INTERNATIONAL STANDARD

# ISO 11855-3

First edition
2012-10-01

# Building environment design — Design, dimensioning, installation and control of embedded radiant heating and cooling systems —

## Part 3: Design and dimensioning

*Conception de l'environnement des bâtiments — Normes pour la conception, la construction et le fonctionnement des systèmes de chauffage et de refroidissement par rayonnement —*

*Partie 3: Conception et dimensionnement*



Reference number
ISO 11855-3:2012(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

# Contents

Page





# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 11855-3 was prepared by Technical Committee ISO/TC 205, *Building environment design*.

ISO 11855 consists of the following parts, under the general title *Building environment design — Design, dimensioning, installation and control of embedded radiant heating and cooling systems*:

— *Part 1: Definition, symbols, and comfort criteria*

— *Part 2: Determination of the design and heating and cooling capacity*

— *Part 3: Design and dimensioning*

— *Part 4: Dimensioning and calculation of the dynamic heating and cooling capacity of Thermo Active Building Systems (TABS)*

— *Part 5: Installation*

— *Part 6: Control*

Part 1 specifies the comfort criteria which should be considered in designing embedded radiant heating and cooling systems, since the main objective of the radiant heating and cooling system is to satisfy thermal comfort of the occupants. Part 2 provides steady-state calculation methods for determination of the heating and cooling capacity. Part 3 specifies design and dimensioning methods of radiant heating and cooling systems to ensure the heating and cooling capacity. Part 4 provides a dimensioning and calculation method to design Thermo Active Building Systems (TABS) for energy saving purposes, since radiant heating and cooling systems can reduce energy consumption and heat source size by using renewable energy. Part 5 addresses the installation process for the system to operate as intended. Part 6 shows a proper control method of the radiant heating and cooling systems to ensure the maximum performance which was intended in the design stage when the system is actually being operated in a building.

# Introduction

The radiant heating and cooling system consists of heat emitting/absorbing, heat supply, distribution, and control systems. The ISO 11855 series deals with the embedded surface heating and cooling system that directly controls heat exchange within the space. It does not include the system equipment itself, such as heat source, distribution system and controller.

The ISO 11855 series addresses an embedded system that is integrated with the building structure. Therefore, the panel system with open air gap, which is not integrated with the building structure, is not covered by this series.

The ISO 11855 series shall be applied to systems using not only water but also other fluids or electricity as a heating or cooling medium.

The object of the ISO 11855 series is to provide criteria to effectively design embedded systems. To do this, it presents comfort criteria for the space served by embedded systems, heat output calculation, dimensioning, dynamic analysis, installation, operation, and control method of embedded systems.

# Building environment design — Design, dimensioning, installation and control of embedded radiant heating and cooling systems —

# Part 3: Design and dimensioning



## 1 Scope

This part of ISO 11855 establishes a system design and dimensioning method to ensure the heating and cooling capacity of the radiant heating and cooling systems.

The ISO 11855 series is applicable to water based embedded surface heating and cooling systems in residential, commercial and industrial buildings. The methods apply to systems integrated into the wall, floor or ceiling construction without any open air gaps. It does not apply to panel systems with open air gaps which are not integrated into the building structure.

The ISO 11855 series applies also, as appropriate, to the use of fluids other than water as a heating or cooling medium. The ISO 11855 series is not applicable for testing of systems. The methods do not apply to heated or chilled ceiling panels or beams.

## 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 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*

ISO 11855-1, *Building environment design — Design, dimensioning, installation and control of embedded radiant heating and cooling systems — Part 1: Definition, symbols, and comfort criteria*

ISO 11855-2, *Building environment design — Design, dimensioning, installation and control of embedded radiant heating and cooling systems — Part 2: Determination of the design heating and cooling capacity*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11855-1 apply.

## 4 Symbols and abbreviated terms

For the purposes of this document, the symbols and abbreviations in Table 1 apply.

**Table 1 — Symbols and abbreviated terms**

| Symbol | Unit | Quantity |
|---|---|---|
| $A_F$ | $m^2$ | Area of the heating/cooling surface |

**Table 1** *(continued)*

| Symbol | Unit | Quantity |
|---|---|---|
| $A_A$ | m$^2$ | Area of the occupied heating/cooling surface |
| $A_R$ | m$^2$ | Area of the peripheral heating/cooling surface |
| $c_W$ | J/(kg·K) | Specific heat of medium |
| $K_H$ | W/(m$^2$·K) | Equivalent heat transmission coefficient |
| $l_p$ | m | Distance between the joists |
| $l_W$ | m | Thickness of the joist |
| $M$ | kg/s | Design heating/cooling medium flow rate |
| $q_{des}$ | W/m$^2$ | Design heat flux |
| $q_{des,A}$ | W/m$^2$ | Design heat flux in the occupied area |
| $q_{des,R}$ | W/m$^2$ | Design heat flux in the peripheral area |
| $q_G$ | W/m$^2$ | Limit heat flux |
| $q_{max}$ | W/m$^2$ | Maximum design heat flux |
| $Q_{des}$ | W | Design heating/cooling capacity |
| $Q_N$ | W | Design heating/cooling load |
| $Q_{N,s}$ | W | Design sensible cooling load |
| $Q_{N,l}$ | W | Design latent cooling load |
| $Q_{out}$ | W | Heat output of supplementary heating equipment |
| $R_o$ | (m$^2$ K)/W | Partial inwards heat transmission resistance of the surface structure |
| $R_u$ | (m$^2$ K)/W | Partial outwards heat transmission resistance of the surface structure |
| $R\lambda_{,B}$ | (m$^2$·K)/W | Thermal resistance of surface covering |
| $R\lambda_{,ins}$ | (m$^2$·K)/W | Back side thermal resistance of insulating layer |
| $s_{ins}$ | m | Effective thickness of thermal insulating layer |
| $W$ | m | Pipe spacing |
| $h$ | W/(m$^2$ K) | Heat transfer coefficient |
| $\lambda_{ins}$ | W/(m·K) | Effective thermal conductivity of the thermal insulation layer |
| $\lambda_i$ | W/(mK) | Thermal conductivity of the thermal insulation layer between the joists |
| $\lambda_w$ | W/(mK) | Thermal conductivity of the joist |
| $\theta_{F,max}$ | °C | Maximum surface temperature |
| $\theta_{F,min}$ | °C | Minimum surface temperature |
| $\theta_i$ | °C | Design indoor temperature |
| $\theta_R$ | °C | Return temperature of heating/cooling medium |
| $\theta_V$ | °C | Supply temperature of heating/cooling medium |
| $\theta_{V,des}$ | °C | Design supply temperature of heating/cooling medium |
| $\Delta\theta_H$ | K | Heating/cooling medium differential temperature |
| $\Delta\theta_{H,des}$ | K | Design heating/cooling medium differential temperature |
| $\Delta\theta_{H,G}$ | K | Limit of heating/cooling medium differential temperature |
| $\Delta\theta_{V,des}$ | K | Design heating/cooling medium differential supply temperature |
| $\sigma$ | K | Temperature drop/rise between supply and return medium |



# 5 Radiant panel

## 5.1 Floor heating systems

### 5.1.1 Design procedure

Floor heating system design requires determining heating surface area, type, pipe size, pipe spacing, supply temperature of the heating medium, and design heating medium flow rate. The design steps are as follows:

Step 1: Calculate the design heating load $Q_N$. The design heating load $Q_N$ shall not include the adjacent heat losses. This step should be conducted in accordance with a standard for heating load calculation, such as EN 12831, based on an index such as operative temperature (OT) (see ISO 11855-1).

Step 2: Determine the area of the heating surface $A_F$, excluding any area covered by immovable objects or objects fixed to the building structure.

Step 3: Establish a maximum permissible surface temperature in accordance with ISO 11855-1.

Step 4: Determine the design heat flux $q_{des}$ according to Equation (1). For floor heating systems including a peripheral area, the design heat flux of peripheral area $q_{des,R}$ and the design heat flux of occupied area $q_{des,A}$ shall be calculated respectively on the area of the peripheral heating surface $A_R$ and on the area of the occupied heating surface $A_A$ complying with Equation (2).

$$q_{des} = \frac{Q_N}{A_F} \quad (1)$$

$$Q_N = q_{des,R} \cdot A_R + q_{des,A} \cdot A_A \quad (2)$$

Step 5: For the design of the floor heating systems, determine the room used for design with the maximum design heat flux $q_{max} = q_{des}$.

Step 6: Determine the floor heating system such as the pipe spacing and the covering type, and design heating medium differential temperature $\Delta\theta_{H,des}$ based on the maximum design heat flux $q_{max}$ and the maximum surface temperature $\theta_{F,max}$ from the field of characteristic curves according to ISO 11855-2 and 5.1.7 in this part of ISO 11855.

Step 7: If the design heat flux $q_{des}$ cannot be obtained by any pipe spacing for the room used for the design, it is recommended to include a peripheral area and/or to provide supplementary heating equipment. In this case, the maximum design heat flux $q_{max}$ for the embedded system may now occur in another room. The amount of heat output of supplementary heating equipment $Q_{out}$ is determined by the following equation:

$$Q_{out} = Q_N - Q_{des} \quad (3)$$

where design heating capacity $Q_{des}$ is calculated by:

$$Q_{des} = q_{des} \times A_F \quad (4)$$

Step 8: Determine the backside thermal resistance of insulating layer $R_{\lambda,ins}$ and the design heating medium flow rate $m$ (see 5.1.6 and 5.1.8).

Step 9: Estimate the total length of heating circuit.

If intermittent operation is common, the characteristics of the increase of the heat flow and the surface temperature and the time to reach the allowable conditions in rooms just after switching on the system shall be considered.

### 5.1.2 Heating medium differential temperature

Heating medium differential temperature $\Delta\theta_H$ is calculated as follows (refer to ISO 11855-2):

$$\Delta\theta_H = \frac{\theta_V - \theta_R}{\ln \dfrac{\theta_V - \theta_i}{\theta_R - \theta_i}} \qquad (5)$$

In this equation, the effect of the temperature drop of the heating medium is taken into account.

### 5.1.3 Characteristic curve

The characteristic curve describes the relationship between the heat flux $q$ and the heating medium differential temperature $\Delta\theta_H$. For simplicity, the heat flux $q$ is taken to be proportional to the heating medium differential temperature $\Delta\theta_H$:

$$q = K_H \cdot \Delta\theta_H \qquad (6)$$

where $K_H$ is the equivalent heat transmission coefficient determined in ISO 11855-2 depending on the type of the system.a

### 5.1.4 Field of characteristic curves

The field of characteristic curves of a floor heating system with a specific pipe spacing $W$ shall at least contain the characteristic curves for values of the thermal resistance of surface covering $R_{\lambda,B}$ = 0, $R_{\lambda,B}$ = 0,05, $R_{\lambda,B}$ = 0,10 and $R_{\lambda,B}$ = 0,15 ($m^2K/W$), in accordance with ISO 11855-2 (see Figure 1). Values of $R_{\lambda,B}$ > 0,15 ($m^2K/W$) shall not be used if possible.

### 5.1.5 Limit curves

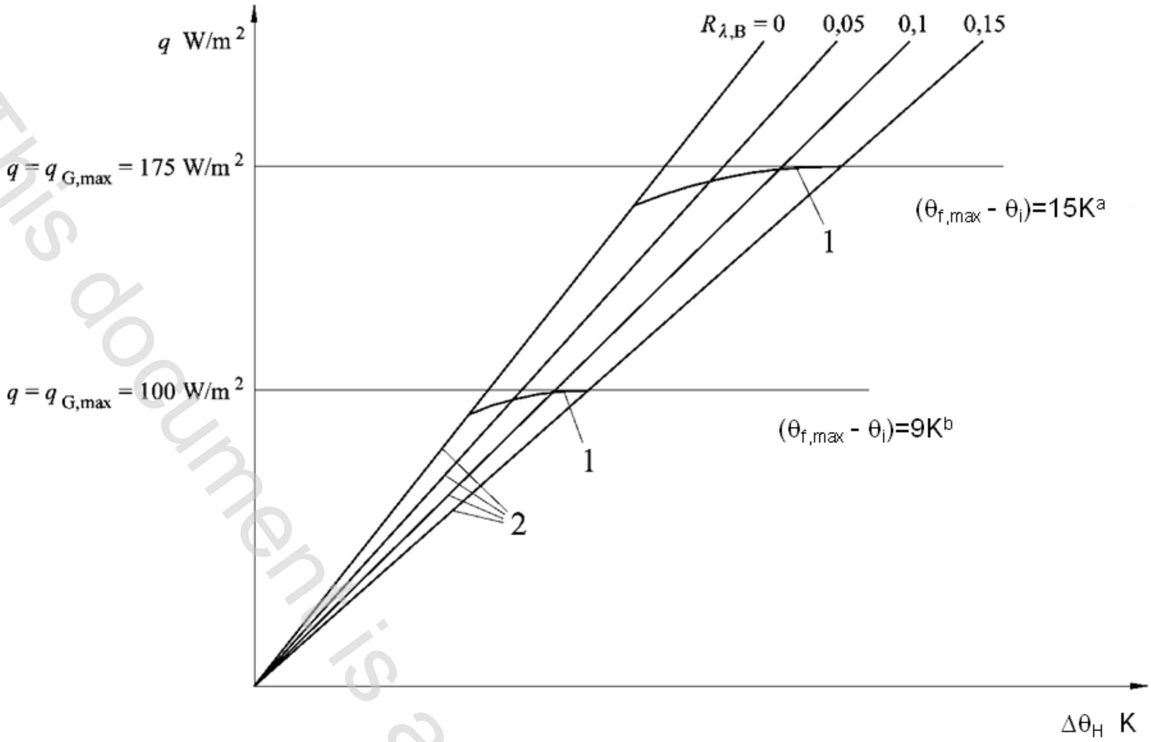
The limit curves in the field of characteristic curves describe, in accordance with ISO 11855-2, the relationship between the heating medium differential temperature $\Delta\theta_H$ and the heat flux $q$ in the case where the physiologically agreed limit values of surface temperatures are reached. For design purposes, i.e. the determination of design values of the heat flux and the associated heating medium differential temperature $\Delta\theta$, the limit curves are valid for temperature drop between supply and return medium $\sigma$ in a range of:

$$0\ \text{K} < \sigma < 5\ \text{K} \qquad (7)$$

The limit curves are used to specify the limit of heating medium differential temperature $\Delta\theta_{H,G}$ and supply temperature (refer to Figure 6).






**Key**

1 limit curves

2 performance characteristic curves

a Peripheral area.

b Occupied area.

**Figure 1 — Field of characteristic curves, including limit curves for floor heating, for constant pipe spacing**



This example is for floor heating, indoor temperature = 20 °C and the maximum temperature is 29 °C (occupied areas) and 35 °C (peripheral area). For bathrooms (the indoor temperature is 24 °C), the limit curve for ($\theta_{F,max} - \theta_i$) = 9K also applies.

### 5.1.6 Downwards thermal insulation

In order to limit the heat flow through the floor towards the space below, the required back side thermal resistance of the insulating layer $R_{\lambda,ins}$ shall be specified in the design to be not lower than the value in Table 2 in ISO 11855-4:2012.

For systems which have a flat insulating layer (Types A, B, C, D and G in ISO 11855-2), the back-side thermal resistance of the insulating layer $R_{\lambda,ins}$ is calculated by Equation (8).

$$R_{\lambda,ins} = \frac{s_{ins}}{\lambda_{ins}} \quad (8)$$

Depending on the construction of the floor heating system, the effective thickness of thermal insulating layer $s_{ins}$ and effective thermal conductivity of the thermal insulation layer $\lambda_{ins}$ are determined differently.

For floor heating systems with flat thermal insulating panels of types A and C in ISO 11855-2:2012, the effective thickness of thermal insulating layer $s_{ins}$ is identical to the thickness of the thermal insulation, and the effective thermal conductivity of the thermal insulation layer $\lambda_{ins}$ is identical to the thermal conductivity of the thermal insulation [Figure 2 a)].

For the system with profiled thermal insulating panels of type B in ISO 11855-2:2012 [Figure 2 b)], the effective thickness of the insulating layer shall be determined by Equation (9).

$$s_{ins} = \frac{s_h \cdot (W - D) + s_l \cdot D}{W} \quad (9)$$

For the system with the light wooden radiant panel on the joist of type G in ISO 11855-2:2012 [Figure 2 c)], the effective thickness of thermal insulating layer $s_{ins}$ is identical to the thickness of the thermal insulating panel, and the effective thermal conductivity of the thermal insulation layer $\lambda_{ins}$ is:

$$\lambda_{ins} = \lambda_i \frac{l_p - l_w}{l_p} + \lambda_w \frac{l_w}{l_p} \quad (10)$$

where:

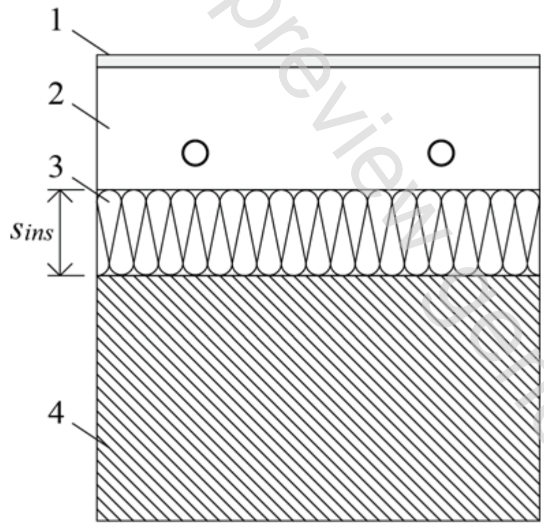
$\lambda_i$ is thermal conductivity of the thermal insulation layer between the joists;

$\lambda_w$ is thermal conductivity of the joist;

$l_p$ is the distance between the joist (see Figure 5);

$l_w$ is the thickness of the joist (see Figure 5).

For type G systems with air cavities see Annex C and E in ISO 11855-2:2012.




**Key**

1 floor covering

2 weight bearing and thermal diffusion layer (cement, anhydrite, or asphalt screed)

3 thermal insulation

4 structural bearing

**Figure 2 — Effective thickness and effective thermal conductivity of thermal insulating layer of flat thermal insulating panel — Types A and C**

