RADIANT SYSTEMS

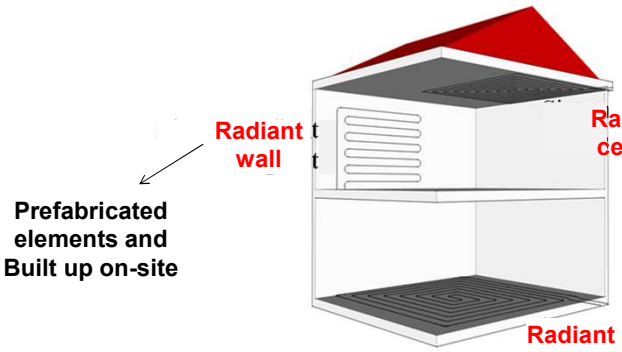
Radiant systems

1. Type of radiant systems
2. Heat transfer phenomena
3. Sizing radiant systems

1. Types of radiant systems

Types of radiant systems

Screed: massetto
Gypsum board: cartongesso



Radiant wall

Prefabricated elements and Built up on-site

Radiant ceiling → Metal panels, Gypsum board, TABS

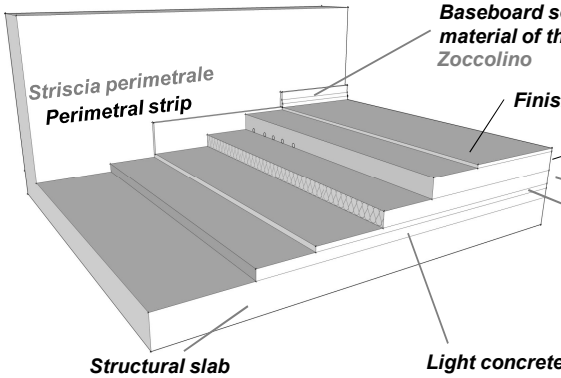
Radiant floor

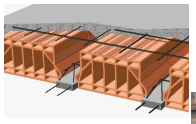
Traditional (high inertia) and Low thickness (low inertia)

Dry

With traditional and fluid screed

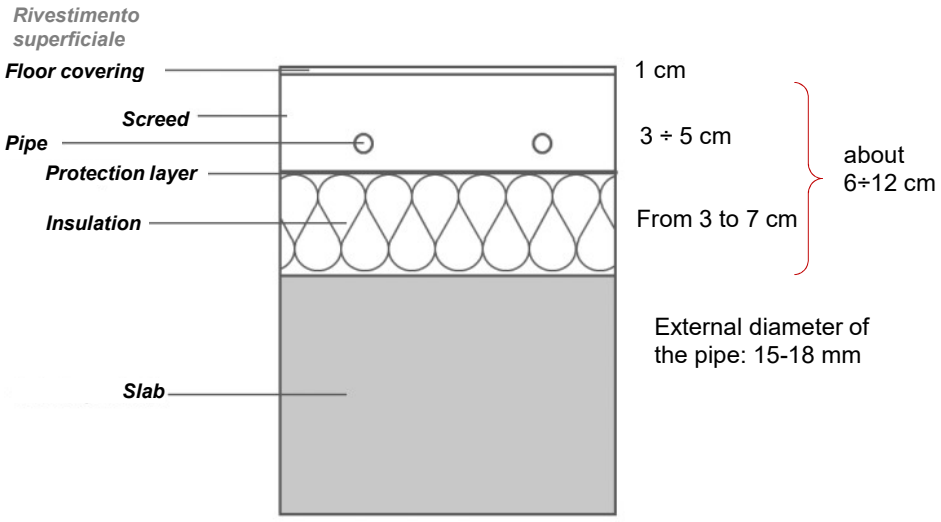
Components of a radiant floor





Solaio strutturale portante

Classic radiant floor (high inertia)

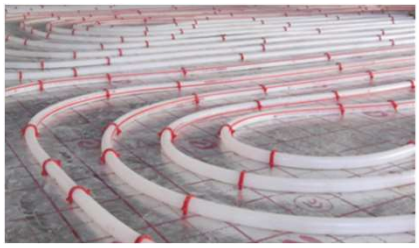


Standard EN 1264: Type A

Classic radiant systems

Use: residential buildings and offices

Fixing systems for the pipes with clips



Velcro tape

Wire mesh & clips

Clip su rete metallica

Rusticated insulating panel

Isolamento con lastra bugnata

Industrial floor radiant system

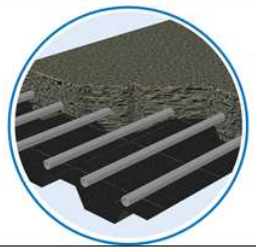
Pipes fixed on welded mesh

External diameter of the pipe: 25 mm

Pipes fixed on welded mesh and pylons armature

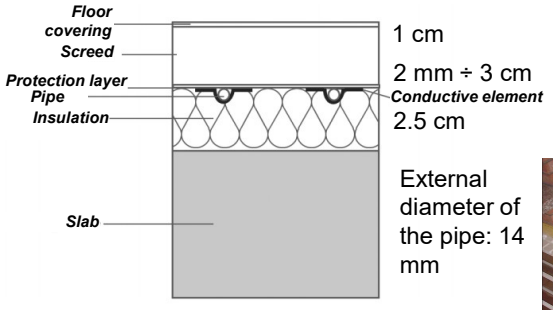
rete elettrosaldata e traliccio di armatura

TABS: Thermo-Active Building systems

TABS	Application	
System with prefabricated welded mesh	Office buildings and industrial buildings	
Light filling materials in structural slabs	Office Buildings	
Corrugated sheet	Office Buildings	

Low thinckess radiant floor

Use: residential buildings and tertiary buildings



External diameter of the pipe: 14 mm

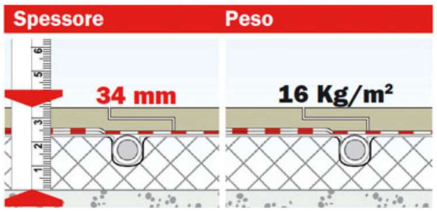
Pipes embedded in the insulation

Dry systems – Thickness: circa 25 mm

Steel sheet – Thickness: 1 mm

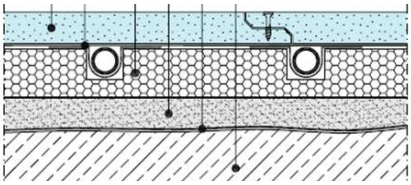
Self-levelling screed (with addivites - 30 mm)

Low thickness Radiant systems 1/3



Calciosilicato

Calciumsilicate sheet
thickness: 9 mm
Therma conductivity: 0.35 W/(m K)
Usual size of the boards: 1.2 m x 1.2 m



Fibrogesso

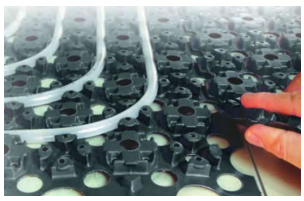
Plaster fibre sheet
thickness: da 18 a 25 mm
Thermal conductivity : 0.28–0.32 W/(m K)
Limit temperature: 45°C

Lastra in acciaio

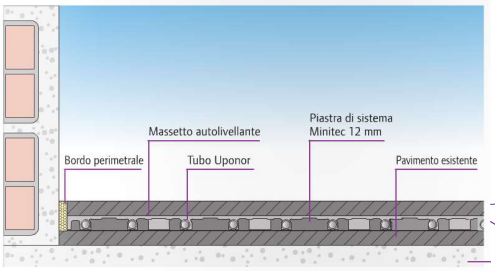
Steel sheet
Limited thickness (2 mm)
High conductivity
Quick installation
Relevant costs

Low thickness Radiant systems 2/3

Pipes inserted in prefabricated panels



Pipes diameter:
9.9 x 1 mm

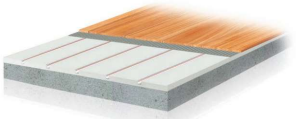


Pipes inserted in prefabricated metal structures

Low thickness Radiant systems 3/3

Tubazioni inserite in un supporto fresato

Pipes inserted in milled in support layer

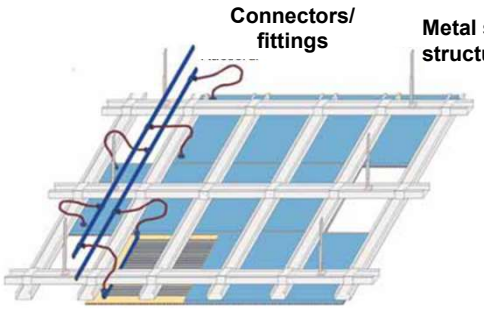


s = 0 mm

Modular systems for raised floors

Sistemi radianti modulari per pavimenti flottanti

Ceiling radiant systems 1/2



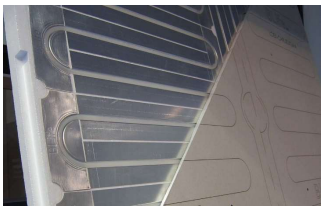
Ceiling radiant systems 2/2

Gipsum board, insulation and pipes. Prefabricated solution

Pipes embedded in the milled gipsum board

Residential and office buildings

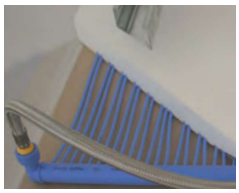
Pipes embedded in the insulation with conductive metal sheets and planar gypsum boards



Metal elements (usually hollowed metal sheets) with plastic and metal pipes

Office buildings

Capillary pipes in radiant ceiling systems



Radiant ceiling Vs. floor

Smaller pipe diameters in the ceiling than in radiant floors (6 ÷ 10 mm external diameter).

In ceiling shorter water circuits than floor radiant systems.

Lower water velocity in ceiling radiant systems than in floor radiant systems.

Temperature difference:

	Heating	Cooling
Floor	3÷7	2÷3
Ceiling	2÷3	3÷4

In both systems the perimetral strip has to be installed.

As an alternative the radiant ceiling has to be finished above the wall.

The ceiling can have sound-absorbing characteristics: acoustic comfort possibility combined with the hollow structure.

With radiant floor the screed has to be decoupled acoustically for tapping noise.

Perimetral strip

The perimetral strip allows the expansion of the support layer embedding the pipes

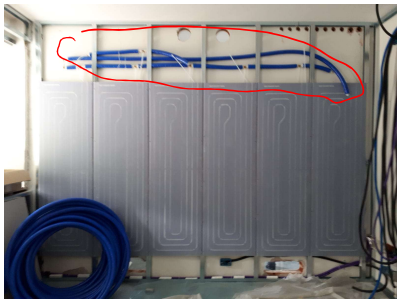



The standard EN 1264 declares that the minmum thickness of the perimetral strip has to allow at least 5 mm expansion.
Usually the thicnkess varies from 5 to 8 mm.


Important: surround pillars and stairs, if any

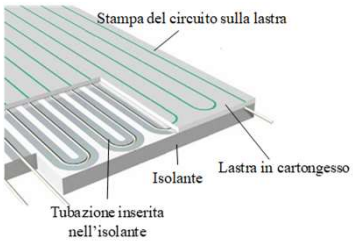
Walls radiant systems 1/2

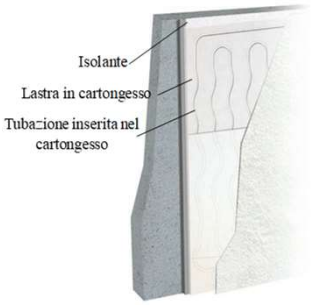


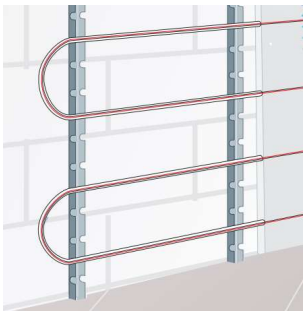


Walls radiant systems 2/2

Pipes embedded in prefabricated panels (similar to radiant floors)



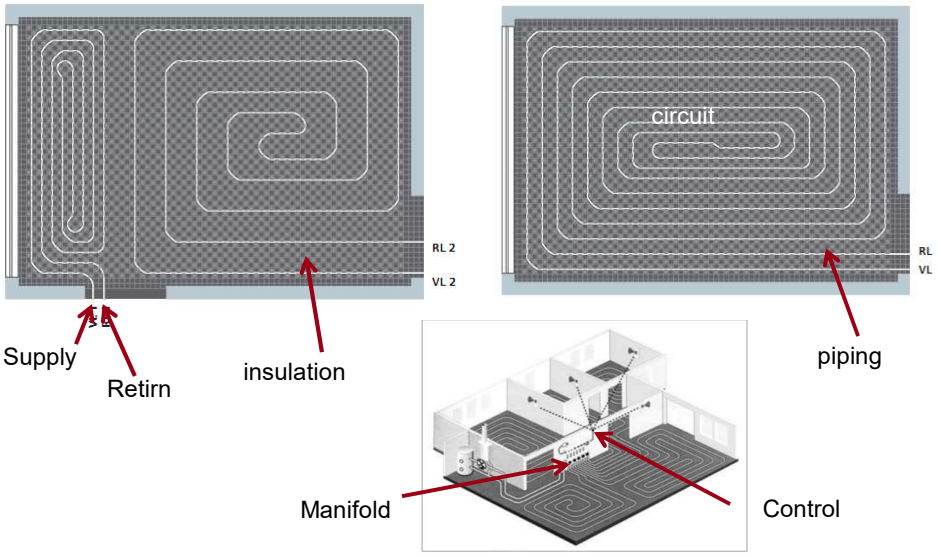




Pipes coupled to fixing elements on the wall

Walls radiant systems are not frequent (limits in the furniture, pictures, ecc.). Interesting as integrated systems in the retrofit of buildings when internal insulation is foreseen.

Components of a radiant system



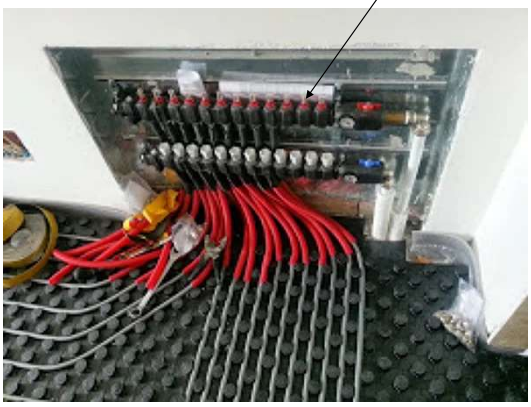
Manifold

Automatic venting: it is installed at the highest point of the hydronic circuit

Flussimetro

Flowmeter

Metal

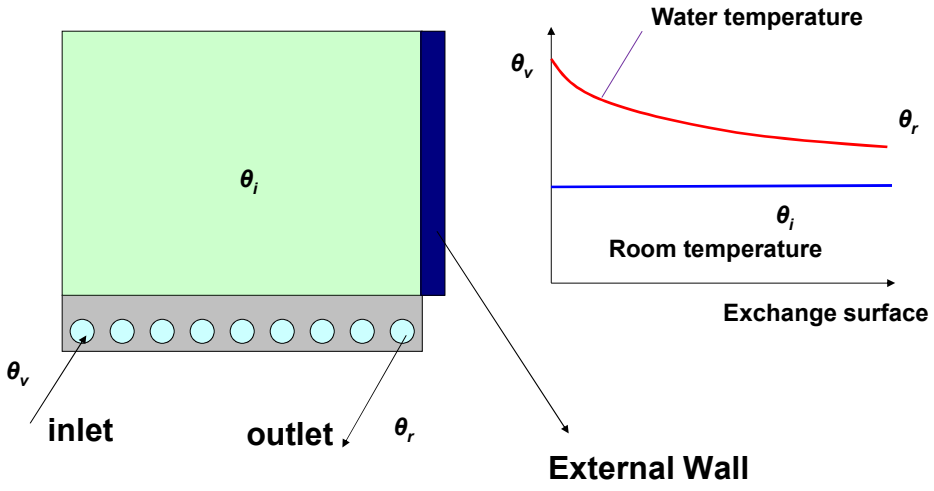


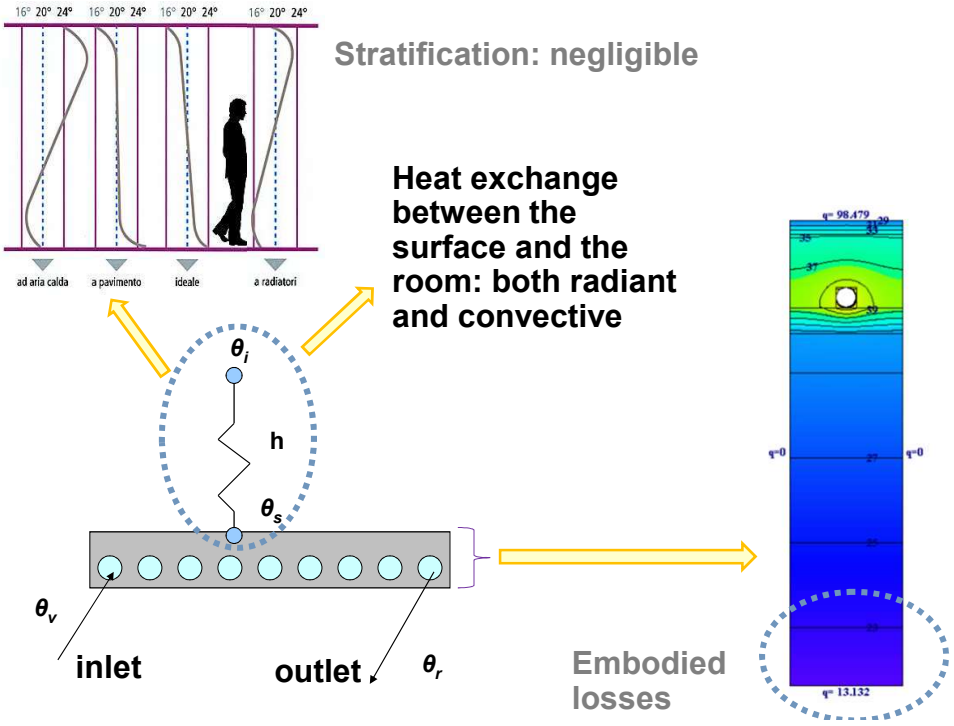
Plastic

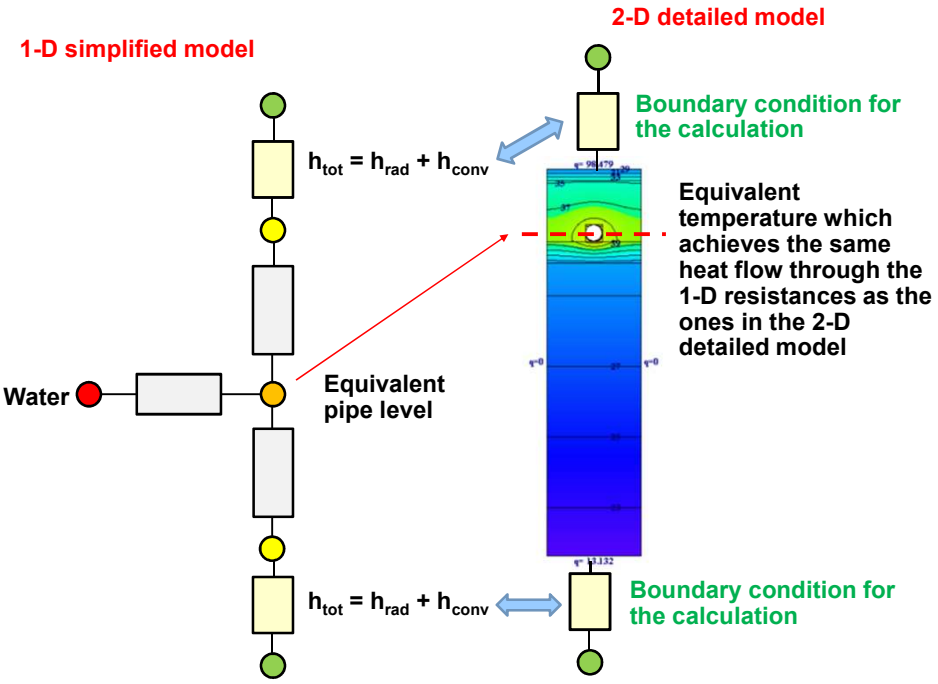
Usual screed

Self-levelling screed

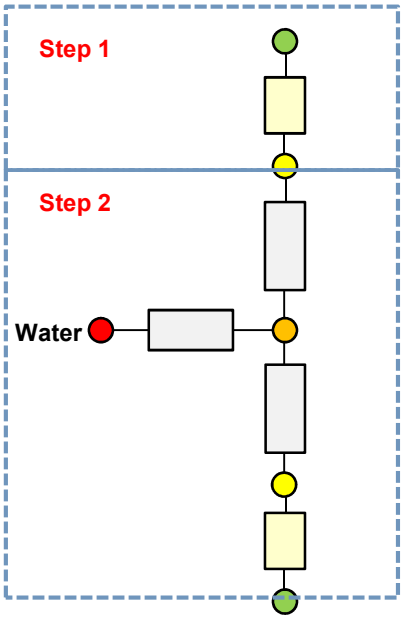
2. Heat transfer phenomena




16° 20° 24°
16° 20° 24°
16° 20° 24°
16° 20° 24°
ad aria calda
a pavimento
ideale
a radiatori
Stratification: negligible
Heat exchange between the surface and the room: both radiant and convective
θi
h
θs
θv
inlet
outlet
θr
Embodied losses


1-D simplified model
2-D detailed model
htot = hrad + hconv
Boundary condition for the calculation
Equivalent temperature which achieves the same heat flow through the 1-D resistances as the ones in the 2-D detailed model
Water
Equivalent pipe level
htot = hrad + hconv
Boundary condition for the calculation

Design steps for sizing the radiant system



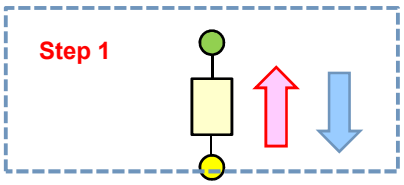
Useful heat exchange between the surface and the room = f (indoor temperature, peak load, surface orientation, local discomfort parameters)

Heat exchange between the water and the structure = f (surface orientation, pipe diameter, layer, surface finishing, pipes spacing)

Step 1: heat exchange between the surface and the room

Overall surface heat exchange coefficients

System Type		RADIANT [W(m² K)]	CONVECTIVE [W(m² K)]	TOTAL [W(m² K)]
Floor	Heating	5.5	5.5	11
	Cooling	5.5	1.5	7
Wall	Heating	5.5	2.5	8
	Cooling	5.5	2.5	8
Ceiling	Heating	5.5	0.5	6
	Cooling	5.5	5.5	11



Specific Peak Load q:

q = Peak power / active area [W/m²]

$q = h_{tot} \times | t_{surf} - t_i |$ [W/m²]

To compare against the maximum/minimum allowable temperature for local discomfort

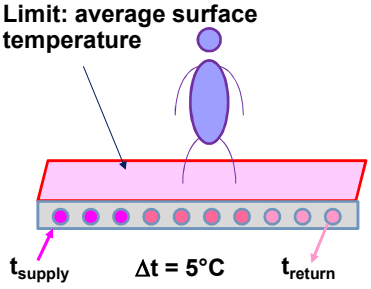
Maximum flow rate: flow rate with the maximum (in heating) and minimum (in cooling) allowable temperature for the surface

Heating: $q_{max} = h_{tot} \times | t_{surf,\ max} - t_i |$ [W/m²]

Cooling: $q_{max} = h_{tot} \times | t_{surf,\ min} - t_i |$ [W/m²]

Floor surface temperature limits:

Limit: average surface temperature

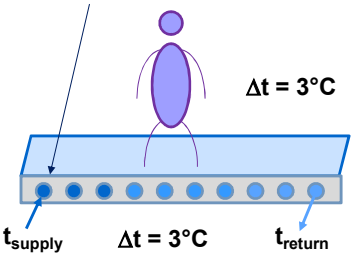


Maximum surface temperature: average surface temperature.

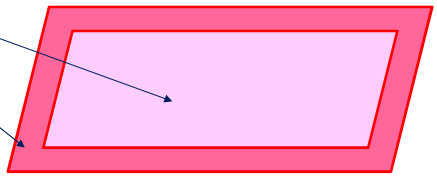
29°C in the occupied area

35°C in the peripheral area

Limit: minimum surface temperature on the top of the room water inlet

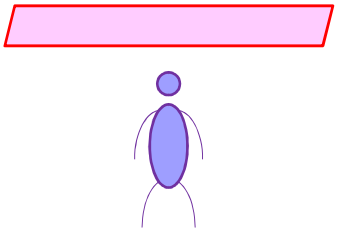


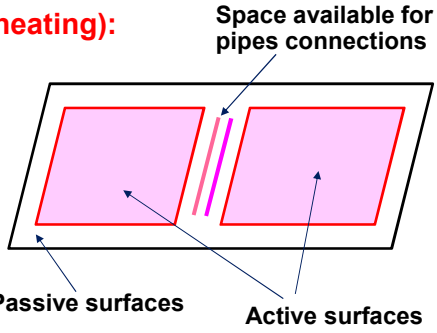
Minimum local surface temperature: on the top of the room water inlet (19°C). The average temperature of the floor will be about 19 +1.5 = 20.5°C



Ceiling surface temperature limit (heating):

Limit: average surface temperature





Active area: ~70% of overall area

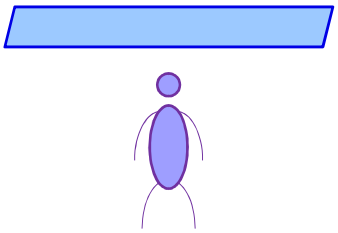
Maximum surface temperature of active area: radiant vertical asymmetry 5°C

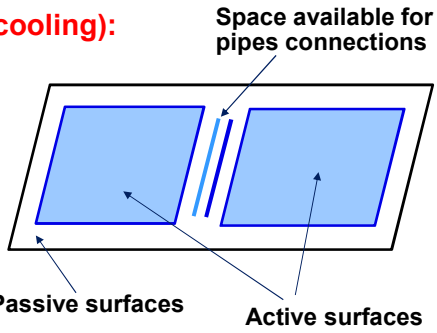
Usually it is a difficult parameter to calculate in design phase. Hence approximately it is estimated as a maximum surface temperature. This parameter is under discussion and recently the temperatures have been risen compared to the past (when a suggested temperature of 30-32°C was provided). The following temperature can be used:

t_{max} =35°C in the active area

Ceiling surface temperature limit (cooling):

Limit: average surface temperature





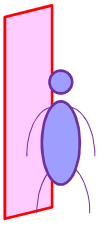
Active area: ~70% of overall area

Minimum surface temperature of active area: not a question of radiant vertical asymmetry.

The minimum temperature depends on the dew point temperature. In general the following temperature can be assumed for the active area:

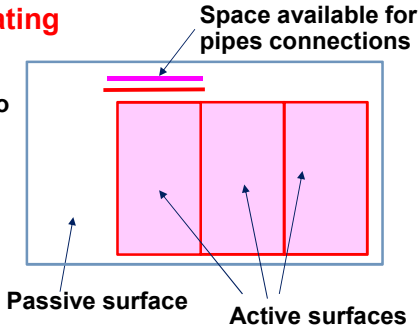
t_{min} =18°C in the active area

Wall surface temperature limits (heating and cooling):



Limit: active surface temperature (difficult to know the passive area and not very useful)

Maximum in the range 35 – 50 °C. The maximum may depend on the application of the wall heating system. If it is used in areas where the occupants may easily get contact with the surface or not. If it is used in buildings for more sensitive persons like children or elderly, the risk for burns and pain is a skin temperature of 42-45 °C.



Active area: ~70% of overall area (even less)

The losses to the backside must be considered.

t_{max} =40°C in the active area

The minimum temperature depends on the dew point temperature. In general the following temperature can be assumed for the active area:

t_{min} =18°C in the active area

Maximum specific power of a radiant system

			t_{min}/t_{max} [°C]	h_{tot} [W/(m² K)]	t_i [°C]	q_{max} [W/m²]
FLOOR	Occupied	Heating	29	11	20	100
		Cooling	20	7	26	40
	Peripheral	Heating	35	11	20	165
		Cooling	19	7	26	50
CEILING	Active area	Heating	35	6	20	90
		Cooling	18	11	26	88
	Overal area	Heating	30.5	6	20	63
		Cooling	20.5	11	26	60
WALL	Active area	Heating	40	8	20	160
		Cooling	19	8	26	55