/m² (Tables A.1 to A.8)

Table A.1 — $\vartheta_1 - \vartheta'_1 = 0K$

Sum of supply period and auxiliary supply period in hours	Heat transfer coefficients U_u in W/(m² · K)				
	0,5	0,45	0,4	0,35	0,25
10	156	148	139	131	114
11	142	134	127	119	104
12	130	123	116	109	100
13	120	114	107	101	100
14	112	106	100	100	100
15	104	100	100	100	100
16	100	100	100	100	100
17	100	100	100	100	100
18	100	100	100	100	100
19	100	100	100	100	100
20	100	100	100	100	100
21	100	100	100	100	100
22	100	100	100	100	100
23	100	100	100	100	100
24	100	100	100	100	100

Table A.2 — $\vartheta_1 - \vartheta'_1 = 5K$

Sum of supply period and auxiliary supply period in hours	Heat transfer coefficients U_u in W/(m² · K)				
	0,5	0,45	0,4	0,35	0,25
10	162	153	144	135	117
11	147	139	131	123	107
12	135	128	120	113	100
13	125	118	111	104	100
14	116	109	103	100	100
15	108	102	100	100	100
16	101	100	100	100	100
17	100	100	100	100	100
18	100	100	100	100	100
19	100	100	100	100	100
20	100	100	100	100	100
21	100	100	100	100	100
22	100	100	100	100	100
23	100	100	100	100	100
24	100	100	100	100	100

Table A.3 — $\vartheta_1 - \vartheta'_1 = 10K$

Sum of supply period and auxiliary supply period in hours	Heat transfer coefficients U_u in W/(m² · K)				
	0,5	0,45	0,4	0,35	0,25
10	168	159	149	139	120
11	153	144	135	127	109
12	140	132	124	116	100
13	129	122	115	107	100
14	120	113	106	100	100
15	112	106	100	100	100
16	105	100	100	100	100
17	100	100	100	100	100
18	100	100	100	100	100
19	100	100	100	100	100
20	100	100	100	100	100
21	100	100	100	100	100
22	100	100	100	100	100
23	100	100	100	100	100
24	100	100	100	100	100

Table A.4 — $\vartheta_1 - \vartheta'_1 = 15K$

Sum of supply period and auxiliary supply period in hours	Heat transfer coefficients U_u in W/(m² · K)				
	0,5	0,45	0,4	0,35	0,25
10	174	164	154	144	123
11	158	149	140	131	112
12	145	137	128	120	103
13	134	126	118	110	100
14	124	117	110	103	100
15	116	109	103	100	100
16	109	103	100	100	100
17	102	100	100	100	100
18	100	100	100	100	100
19	100	100	100	100	100
20	100	100	100	100	100
21	100	100	100	100	100
22	100	100	100	100	100
23	100	100	100	100	100
24	100	100	100	100	100

Table A.5 — $\vartheta_1 - \vartheta'_1 = 20\text{K}$

Sum of supply period and auxiliary supply period in hours	Heat transfer coefficients U_u in W/(m² · K)				
	0,5	0,45	0,4	0,35	0,25
10	180	169	159	148	126
11	164	154	144	134	115
12	150	141	132	123	105
13	139	130	122	114	100
14	129	121	113	106	100
15	120	113	106	100	100
16	113	106	100	100	100
17	106	100	100	100	100
18	100	100	100	100	100
19	100	100	100	100	100
20	100	100	100	100	100
21	100	100	100	100	100
22	100	100	100	100	100
23	100	100	100	100	100
24	100	100	100	100	100

Table A.6 — $\vartheta_1 - \vartheta'_1 = 30\text{K}$

Sum of supply period and auxiliary supply period in hours	Heat transfer coefficients U_u in W/(m² · K)	
	0,35	0,25
10	156	132
11	142	120
12	130	110
13	120	102
14	112	100
15	104	100
16	100	100
17	100	100
18	100	100
19	100	100
20	100	100
21	100	100
22	100	100
23	100	100
24	100	100

Table A.7 — $\vartheta_1 - \vartheta'_1 = 35\text{K}$

Sum of supply period and auxiliary supply period in hours	Heat transfer coefficients U_u in W/(m² · K)	
	0,35	0,25
10	161	136
11	147	123
12	134	113
13	124	104
14	115	100
15	108	100
16	101	100
17	100	100
18	100	100
19	100	100
20	100	100
21	100	100
22	100	100
23	100	100
24	100	100

Table A.8 — $\vartheta_1 - \vartheta'_1 = 38\text{K}$

Sum of supply period and auxiliary supply period in hours	Heat transfer coefficients U_u in W/(m² · K)	
	0,35	0,25
10	163	137
11	148	125
12	136	114
13	125	105
14	116	100
15	109	100
16	102	100
17	100	100
18	100	100
19	100	100
20	100	100
21	100	100
22	100	100
23	100	100
24	100	100

A.3.2.3 Maximum rating per unit area for an underfloor direct heating system in rooms with bathtubs or showers

The maximum rating per unit area can be 160 W/m², independent of Tables A.1 to A.8 and A.3.2.4. Auxiliary heating equipment such as convector panels, radiators or ceiling heater panels shall be installed in these rooms. Temperature regulation shall be carried out according to 4.14.

A.3.2.4 Limited rating per unit area

The values for maximum rating per unit area in Tables A.1 to A.8 P'_{F} apply to a standard heat load per unit area $\dot{q}^{*}_{\mathrm{N}} \geq 70$ W/m^2. If the standard heat load is < 70 W/m^2, the value of the maximum rating per unit area shall be multiplied by the factor of limitation *C* from Table A.9. Interim values of *C* are to determined via interpolation. The following equation applies for the limited rating per unit area P'_{FE}:

$$P'_{\mathrm{FE}} = C \;\; P'_{\mathrm{F}} \qquad \text{inW/m}^2 \tag{A.2}$$

Table A.9 — Factor of limitation *C* in relation to standard heat load per unit area $\dot{q}^{*}_{\mathrm{N}}$

Standard Heat Load per unit area $\dot{q}^{*}_{\mathrm{N}}$ W/m^2	Factor of Limitation *C*
≥ 70	1,00
65	0,96
60	0,92
55	0,87
50	0,83
45	0,79
≤ 40	0,75

A.3.2.5 Heating floor surface area

The heating floor surface area A_{F} shall be determined using 3.20. If the heating element manufacturer and thus the dimensions of the elements as well as those of permanent installation areas are not known at the planning stage, following values are to assumed:

$$A_{\mathrm{F}} = 0{,}85 \cdot A \qquad A_{\mathrm{F}} \text{ in m}^2 \tag{A.3}$$

A.3.2.6 Permissible rating

The permissible rating per room P_{ZUL} is calculated as:

$$P_{\mathrm{ZUL}} = P'_{\mathrm{FE}} \cdot A_{\mathrm{F}} \qquad P_{\mathrm{ZUL}} \text{ in W} \tag{A.4}$$

A.3.2.7 Rating of a room

The rating of the underfloor heating in a room P is the sum of the nominal ratings of the heating elements installed in that room:

$$P = P_{\mathrm{N1}} + P_{\mathrm{N2}} + P_{\mathrm{N3}} + ... \qquad P \text{ in W} \tag{A.5}$$

The resulting sum shall not exceed the permissible rating P_{ZUL} by more than 10 %.

If the heating element manufacturer and thus the ratings of the elements are unknown at the planning stage, the value of P shall be deemed to be P_{ZUL}.

A.3.2.8 Rating per unit area

The value of the rating per unit area P'_{IN} in W/m^2 shall not exceed the value of the maximum rating per unit area P'_F or the limited rating per unit area P'_{FE}. However, in order to achieve a substantially complete coverage of the standard heat load of the room be heated via heat dissipation from the floor, the value of the rating per unit area shall be at least 85% of the values from A.3.2.2 and A.3.2.4 respectively. If this is not the case, the heat load shall be reduced by changes to the construction.

A.3.2.9 Mean heating capacity

When sizing an underfloor heating system, following arithmetic values for the mean heat flow density $\dot{q}_F$:shall be used:

- Underfloor Storage Heating: 70 W/m^2
- Controlled Underfloor Heating: 80 W/m^2
- Underfloor Direct Heating: 90 W/m^2
- Underfloor Heating in Rooms with Bathtubs or Showers: 120 W/m^2

If the rating per unit area is limited according to A.3.2.4 and Table A.9, the mean heating capacity is

$$\dot{q}_{FE} = C \ \dot{q}_F .$$

This does not apply to underfloor direct heating in rooms with bathtubs or showers.

It will be assumed here that the mean surface temperature on the inside of other surrounding constructional elements, including glazing, is no more than 2.5K lower than the standard room temperature.

The mean heating capacity of an underfloor heating system $\dot{Q}_F$ for the room to be heated is thus determined from:

$$\dot{Q}_F = \dot{q}_F \ A_F. \qquad \dot{Q}_F \text{ in W} \qquad \text{(A.6)}$$

or

$$\dot{Q}_F = \dot{q}_{FE} \ A_F \ . \qquad \dot{Q}_F \text{ in W} \qquad \text{(A.6 a))}$$

When sizing the peripheral areas, an arithmetic mean heat transfer density of $\dot{q}_R$ shall be applied, provided the rating per unit area of the peripheral area is > 180 W/m².

The mean heating rating of a peripheral area $\dot{Q}_R$ is thus calculated as follows t:

$$\dot{Q}_R = \dot{q}_R \ A_R. \qquad \dot{Q}_R \text{ in W} \qquad \text{(A.7)}$$

In this case A_R in m^2 is the floor area in which peripheral heating elements are installed.

If a peripheral area lies within the heating floor area A_F of an underfloor storage heating system (standard case), then only the difference $D\dot{q}_R$ between the heat transfer density of the peripheral area $\dot{q}_R$ and the underfloor storage heating system $\dot{q}_F$

$$D\dot{q}_R = \dot{q}_R \quad \dot{q}_F - \qquad D\dot{q}_R \text{ in W/m}^2 \qquad \text{(A.7 a))}$$

$$D\dot{q}_R = \dot{q}_R \quad \dot{q}_{FE} \qquad D\dot{q}_R \text{ in W/m}^2 \qquad \text{(A.7 b))}$$

shall be considered.

A.3.2.10 Auxiliary heat capacity

If the mean heating capacity $\dot{Q}_F$ is lower than the standard heating capacity $\dot{Q}_N^*$, the deficiency shall be overcome using an auxiliary heating capacity $\dot{Q}_Z$.

$$\dot{Q}_Z = \dot{Q}_N^* \quad \dot{Q}_F - \qquad \dot{Q}_Z \text{ in W} \qquad \text{(A.8)}$$

If the auxiliary heating capacity is in the form of peripheral heating, then

$$\dot{Q}_Z = D\dot{q}_R \quad A_R \quad \cdot \qquad \dot{Q}_Z \text{ in W} \qquad \text{(A.9)}$$

The peripheral heating area is

$$A_R = l_R \cdot b_R \qquad A_R \text{ in m}^2 \qquad \text{(A.10)}$$

Where:

l_R Length of the peripheral area in m;

b_R Width of the peripheral area in m.

According to 3.22, the width of a peripheral area, measured at right angles to the external wall, should not exceed 1m.

The auxiliary heating system should be installed under the glazed areas, as evenly as possible over the total width.

In order to improve the regulation of an underfloor storage heating system in living areas, an auxiliary heating system should be installed, even if it is arithmetically not necessary. The auxiliary heat capacity shall be a minimum of:

$$\dot{Q}_Z \geq 0{,}2 \cdot \dot{Q}_N$$

A.3.2.11 Rating of the auxiliary heating system

For purposes of sizing the auxiliary heating system it is assumed that for:

- Convector Panel Heating:

  Panel rating is

  $$P_K \geq \dot{Q}_Z$$

- Peripheral Heating:

  The rating per unit area P'_R may not exceed 250 W/m². Thus, the rating of the peripheral heat P_R is calculated as follows:

  $$P_R = P'_R \quad A_R \cdot \qquad P_R \text{ in W} \qquad \text{(A.11)}$$

Dimensions in cm

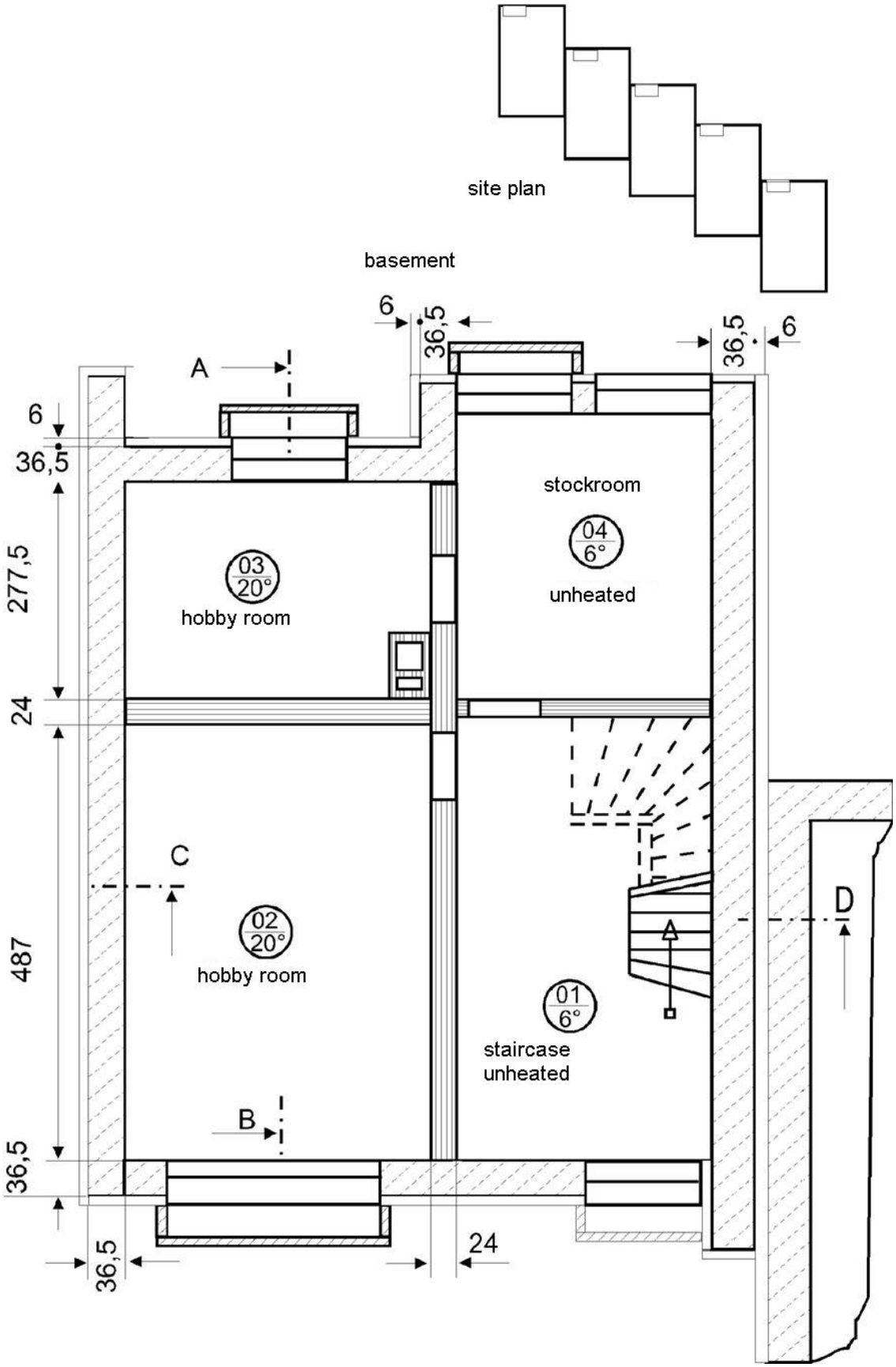


Figure A.4 — Plan of basement

Dimensions in cm

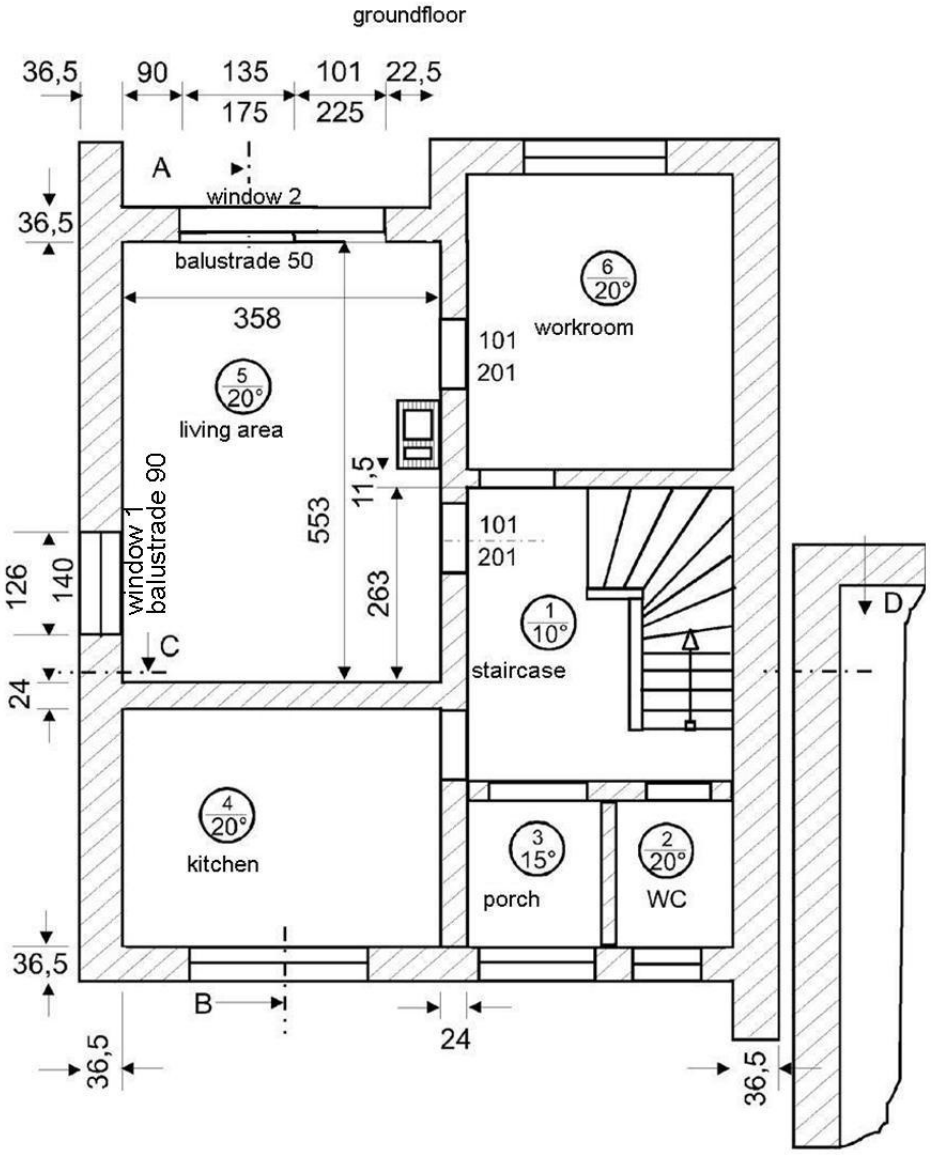


Figure A.5 — Plan of ground floor

Dimensions in cm

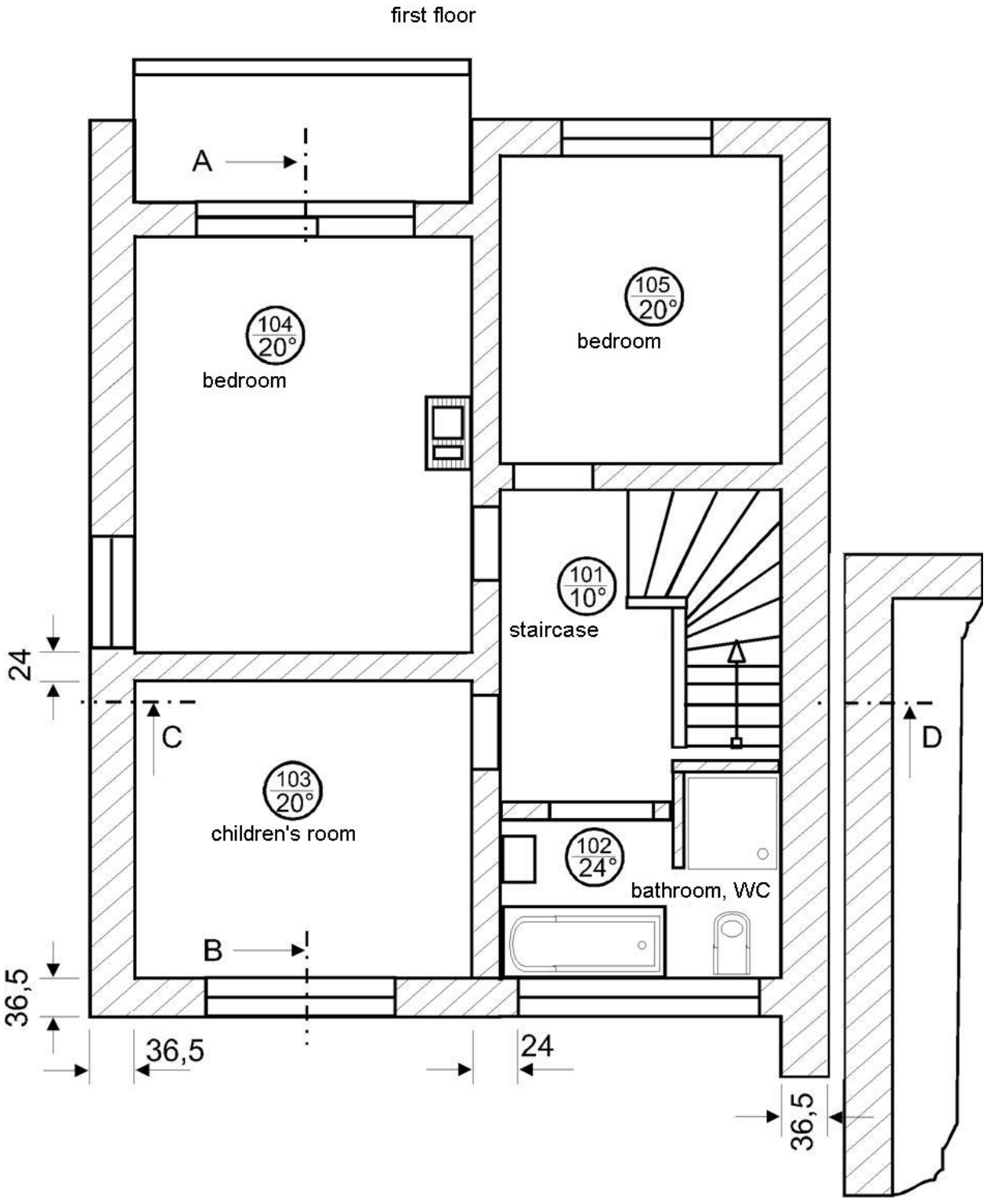


Figure A.6 — Plan of upper floor

Dimensions in cm

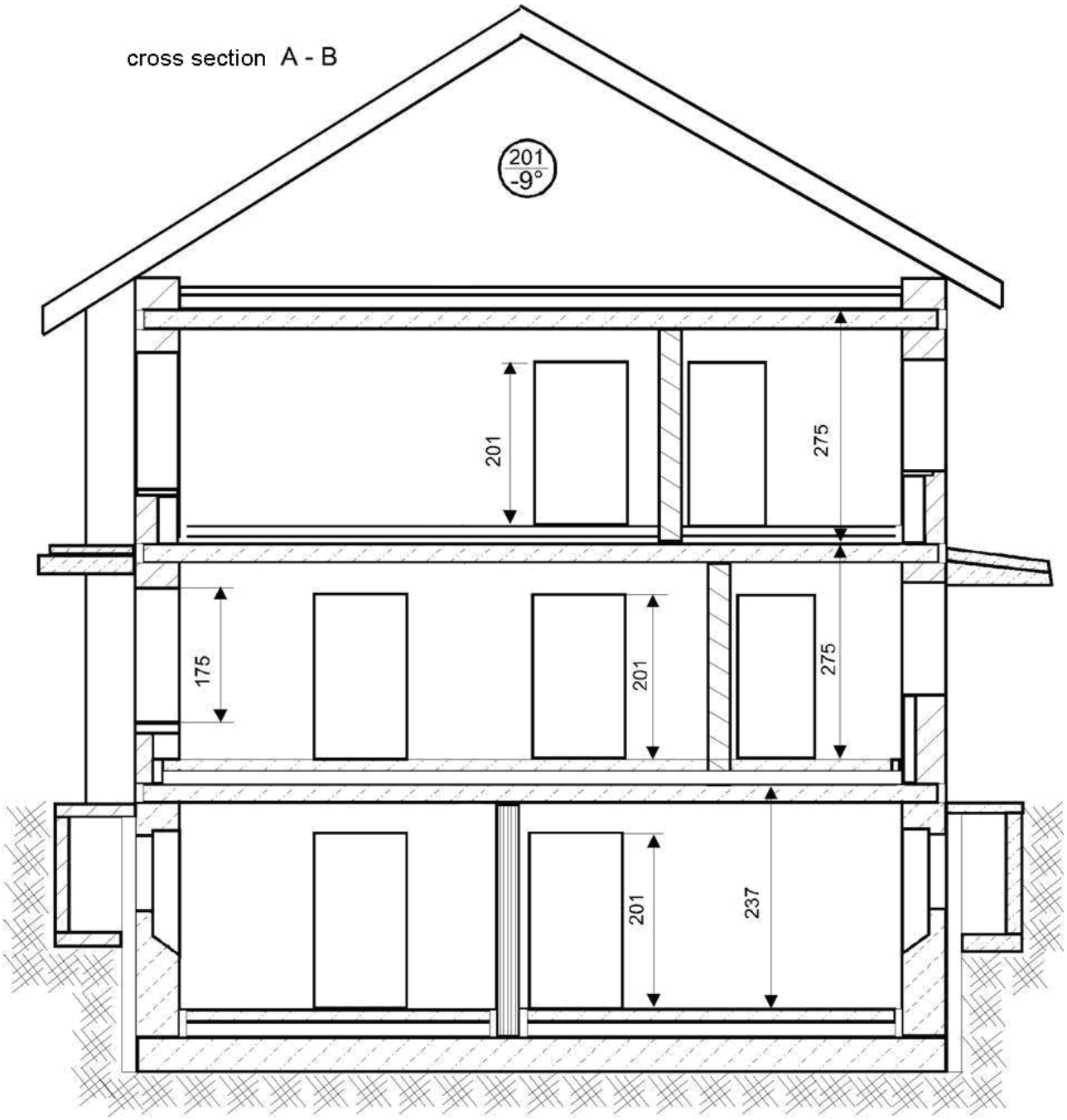
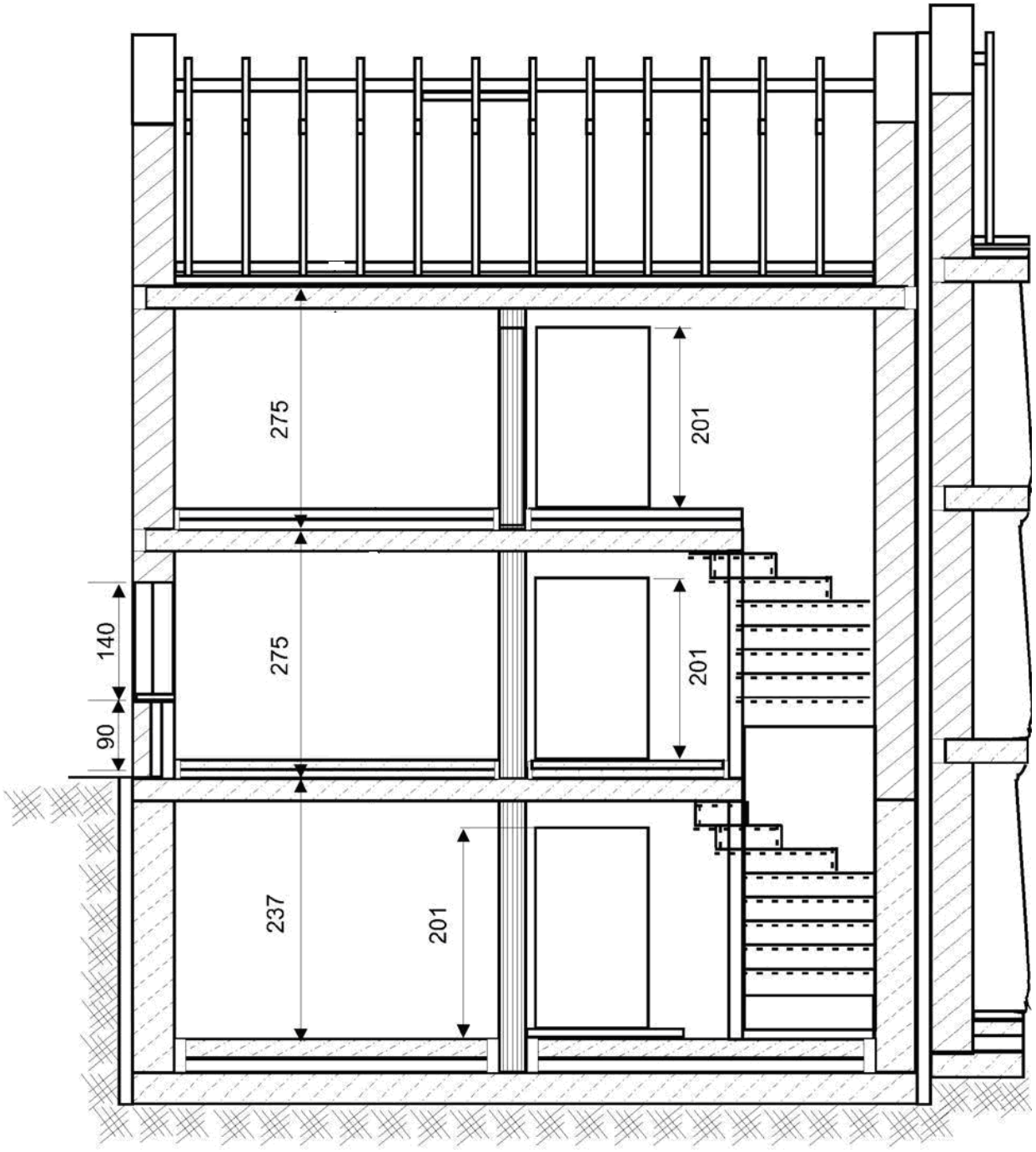


Figure A.7 — Cross section A – B

Dimensions in cm



concrete

brick work: aerated concrete 400 kg/m³

brick work: light bricks 700 kg/m³

brick work: sand-lime bricks 1000 kg/m³

insulation (0,06m basement outer walls, 0,11m underneath basement and groundfloor screed, 0,04m underneath first floor screed

Figure A.8 — Cross section C – D

Annex B
(informative)

Sizing procedure — Examples of sizing procedure of an underfloor storage heating system — Example for a living area

B.1 General

Underfloor storage heating for the living area shall be sized according to Figure A.5. The procedure of sizing is shown schematically in Figure A.2.

Dimensions in mm

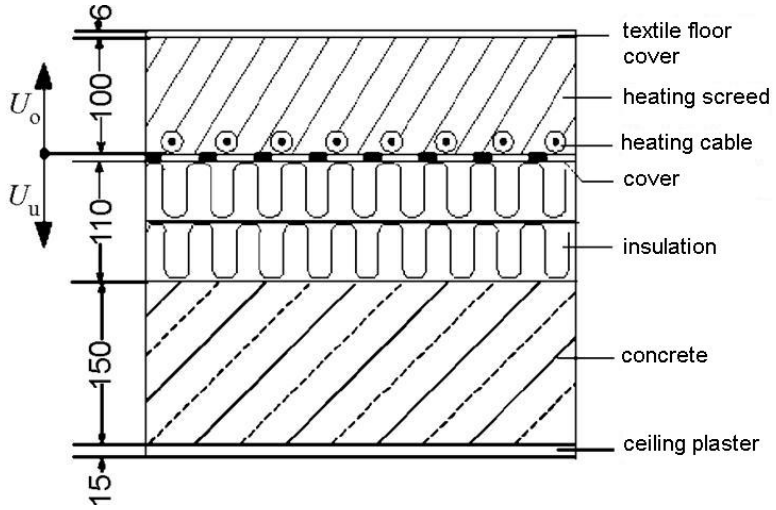


Figure B.1 — Ceiling construction

B.2 Standard heat load of an underfloor heated room $\dot{Q}^*_N$

The standard heat load of an underfloor heated room $\dot{Q}^*_N$ is 1 090 W.

NOTE See EN 12831.

B.3 Standard heat load per unit area $\dot{q}^*_N$

The standard heat load per unit area is calculated using Formula (A.1)

$$q^*_N = \frac{Q^*_N}{A} \quad \frac{1090}{19.8} = 55\,\text{W/m}^2 =$$

B.4 Storage mass per unit external area of the room $m/\Sigma A_a$

The value of the effective storage capacity of storage mass per unit of external area $m/\Sigma A_a$ is 320 kg/m^2.

Chosen construction: Lightweight construction

NOTE See EN 12831.

B.5 Thickness of storage layer δ

Following criteria are to be used in the calculation:

- Supply period = 8 h;
- Auxiliary supply period = 2 h;
- Textile floor covering = $6 \cdot 10^{-3}$ m thick.

Using Figure A.1 the resulting storage layer thickness is

$$\delta = 10.0 \cdot 10^{-2} \text{ m}.$$

B.6 Relation of coefficients of conductivity

According to 4.15 the relation between the coefficient of heat conductivity U_o of the floor construction above the insulation and the coefficient of heat conductivity U_u for all layers below the screed shall be calculated and recorded. Being a basement ceiling above partially unheated rooms, the relation for equal construction thickness shall be

$$U_o \geq 6{,}0\ U_u$$

This is fulfilled, because:

$$3{,}33 > 6{,}0 \cdot 0{,}34$$

$$3{,}33 > 1{,}98$$

(see Figure B.1 and Tables B.1 and B.2).

Table B.1 — Determination of heat conductivity coefficient U_o

Structure	Thickness in m	Resistance to Heat Conductivity R_λ (m^2 K)/W
Flooring, Textile	0,006	0,10
Screed	0,10	0,07
thermal contact resistance R_i	0,13 (m^2 K)/W	
thermal resistivity R_o	0,30 (m^2 K)/W	
$U_o = \frac{1}{R_o}$ = 3,33 W/(m^2 K)		

Table B.2 — Determination of heat conductivity coefficient U_u

Structure	Thickness in m	Resistance to Heat Conductivity R_λ ($m^2 \cdot$ K)/W
Insulation layer	0.11	2.75
Concrete	0.15	0.06
Ceiling plaster	0.015	0.01
thermal contact resistance R_i	0,17 ($m^2 \cdot$K)/W	
thermal resistivity R_u	2,89 (m^2 K)/W	
$U_u = \frac{1}{R_u} = \frac{1}{2{,}89}$ = 0,34 W/($m^2 \cdot$ K)		

B.7 Maximum rating per unit area P'_F

Following criteria are to be used in the calculation:

- Coefficient of heat conductivity Uk_u = 0.34 W/(m^2 · K);
- Difference in standard temperature between living room and utility room below: $\vartheta_i - \vartheta'_i = 20 - 20 = 0$ K .

Maximum rating per unit area P'_F selected from Table A.1:

$$P'_F = 131 \text{ W/m}^2$$

B.8 Limited rating per unit area P'_{FE}

Limited rating per unit area using Formula (A.2)

$$P'_{FE} = C \cdot P'_F$$

$$P'_{FE} = 0{,}87 \cdot 131 \text{ W/m}^2 = 114 \text{ W/m}^2$$

As the standard heat load per unit area $\dot{q}^*_N < 70$ W/m^2 , the factor C from Table A.9 = 0,87.

B.9 Heating floor area A_F

As the permanent installation areas and the dimensions of the heating elements are not yet known, A_F is calculated using Formula (A.3):

$$A_F = 0.85 \cdot A = 0{,}85 \cdot 19.8 = 16{,}8 \text{ m}^2$$

B.10 Permissible rating P_{ZUL}

The permissible rating is calculated using Formula (4)

$$P_{ZUL} = P'_{FE} \cdot A_F = 114 \cdot 16{,}8 = 1915 \text{ W}$$

In order to simply the calculation the heating floor area shall be deemed as the area in which heating elements are installed.

B.11 Rating of the room P

As the manufacturer and thus the rating of the individual heating elements is not known, A.3.2.7 will be used

$$P = P_{ZUL} = 1\,915 \text{ W}$$

B.12 Rating per unit area P'_{IN}

As $P = P_{ZUL}$, then $P'_{IN} = P'_{FE} = 114$ W/m^2

B.13 Mean heating capacity $\dot{Q}_F$

The mean heating capacity is calculated using Formula (A.6 a)):

$$\dot{Q}_F = q_{FE} \cdot A_F = 61 \cdot 16{,}8 = 1025 \text{ W}$$

B.14 Auxiliary heating capacity $\dot{Q}_Z$

The auxiliary heating capacity is calculated using Formula (A.8)

$$\dot{Q}_Z = \dot{Q}^*_N - \dot{Q}_F = 1090 - 1025 = 65 \text{ W}$$

The requirement

$$\dot{Q}_Z \geq 0{,}2 \cdot \dot{Q}^*_N = 0{,}2 \cdot 1090 = 218 \text{ W}$$

is not met. Thus, instead of $\dot{Q}_Z$ 65 W, a value of 218 W shall be used.

When using peripheral heating, the following applies:

Observing the restrictions in width from 3.22, the peripheral zone width b_R to

- Window 2: b_{R2} selected = 1,00 m.

The required floor heating area when the peripheral zone lies within the heated floor area is, according to (A.7 b)) and (A.9):

$$A_R = \frac{\dot{Q}_Z}{\dot{q}_R} = \frac{218}{89} = 2{,}45 \text{ m}^2$$

$$l_R = \frac{A_R}{b_R} \text{ in m}$$

B.15 Auxiliary heat rating

As convector panel heating:

Rating $P_K \geq \dot{Q}_Z \geq 218$ W selected:

A convector 250 W (as underfloor convector).

As peripheral zone heating using Formula (A.11):

below Window 2: Rating $P_{R2} = P'_R \cdot A_{R2} = 250 \cdot 2{,}45 = 613$ W .

Annex C
(informative)

Sizing procedure — Example of sizing procedure of an underfloor direct heating system — Example for a living area

C.1 General

Underfloor direct heating shall be sized for the living room according to Figure A.5. The procedure of sizing is shown schematically in Figure A.3.

Dimensions in mm

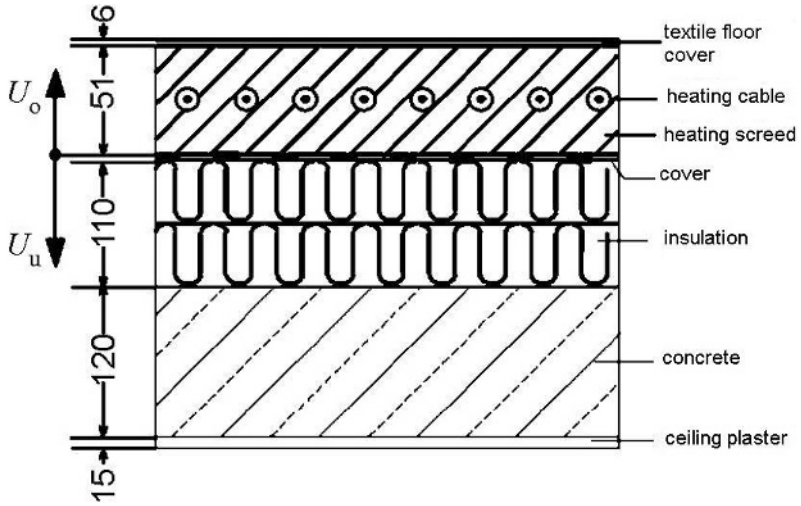


Figure C.1 — Ceiling construction

C.2 Design heating capacity $\dot{Q}^*_H$ of a room with underfloor direct heating

The standard heat load of the underfloor heated room $\dot{Q}^*_N$ is 1 090 W.

The design capacity of the underfloor heated room $\dot{Q}^*_H$ including the supplement for the re-heating factor f_{RH} of ca. 15 % = 1 253,5 W

$$\dot{Q}^*_H = \dot{Q}^*_N \cdot 1{,}15 \quad \text{in W}$$

$\dot{Q}^*_H$ = 1 090 · 1,15 = 1 253,5 W

rounded up to 1 254 W

NOTE See EN 12831.

C.3 Design heating capacity per unit area $\dot{q}^*_H$

The design heating capacity per unit area is calculated following Formula (A.1):

$$\dot{q}^{*}_{N} = \frac{\dot{Q}^{*}_{N}}{A} \quad \frac{1\,254}{19{,}8} \quad 64 \ \mathrm{W/m^2}$$

C.4 Depth of the heating screed

The minimum depth of the heating screed shall be determined from the bedding heating cable with a diameter $d = 6 \cdot 10^{-3}$ m in heating screed, the minimum depth of the screed is
$= 45 \cdot 10^{-3}$ m + $6 \cdot 10^{-3}$ m = $51 \cdot 10^{-3}$ m.

(d = external diameter of the heating cable in mm)

C.5 Relation of coefficients of conductivity

According to 4.15 the relation between the coefficient of heat conductivity U_o of the floor construction above the heat and sound insulation and the coefficient of heat conductivity U_u for all layers below the screed shall be calculated and recorded. Being a basement ceiling above partially unheated rooms, the relation by equal construction thickness shall be:

$$U_o \geq 6{,}0\ U_u$$

This is fulfilled because:

$$3{,}33 > 6{,}0 \cdot 0{,}34$$

$$3{,}33 > 1{,}98$$

(see Figure C.1 and Tables C.1 and C.2).

Table C.1 — Determination of heat conductivity coefficient U_o

Structure	**Thickness in m**	**Resistance to Heat Conductivity R_λ ($m^2 \cdot K$)/W**
Flooring, textile	0,006	0,10
Screed	0,051	0,04
thermal contact resistance R_i	0,13 (m^2 K)/W	
thermal resistivity R_o	0,27 (m^2 K)/W	
$U_o = \frac{1}{R_o} = \frac{1}{0{,}27} = 3.7$ W/($m^2 \cdot$ K)		

Table C.2 — Determination of heat conductivity coefficient U_u

Structure	**Thickness in m**	**Resistance to Heat Conductivity R_λ ($m^2 \cdot K$)/W**
Insulation layer	0,11	2,75
Concrete	0,12	0,06
Ceiling plaster	0,015	0,01
thermal contact resistance R_i	0,17 (m^2 K)/W	
thermal resistivity R_u	3,01 (m^2 K)/W	
$U_u = \frac{1}{R_u} = \frac{1}{3{,}01} = 0{,}33$ W/(m^2 K)		

C.6 Maximum rating per unit area P'_F

Following criteria are to be used in the calculation:

- Heat conductivity U_u = 0,33 W/(m^2 · K);
- Supply and auxiliary supply periods t_F + t_{ZF} = 24 h.

Difference in the standard internal temperature between living room and utility room below:

$$\vartheta_i - \vartheta'_i = 20 - 20 = 0 \text{ K}$$

Maximum rating per unit area P'_F from Table A.1:

$$P'_F = 100 \text{ W/m}^2$$

C.7 Limited rating per unit area P'_{FE}

Limited rating per unit area using Formula (A.2)

$$P'_{FE} = C \cdot P'_F$$

$$P'_{FE} = 0,94 \cdot 100 \text{ W/m}^2 = 94 \text{ W/m}$$

as the standard heat load per unit area $\dot{q}^*_N < 70 \text{ W/m}^2$ the factor C from Table A.9 = 0,94.

C.8 Heating floor area A_F

As the permanent installation areas and the dimensions of the heating elements are not yet known, A_F is calculated using Formula (A.3)

$$A_F = 0,85 \cdot A = 0,85 \cdot 19.8 = 16,8 \text{ m}^2$$

C.9 Permissible rating P_{ZUL}

The permissible rating is calculated using (4)

$$P_{ZUL} = P'_{FE} \cdot A_F = 94 \cdot 16,8 = 1579 \text{ W}$$

In order to simply the calculation the heating floor area shall be deemed as the area in which heating elements are installed.

C.10 Rating of the room P

As the manufacturer and thus the rating of the individual heating elements is not known, A.3.2.7 will be used

$$P = P_{ZUL} = 1\,579 \text{ W}$$

C.11 Rating per unit area P'_{IN}

As $P = P_{ZUL}$, then $P'_{IN} = P_{FE} = 94 \text{ W/m}^2$.

C.12 Mean heating capacity $\dot{Q}_F$

The mean heating capacity is calculated using Formula (A.6 a))

$$\dot{Q}_{\mathrm{F}} = \dot{q}_{\mathrm{FE}} \cdot A_{\mathrm{F}} = 85 \cdot 16{,}8 = 1\,428 \text{ W}$$

C.13 Auxiliary heating capacity $\dot{Q}_{\mathrm{Z}}$

The auxiliary heating capacity is calculated using Formula (A.8)

$$\dot{Q}_{\mathrm{Z}} = \dot{Q}^{*}_{\mathrm{H}} - \dot{Q}_{\mathrm{F}} = 1\,254 - 1\,428 = -174 \text{ W}$$

In practice the heating elements will normally selected such that, instead of installing a special peripheral heating mat, one normal mat but with a higher rating per unit area will be installed.

Formula symbols and units

Symbol	Unit	Description
A	m^2	Floor area of room to be heated
A_F	m^2	Heating floor area
A_R	m^2	Area of the peripheral zone
A_V	m^2	Permanent dwelling area
b_R	m	Width of the peripheral area
C		Factor of limitation of rating per unit area
d	cm	Depth of heating screed
U_o	$W/(m^2 \cdot K)$	Coefficient of heat transfer of floor construction above the heat and sound insulation layer
U_u	$W/(m^2 \cdot K)$	Coefficient of heat transfer of floor construction below the storage layer
l_R	m	Length of peripheral layer
$m/\Sigma A_a$	kg/m^2	Storage mass per external unit area of the room to be heated
P	W	Capacity of a room
P_F	W/m^2	Maximum capacity per unit area
P_{FE}	W/m^2	Limited capacity per unit area
P_{IN}	W/m^2	Capacity per unit area
P_K	W	Rating of the convector heating
P_N	W	Sizing rating of a heating element
P_R	W	Capacity of the peripheral zone
$P_R{}^*$	W/m^2	Capacity per unit area of the peripheral zone
P_{zul}	W	Permissible rating
$\dot{Q}_F$	W	Mean heating capacity
$\dot{q}_F$	W/m^2	Mean heat flow density
$\dot{q}_{FE}$	W/m^2	Limited mean heat flow density
$\dot{Q}_H^*$	W	Design heat capacity of a room with underfloor direct heating or controlled underfloor heating
$\dot{q}_H^*$	W/m^2	Design heat capacity per unit area
$\dot{Q}_H$	W	Design heat capacity according to EN 1264
$\dot{Q}_N^*$	W	Standard heat load of an underfloor heated room
$\dot{q}_N^*$	W/m^2	Standard heat load per unit area of an underfloor heated room
$\dot{Q}_N$	W	Standard heat load according to EN 12831

Symbol	Unit	Description
$\dot{Q}_R$	W	Mean heat capacity of a peripheral zone
$\dot{q}_R$	W/m^2	Mean heat transfer density of a peripheral zone
$\dot{Q}_Z^*$	W	Auxiliary heat capacity
R_a	(m^2 · K)/W	External heat transfer resistance
R_i	(m^2 · K)/W	Internal thermal contact resistance
R_k	(m^2 · K)/W	thermal contact resistance
R_o	(m^2 · K)/W	thermal resistivity of the floor construction above the heating level
R_u	(m^2 · K)/W	thermal resistivity of the floor construction below the heating level
R_λ	(m^2 · K)/W	thermal resistivity = Resistance to heat conductivity
Δt	h	Period of exceeding the mean permissible floor surface temperature
t_B	h	Period of room use
T_E	Kh	Effect of excess temperature of floor
t_F	h	Supply charge period
t_N	h	Design supply period
t_{ZF}	h	Auxiliary supply period
t_{ZL}	h	Auxiliary charge period
δ	cm	Depth of storage layer
ϑ_a	°C	External air temperature
ϑ_{am}	°C	Daily mean of external air temperature
ϑ_N	°C	Design temperature
ϑ_F	°C	Floor surface temperature
ϑ_{FM}	°C	Mean floor surface temperature during period of room use
ϑ_{Fmax}	°C	Maximum floor surface temperature during period of room use
ϑ_{Fzul}	°C	Permissible floor surface temperature
ϑ_i	°C	Standard inside temperature
ϑ_i'	°C	Standard inside temperature of room below the heated floor
$\Delta\vartheta_F$	K	Pulsation factor
λ	W/(m · K)	Heat conductivity
ρ	kg/m^3	Density

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