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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

Conception de l'environnement des bâtiments — Conception, construction et fonctionnement des systèmes de chauffage et de refroidissement par rayonnement —

Partie 1: Définition, symboles et critères de confort

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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 11855-1 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 1: Definition, symbols, and comfort criteria

1 Scope

This part of ISO 11855 specifies the basic definitions, symbols, and a comfort criteria for 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 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

ISO 7726:1998, *Ergonomics of the thermal environment — Instruments for measuring physical quantities*

ISO 7730:2005, *Ergonomics of the thermal environment — Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria*

ISO 13731:2003, *Ergonomics of the thermal environment — Vocabulary and symbols*

3 Terms and definitions

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

2.1
additional thermal resistance
thermal resistance representing layers added to the building structure and acting mostly as thermal resistances because of their own low thermal inertia

EXAMPLE Carpets, moquette, and suspended ceilings.

2.2
average specific thermal capacity of the internal walls
thermal capacity related to one square metre of the internal walls

NOTE Since internal walls are shared with other rooms, then just half of the total specific thermal capacity of the wall must be taken into account, since the second half is influenced by the opposite rooms that are considered to be at the same thermal conditions as the one under consideration.

2.3
average surface temperature
$\theta_{s,m}$
average value of all surface temperatures in the occupied or peripheral area

2.4
basic characteristic curve
curve or formula reflecting the relationship between the heat flux and the mean surface temperature difference

NOTE This depends on heating/cooling and surface (floor/wall/ceiling) but not on the type of embedded system.

2.5
calculation time step
length of time considered for the calculation of the temperatures and heat flows in the room and slab

NOTE This is typically assumed to equal 3 600 s.

2.6
circuit
section of system connected to a distributor which can be independently switched and controlled

2.7
circuit total thermal resistance
thermal resistance representing the circuit as a whole, determining a straight connection between the water inlet temperature and the mean temperature at the pipe level

NOTE It includes the water flow thermal resistance, the convection thermal resistance at the pipe inner side, the pipe thickness thermal resistance, and the pipe level thermal resistance.

2.8
clothing insulation
basic clothing insulation that is the resistance of a uniform layer of insulation covering the entire body that has the same effect on sensible heat flow as the actual clothing under standardized (static, wind-still) conditions

NOTE The definition of clothing insulation also includes the uncovered parts of the body, e.g. the head. It is described as the intrinsic insulation from the skin to the clothing surface, not including the resistance provided by the air layer around the clothed body, and is expressed in the clo unit or in m^2K/W; 1 clo = 0,155 m^2K/W.

2.9
conductive region of the slab
region of the slab that includes the pipes with thermal conductivities of the layers higher than 0,8 W/(m·K)

NOTE Due to the subdivision of the slab into an upper slab and a lower slab, the conductive region is also subdivided into an upper conductive region and a lower conductive region.

2.10
convection thermal resistance at the pipe inner side
thermal resistance associated to the convection heat transfer taking place between the water flowing in the pipe and the pipe inner side, thus connecting the mean water temperature along the circuit with the mean temperature of the pipe inner side

2.11
convective heating and cooling system
system that directly conditions the air in the room for the purpose of heating and cooling

2.12
convective peak load
maximum cooling load to be extracted by a virtual convective system used to keep comfort conditions in the room

2.13
daily average temperature of the conductive region of the slab
average temperature of the conductive region of the slab during the day

2.14
design cooling capacity
$Q_{H,c}$
thermal output by a cooling surface at design conditions

2.15
design cooling load
$Q_{N,c}$
required thermal output necessary to achieve the specified design conditions in outside summer design conditions

2.16
design sensible cooling load
required sensible thermal output necessary to achieve the specified design conditions in outside summer design conditions

2.17
design dew point
$\theta_{Dp,des}$
dew point determined for the design

2.18
design supply temperature of heating/cooling medium
$\theta_{V,des}$
value of flow water temperature with the thermal resistance of the chosen floor covering, at maximum value of heat flux q_{max}

NOTE The flow and the supply temperature are the same throughout the EN 1264 series.

2.19
design heat flux
q_{des}
heat flow divided by the heating or cooling surface, taking into account the surface temperature required to reach the design thermal capacity of a surface heated or cooled space, Q_H, reduced by the thermal capacity of any supplementary heating or cooling equipment, if applicable

2.20
design heating capacity
$Q_{H,h}$
thermal output from a heating surface at design conditions

2.21
design heating load
$Q_{N,h}$
required thermal output necessary to achieve the specified design conditions in outside winter design conditions

NOTE When calculating the value of the design heat load, the heat flow from embedded heating systems into neighbouring rooms is not taken into account.

2.22
design heating/cooling medium differential temperature
$\Delta\theta_{H,des}$
temperature difference at design heat flux

2.23
design heating medium differential supply temperature
$\Delta\theta_{V,des}$
temperature difference between the design supply medium temperature and indoor temperature at design heat flux

2.24
design heating/cooling medium flow rate
m_H
mass flow rate in a circuit which is needed to achieve the design heat flux

2.25
design indoor temperature
θ_i
operative temperature at the centre of the conditioned space used for calculation of the design load and capacity

NOTE The operative temperature is considered relevant for thermal comfort assessment and heat loss calculations. This value of internal temperature is used for the calculation method.

2.26
distributor
common connection point for several circuits

2.27
draught
unwanted local cooling of a body caused by movement of air and related to temperature

2.28
electric floor (wall, ceiling) heating system
several panel systems that convert electrical energy to heat, raising the temperature of conditioned indoor surfaces and the indoor air

2.29
embedded surface heating and cooling system
system consisting of circuits of pipes embedded in floor, wall or ceiling construction, distributors and control equipments

2.30
equivalent heat transmission coefficient
K_H
coefficient describing the relationship between the heat flux from the surface and the heating/cooling medium differential temperature

2.31
family of characteristic curves
curves denoting the system-specific relationship between the heat flux, q, and the required heating medium differential temperature $\Delta\theta_H$ for conduction resistance of various floor coverings

2.32
heat flux
q
heat flow between the space and surface divided by the heated/cooled surface

NOTE For heating it is a positive value and for cooling it is a negative value.

2.33
heat transfer coefficient
h_t
combined convective and radiative heat transfer coefficient between the heated or cooled surface and the space operative temperature (design indoor temperature)

2.34
heating or cooling surface
surface (floor, wall, ceiling) covered by the embedded surface heating/cooling system between the pipes at the outer edges of the system with the addition of a strip at each edge of width equal to half the pipe spacing, but not exceeding 0,15 m

2.35
heating or cooling surface area
A_F
area of surface (floor, wall, ceiling) covered by the embedded surface heating/cooling system between the pipes at the outer edges of the system with the addition of a strip at each edge of width equal to half the pipe spacing, but not exceeding 0,15 m

2.36
heating/cooling capacity for circuit
Q_{HC}
heat exchange between a pipe circuit and the conditioned room

2.37
heating/cooling medium differential temperature
$\Delta\theta_H$
logarithmically determined average difference between the temperature of the heating/cooling medium and the design indoor temperature

2.38
internal convective heat gains
convective contributions by internal heat gains acting in the room

NOTE Mainly due to people or electrical equipment.

2.39
internal radiant heat gains
radiant contributions by internal heat gains acting in the room

NOTE Mainly due to people or electrical equipment.

2.40
internal thermal resistance of the slab conductive region
total thermal resistance connecting the pipe level with the middle points of the upper conductive region and lower conductive region of the slab

2.41
limit curves
curves in the field of characteristic curves showing the pattern of the limit heat flux depending on the heating medium differential temperature and the floor covering

2.42
limit heat flux
q_G
heat flux at which the maximum or minimum permissible surface temperature is achieved

2.43
limit heating medium temperature difference
$\Delta\theta_{H,G}$
intersection of the system characteristic curve with the limit curve

2.44
maximum cooling power
maximum thermal power of the cooling equipment, referring only to the room under consideration

2.45
maximum permissible surface temperature
q_{max}
required design heat flux in the room in order to design supply medium temperature

2.46
maximum operative temperature allowed for comfort conditions
maximum operative temperature allowed in the room according to comfort requirements in cooling conditions

2.47
maximum operative temperature drift allowed for comfort conditions
maximum drift in operative temperature allowed in the room according to comfort requirements

2.48
maximum permissible surface temperature
$\theta_{S,max}$
maximum temperature permissible for physiological reasons or for the physical building, for calculation of the limit curves, which may occur at a point on the surface (floor, wall, ceiling) in the occupied or peripheral area depending on the particular usage at a temperature drop σ of the heating medium equal to 0

2.49
mean radiant temperature
uniform surface temperature of an imaginary black enclosure in which an occupant would exchange the same amount of radiant heat as in the actual non-uniform enclosure

2.50
mean surface temperature difference
difference between the average surface temperature $\theta_{S,m}$ and the design indoor temperature θ_i

NOTE It determines the heat flux.

2.51
metabolic rate
rate of transformation of chemical energy into heat and mechanical work by aerobic and anaerobic metabolic activities within an organism, usually expressed in terms of unir area of the total body surfaces

NOTE The metabolic rate varies with each activity. It is expressed in the met unit or in W/m^2; 1 met = 58,2 W/m^2. 1 met is the energy produced per unit surface area of a sedentary person at rest. The surface area of an average person can be determined by Dubois Equation, Body Surface Area (m^2) = 0,20 247 × Height (m)^{0,725} × Weight (kg)^{0,425}.

2.52
minimum permissible surface temperature
$\theta_{S,min}$
minimum temperature permissible for physiological reasons or for the physical building, for calculation of the limit curves, which may occur at a point on the surface (floor, wall, ceiling) in the occupied or peripheral area depending on the particular usage at a temperature drop σ of the heating medium equal to 0

2.53
nominal heat flux
q_N
limit heat flux achieved without surface covering

2.54
nominal heating/cooling medium differential temperature
$\Delta\theta_N$
absolute temperature difference at nominal heat flux q_N

2.55
non-active area
area of the surface not covered by a heating/cooling system

2.56
number of active surfaces
number of surfaces in straight thermal connection with the pipe level, so that it distinguishes whether the slab transfers heat both through the floor side and through the ceiling side or whether the ceiling side is much more active than the floor side

NOTE Two active surfaces when the conductive region extends from the floor to the ceiling, one active surface otherwise.

2.57
number of operation hours of the circuit
length of time during which the system runs in the day

