# SLOVENSKI STANDARD
# oSIST prEN ISO 11855-4:2020

**01-maj-2020**

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**Načrtovanje okolja v stavbah - Vgrajeni hladilni in ogrevalni sistemi - 4. del: Dimenzioniranje in izračun zmogljivosti dinamičnega ogrevanja in hlajenja termoaktivnega gradbenega sistema (TAGS) (ISO/DIS 11855-4:2020)**

Building environment design - Embedded radiant heating and cooling systems - Part 4: Dimensioning and calculation of the dynamic heating and cooling capacity of Thermo Active Building Systems (TABS) (ISO/DIS 11855-4:2020)

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Conception de l'environnement des bâtiments - Systèmes intégrés de chauffage et de refroidissement par rayonnement - Partie 4: Dimensionnement et calculs relatifs au chauffage adiabatique et à la puissance frigorifique pour systèmes thermoactifs (TABS) (ISO/DIS 11855-4:2020)

**Ta slovenski standard je istoveten z:** **prEN ISO 11855-4**

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| 91.140.30 | Prezračevalni in klimatski sistemi | Ventilation and air-conditioning systems |

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DRAFT INTERNATIONAL STANDARD

# ISO/DIS 11855-4

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# Building environment design — Embedded radiant heating and cooling systems —

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

*Conception de l'environnement des bâtiments — Systèmes intégrés de chauffage et de refroidissement par rayonnement —*

*Partie 4: Dimensionnement et calculs relatifs au chauffage adiabatique et à la puissance frigorifique pour systèmes thermoactifs (TABS)*

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# 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 11855-4 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 7: Input parameters for the energy calculation

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. Part 7 presents a calculation method for input parameters to ISO 52031.

# 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, control method of embedded systems, and input parameters for the energy calculations.

**DRAFT INTERNATIONAL STANDARD** **ISO/DIS 11855-4:2020(E)**

# Building environment design — Embedded radiant heating and cooling systems —

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

## 1 Scope

This part of ISO 11855 allows the calculation of peak cooling capacity of Thermo Active Building Systems (TABS), based on heat gains, such as solar gains, internal heat gains, and ventilation, and the calculation of the cooling power demand on the water side, to be used to size the cooling system, as regards the chiller size, fluid flow rate, etc.

This part of ISO 11855 defines a detailed method aimed at the calculation of heating and cooling capacity in non-steady state conditions.

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 also applies, 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.

ISO 11855-1, *Building environment design — Embedded radiant heating and cooling systems — Part 1: Definition, symbols, and comfort criteria*

## 3 Terms and definitions

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

## 4 Symbols and abbreviations

For the purposes of this part of ISO 11855, the symbols and abbreviations in Table 1 apply:

**Table 1 — Symbols and abbreviations**

| Symbol | Unit | Quantity |
|---|---|---|
| $A_F$ | $m^2$ | Area of the heating/cooling surface area |
| $A_W$ | $m^2$ | Total area of internal vertical walls (i.e. vertical walls, external façades excluded) |
| $C$ | $J/(m^2 \cdot K)$ | Specific thermal capacity of the thermal node under consideration |

**Table 1** *(continued)*

| Symbol | Unit | Quantity |
|---|---|---|
| $C_W$ | J/(m²·K) | Average specific thermal capacity of the internal walls |
| $c_j$ | J/(kg·K) | Specific heat of the material constituting the j-th layer of the slab |
| $c_w$ | J/(kg·K) | Specific heat of water |
| $d_a$ | m | External diameter of the pipe |
| $E_{Day}$ | kWh/m² | Specific daily energy gains |
| $f_{rm}^{h}$ | - | Running mode (1 when the system is running; 0 when the system is switched off) in the h-th hour |
| $f_s$ | - | Design safety factor |
| $F_{v\ F\text{-}C}$ | - | View factor between the floor and the ceiling |
| $F_{v\ F\text{-}EW}$ | - | View factor between the floor and the external walls |
| $F_{v\ F\text{-}W}$ | - | View factor between the floor and the internal walls |
| $h_{A\text{-}C}$ | W/(m²·K) | Convective heat transfer coefficient between the air and the ceiling |
| $h_{A\text{-}F}$ | W/(m²·K) | Convective heat transfer coefficient between the air and the floor |
| $h_{A\text{-}W}$ | W/(m²·K) | Convective heat transfer coefficient between the air and the internal walls |
| $h_{F\text{-}C}$ | W/(m²·K) | Radiant heat transfer coefficient between the floor and the ceiling |
| $h_{F\text{-}W}$ | W/(m²·K) | Radiant heat transfer coefficient between the floor and the internal walls |
| $H_A$ | W/K | Heat transfer coefficient between the thermal node under consideration and the air thermal node (“A”) |
| $H_C$ | W/K | Heat transfer coefficient between the thermal node under consideration and the ceiling surface thermal node (“C”) |
| $H_{Circuit}$ | W/K | Heat transfer coefficient between the thermal node under consideration and the circuit |
| $H_{CondDown}$ | W/K | Heat transfer coefficient between the thermal node under consideration and the next one |
| $H_{CondUp}$ | W/K | Heat transfer coefficient between the thermal node under consideration and the previous one |
| $H_{Conv}$ | - | Fraction of internal convective heat gains acting on the thermal node under consideration |
| $H_F$ | W/K | Heat transfer coefficient between the thermal node under consideration and the floor surface thermal node (“F”) |
| $H_{Inertia}$ | W/K | Coefficient connected to the inertia contribution at the thermal node under consideration |
| $H_{IWS}$ | W/K | Heat transfer coefficient between the thermal node under consideration and the internal wall surface thermal node (“IWS”) |
| $H_{Rad}$ | - | Fraction of total radiant heat gains impinging on the thermal node under consideration |
| $h_t$ | W/(m²·K) | Total heat transfer coefficient (convection + radiation) between surface and space |
| $J$ | - | Number of layers constituting the slab as a whole |
| $J_1$ | - | Number of layers constituting the upper part of the slab |
| $J_2$ | - | Number of layers constituting the lower part of the slab |
| $L_R$ | m | Length of installed pipes |
| $\dot{m}_{H,sp}$ | kg/(m²·s) | Specific water flow in the circuit, calculated on the area covered by the circuit |
| $m_j$ | - | Number of partitions of the j-th layer of the slab |
| $n$ | - | Actual number of iteration in iterative calculations |
| $n_h$ | h | Number of operation hours of the circuit |

**Table 1** *(continued)*

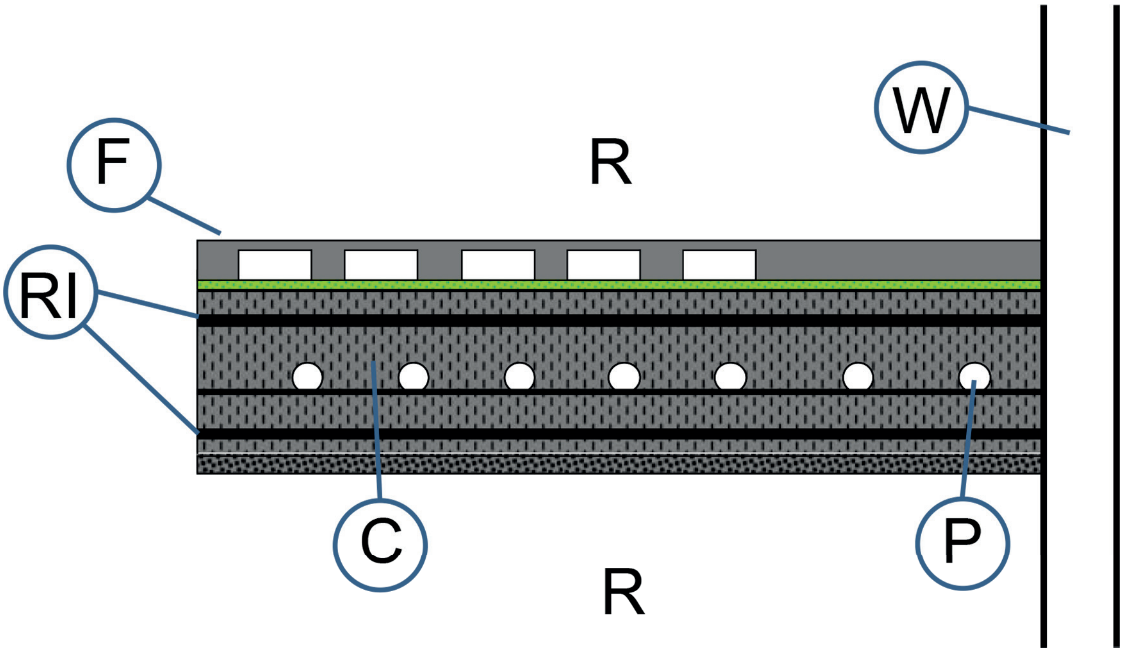
| Symbol | Unit | Quantity |
|---|---|---|
| $n^{\mathrm{Max}}$ | - | Maximum number of iterations allowed in iterative calculations |
| $P_{\mathrm{Circuit}}^{\mathrm{Max,h}}$ | W | Maximum cooling power reserved to the circuit under consideration in the h-th hour |
| $P_{\mathrm{Circuit,Spec}}^{\mathrm{Max}}$ | W/m$^2$ | Maximum specific cooling power (per floor square metre) |
| $q_{\mathrm{i}}$ | W/m$^2$ | Inward specific heat flow |
| $q_{\mathrm{u}}$ | W/m$^2$ | Outward specific heat flow |
| $Q_{\mathrm{C}}^{\mathrm{h}}$ | W | Heat flow impinging on the ceiling surface (“C”) in the h-th hour |
| $Q_{\mathrm{Circuit}}^{\mathrm{h}}$ | W | Heat flow extracted by the circuit in the h-th hour |
| $Q_{\mathrm{Conv}}^{\mathrm{h}}$ | W | Total convective heat gains in the h-th hour |
| $Q_{\mathrm{F}}^{\mathrm{h}}$ | W | Heat flow impinging on the floor surface (“F”) in the h-th hour |
| $Q_{\mathrm{IntConv}}^{\mathrm{h}}$ | W | Internal convective heat gains in the h-th hour |
| $Q_{\mathrm{IntRad}}^{\mathrm{h}}$ | W | Internal radiant heat gains in the h-th hour |
| $Q_{\mathrm{IWS}}^{\mathrm{h}}$ | W | Heat flow impinging on the internal wall surface (“IWS”) in the h-th hour |
| $Q_{\mathrm{PrimAir}}^{\mathrm{h}}$ | W | Primary air convective heat gains in the h-th hour |
| $Q_{\mathrm{Rad}}^{\mathrm{h}}$ | W | Total radiant heat gains in the h-th hour |
| $Q_{\mathrm{Sun}}^{\mathrm{h}}$ | W | Solar heat gains in the room in the h-th hour |
| $Q_{\mathrm{Transm}}^{\mathrm{h}}$ | W | Transmission heat gains in the h-th hour |
| $Q_{\mathrm{W}}$ | W/m$^2$ | Average specific cooling power |
| $R$ | (m$^2$·K)/W | Generic thermal resistance |
| $R_{\mathrm{Add\ C}}$ | (m$^2$·K)/W | Additional thermal resistance covering the lower side of the slab |
| $R_{\mathrm{Add\ F}}$ | (m$^2$·K)/W | Additional thermal resistance covering the upper side of the slab |
| $R_{\mathrm{int}}$ | (m$^2$·K)/W | Internal thermal resistance of the slab conductive region |
| $R_{\mathrm{L,p}}$ | (m$^2$·K)/W | Conduction thermal resistance connecting the p-th thermal node with the boundary of the (p+1)-th thermal node |
| $R_{\mathrm{r}}$ | (m$^2$·K)/W | Pipe thickness thermal resistance |
| $R_{\mathrm{t}}$ | (m$^2$·K)/W | Circuit total thermal resistance |
| $R_{\mathrm{U,p}}$ | (m$^2$·K)/W | Conduction thermal resistance connecting the p-th thermal node with the boundary of the (p-1)-th thermal node |
| $R_{\mathrm{Walls}}$ | (m$^2$·K)/W | Wall surface thermal resistance |
| $R_{\mathrm{w}}$ | (m$^2$·K)/W | Water flow thermal resistance |
| $R_{\mathrm{x}}$ | (m$^2$·K)/W | Pipe level thermal resistance |
| $R_{\mathrm{z}}$ | (m$^2$·K)/W | Convection thermal resistance at the pipe inner side |
| $s_{\mathrm{r}}$ | m | Pipe wall thickness |
| $s_1$ | m | Thickness of the upper part of the slab |
| $s_2$ | m | Thickness of the lower part of the slab |
| $W$ | m | Pipe spacing |
| ´$_{\mathrm{j}}$ | m | Thickness of the j-th layer of the slab |

**Table 1** *(continued)*

| Symbol | Unit | Quantity |
|---|---|---|
| $\Delta\theta$ | K | Generic temperature difference |
| $\Delta\theta_{\mathrm{Comfort}}^{\mathrm{Max}}$ | K | Maximum operative temperature drift allowed for comfort conditions |
| $\Delta t$ | s | Calculation time step |
| $\theta_{\mathrm{A}}^{\mathrm{h}}$ | °C | Temperature of the air thermal node (“A”) in the h-th hour |
| $\theta_{\mathrm{C}}^{\mathrm{h}}$ | °C | Temperature of the ceiling surface thermal node (“C”) in the h-th hour |
| $\theta_{\mathrm{Comfort}}^{\mathrm{Max}}$ | °C | Maximum operative temperature allowed for comfort conditions |
| $\theta_{\mathrm{Comfort,Ref}}$ | °C | Maximum operative temperature allowed for comfort conditions in the reference case |
| $\theta_{\mathrm{F}}^{\mathrm{h}}$ | °C | Temperature of the floor surface thermal node (“F”) in the h-th hour |
| $\theta_{\mathrm{IW}}^{\mathrm{h}}$ | °C | Temperature of the core of the internal walls thermal node (“IW”) in the h-th hour |
| $\theta_{\mathrm{IWS}}^{\mathrm{h}}$ | °C | Temperature of the internal wall surface thermal node (“IWS”) in the h-th hour |
| $\theta_{\mathrm{MR}}^{\mathrm{h}}$ | °C | Room mean radiant temperature in the h-th hour |
| $\theta_{\mathrm{Op}}^{\mathrm{h}}$ | °C | Room operative temperature in the h-th hour |
| $\theta_{\mathrm{p}}^{\mathrm{h}}$ | °C | Temperature of the p-th thermal node in the h-th hour |
| $\theta_{\mathrm{PL}}^{\mathrm{h}}$ | °C | Temperature of the pipe level thermal node (“PL”) in the h-th hour |
| $\theta_{\mathrm{Slab}}^{\mathrm{Av}}$ | °C | Daily average temperature of the conductive region of the slab |
| $\theta_{\mathrm{Water,In}}^{\mathrm{h}}$ | °C | Water inlet actual temperature in the h-th hour |
| $\theta_{\mathrm{Water,In}}^{\mathrm{Setp,h}}$ | °C | Water inlet set-point temperature in the h-th hour |
| $\theta_{\mathrm{Water,In,Ref}}^{\mathrm{Setp}}$ | °C | Water inlet set-point temperature in the reference case |
| $\theta_{\mathrm{Water,Out}}^{\mathrm{h}}$ | °C | Water outlet temperature in the h-th hour |
| $\lambda_{\mathrm{b}}$ | W/(m·K) | Thermal conductivity of the material of the pipe embedded layer |
| »$_{\mathrm{j}}$ | W/(m·K) | Thermal conductivity of the material constituting the j-th layer of the slab |
| $\lambda_{\mathrm{r}}$ | W/(m·K) | Thermal conductivity of the material constituting the pipe |
| $\xi$ | K | Actual tolerance in iterative calculations |
| $\xi_{\mathrm{Max}}$ | K | Maximum tolerance allowed in iterative calculations |
| $\rho_{\mathrm{j}}$ | kg/m$^3$ | Density of the material constituting the j-th layer of the slab |
| $\omega$ | various | Slope of correlation curves |

## 5 The concept of Thermally Building Active Surfaces (TABS)

A Thermally Active Building Surface (TABS) is an embedded water based surface heating and cooling system, where the pipe is embedded in the central concrete core of a building construction (see Figure 1).

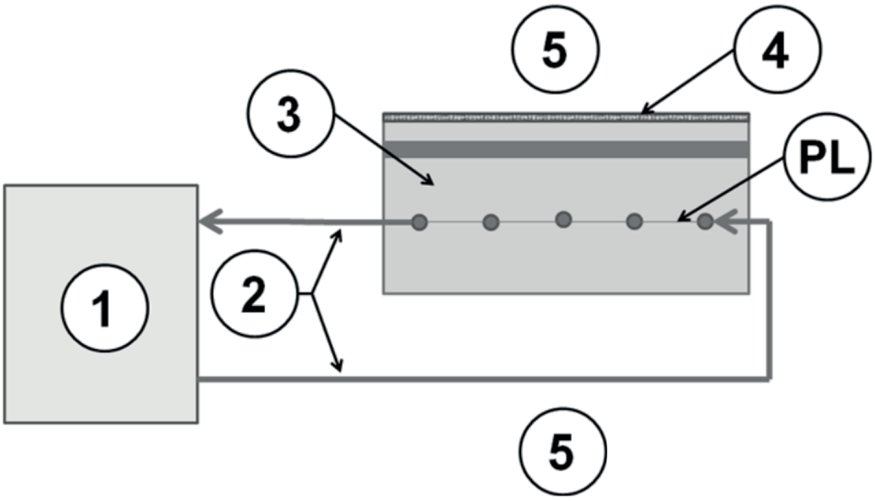


**Key**

| | |
|---|---|
| C | concrete |
| F | floor |
| P | pipes |
| R | room |
| RI | reinforcement |
| W | window |

Figure 1 — Example of position of pipes in TABS

The building constructions embedding the pipe are usually the horizontal ones. As a consequence, in the following sections, floors and ceilings are usually referred to as active surfaces. Looking at a typical structure of a TAS, heat is removed by a cooling system (for instance, a chiller), connected to pipes embedded in the slab. The system can be divided into the elements shown in Figure 2.

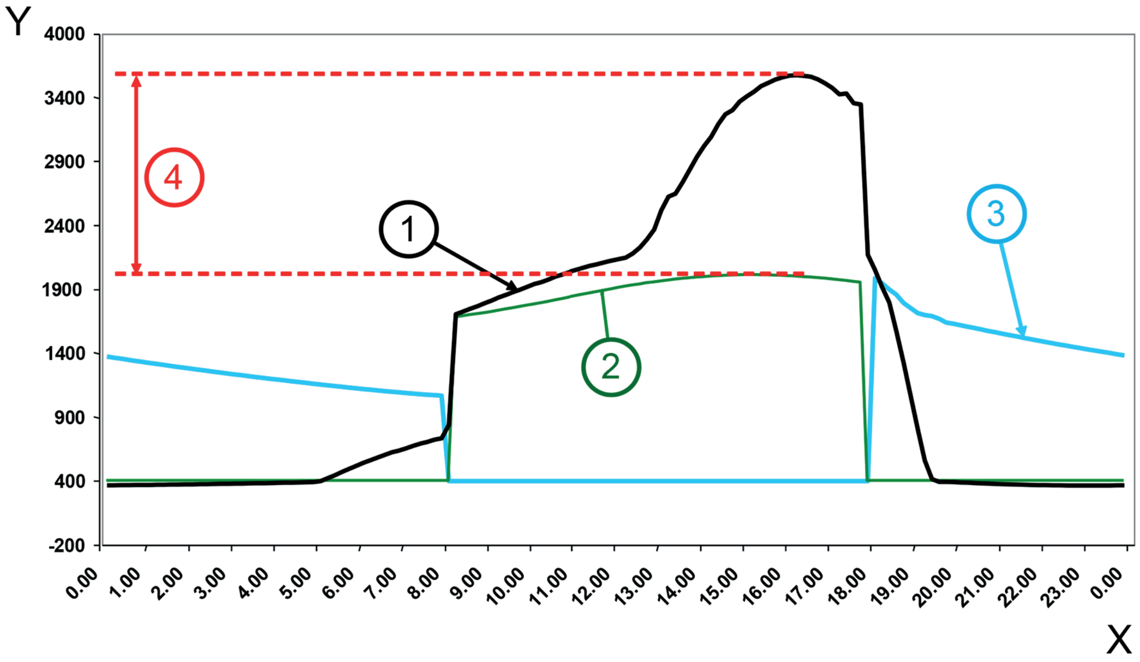


**Key**

| | |
|---|---|
| 1 | heating/cooling equipment |
| 2 | hydraulic circuit |
| 3 | slab including core layer with pipes |
| 4 | possible additional resistances (floor covering or suspended ceiling) |
| 5 | room below and room above |
| PL | pipe level |

**Figure 2 — Simple scheme of a TAS**

Thermally active surfaces exploit the high thermal inertia of the slab in order to perform the peak-shaving. The peak-shaving consists in reducing the peak in the required cooling power (see Figure 3), so that it is possible to cool the structures of the building during a period in which the occupants are absent (during night time, in office premises). This way the energy consumption can be reduced and a lower night time electricity rate can be used. At the same time a reduction in the size of heating/cooling system components (including the chiller) is possible.



**Key**

X time, h

Y cooling power, W

1 heat gain

2 cooling power needed for conditioning the ventilation air

3 cooling power needed on the water side

4 reduction of the required peak power

Figure 3 — Example of peak-shaving effect

TABS may be used both with natural and mechanical ventilation (depending on weather conditions). Mechanical ventilation with dehumidifying may be required depending on external climate and indoor humidity production. In the example in Figure 3, the required peak cooling power needed for dehumidifying the air during day time is sufficient to cool the slab during night time.

As regards the design of TABS, the planner needs to know if the capacity at a given water temperature is sufficient to keep the room temperature within a given comfort range. Moreover, the planner needs also to know the heat flow on the water side to be able to dimension the heat distribution system and the chiller/boiler. This part of ISO 11855 provides methods for both purposes.

When using TABS, the indoor temperature changes moderately during the day and the aim of a good TABS design is to maintain internal conditions within the range of comfort, i.e. –0,5 < PMV < 0,5, during the day, according to ISO 7730 (see Figure 4).