LECTURE N° 6-7

- Heat Distribution Network-

DU

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Lecture contributions

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LECTURE 6

HEAT DISTRIBUTION NETWORK

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Heating systems

- Function:
  - transfer of the heat from the source to the heat emitter
- Heat transfer medium
  - water, steam, air

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Heating system decision

- Initial information about building
  - Type
    - industrial, office, dwelling
  - Operation
    - continuous, intermittent
    - single, multiple
  - Structure
    - heavy, light
    - new, reconstruction

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WATER BASED HEATING SYSTEMS

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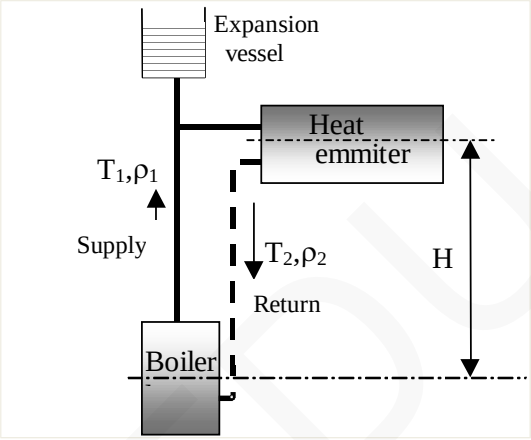
Water based heating

- Principle
  - Heat source
  - Distribution network
  - Heat emitter



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Water Based Heating System Design Optimisation Criterions

- Length of the pipes
- Location of the heat emmiters
- Control of the system
- Investment costs
- Operational costs
- Maintenance

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Water- based heating

Technical remarks

- Water quality
- Pipework
  - materials, insulation, placing, deaeration, draining
- Fittings
  - shutoff, control, radiator valves
  - drain / feed cocks, deaerating devices
  - pumps, filters

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Water-based heating

Classification

- Temperature
  - low temperature hot-water systems
  - medium temperature hot-water systems
  - high temperature hot-water systems
- Circulation
  - Gravity
  - Forced

EN 12828 Heating systems in buildings
Design for water-based heating systems

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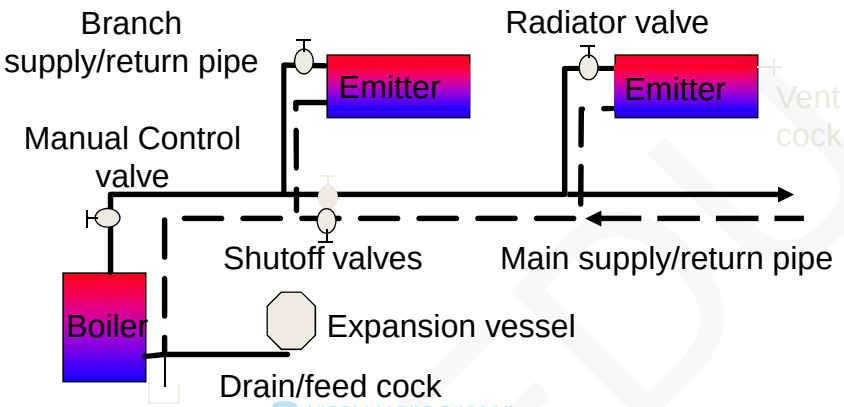
Water-based heating

Terminology



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Water-based heating

Design parameters

(1) Water circulation
(2) Geometry of the system
(3) Water temperature
(4) Expansion vessel
(5) Materials

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Water-based heating

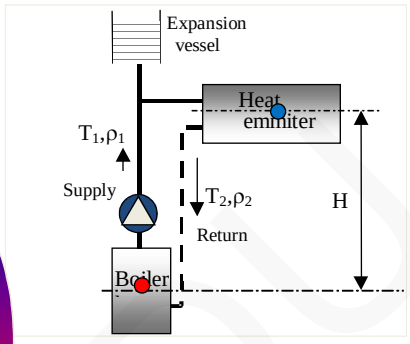
Water circulation

- Gravity – without pump

$P_1 = h.\rho_1.g$

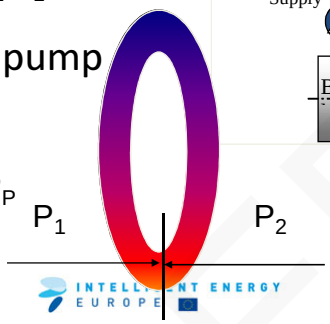
$P_2 = h.\rho_2.g$

$\Delta P_n = P_2 - P_1 = h.(\rho_2 - \rho_1).g$



- Forced – with pump

$\Delta P_F = \Delta P_n + \Delta P_P$



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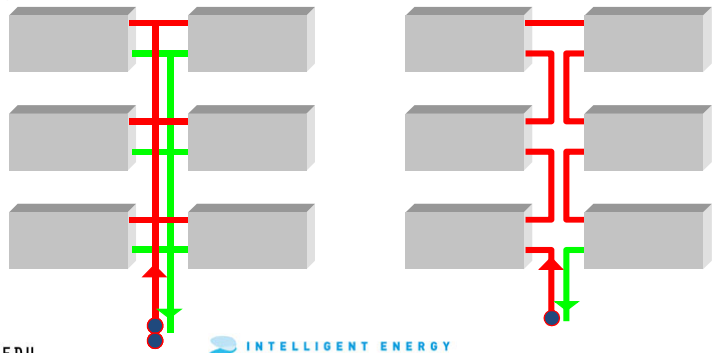
Water-based heating

Geometry of the system

Relative connection of the heat emitters

Two-pipe system

One-pipe system



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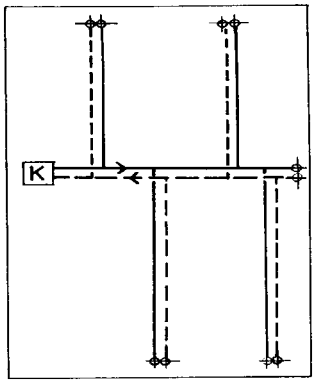
Water-based heating

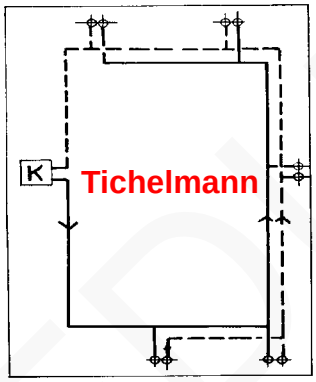
Geometry of the system

Two-pipes systems

Contraflow



Parallel



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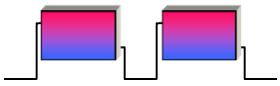
Water-based heating

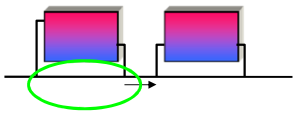
Geometry

One-pipe systems - connection

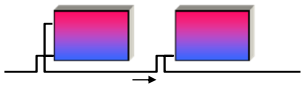
- Serial



- With By-Pass
  - –"Horse Rider"
  - – Controlled by-pass



- With mixing valve
  - Two-point
  - One-point



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Water-based heating

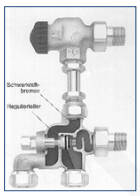
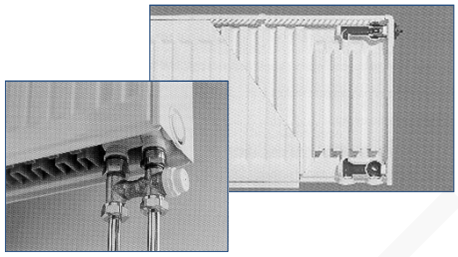
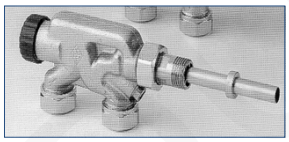
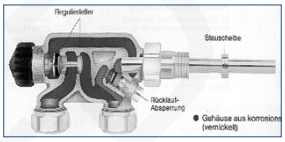
Geometry

One-pipe systems - connection

Two-point valves

One-point valves

Ventil compact

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Water-based heating

Geometry

Two-pipe x one-pipe system

- *Length of the pipes*
- *Water circulation*
- *Measuring and control*
- *Pressures in the system*

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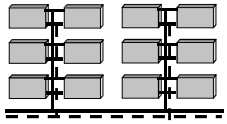
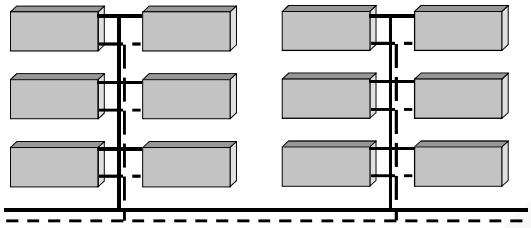
Water-based heating

Geometry

Main-pipe location



Lower



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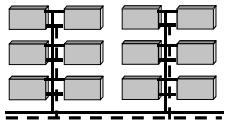
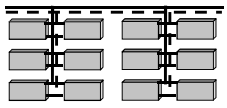
Water-based heating

Geometry

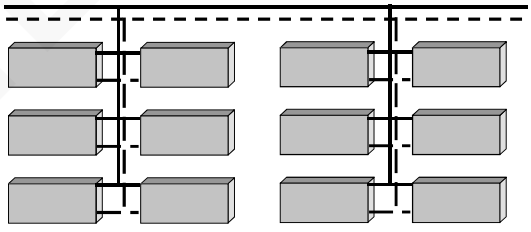
Main-pipe location



Lower



Upper



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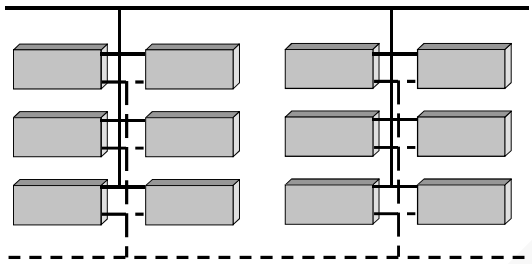
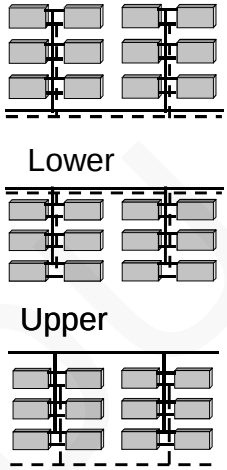
Water-based heating

Geometry

Main-pipe location





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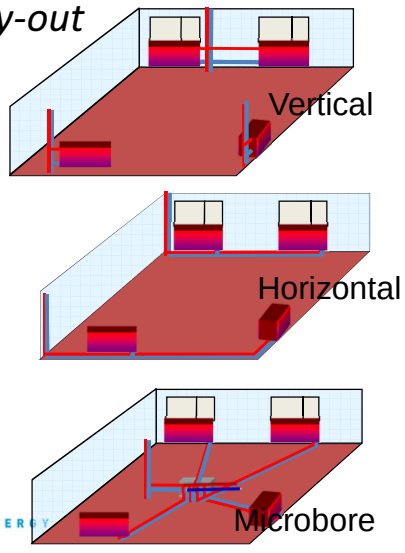
Water-based heating

Geometry

Branch pipes lay-out



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Water-based heating

Operational temperature

- *Design temperature*

  System supply t_1

  System return t_2

  Emitter supply t_{w1}

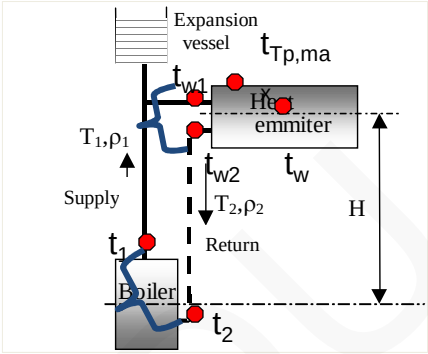
  Emitter return t_{w2}

  Mean emitter temperature tw

  Maximal emitter surface temperature $t_{Tp\ max}$

  Temperature gradient - emitter $dt_w = t_{w1} - t_{w2}$

  Temperature gradient - system $dt = t_1 - t_2$



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Water-based heating

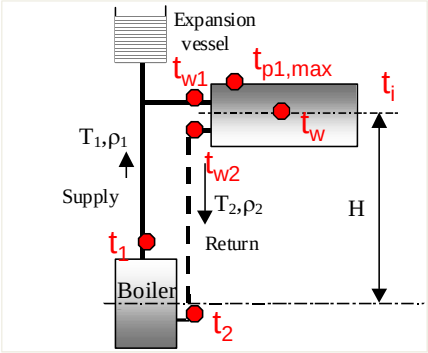
Operational temperature and output

- Heat transferred by the system

$$\dot{Q} = M \cdot c \cdot (t_1 - t_2)$$

- Heat transferred by the emitter

$$\dot{Q}_t = h \cdot A \cdot (t_w - t_i)$$



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Water-based heating

Operational temperature design criterions

- *Economical criterions*
- *Physical properties of the medium, toxicity*
- *Hygiene requirements*
- *Technical properties of the heat source*
- *Space requirements*
- *Operation, maintenance, noise*

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Water-based heating

Operational temperature design

- Heating system supply temperature:
  - Low- temperature $t_1 <= 65$ °C
  - Medium - temperature 65 °C $< t_1 <= 115$ °C
  - High temperature $t_1 > 115$ °C
- Temperature gradient- system
  - 10 K – 25 K, high temperature 40 K – 50 K.
  - 90/70 °C, 80/60 °C, 75/55 °C, 55/45 °C

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COOLING SYSTEMS

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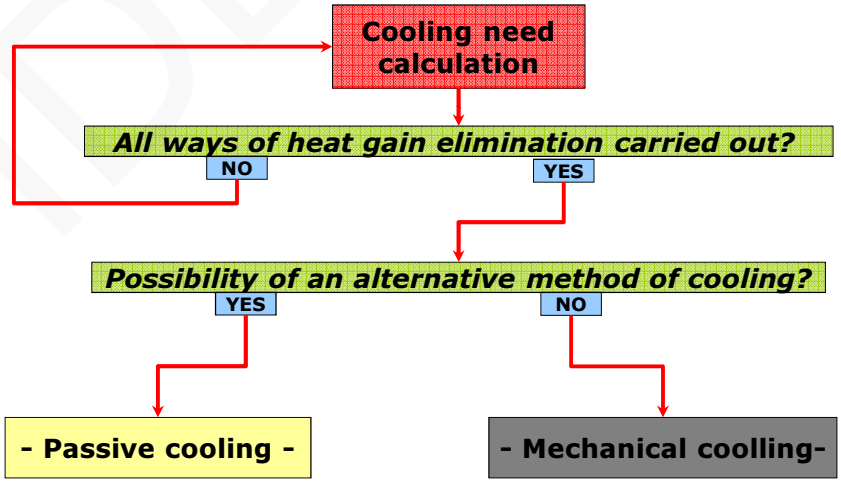
Cooling desing concept



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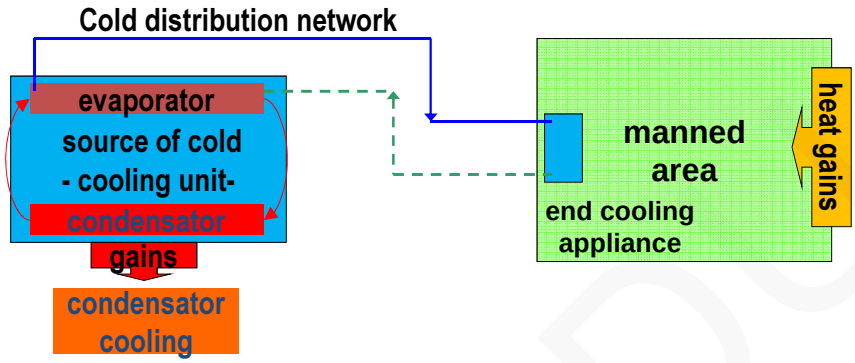
Mechanical cooling system



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Mechanical cooling system

Cooling temperature parameters design

Medium

- **chilled water** - temperature gradient 6/12, 18/25 ℃
- **binary ice**
- **refrigerant alone** - direct evaporation
- **salt solutions** - antifreeze for t < 0 ℃
- **air/air**- conditioning system

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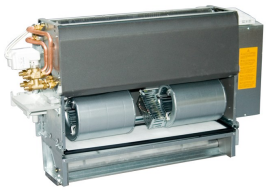
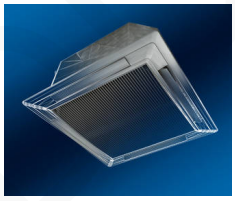
Mechanical cooling system

Chilled water distribution

- **Geometry**
  - Two-pipe *(flow and return + heating/cooling - switching mode required*)
  - Three-pipe *(heating/cooling flows separated, return shared)*
  - Four-pipe *(Flow and return separated, independent response to operation mode changes – optimal operation)*





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Mechanical cooling system

Chilled water distribution

Source: photo Karel Kabele, Arena Liberec,2005

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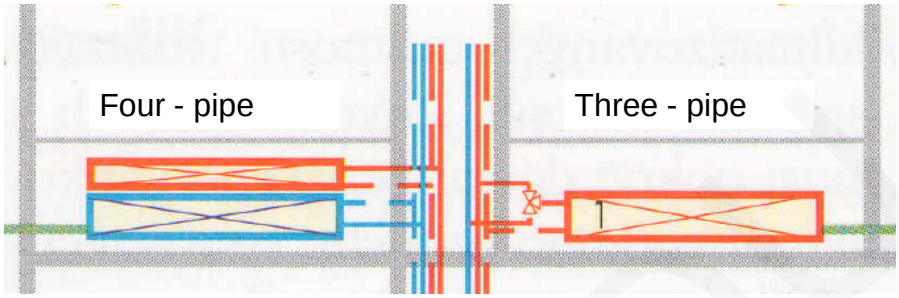
Three-pipe and Four - pipe systems
Basic schemes of the connection



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Four - pipe systems
Basic schemes of the connection

Source: photo Karel Kabele, Apartment Praha 7, 2006

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Piping materials

- The material should be selected at the beginning of the design process
- Used materials
  - steel
  - copper
  - plastic

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Piping materials
Steel

- Traditional material
- Welding

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Piping material
Copper

- Lower material usage
- Chemical reaction with water pH min7
- Electrochemical corrosion (Al)
- soldering , torch brazing

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Piping material
Plastic

- Materials
  - *Netted polyethylene (PEX, VPE),*
  - *polybuten (polybutylen, polybuten-1,PB),*
  - *polypropylen (PP-R, PP-RC,PP-3),*
  - *Chlorided PVC (C-PVC, PVC-C)*
  - *Multilayer pipes with metal*
- Life-cycle !!!
- Oxygen barierre ?

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Piping
Insulation

- Pipe insulation

Thickness of thermal insulation on internal wiring is selected in DN20> = 20 mm, DN20 to DN35> = 30 mm, DN 40 to DN 100 are selected> DN

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Insulation
Refitting in plants and buildings

Pipe insulation in heated area (no unwanted floor heating)

Insulation thicker than required by heating systems ordinance

Insulation also in difficult places

line	Type of circuits/armatures	Minimum thickness of insulation layer relating to heat conductivity of 0.035 W/(m*K)
1	Internal diameter up to 22 mm	20 mm
2	Internal diameter from 22 mm to 35 mm	30 mm
3	Internal diameter from 35 mm to 100 mm	equal to internal diameter
4	Internal diameter over 100 mm	100 mm
5	Circuits and armatures as in lines 1 to 4 in wall and ceiling openings, at circuit intersections, circuit connection points, at central power circuit distribution points	1/2 of requirements in lines 1 to 4
6	Central heating circuits as in lines 1 to 4, which are installed after this Ordinance takes effect in components between heated rooms used by multiple users.	1/2 of requirements in lines 1 to 4
7	Circuits as in line 6 used in floor construction	6 mm

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Dispersal losses

Parts without insulation = equivalent pipe length
e.g. DN 100 approx. 0.8m at 3.4 W/mK insulated actual length at 0.2 W/mK

Degree of dispersal effect should be around 96% - 99% depending on network length but may be below 90%

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Distribution network

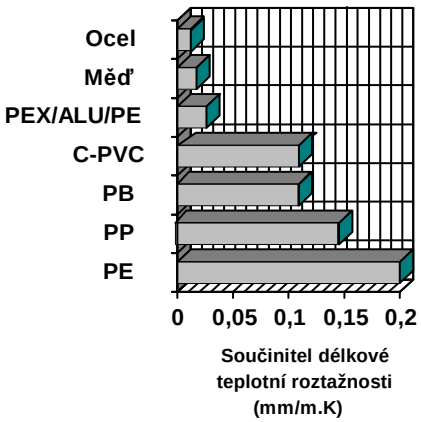
Materials – linear dilatation

Pipe materials

Galvanized steel pipes

plastic pipes
PP, RPE, PB,
VC, laminated tubes

copper pipe



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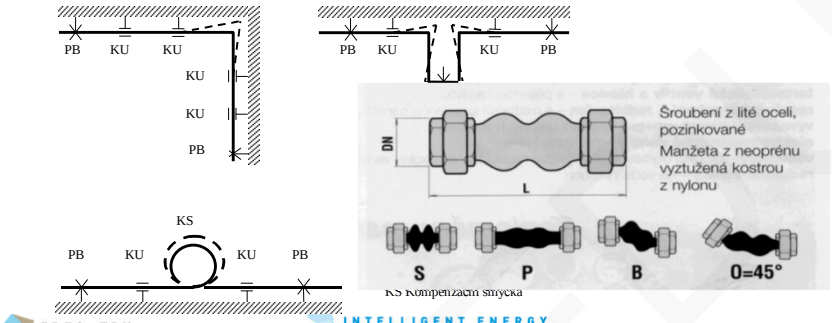
Compensation of linear expansion

- compensators (axial bellows, rubber)
- compensation path



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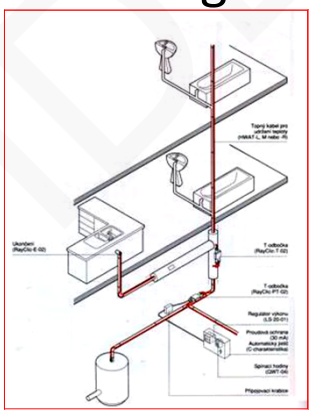
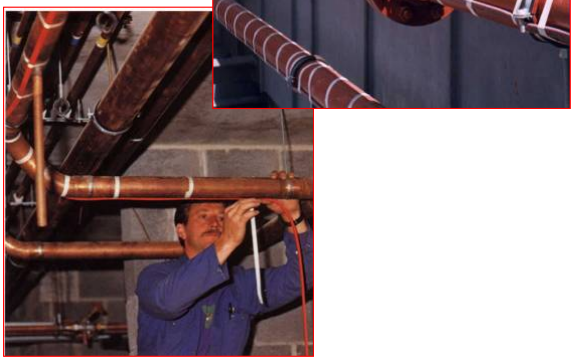
Pipe reheating by self-regulating heating cable





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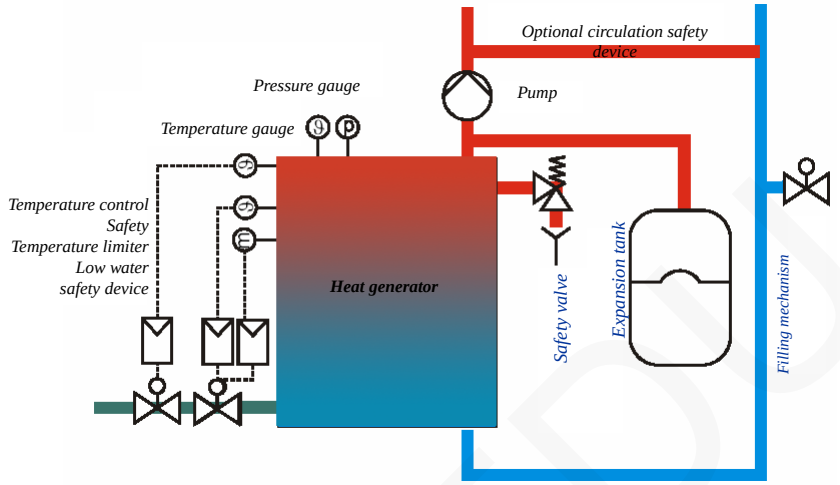
Safety devices

Heat generating boiler



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Safety devices

- **Safety device**
  - devices that protect against excessive heat pressure, vacuum, temperature, and against the lack of water in the system
- **Expansion tank**
  - compensates changes in thermal expansion of a water heating system without unnecessary losses;
  - maintains pressure in the heating system within the prescribed limits;
  - Automatic water supply to the heating system
- **EN 12828**

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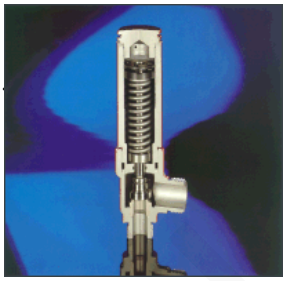
Safety valve



- Always directly at the source, without any possibility of closing
  - Gauge-pressure
    - Safety valve or hydrostatically
  - Temperature
    - At the highest operating temperature the fuel or air supply will be closed
  - Lack of water in the system
    - When the pressure drops in the system it indicates, or automatically closes the fuel supply
- Barometer, thermometer (water shortage sensor)

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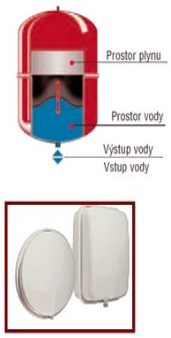
Expansion tank

Expansion devices are according to the source pressure, which may be:

- Hydrostatic pressure (svislé potrubí s otevřenou nádobou);
- čerpadlo s přepouštěcí armaturou;
- přepouštění z vyšší tlakové hladiny na nižší;
- přetlak plynového nebo parního polštáře působícího přímo na vodní hladinu v systému nebo přes membránu či vak s konstantním nebo proměnným množstvím plynu.



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Safety devices - cooling

- **Gauge-pressure**
  - each source of cold must be equipped with safety valve
- **Thermal expansion**
  - operating temperature is significantly lower than for the heating system
  - volume changes of the medium
  - usually smaller expansion volumes
- **Quality assurance of working medium**
  - follow the requirements of the producer
  - pH neutralization or demineralization usually sufficient (larger installations with small water treatment plants - for filling)
  - Mechanical protection against dirt

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