# Terminal units

*Michele De Carli*

## Types of plants

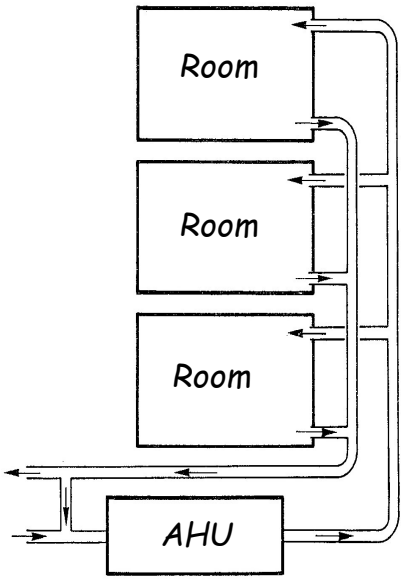
*Heat carrier fluid:*

1. *All air plants*
2. *Water based systems*
   - *Two pipes, four pipes*
3. *Air-water plants*
4. *High temperature radiant systems*
5. *Direct expansion systems*

*Type of service:*

- *Just heating*
- *Just cooling*
- *Heating and cooling*

# 1. All air systems

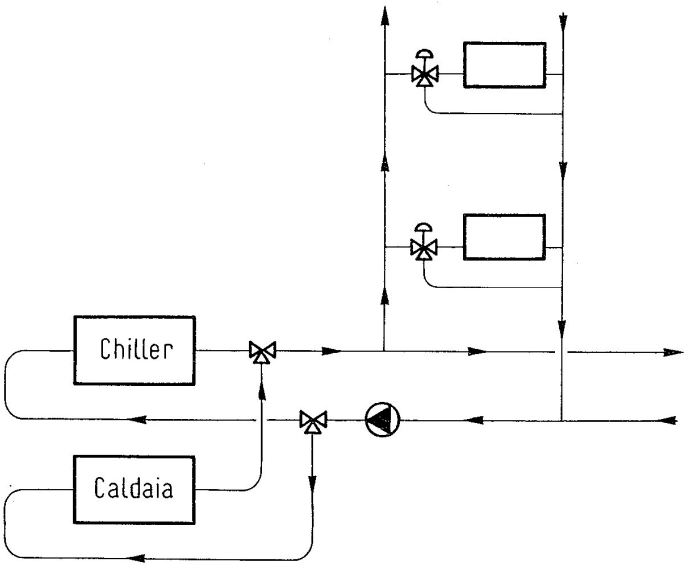



# 2. Water based systems

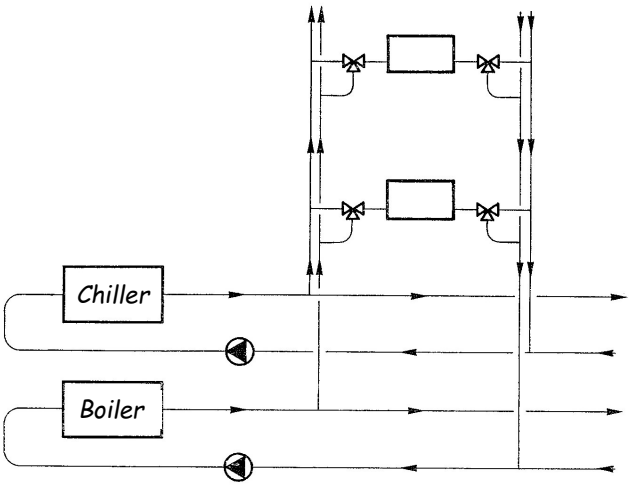
Convction

- NATURAL
  - Limited surface → Large Δt Room-fluid
  - Relevant surface → Low Δt Room-Fluid
- FORCED → Low Δt Room-fluid Limited dimensions

## Two pipes plant

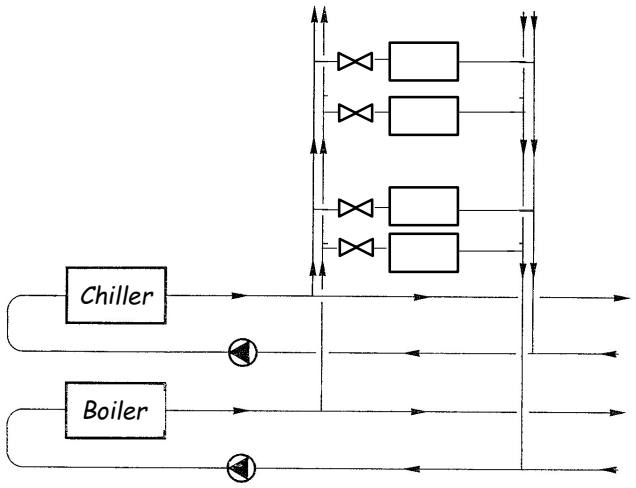



## Four pipes plant




Two 3-way valves or 2 different coils { Warmed water / Chilled water

## Four pipes plant




Two 3-way valves or 2 different coils { Warmed water / Chilled water

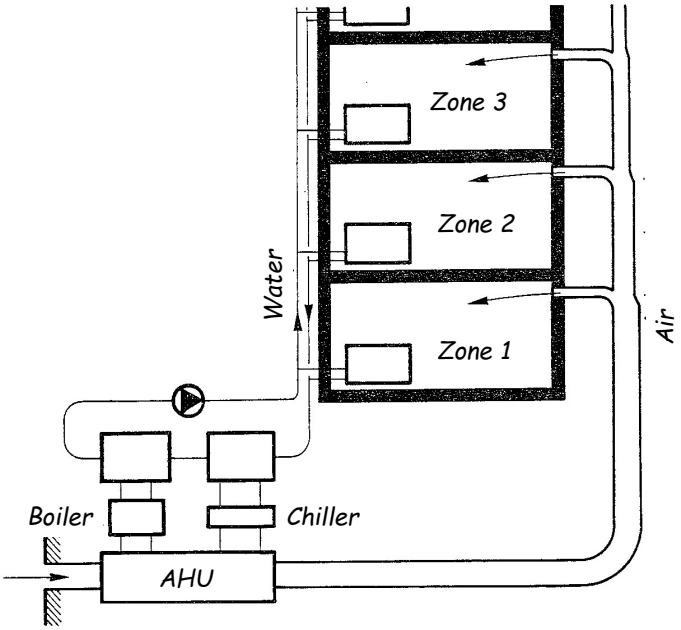
## 3. Air-water system

AIR

Vapour balance in the room

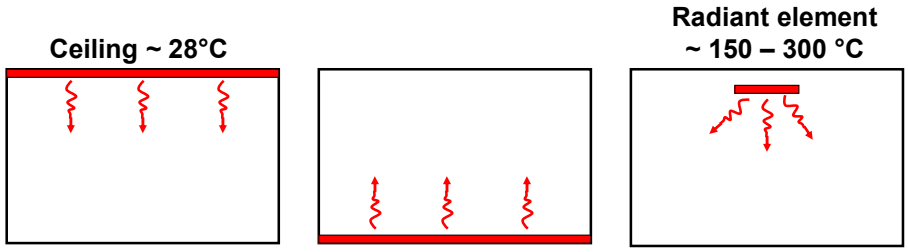
WATER

Sensible load




# Radiant systems

Radiation form different surfaces

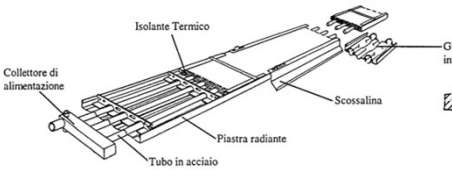


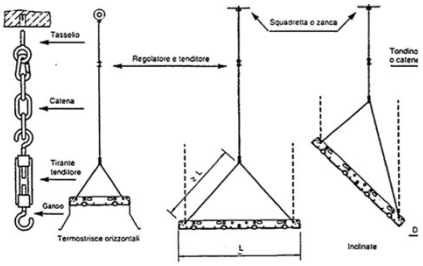

Let us consider a panel with surface temperature $t_p$ and a room at 20°C

$$q / A = \sigma_n \varepsilon \ (T_p^4 - T_s^4)$$

| $t_p$ [°C] | $T_p$ [K] | q/A [W/m$^2$] |
|---|---|---|
| 28 | 300 | 43 |
| 50 | 322 | 180 |
| 100 | 372 | 613 |
| 200 | 472 | 2’181 |
| 400 | 672 | 10’101 |

# Water based suspended radiant systems



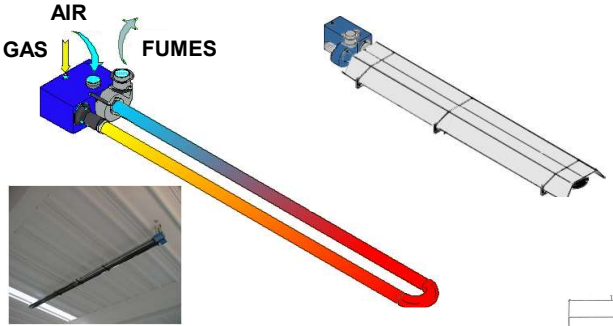




**Water at 90°C or pressurized water or vapour at 110-130°C.**
**Length from 4 m to 6 m.**
**Modular solution**

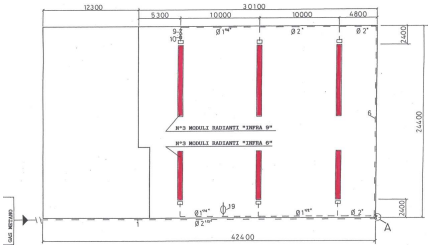
# High temperature suspended radiant systems 1/2

**Radiant tubes**

**The gas enters the combustion chamber with air providing combustion.**





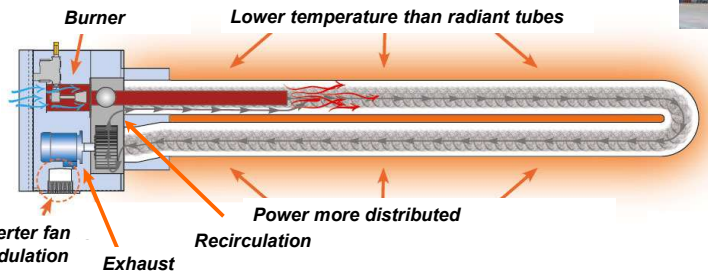



**Combustion fumes flow inside the radiant tube and they exchange heat with the room.**
**Surface temperature 300°C-400°C**
**Length from 5 m to 15 m (from 15 to 50 kW).**
**The fan is installed on the exhaust soa s to provide depression to avoid fumes in the room**

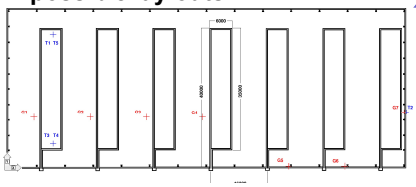
# High temperature suspended radiant systems 2/2

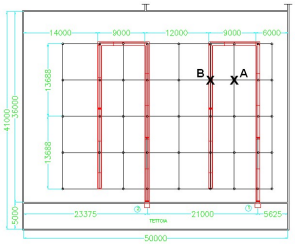
**Radiant strips**

**The gas enters the combustion chamber with air providing combustion as in radiant tubes. In this case there is a recirculation of fumes provided by Venturi effect.**



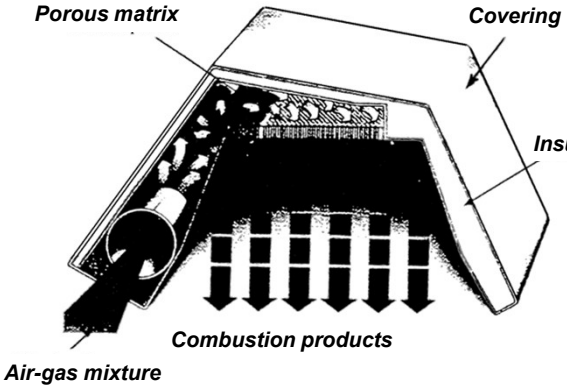

**The length of a strip can be up to 140 m. There are 2 possible lay-outs**



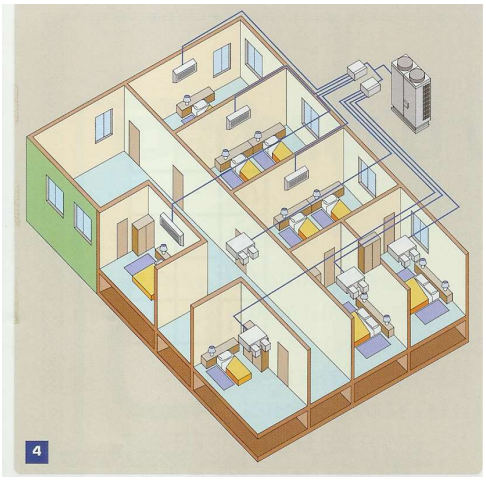


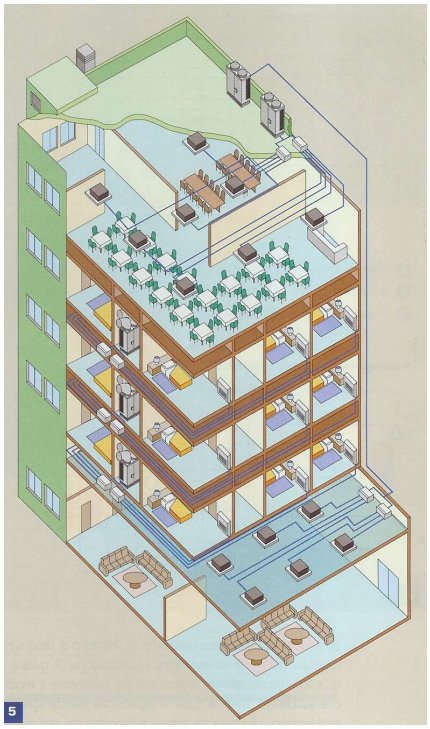

# Radiant Luminous Systems

**The combustion chamber is in the ambient (need of adequate ventilation or open spaces**




# 5. DIRECT EXPANSION UNITS



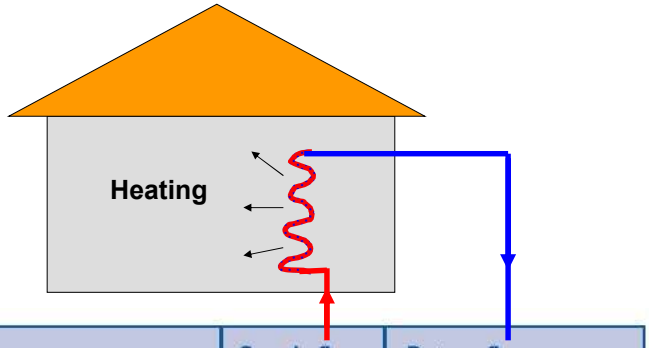




## WATER AND AIR-WATER BASED SYSTEMS

### Heating operation

**In the past the heating systems have been designed and they were supposed to operate at high temperature, due to the use of combustion boilers.**
**Hence the usual temperature in the ’70ies was 90°C or even vapour or high pressure hot water.**
**In the ‘90ies the condensing boilers were introduced reducing the water temperature at 60°C or even less.**
**The increase use of radiant systems and of the heat pumps has also lead to further reduction of the water temperature in the building**

## Usual temperatures in heating systems



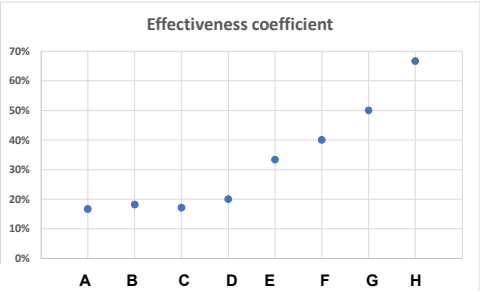

| System | Supply flow | Return flow |
|---|---|---|
| High temperatures (HT) | 90 °C | 70 °C |
| Medium temperatures (MT) | 55 °C | 35 – 40 °C |
| Low temperatures (LT) | 45 °C | 25 – 35 °C |
| Very low temperatures (VLT) | 35 °C | 25 °C |

*Table 1. Definition of temperature ranges for heating designs*

## Effectiveness coefficient in heating

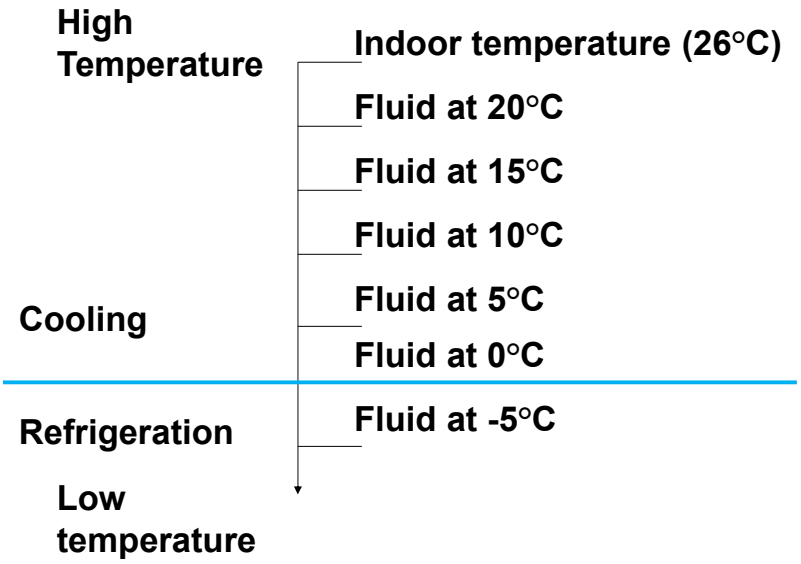
**It is a qualitative parameter which is not useful for sizing the systems, but it is interesting to show the qualitative efficiency for heating solutions:**

$$\Phi = \frac{t_{supply} - t_{return}}{t_{supply} - t_i}$$




| | | Supply Temp. | Return Temp. | Effectiveness coefficient |
|---|---|---|---|---|
| A | High temperature radiators (70ies) | 80 | 70 | 17% |
| B | Mid temperature radiators (90ies) | 75 | 65 | 18% |
| C | Low temperature radiators (today) | 55 | 49 | 17% |
| D | Fan-coil | 45 | 40 | 20% |
| E | Chilled beams | 35 | 30 | 33% |
| F | Radiant systems (90ies) | 35 | 29 | 40% |
| G | Radiant systems (2000) | 30 | 25 | 50% |
| H | Radiant systems (today) | 26 | 22 | 67% |

## Temperatures in cooling




## Effectiveness coefficient in cooling

| | | Supply Temp. | Return Temp. | Effectiveness coefficient |
|---|---|---|---|---|
| A | Fan coils | 7 | 12 | 26% |
| B | All air/dehumidification | 7 | 12 | 26% |
| C | Fan beams | 15 | 18 | 27% |
| D | Radiant ceiling | 17 | 20 | 33% |
| E | Radiant floor | 19 | 21 | 29% |
| F | TABS | 19 | 22 | 43% |

# Hydronic terminal units

- *Radiators*
- *Finned coils/baseboard*
- *Convector heating system*
- *Fan-coils*
- *Active beams / chilled beams*
- *Unit heaters*
- *Radiant systems*