RADIATORS,

FINNED COILS/BASEBOARD HEAT

CONVECTOR HEATING SYSTEM

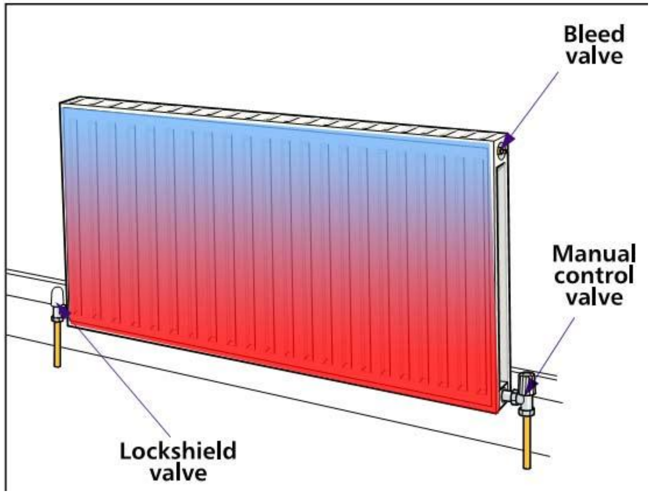
FAN-COILS

ACTIVE BEAMS / CHILLED BEAMS

UNIT HEATERS

Radiators 1/2

- They are used only for heating;
- Water based emission system;
- They may be equipped with additional electric resistances (especially in bathrooms).
- They present a shut-off valve to interrupt the water flow, a beed (vent) valve and a manual control valve or a thermostatic valve .



Radiators 2/2

- Radiators are made of vertical elements in cast iron, sheet steel, or aluminium, put together.
- Each element can have one or more columns or planar, smooth or with vertical profiles

Cast iron

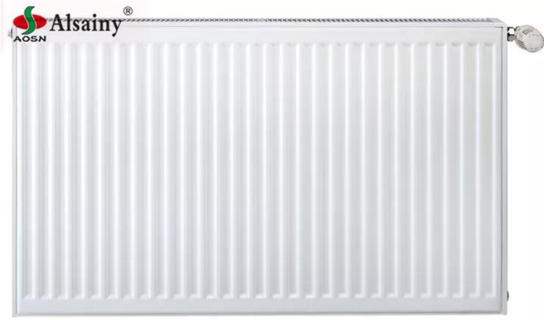
5 columns

Sheet steel

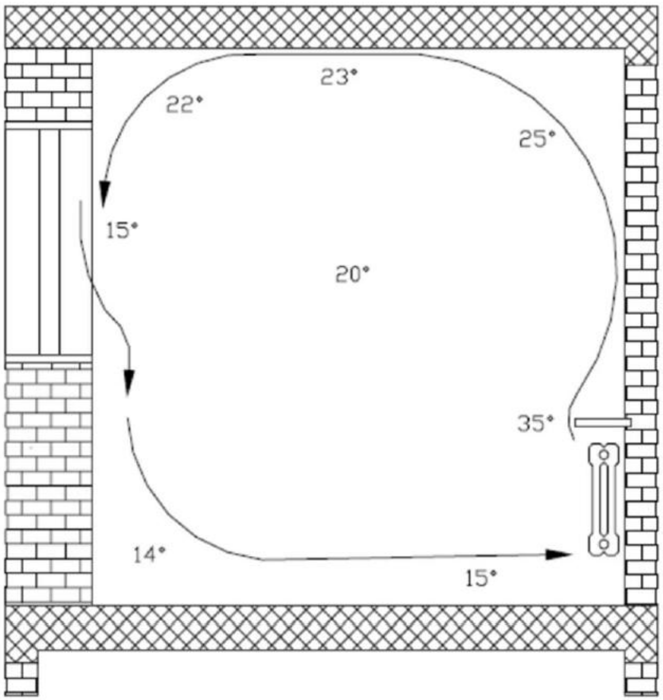
Aluminium

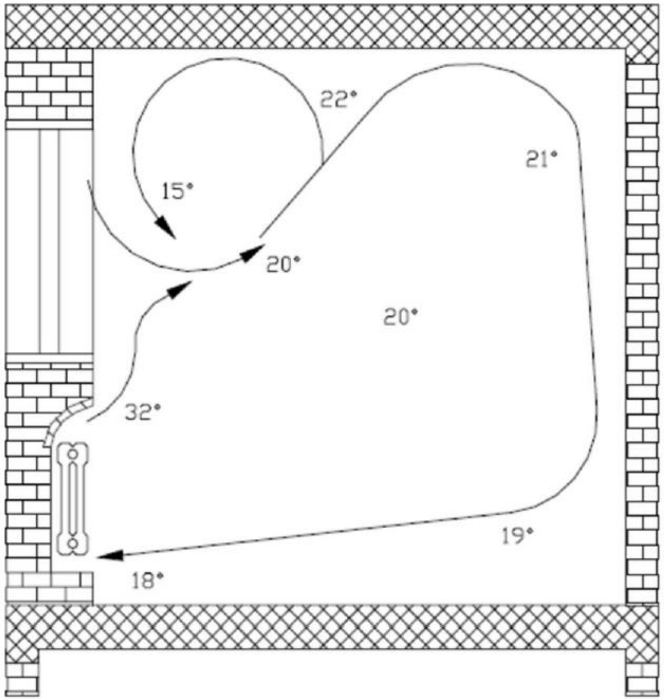
Flat smooth radiator

Flat with vertical elements



Radiators positioning

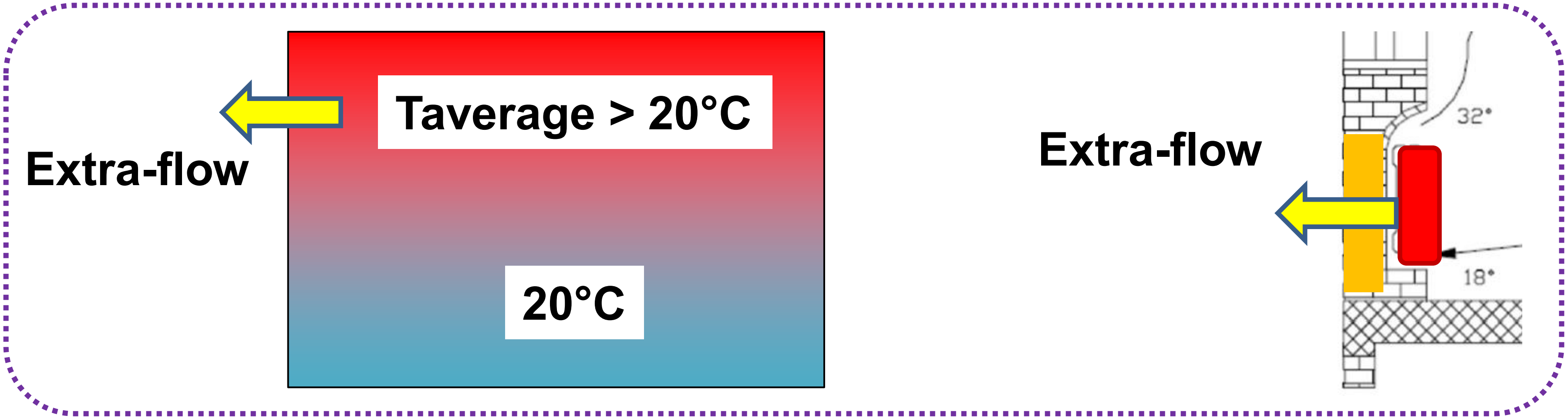




They are usually installed below the windows in order to counteract the down draft effect which may occur with the windows.

This makes the air temperature distribution more uniform in the room

Radiators efficiency



Extra-flow

Taverage > 20°C

20°C

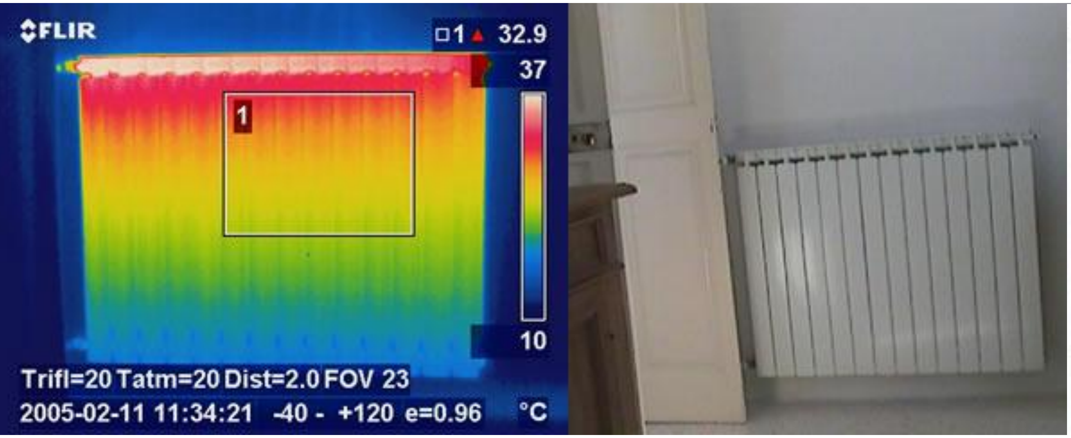
Extra-flow

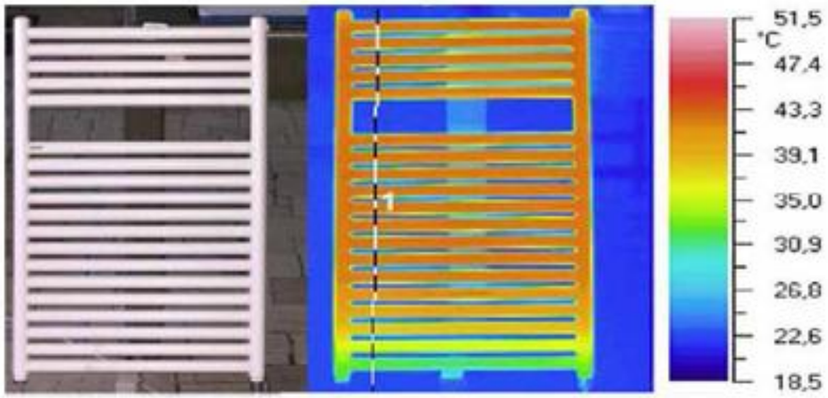
Emission efficiency

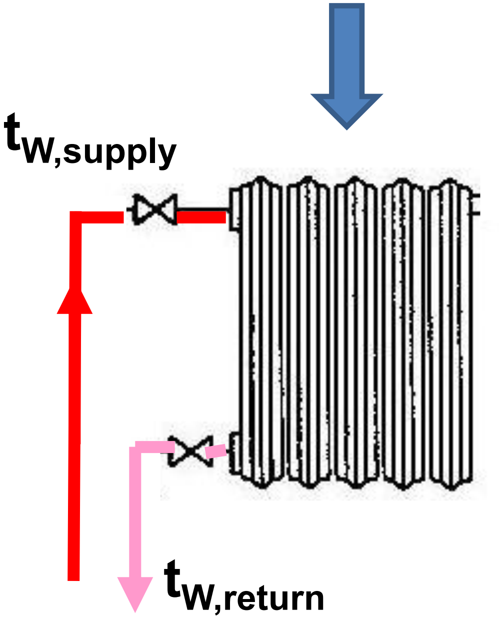
Although trying to make the air distribution in the room more uniform, with radiators stratification effects occur. Hence in order to get 20°C in the occupied zone, the average temperature is higher. This leads to higher losses.

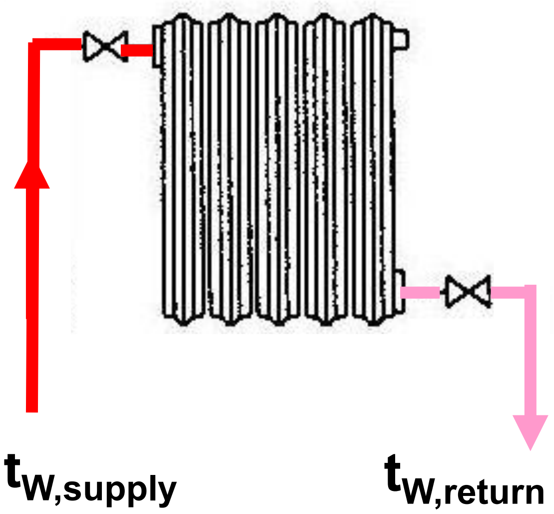
Moreover the installation of the radiator in the nieche below the window leads to losses named embedded losses. The radiator when is on heats up the wall below the window and this heat flows outwards.

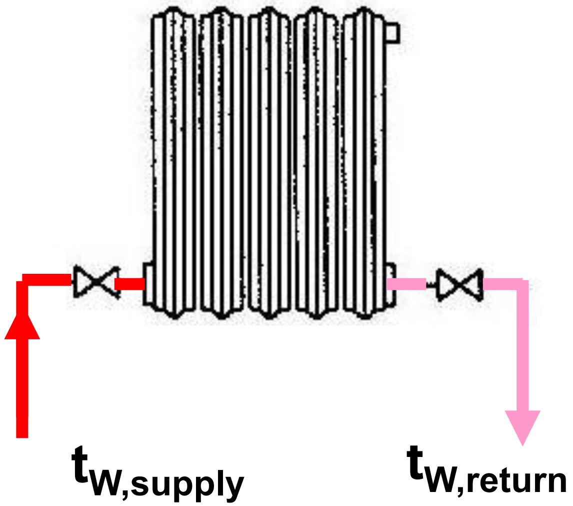
Distribution of the water within the radiators







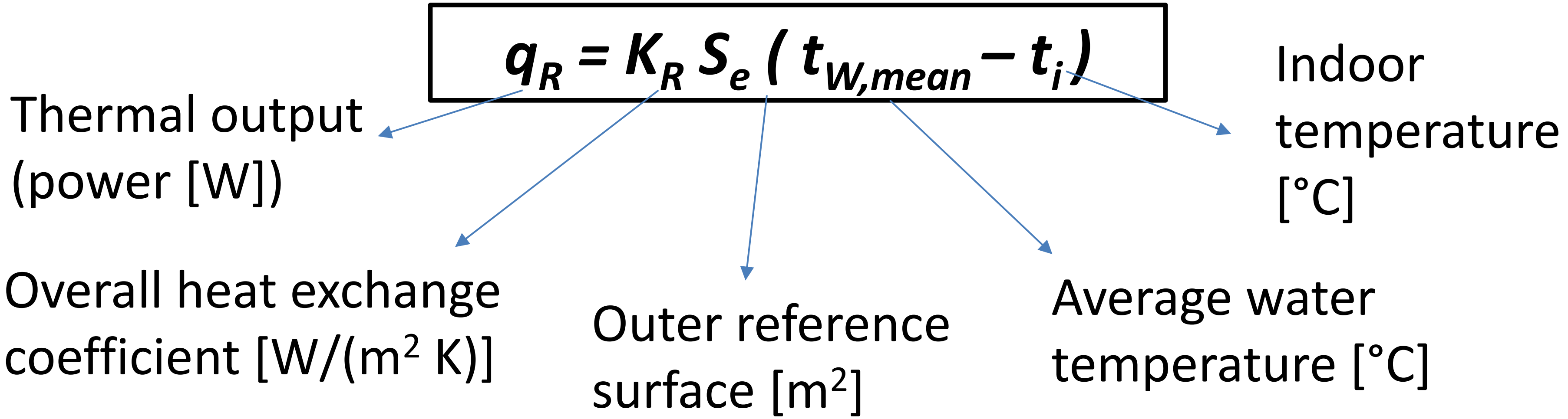




Radiators – Thermal output

- Factors influencing the radiators performance:
  - Position;
  - Temperature of the water;
  - Characteristics of the finishing/painting.

- The radiator is a heat exchanger between the water and the room. It is a combination between natural convection and radiation:



$$\boxed{q_R = K_R\, S_e\, (\, t_{W,mean} - t_i \,)}$$

Thermal output (power [W])

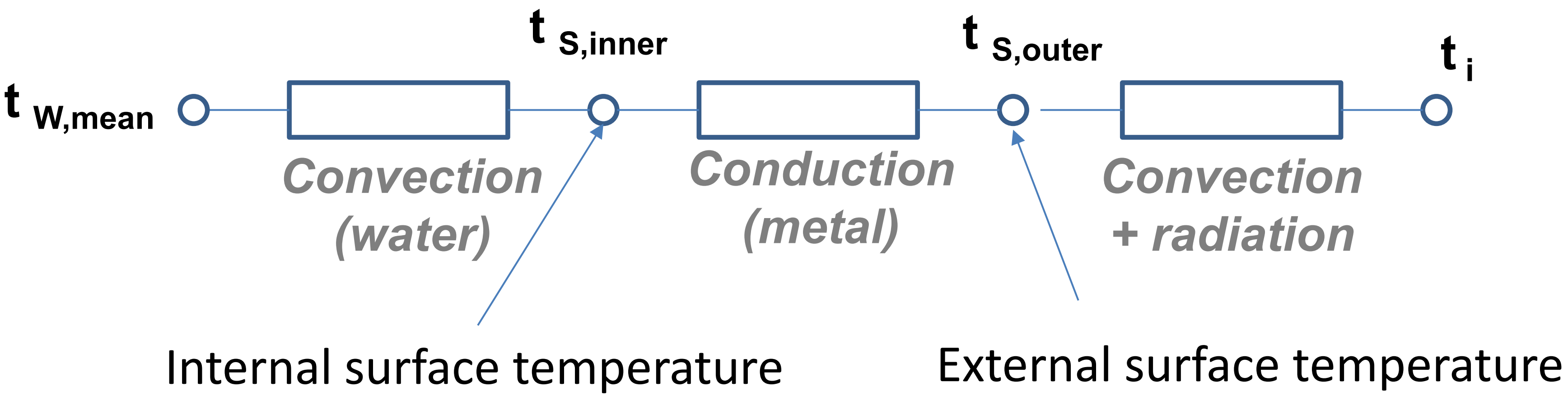
Overall heat exchange coefficient [W/(m² K)]

Outer reference surface [m²]

Average water temperature [°C]

Indoor temperature [°C]

- In principle the coefficient K_R could be calculated as a function of the geometry of the heat exchanger.



$t_{W,mean}$

$t_{S,inner}$

$t_{S,outer}$

t_i

Convection (water)

Conduction (metal)

Convection + radiation

Internal surface temperature

External surface temperature

- The internal heat transfer coefficient depends on the velocity and on the average temperature of the fluid
- The conduction depends on the material and the geometry of the heat exchanger
- The external resistance is the most relevant for the heat exchange.

- The radiant heat transfer coefficient is constant: h_R = 5.5 W/(m^2 K)
- The convective heat exchange coefficient is dependent on the temperature difference between the air and the surface of the radiator:

$$h_c = f\,(t_{surface} - t_{air})$$

- Hence the overall heat transfer coefficient K_R depends on the surface temperature. The calculation would require an iterative process. Moreover the calculation would change from one radiator to another. Thus there is the need of a simpler solution.
- The radiators are modular elements made combining different vertical elements.

- The thermal output is defined based on standardized tests (EN 442) where the radiators are defined in an experimental way. The thermal output is defined by means of two coefficients:

$$\boxed{q_R = K_m \,(t_{W,average} - t_i)^{n}}$$

Radiator model constant

n= 1.25 - 1.35

- The test room dimension is 4 m x 4 m x 3 m
- Different sets of measurements are carried out. The nominal thermal output is defined at an average water temperature of 70°C

Radiators - Example

3 COLONNE

3 COLUMNS

Cod. Modello Cod. Model	Altezza Height H mm	Interasse Dist. betw. centers N mm	Cont. acqua Water content lt	Peso Weight kg	Resa/Outputs EN 442-1 Δt=50k watt/el.	Resa/Outputs EN 442-1 Δt=50k kcal/h-el.	K_m	Esponente n Exponent n
C3/300	300	230	0,60	0,85	**32,2**	27,6	0,225	1,26863
C3/350	350	280	0,66	0,96	**37,1**	31,9	0,260	1,26802
C3/400	400	330	0,72	1,08	**41,9**	36,0	0,294	1,26740
C3/450	450	380	0,77	1,18	**46,7**	40,2	0,329	1,26679
C3/500	500	430	0,83	1,29	**51,4**	44,2	0,363	1,26617
C3/550	550	480	0,89	1,40	**56,2**	48,3	0,398	1,26556
C3/600	600	530	0,95	1,51	**60,9**	52,4	0,432	1,26495
C3/685	685	615	1,06	1,69	**68,9**	59,2	0,491	1,26390
C3/750	750	680	1,13	1,83	**75,0**	64,5	0,536	1,26310
C3/885	885	815	1,29	2,13	**87,8**	75,5	0,631	1,26144
C3/900	900	830	1,31	2,16	**89,2**	76,7	0,642	1,26126
C3/1000	1000	930	1,43	2,38	**98,6**	84,8	0,689	1,26901
C3/1100	1100	1030	1,55	2,60	**108,1**	92,9	0,733	1,27675
C3/1200	1200	1130	1,67	2,82	**117,7**	101,2	0,773	1,28450
C3/1500	1500	1430	2,03	3,47	**146,7**	126,1	0,880	1,30774
C3/1800	1800	1730	2,39	4,13	**176,4**	151,7	0,966	1,33098
C3/2000	2000	1930	2,62	4,56	**196,6**	169,0	1,098	1,32603
C3/2200	2200	2130	2,86	5,00	**217,2**	186,8	1,237	1,32108
C3/2500	2500	2430	3,22	5,65	**249,0**	214,1	1,460	1,31365
C3/2800	2800	2730	3,58	6,30	**282,0**	242,5	1,598	1,32242
C3/3000	3000	2930	3,82	6,74	**304,5**	261,8	1,698	1,32648

Lunghezza= numero elementi x 46 mm toll. +/- 1.5% - *Length= number of elements x 46 mm tol. +/- 1.5%*

Radiators – Choice

- Once known the peak power load of a room the amount of terminal units has to be decided (depending opn the size of the room);
- It has to be decided the mean water temperature in the radiator;
- Choice of the type of radiator. Based on the Tables declared by the producer the area of the radiator is fixed; the amount of elements is calculated as the ratio between the peak load and the nominal power per element;
- Once determined the amount of the elements the water temperature has to be refined
- Check the effective size of the radiators, if they fit in the room

Sizing

- The values “C” and “n” are provided by the producer
- The actual power output of the radiator (or by an element) q_{actual} is different from the declared value ($q_{nominal}$) at $t_{W,average} = 70°C$ and the room at $t_i = 20°C$) :

$$q_{actual} = q_{nominal} \left[\left(t_{W,average} - t_i \right) / 50 \right]^n$$

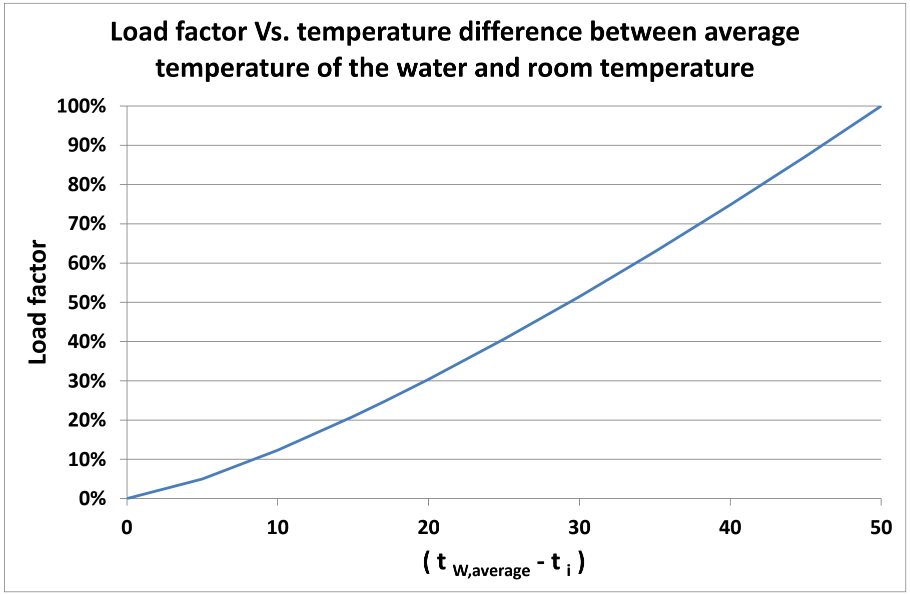
- If q_{actual} is referred to a single element, the amount N of elements is given by:

$$N = q_{design} / q_{actual}$$

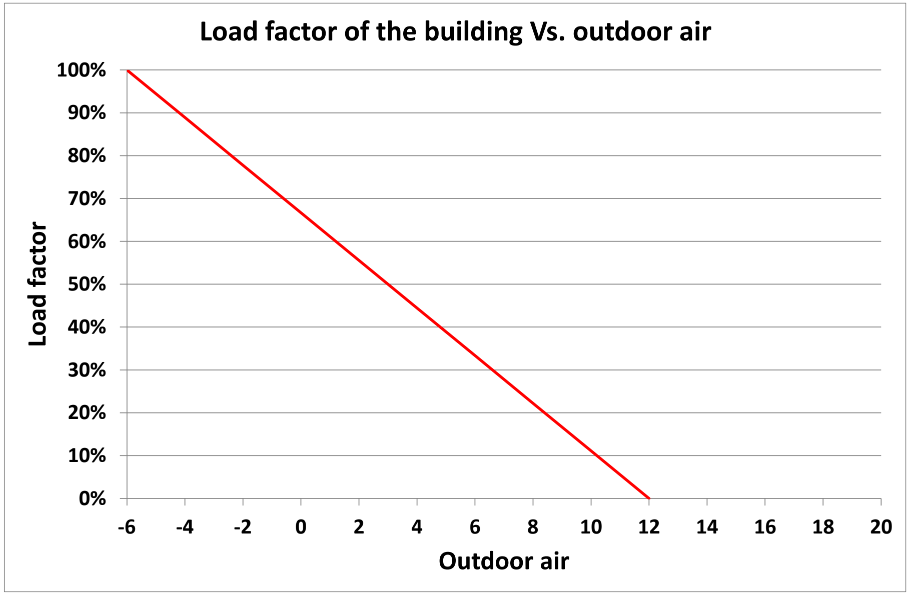
- The value N is usually rounded up.

Climatic control startegies 1/2

- The radiator has a self-regulation power output depending on the average temperature of the water

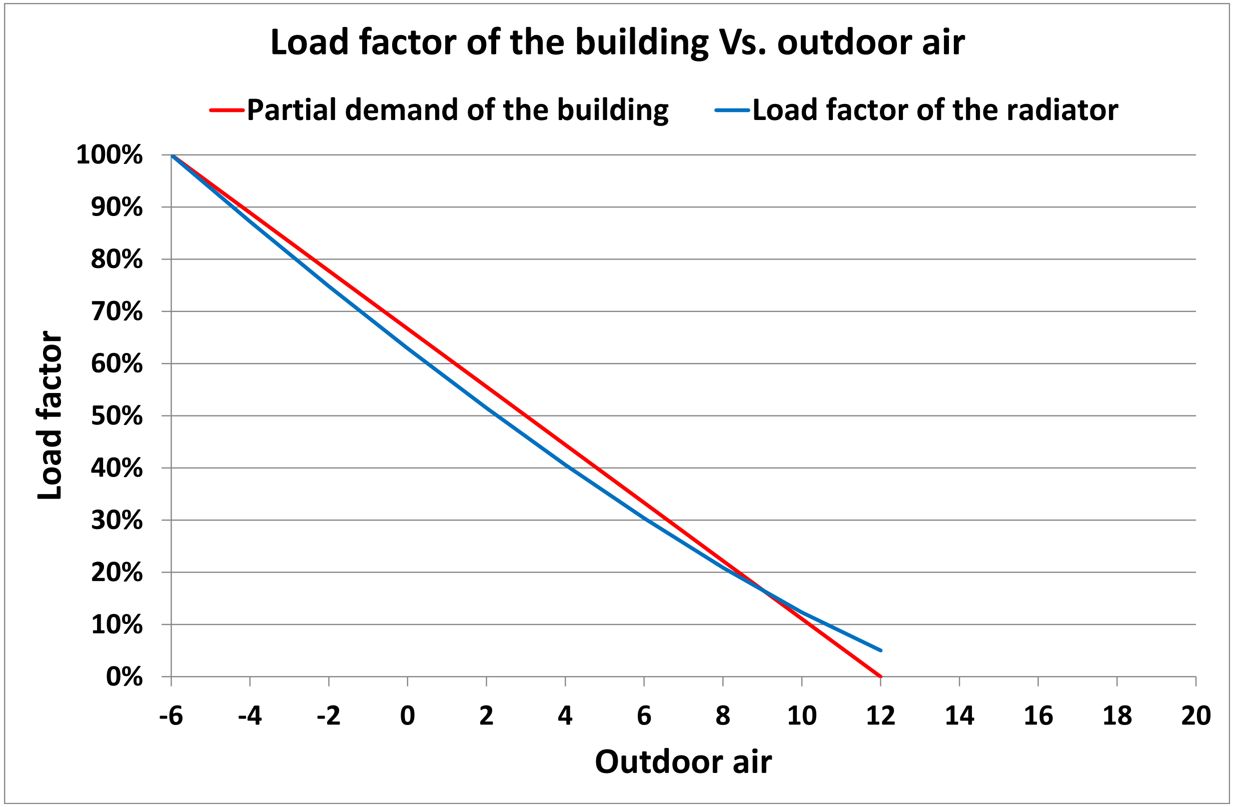


- The room in the most simple approach has a linear heat loss as a function of outdoor air



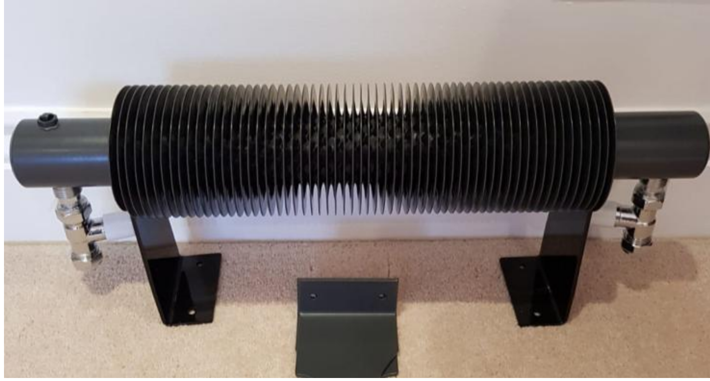
Climatic control startegies 2/2

- By choosing a suitable funciotn for reducing the average temperature in the radiator it is possible in principle to adapt the poeìwer output of the radiator by means of outdoor temperature

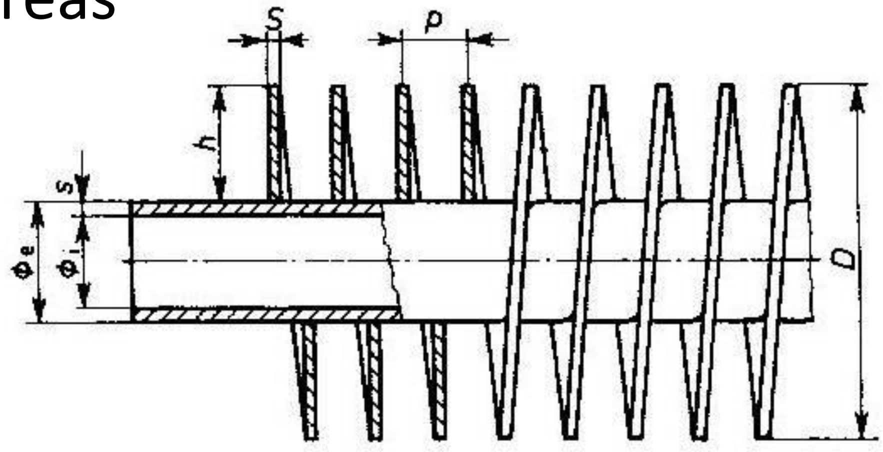


- It has to be underlined that the linear model for the energy need of the building does not take into account the internal gains and the solar radiation, hence the approach has some limits.

Finned tube

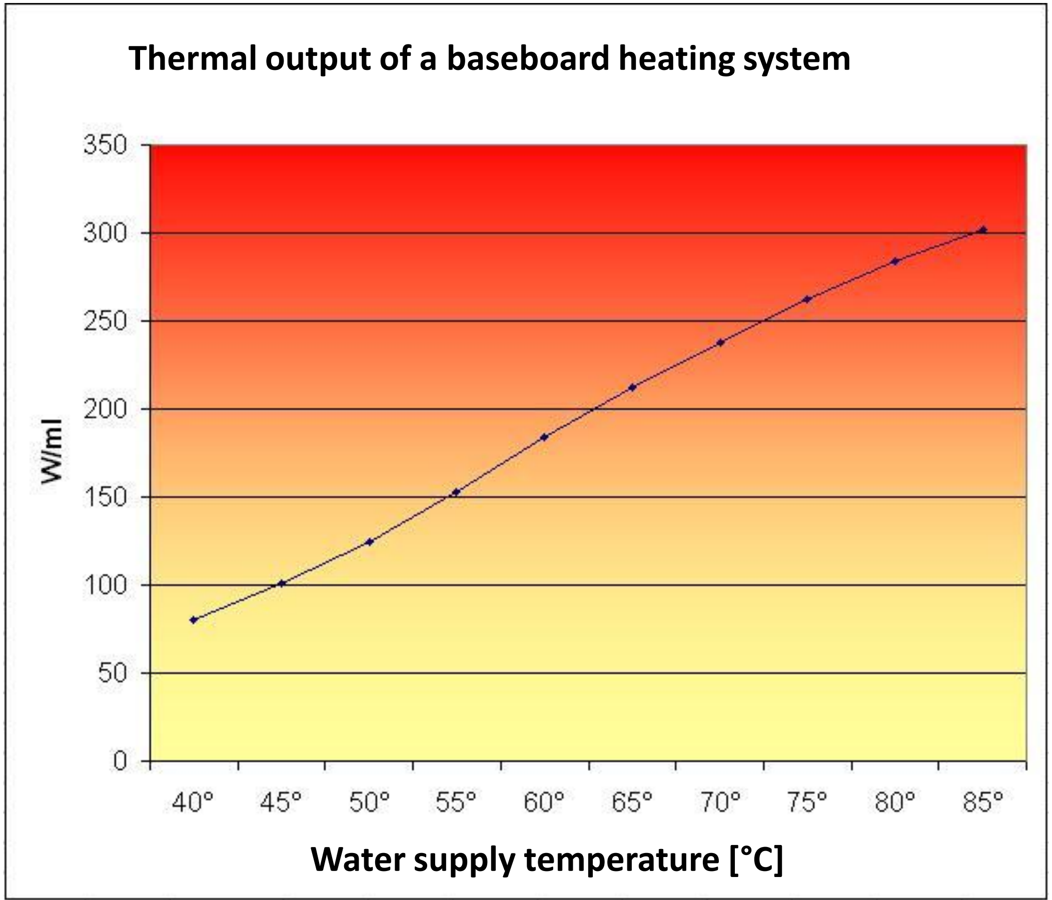


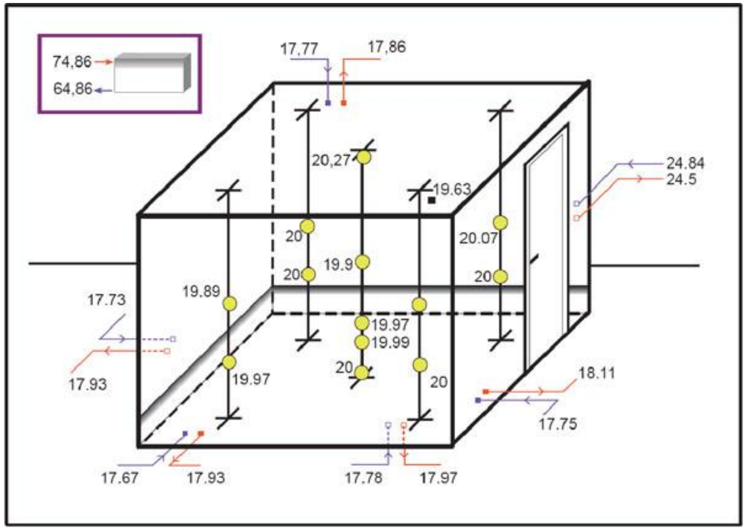
- They operate with high Δt (60°C)
- Power from 350 W/m to 625 W/m depending on the amount of fins
- Used mainly in industrial buildings, green houses, car garages, etc.
- It may be used in Central Europe as auxiliary system in case of large glazed areas to cover the peak load



Baseboard heating

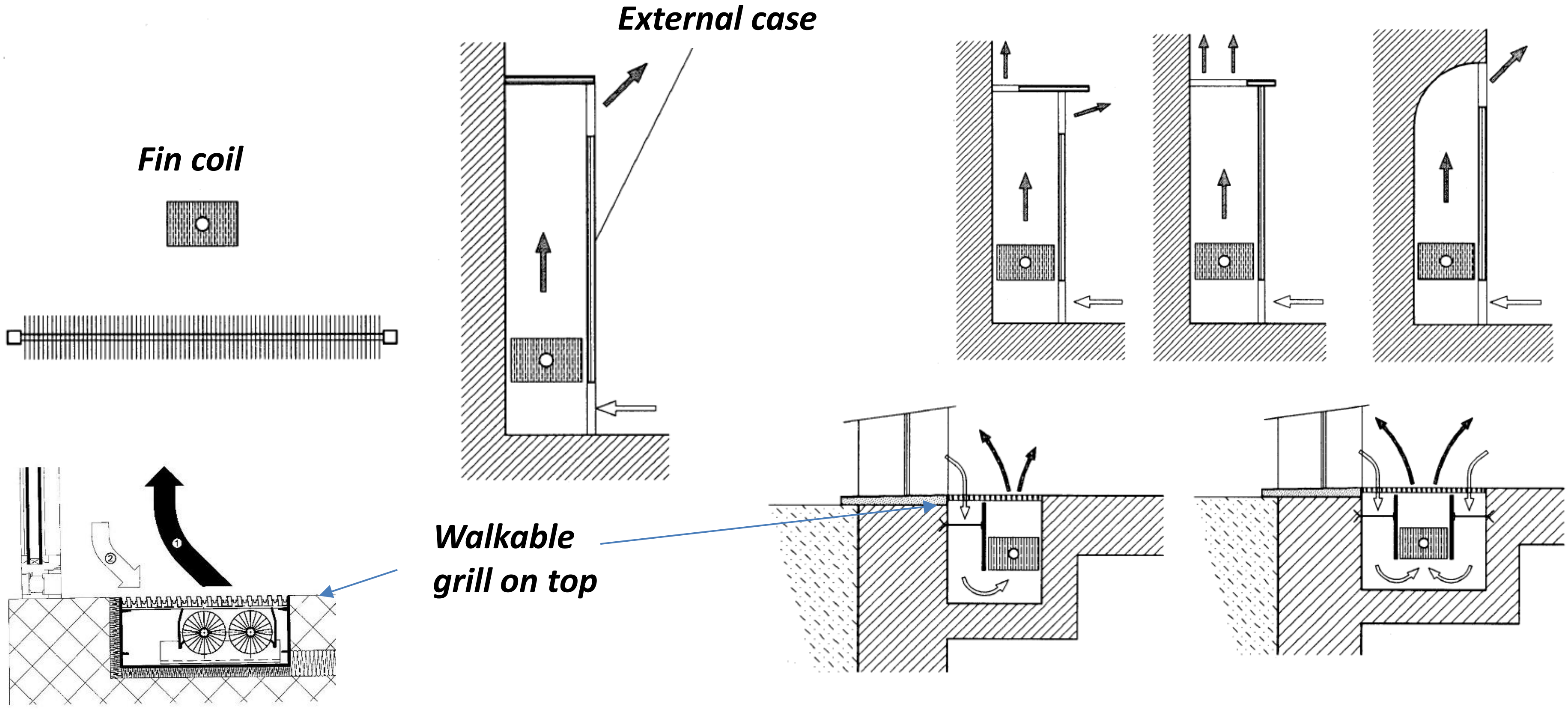
Finned coils installed in the bottom part of a wall with a plastic casing which allows the natural convection


Thermal output of a baseboard heating system



Convector heating systems 1/2

- Convector heating systems are mainly based on convection.
- They are based on fin coils in casings with openings which allow the natural convection and the buoyancy effect;
- They can be verticals, horizontal, or they can put in the floor;



External case

Fin coil

Walkable grill on top

Convector heating systems 2/2

- They can be used as additional auxiliay system for large glazing elements;
- The fin coil is usually fed by water supply at 60 ÷ 80 °C, also used with high pressure hot water.
- Material used is usually iron or copper for the pipes and for the heads, steel or aluminium for the fins.
- Compared to radiators (pros): less thermal inertia, more compact, cheaper
- Compared to radiators (cons): more difficult to be cleaned (they are not suitable for dusty applications), they are not modular solutions, it is not possible to modulate the thermal output by reducing the supply temperature