放射（輻射）冷暖房協議会，**発足記念セミナー**
サピアタワー5階【サピアホール】，2016年10月28日（金） 13：00開場13：30～16：40

「ISOにおける放射（輻射）冷暖房」

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芝浦工業大學
SHIBAURA INSTITUTE OF TECHNOLOGY
Established 1927

ISO/TC 205：建築環境設計
Building environment design

新築建物及び既存建物の改修の設計において、許容できる室内環境と実効性のある省エネルギーのための標準化を行う。室内環境は空気質、温熱、音、光の要素を含む。

但し、下記の事項は除く。

- 他の人間工学的要素
- 大気汚染質、及び温熱・音・光の特性の測定方法
- 建築環境機器と断熱の性能試験・格付けの方法

ISO/TC 205：建築環境設計
Building environment design

WG	名称	幹事国
-	Building environment design（建築環境設計）	ANSI(アメリカ)
1	General principles（一般原則）	BSI(イギリス)
2	Design of energy-efficient buildings（建築の省エネルギー設計）	EOS(エジプト)
3	Building Automation and Control System (BACS) Design（ビル自動管理制御システム設計）	ANSI(アメリカ)
5	Indoor thermal environment（室内温熱環境）	SAI(オーストラリア)
7	Indoor visual environment（室内光環境）	AFNOR(フランス)
8	Radiant heating and cooling systems（放射(輻射)冷暖房ｼｽﾃﾑ）	KATS(韓国)
9	Heating and cooling systems（暖冷房システム）	AFNOR(フランス)
10	Commissioning（コミッショニング）	JISC(日本)

WG8：放射(輻射)冷暖房システム
Radiant heating and cooling systems

- **これまでの活動**

2007.6 **1st meeting at Helsinki, Finland**
2007.11 **2nd meeting at Cairo, Egypt**
2008.6 **3rd meeting at Salt Lake city, USA**
2008.11 **4th meeting at Delft, Netherland**
2009.5 **5th meeting at Busan, Korea**
2009.11 **6th meeting at Kyoto, Japan**
2010.11 **7th meeting at Sydney, Australia**
2011.9 **8th meeting at Chicago, USA**
2012.9 **9th meeting at La Rochelle, France**
2013.9 **10th meeting at Stockholm, Sweden**
2014.9 **11th meeting at Wuxi, China**
2015.9 **12th meeting at Victoria, Canada**
2016.9 **13th meeting at Berlin, Germany**

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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 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

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

- **Part 7: Input parameter for the energy calculation**

  Determination of parameters for the energy efficiency of heating and cooling emission products in relation to the ISO 52031

2016年5月新規プロジェクトとして承認

ISO 18566 (ISO/DIS, NP TR, NP)

Building Environment Design — Design, test methods and control of hydronic radiant heating and cooling panel systems --

- **Part 1:** Definition, symbols, technical specifications and requirements
- **Part 2:** Determination of heating and cooling capacity of ceiling mounted radiant panels
- **Part 3:** Design of ceiling mounted radiant panels
- **Part 4:** Control of ceiling mounted radiant heating and cooling panels
- **Part 5:** Technical report
- **Part 6:** Input parameter for the energy calculation

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

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

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.

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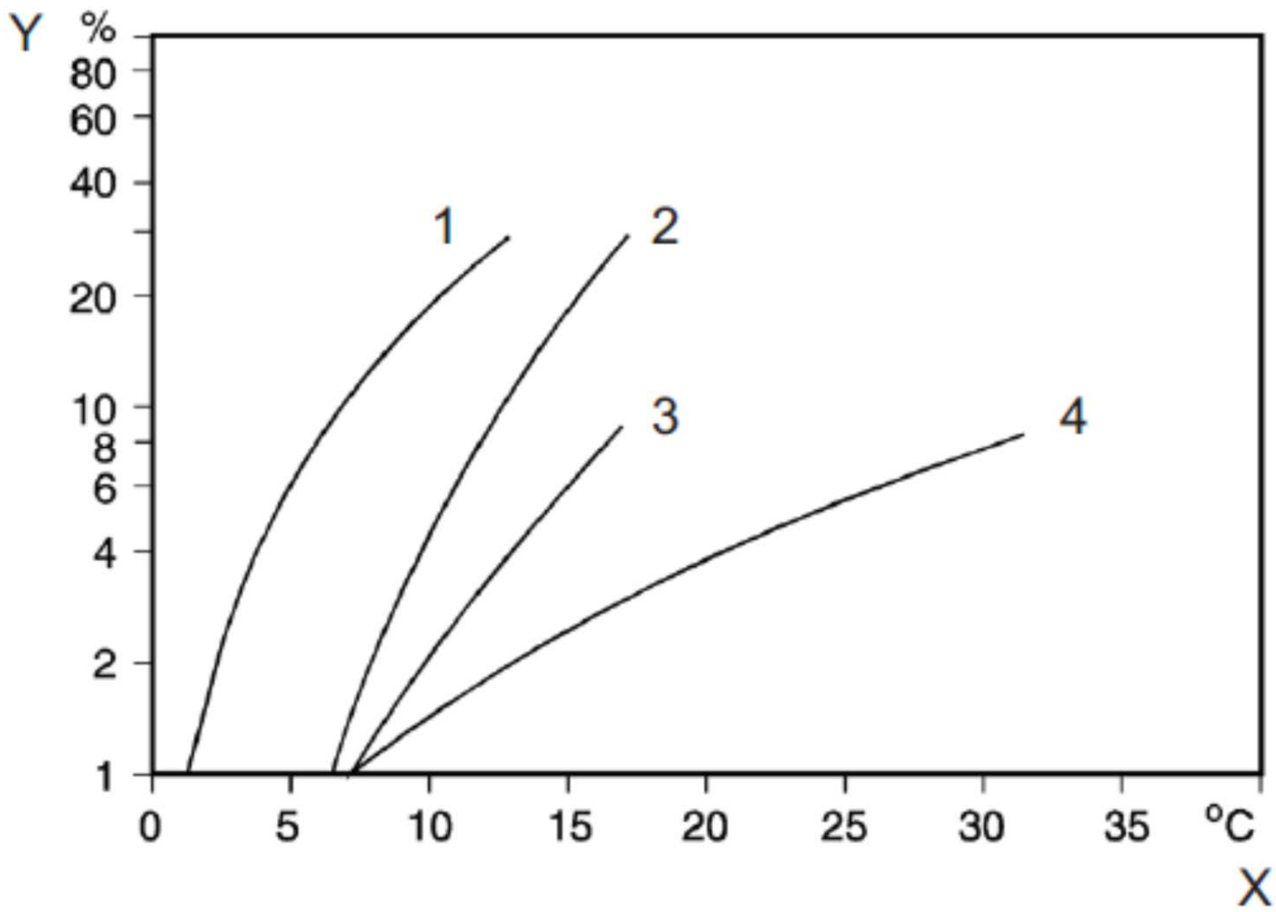
Building environment design — Design, dimensioning, installation and control of embedded radiant heating and cooling systems

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

  5 Comfort criteria
  - **5.1 General thermal comfort**
  - **5.2 Local thermal comfort**
  - **5.3 Acoustical comfort**

  Annex A (informative)
  Floor surface temperature for thermal comfort

  Annex B (informative)
  Draught.



Key

X radiant temperature asymmetry

Y dissatisfied

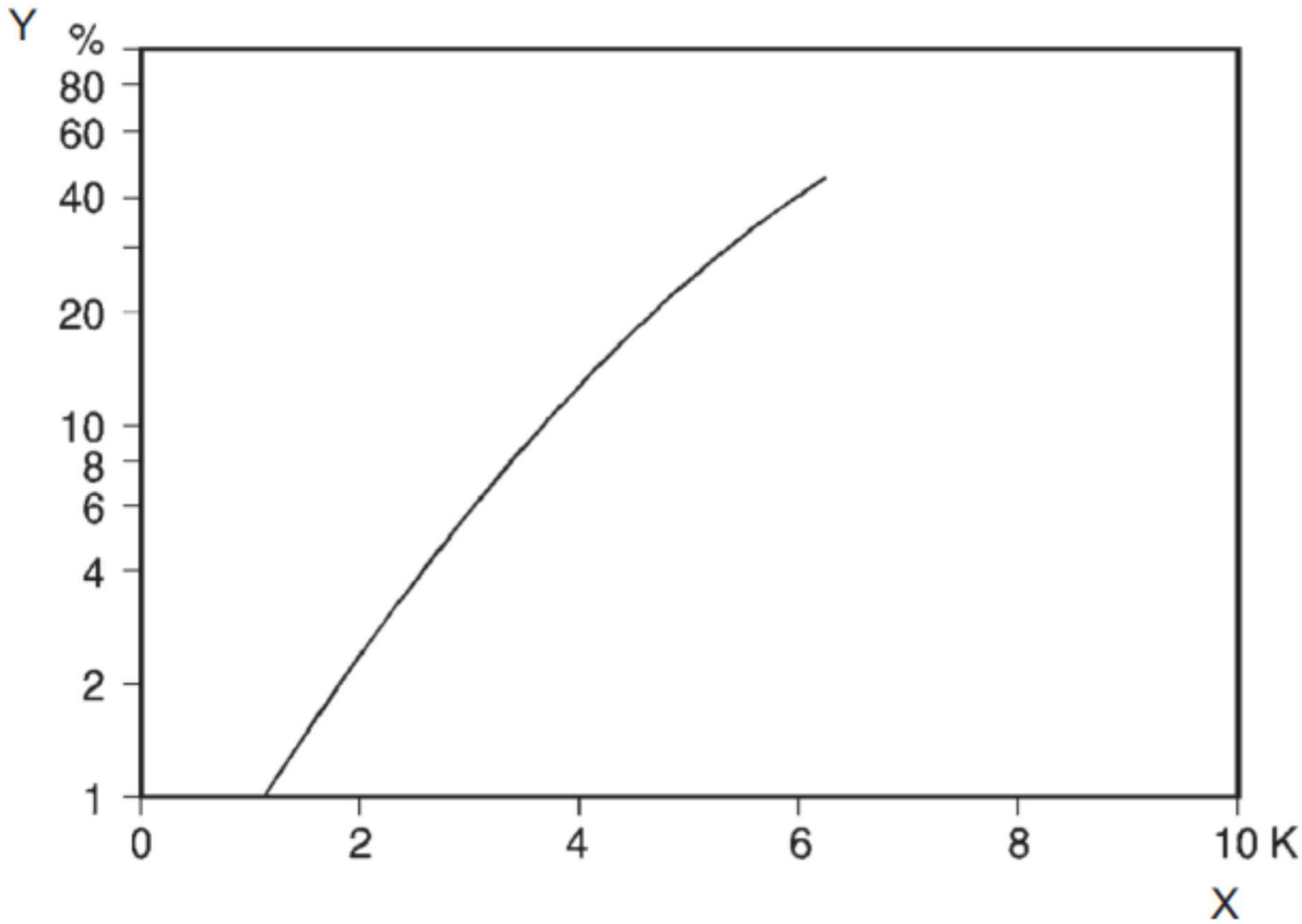
1 warm ceiling

2 cool wall

3 cool ceiling

4 warm wall

Figure 1 — Local thermal discomfort caused by radiant temperature asymmetry

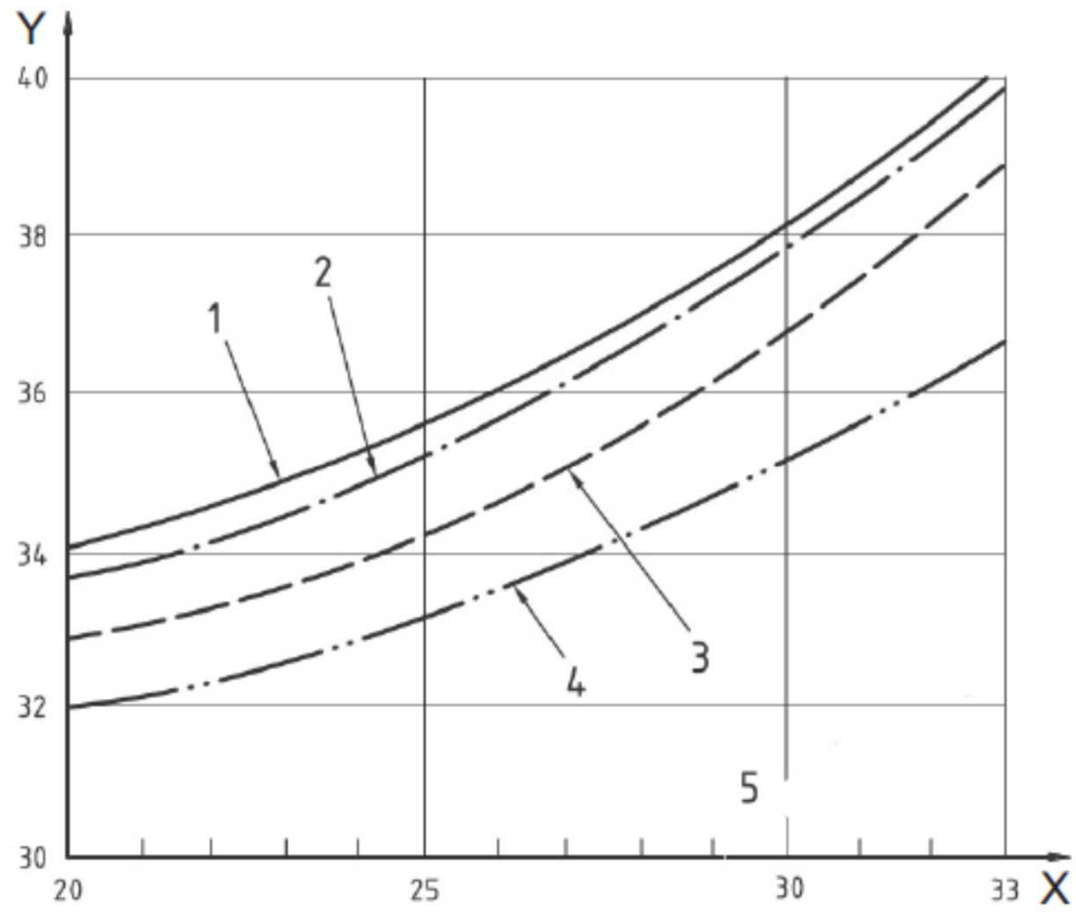


Key

X air temperature difference between head and feet

Y dissatisfied

Figure 2 — Local thermal discomfort caused by vertical air temperature difference



Key

X floor temperature, °C

Y skin temperature, °C

1 contact time, 90 min

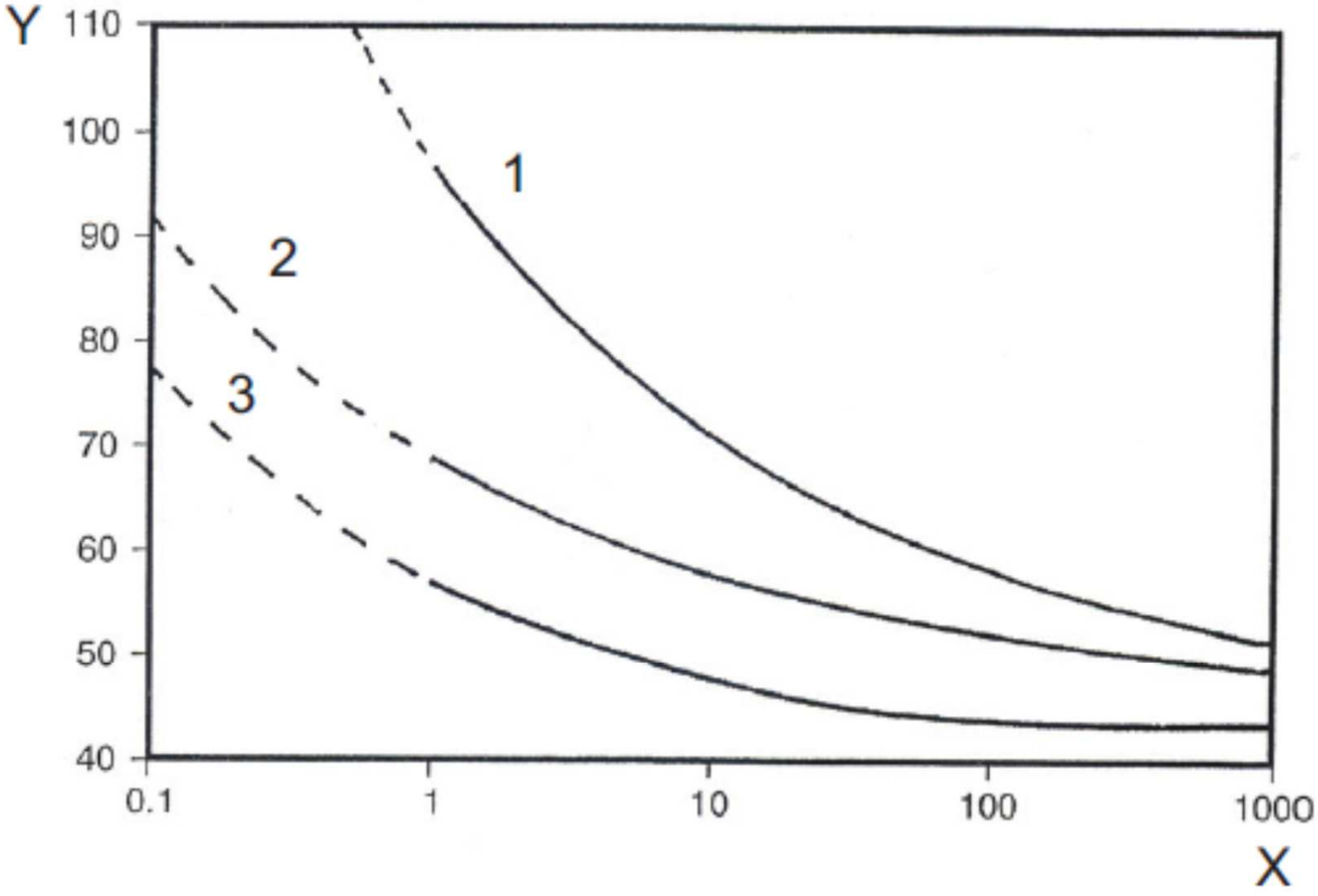
2 contact time, 60 min

3 contact time, 30 min

4 contact time, 10 min

5 wood floor covering with electric floor heating panel

Figure A.1 — Relation between floor temperature and skin temperature when seated on an electrically heated floor



Key

X contact time, s

Y skin temperature, °C

1 full skin thickness burn

2 partial skin thickness burn

3 discomfort

Figure A.2 — Skin temperatures that cause discomfort and burns

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

Part 2 provides steady-state calculation methods for determination of the heating and cooling capacity.

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

5 Concept of the method to determine the heating and cooling capacity
6 Heat exchange coefficient between surface and space
7 Simplified calculation methods for determining heating and cooling capacity or surface temperature
8 Use of basic calculation programs
9 Calculation of the heating and cooling capacity

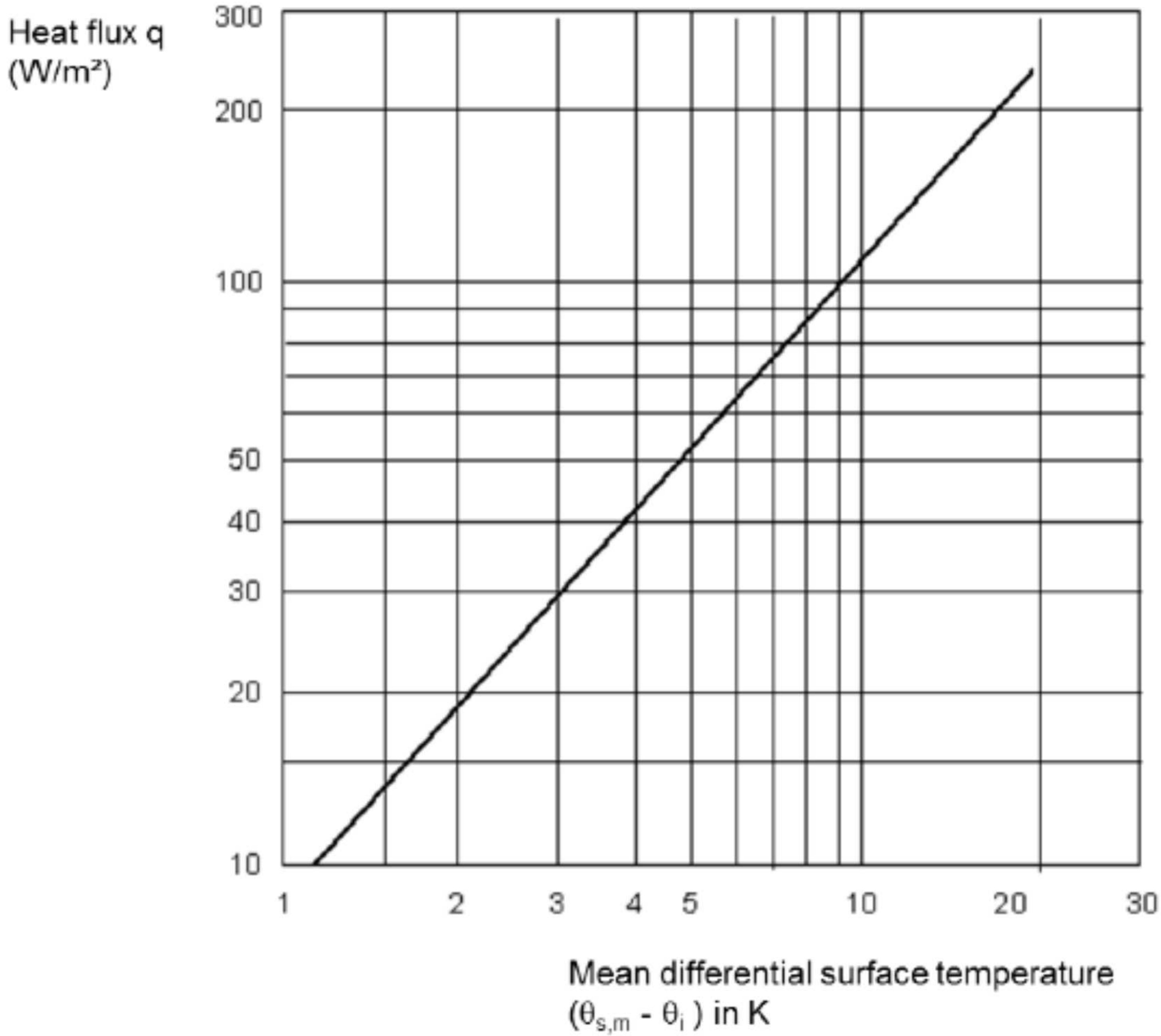
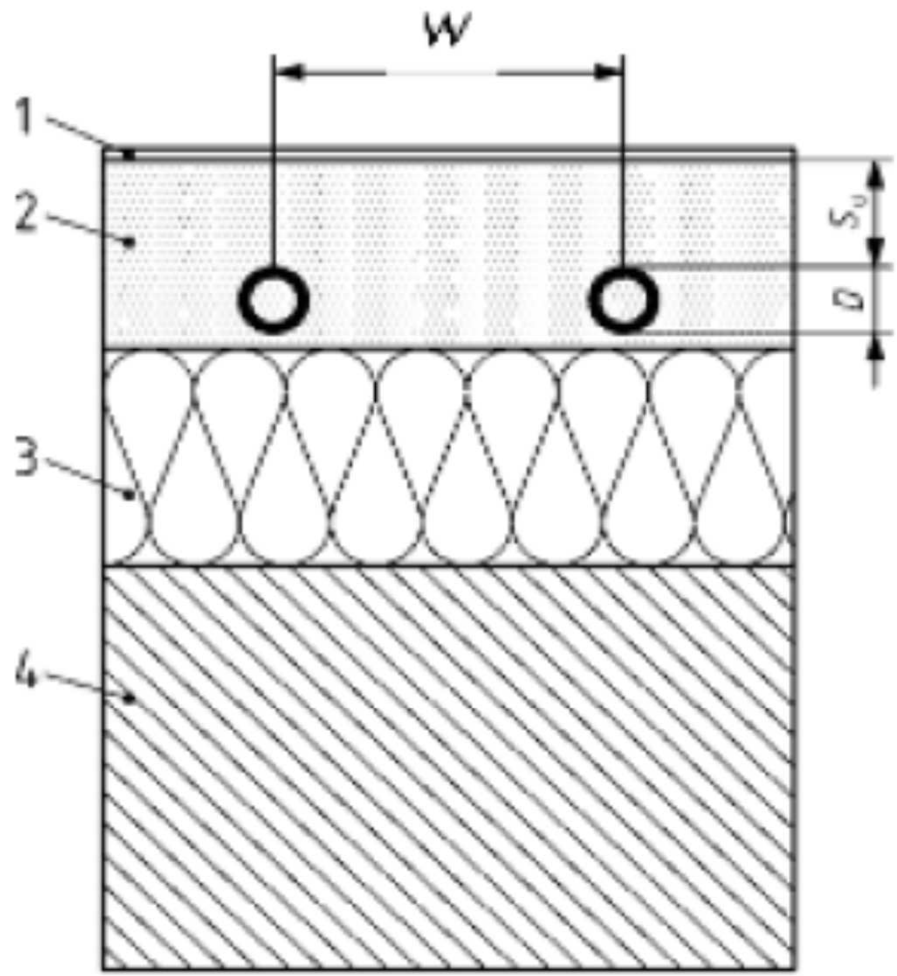


Figure 1 — Basic characteristic curve for floor heating and ceiling cooling



a) **Type A and C**

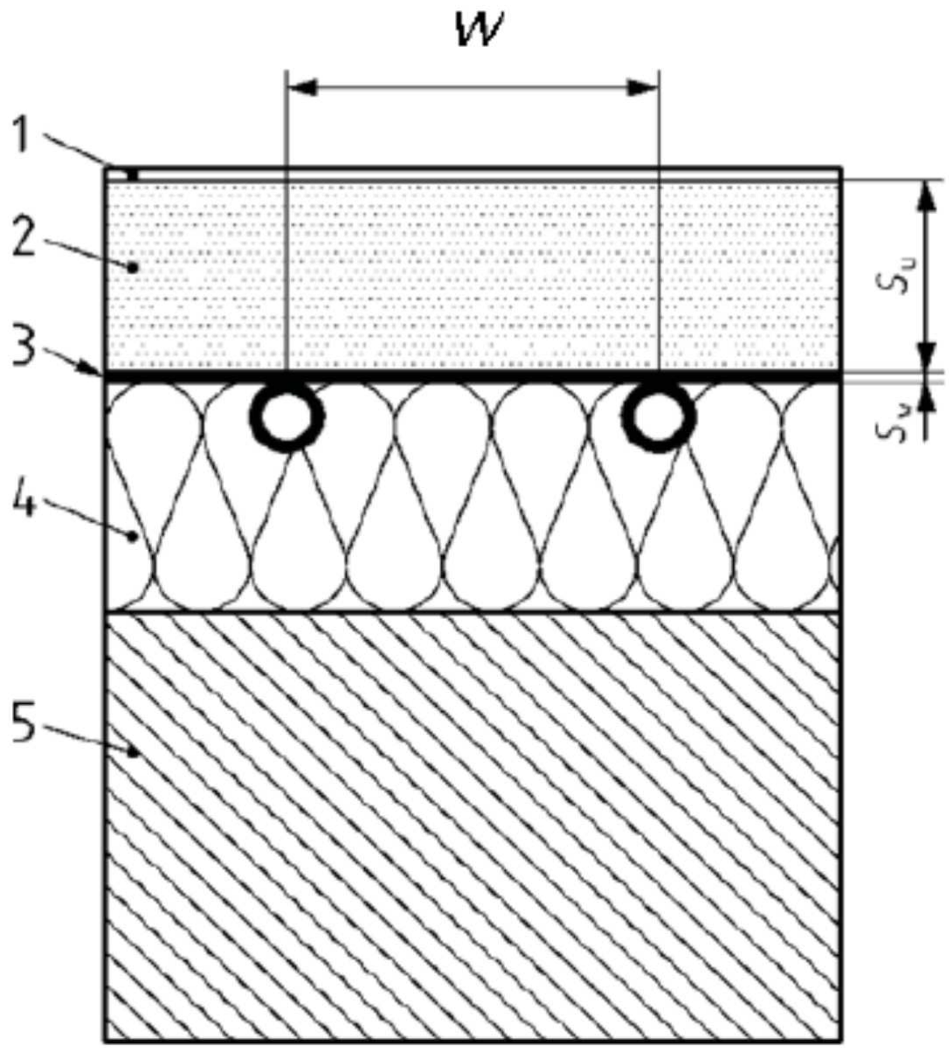
Key

1 floor covering

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

3 thermal insulation

4 structural bearing



b) Type B

Key

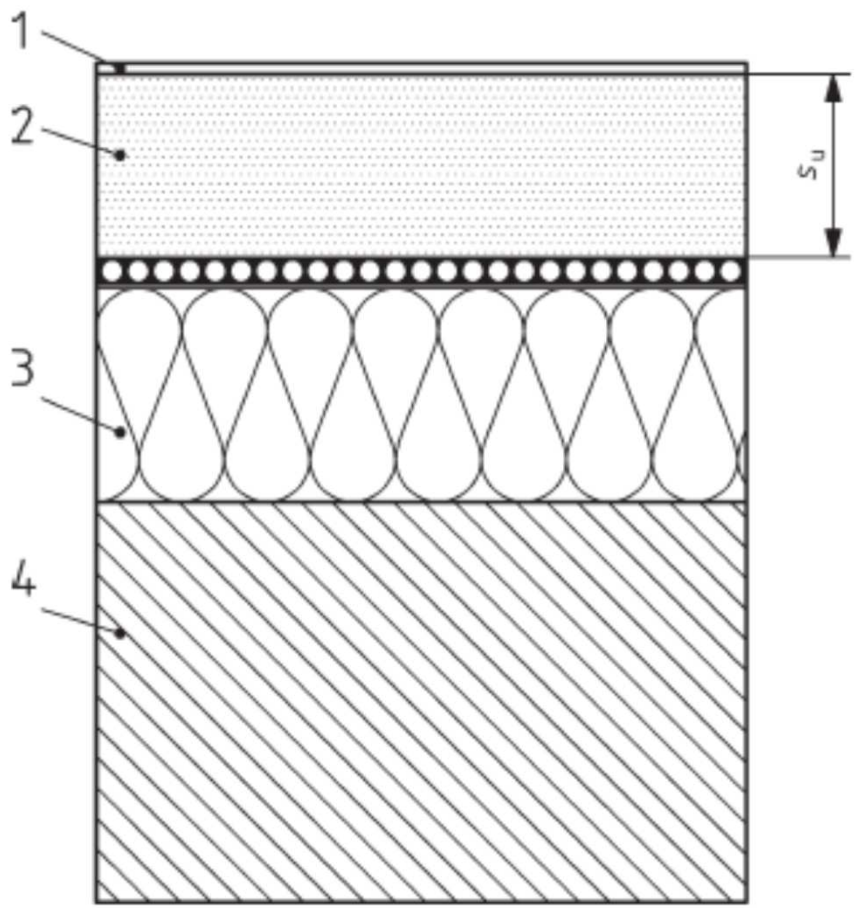
1 floor covering

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

3 heat diffusion devices

4 thermal insulation

5 structural bearing



c) Type D

Key

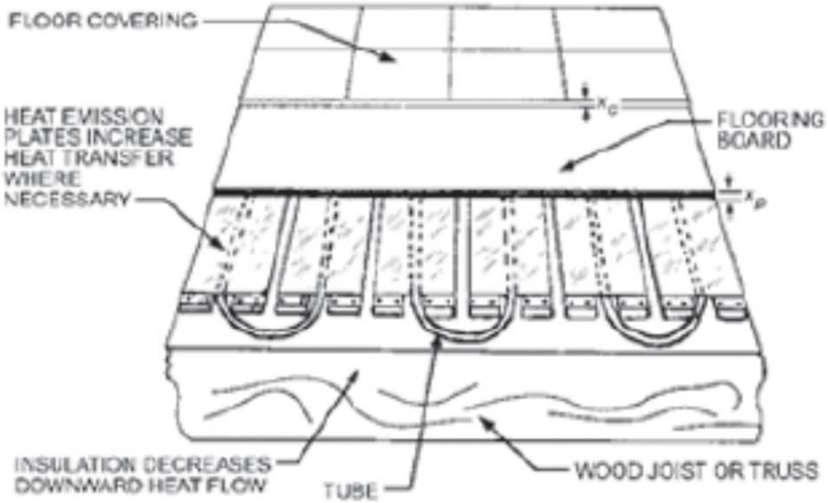
1 floor covering R_λ, B

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

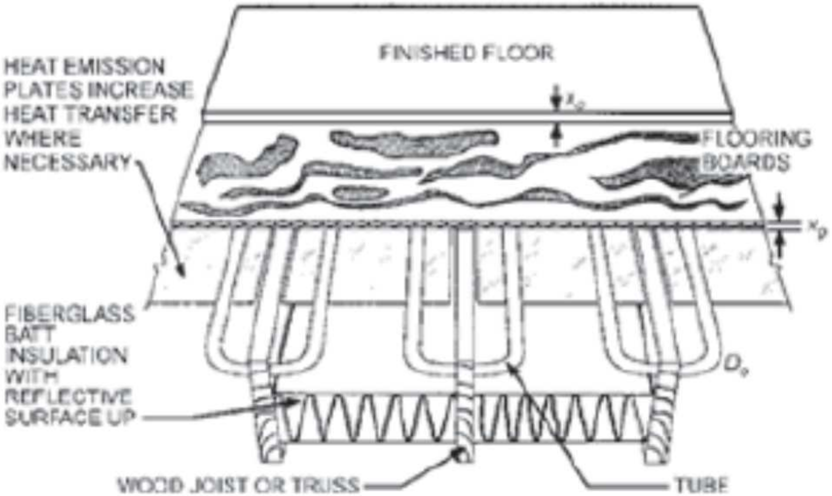
3 thermal insulation

4 structural bearing

Figure 2 — System types A, B and C covered by the method in Annex A



Tube in Subfloor



Tube under Subfloor

Figure 6 — Pipes in wooden constructions, TYPE G

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

- **Part 3:　Design and dimensioning**

Part 3 specifies design and dimensioning methods of radiant heating and cooling systems to ensure the heating and cooling capacity.

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

- **Part 3: Design and dimensioning**

5 Radiant panel

5.1 Floor heating systems

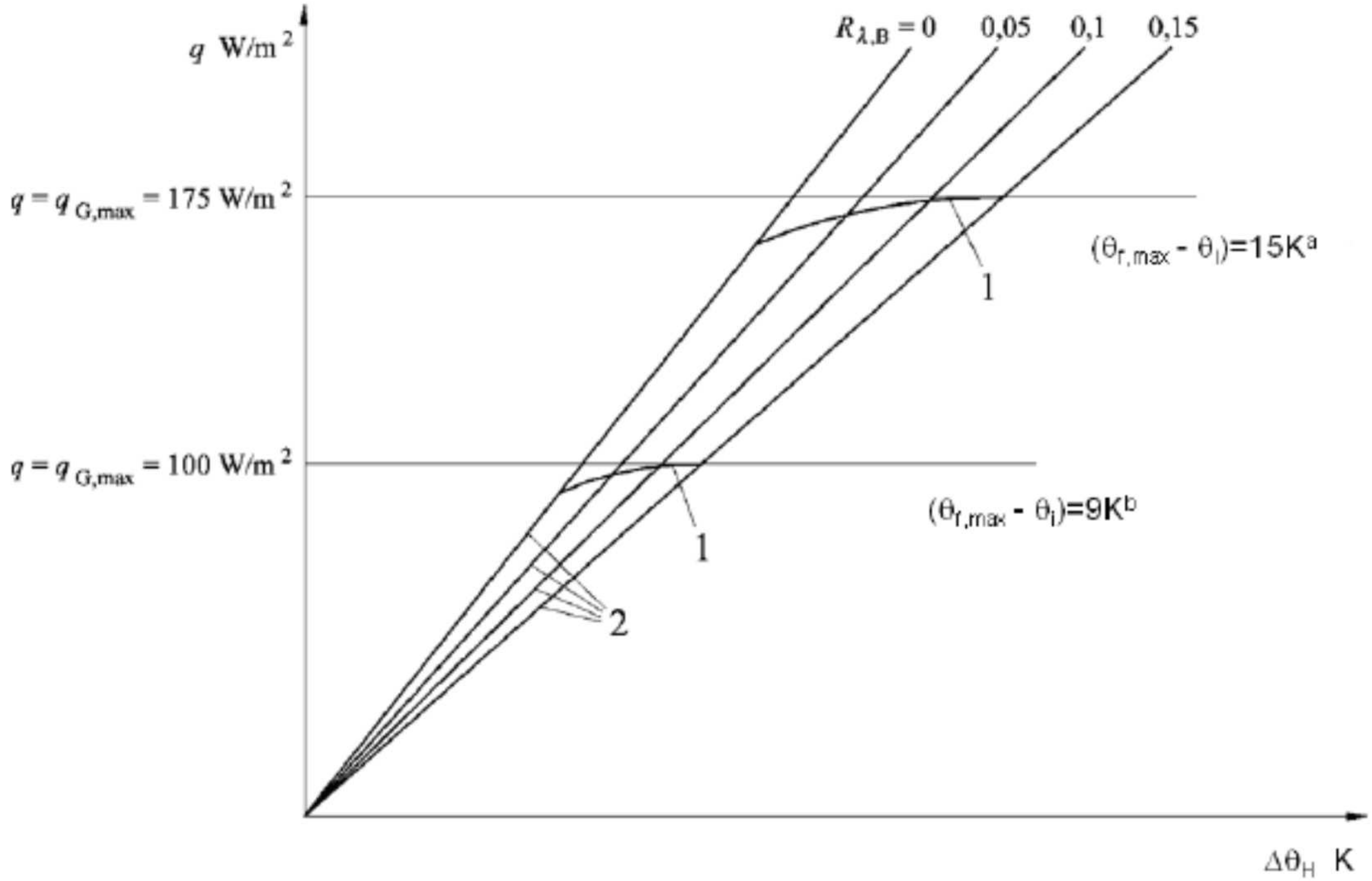
5.2 Ceiling heating systems

5.3 Wall heating systems

5.4 Floor cooling systems

5.5 Ceiling cooling systems

5.6 Wall cooling systems



Key

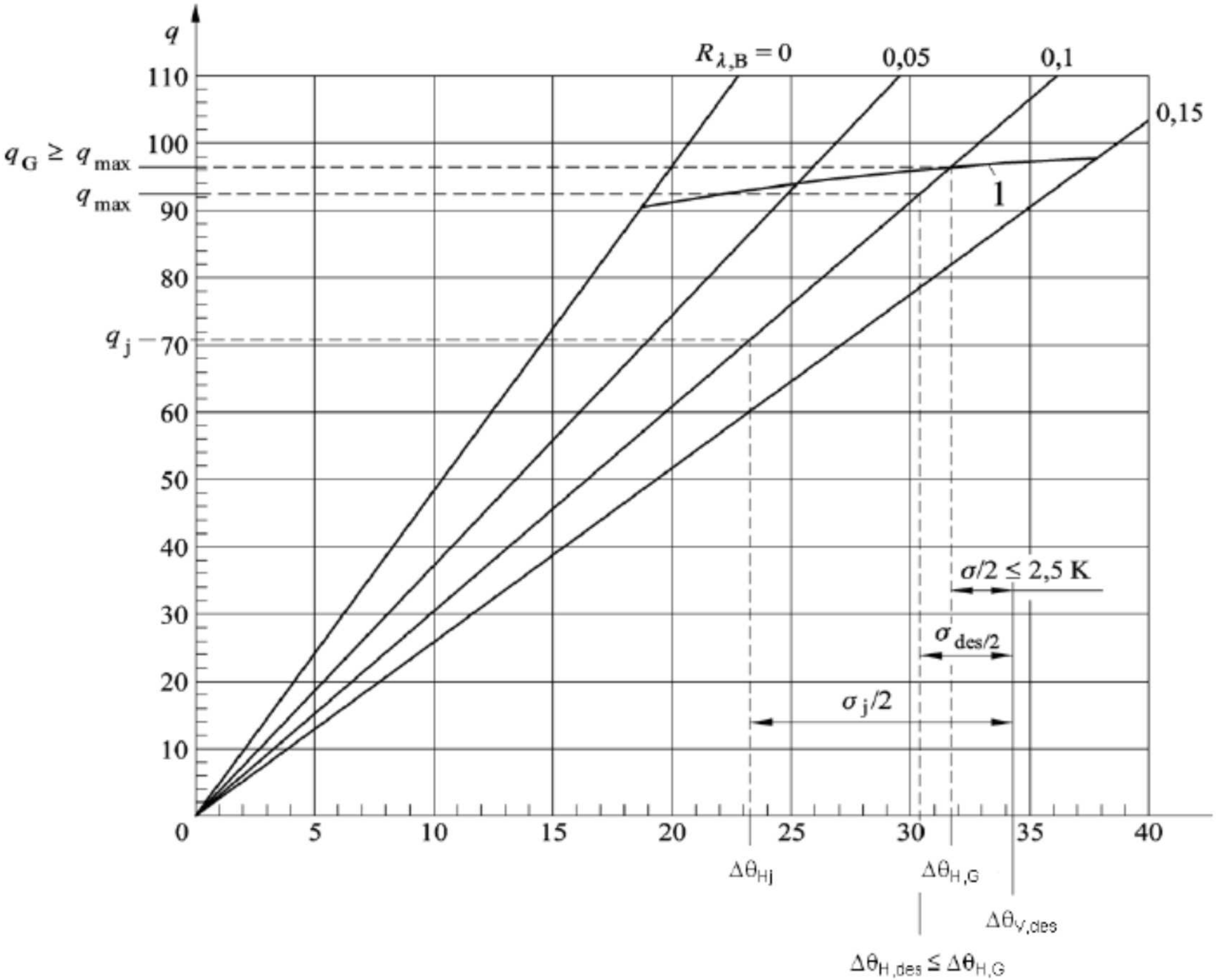
1 limit curves

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



Key

1 limit curve

Figure 6 — Determination of the design supply temperature difference and temperature drop σ_j for the other rooms

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

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

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.

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

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

5 The concept of Thermally Active Surfaces (TAS)

6 Calculation methods

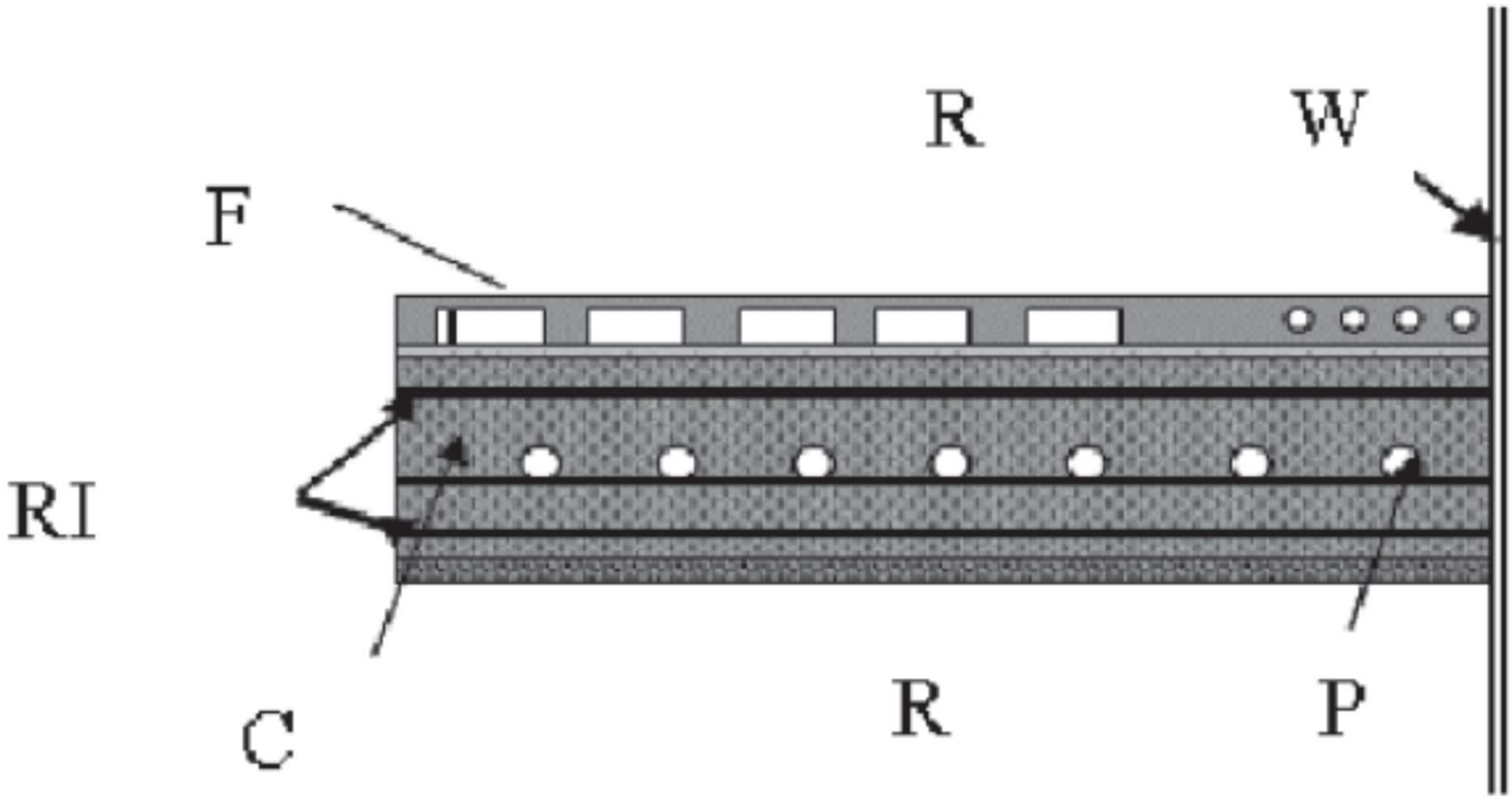
6.1 General

6.2 Rough sizing method

6.3 Simplified sizing by diagrams

6.4 Simplified model based on finite difference method (FDM)

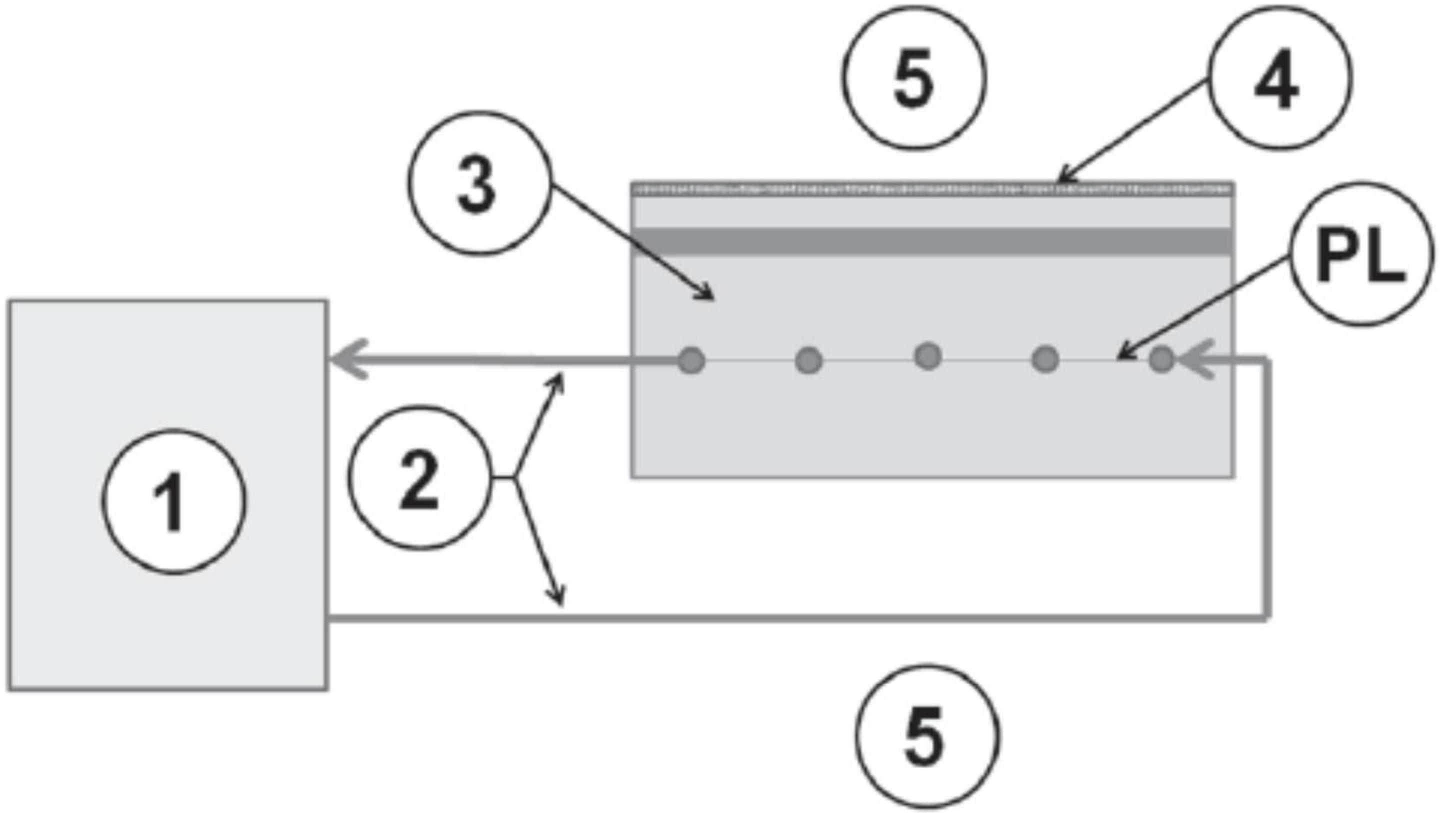
6.5 Dynamic building simulation programs



Key

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

Figure 1 — Example of position of pipes in TAS



Key

1 heating/cooling equipment

2 hydraulic circuit

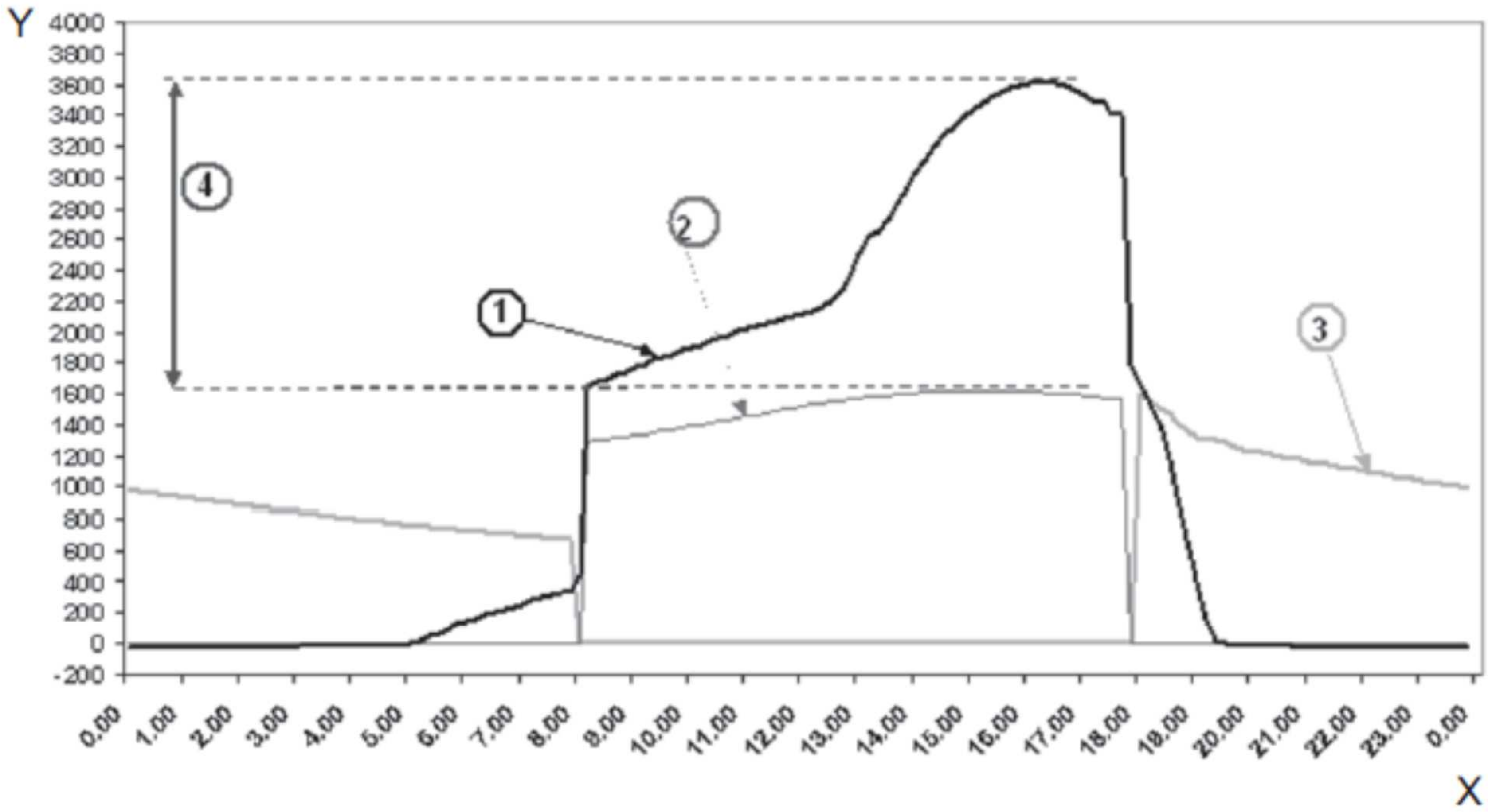
3 slab including core layer with pipes

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



Key

X time, h

Y cooling power, W

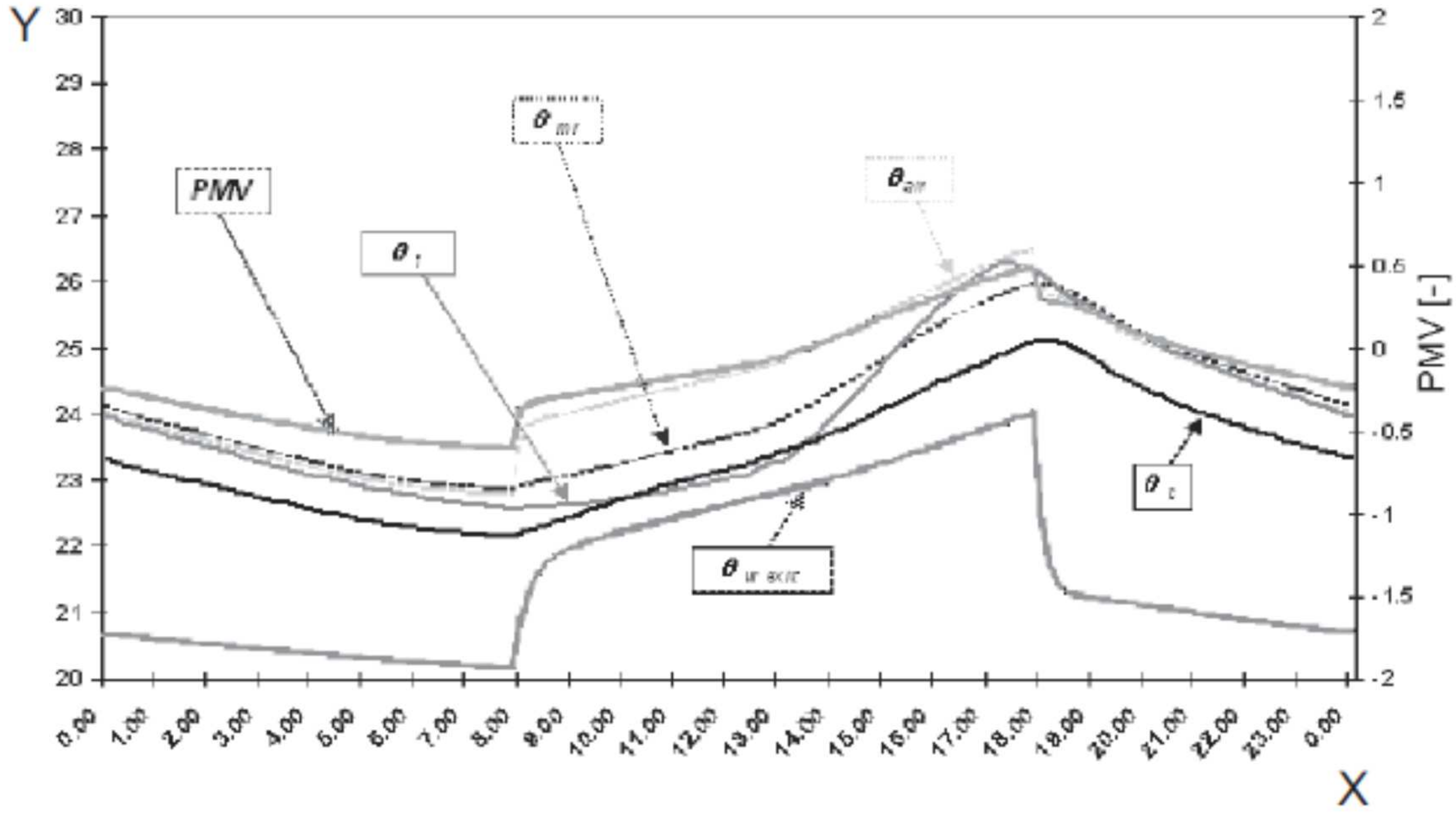
1 heat gain

2 cooling power needed for conditioning the ventilation air

3 cooling power needed on the water side

4 reduction of the required peak power

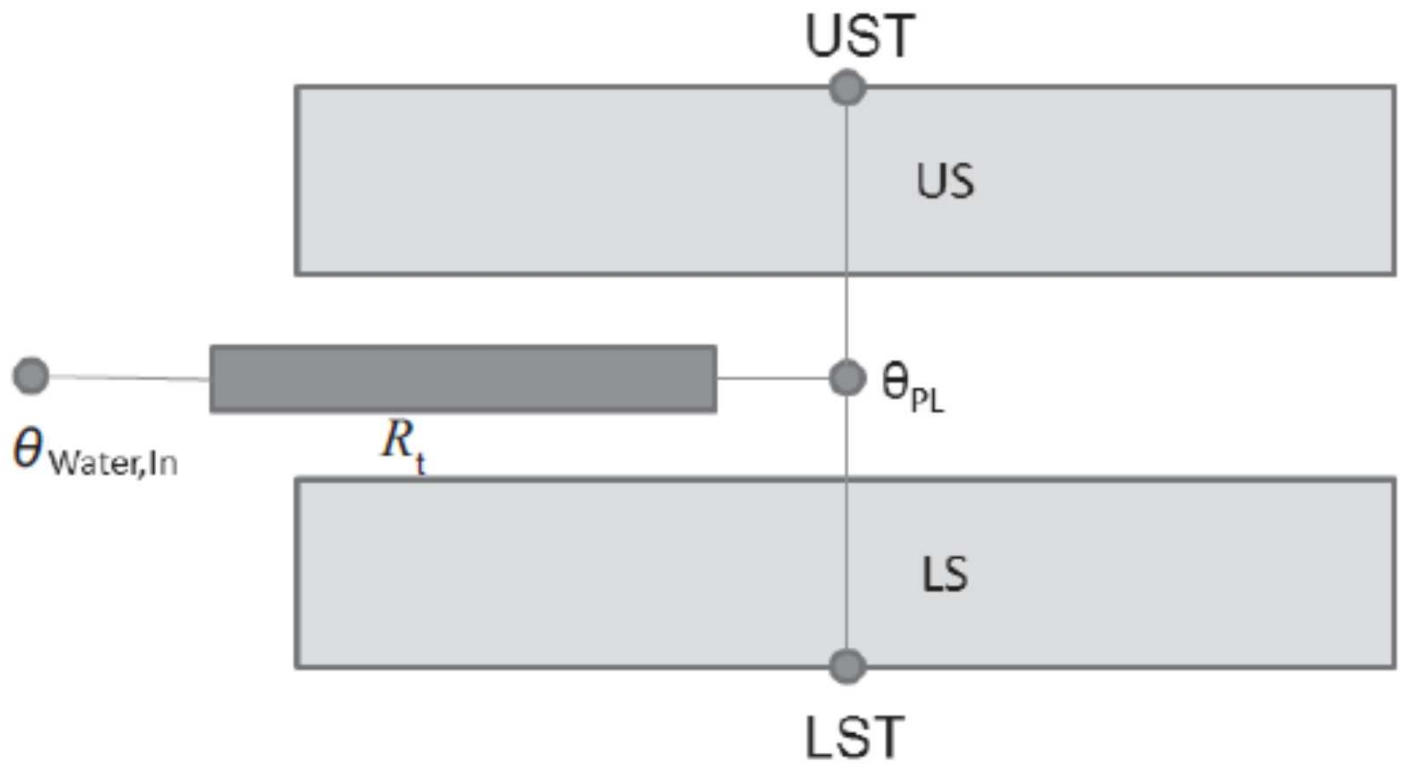
Figure 3 — Example of peak-shaving effect



Key

X	time, h
Y	temperature, °C
PMV	Predicted Mean Vote
θ_{air}	air temperature
θ_c	ceiling temperature
θ_{mr}	mean radiant temperature
θ_f	floor temperature
$\theta_{w\ exit}$	water return temperature

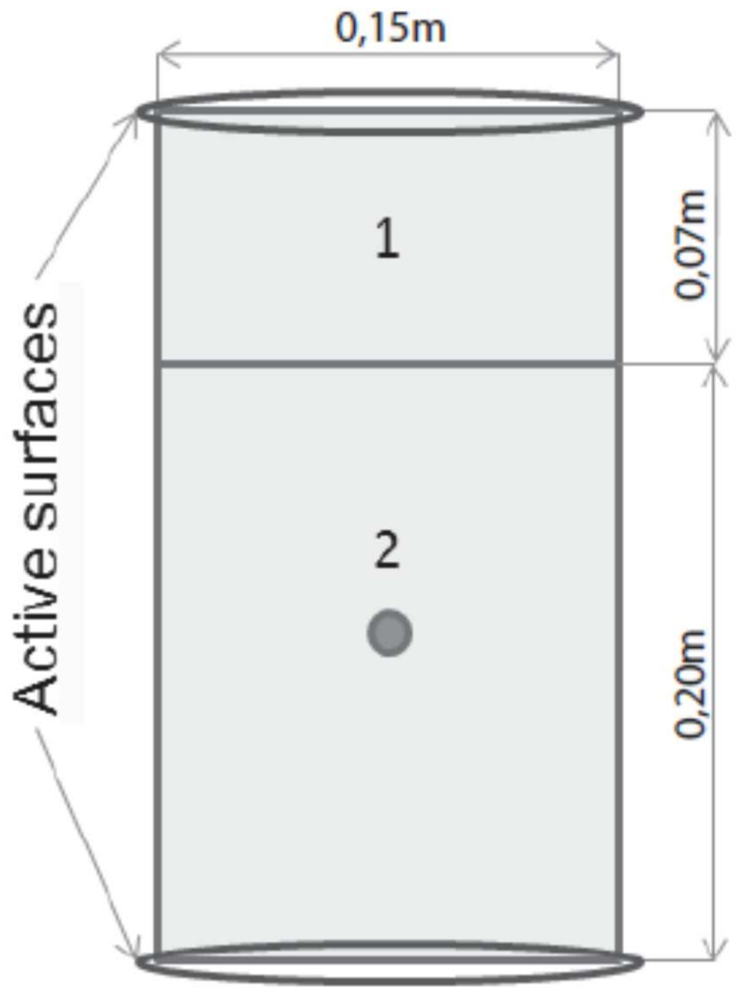
Figure 4 — Example of temperature profiles and PMV values vs. time



Key

LS	lower part of the slab
LST	lower surface temperature (ceiling)
R_t	circuit total thermal resistance
US	upper part of the slab
UST	upper surface temperature (floor)
θ_{PL}	mean temperature at the pipe level
$\theta_{Water,In}$	water supply temperature

Figure 8 — Simplified model for the conductive heat transfer in a structure containing pipes



Key

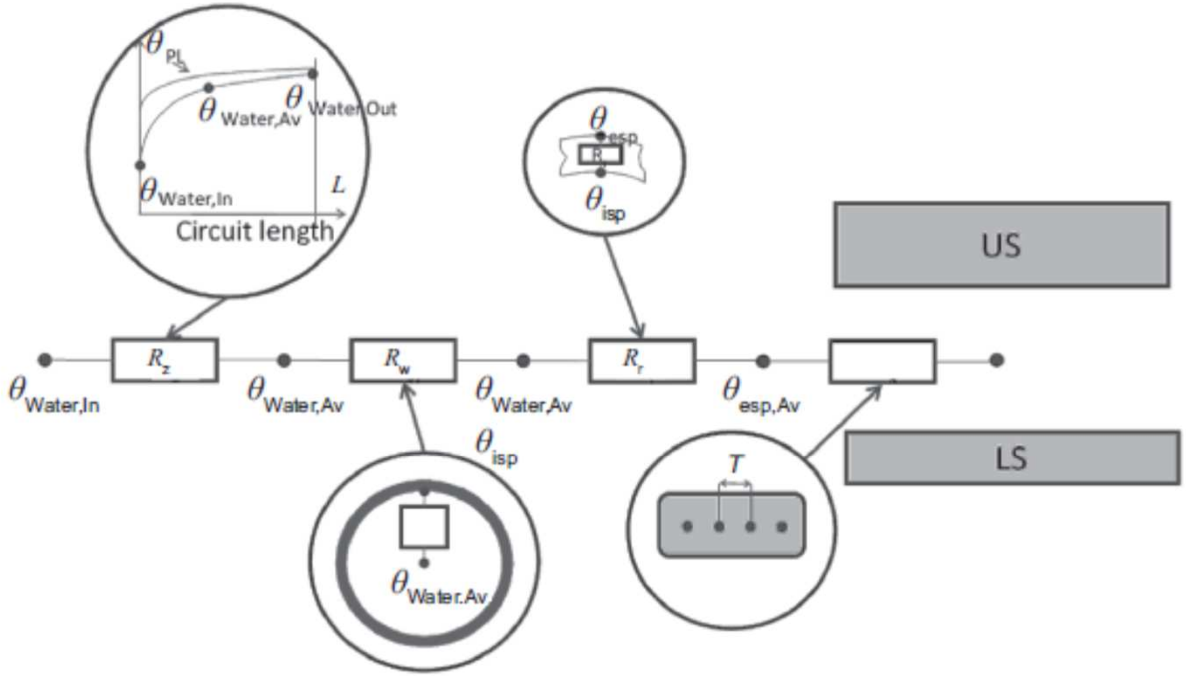
1 concrete

2 reinforced concrete

Conductive region: Material 1 and Material 2

Number of active surfaces: 2

Figure 9 — Example 1 — Conductive regions and numbers of active surfaces



Key

L	length of installed pipes
LS	lower part of the slab
R_r	pipe thickness thermal resistance
R_w	convection thermal resistance at the pipe inner side
R_x	pipe level thermal resistance
R_z	water flow thermal resistance
T	pipe spacing
US	upper part of the slab
$\theta_{esp,Av}$	average temperature at the outer side of the pipe
$\theta_{isp,Av}$	average temperature at the inner side of the pipe
θ_{PL}	average temperature at the pipe level
$\theta_{Water,Av}$	water average temperature
$\theta_{Water,In}$	water inlet temperature
$\theta_{Water,Out}$	water outlet temperature

Figure 15 — General scheme of the Resistance Method

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- **Part 5: Installation**

Part 5 addresses the installation process for the system to operate as intended.

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- **Part 5: Installation**

5 Installation

5.1 Floor heating and cooling systems

5.2 Heating and cooling systems embedded in ceilings and walls

Annex A (informative)

Corrosion prevention

Table 2 — Minimum thermal resistance of insulating layers below the pipes of heating/cooling systems $(m^2\ K)/W$

	Heated room below	Unheated or intermittent heated room below or directly on the ground [a]	External design temperature below		
			$\theta_d \geq 0$ °C	0 °C $> \theta_d \geq -5$ °C	-5 °C $> \theta_d \geq -15$ °C
thermal resistance $R_{\lambda,ins}$	0,75	1,25	1,25	1,50	2,00

[a] With ground water level ≤ 5m below the supporting base, the value should be increased.

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- **Part 6: Control**

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.

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- **Part 6: Control**

4 Controls

4.1 General

4.2 Central control

4.3 Zone control

4.4 Local (room) control

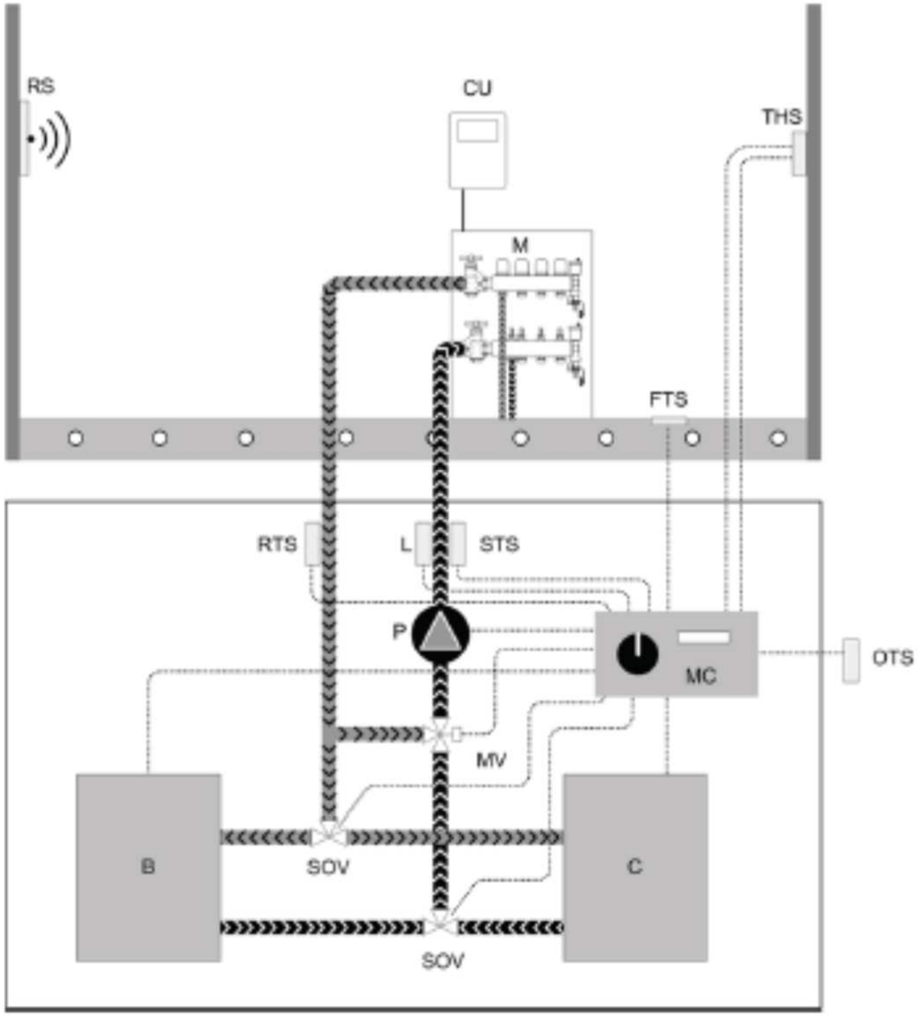
4.5 Influence of thermal mass of embedded systems

4.6 Self-regulating effect

4.7 Control of TABS

Annex A (informative)

Control of radiant floor heating-cooling systems



Key

B	boiler	OTS	outside temperature sensor
C	chiller	P	pump
CU	control unit	RS	room sensor
FTS	floor temperature sensor	RTS	return medium temperature sensor
L	limiter	SOV	shut off valve
M	manifold	STS	supply medium temperature sensor
MC	main controller	THS	temperature-humidity sensor
MV	mixing valve		

Figure 1 — Principal diagram of an embedded radiant heating and cooling system exemplified by a floor system

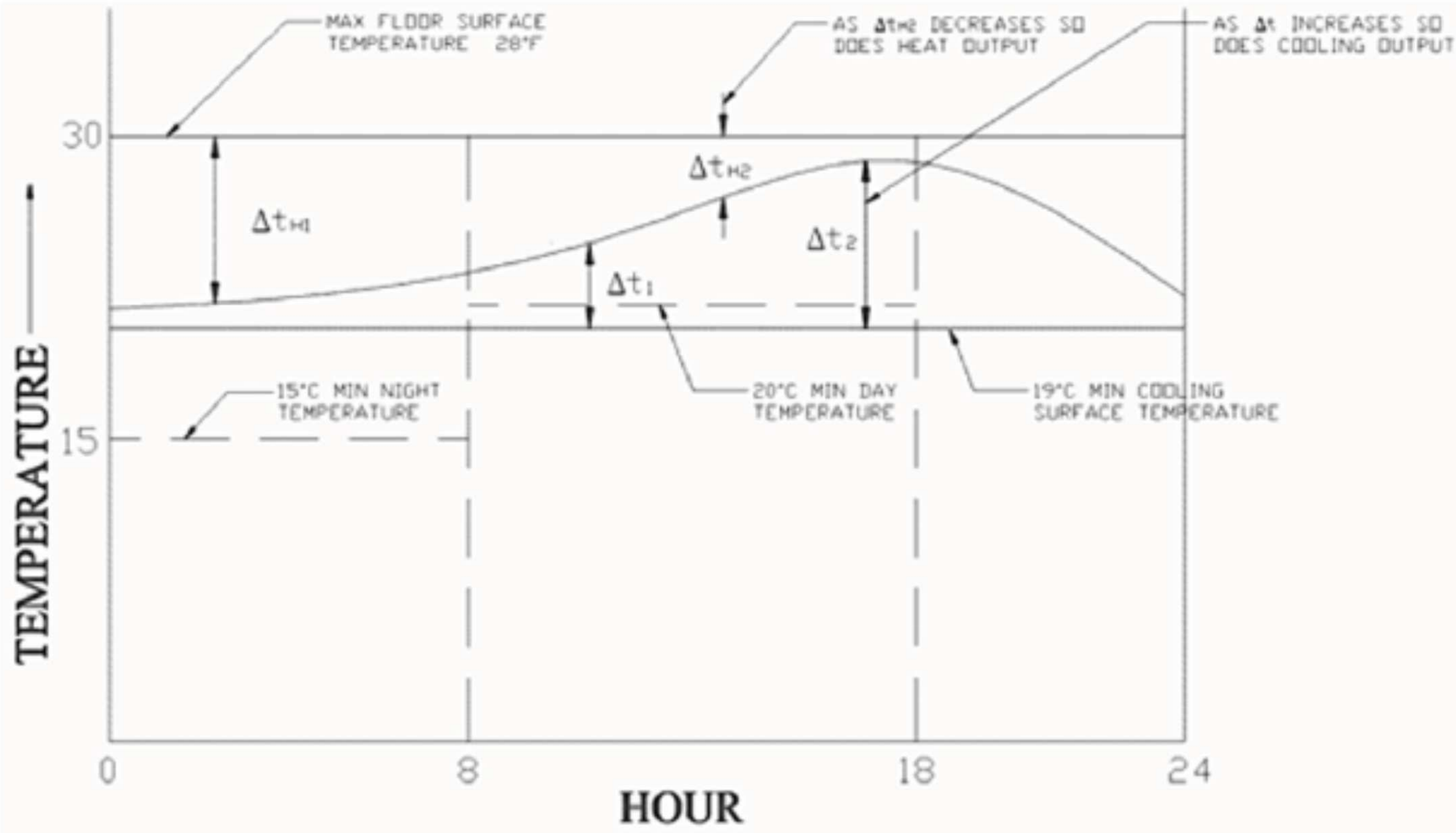


Figure 2 — Self-regulating effect of a radiant floor

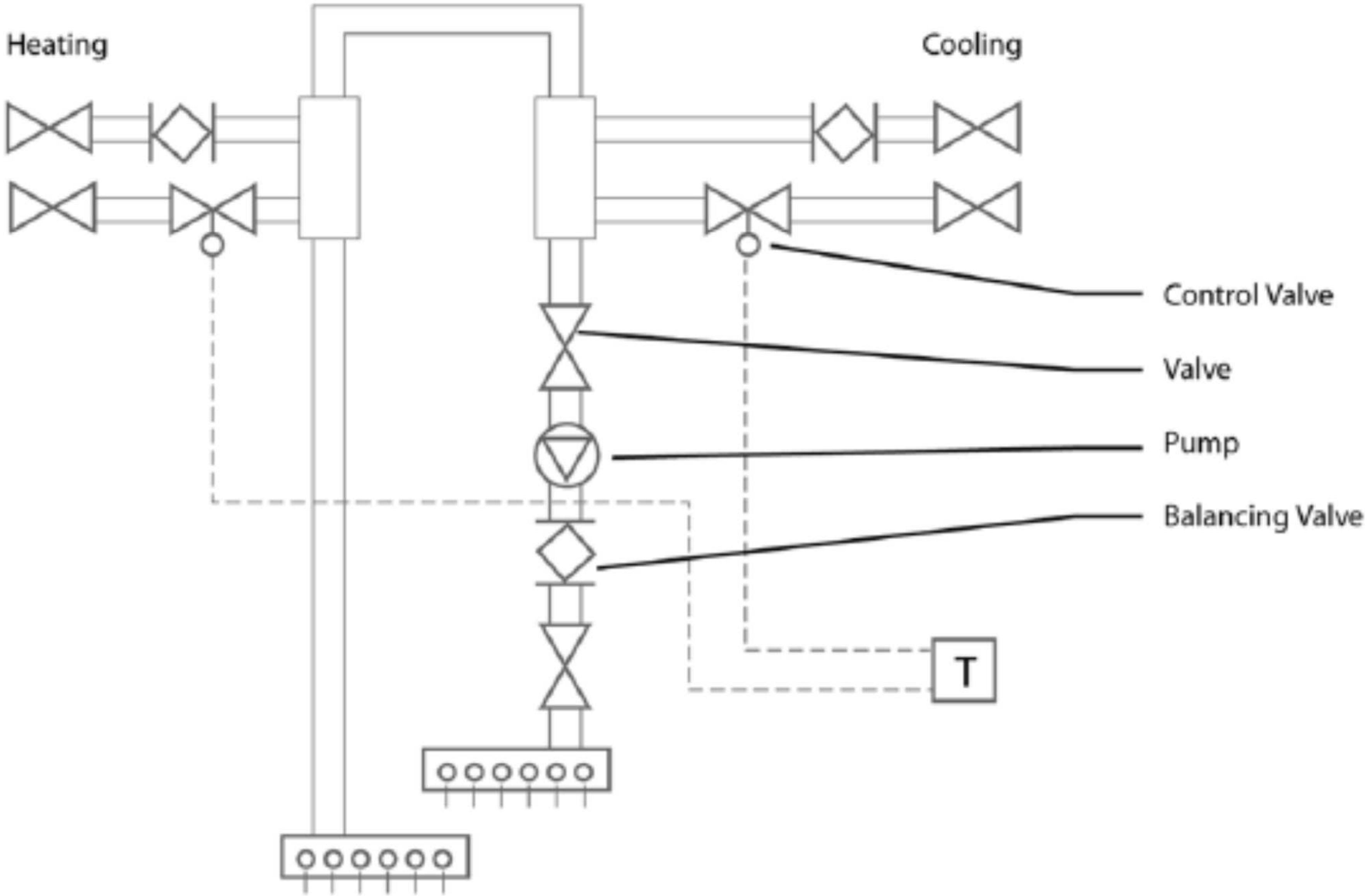


Figure A.1 — A typical radiant floor header connection