Effective water balancing to optimize energy efficiency

Energy Efficiency – Innovation, Technology & Experience Workshop

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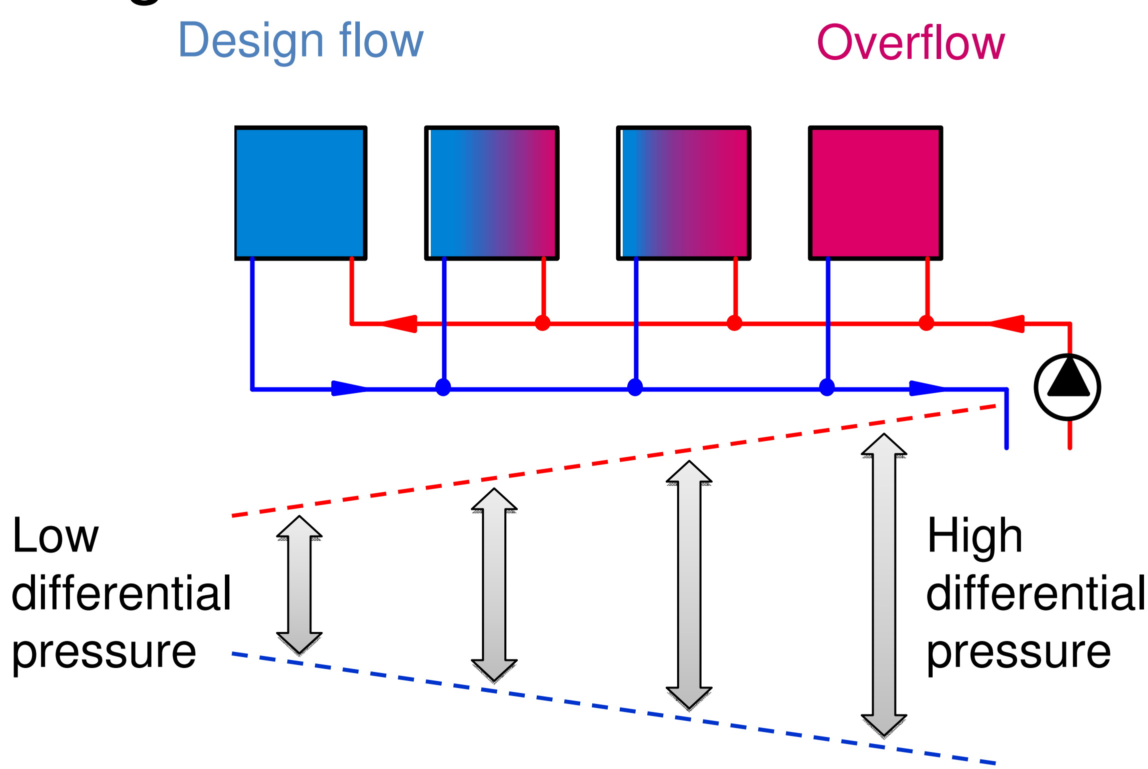
HYDRONIC COLLEGE

Needs for balancing

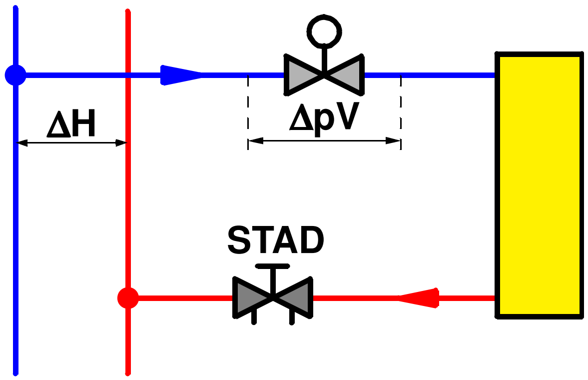
- To overcome difference in pipe and fittings pressure drops
- Terminal units are generally oversized
- Control valves oversizing
- Pump oversizing



Control valve oversizing

Control valves are commercially available with Kvs values increasing according to the Reynard series:

Kvs: 1.0 1.6 2.5 4.0 6.3 10 16 …

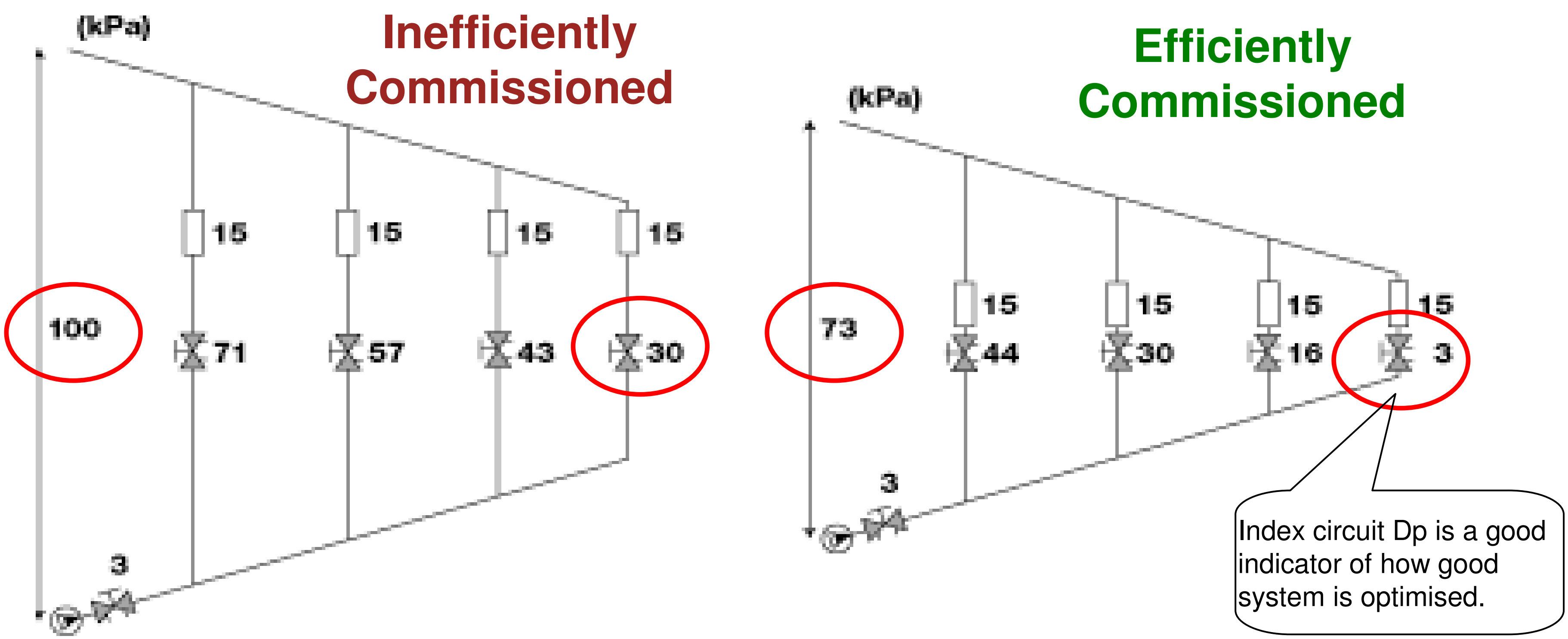


For a water flow of 6 m³/h=1.66 l/s, the commercially available control valves create a design ΔpV of:
14, 36 or 91 kPa, nothing in between.

Conclusion:
Control valves are generally **oversized**.

Objectives of balancing

- Every terminal obtain design flow at design condition
- To obtain the minimum pump head required
  - In most case, index circuit takes excessive pressure drop
  - Index circuit not identified correctly



Energy saving hierarchy

Dynamic balanced system

- Reduced overflow at part load

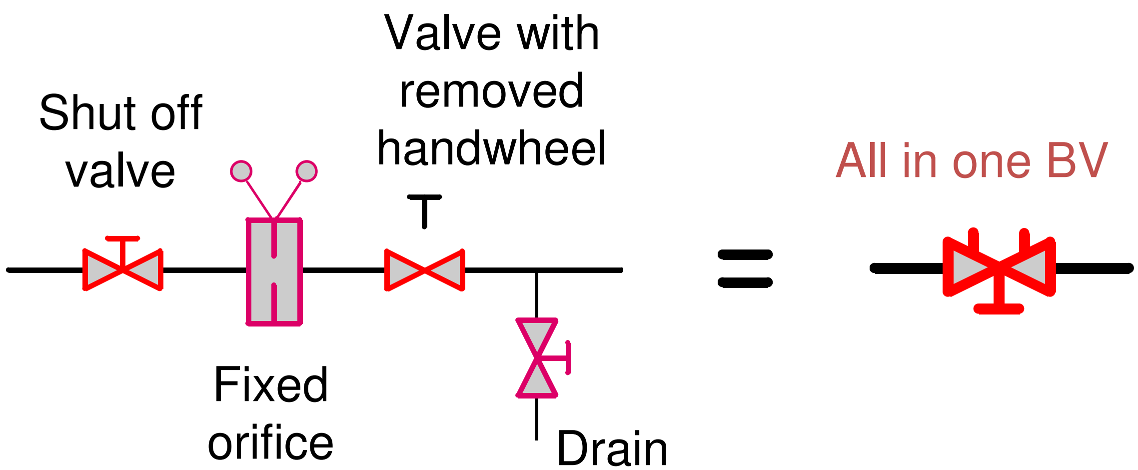
Balanced system at design condition

- Reduced overflow
- Optimized pump head

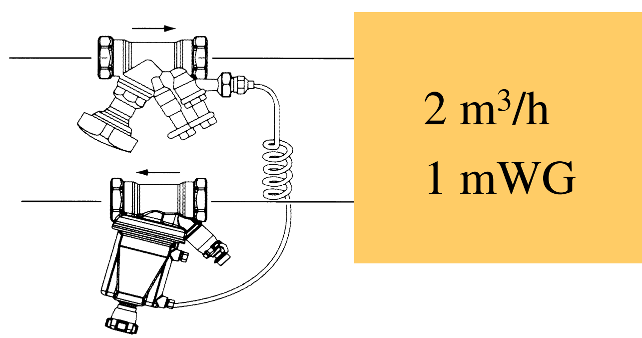
Oversized plant

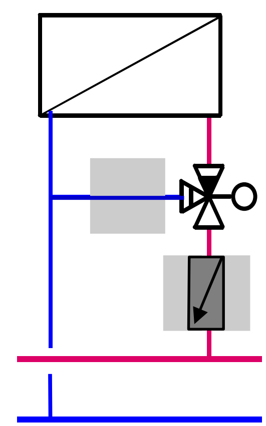
3 balancing measures

- Manual balancing valve



- Automatic flow controller
- Differential pressure controller

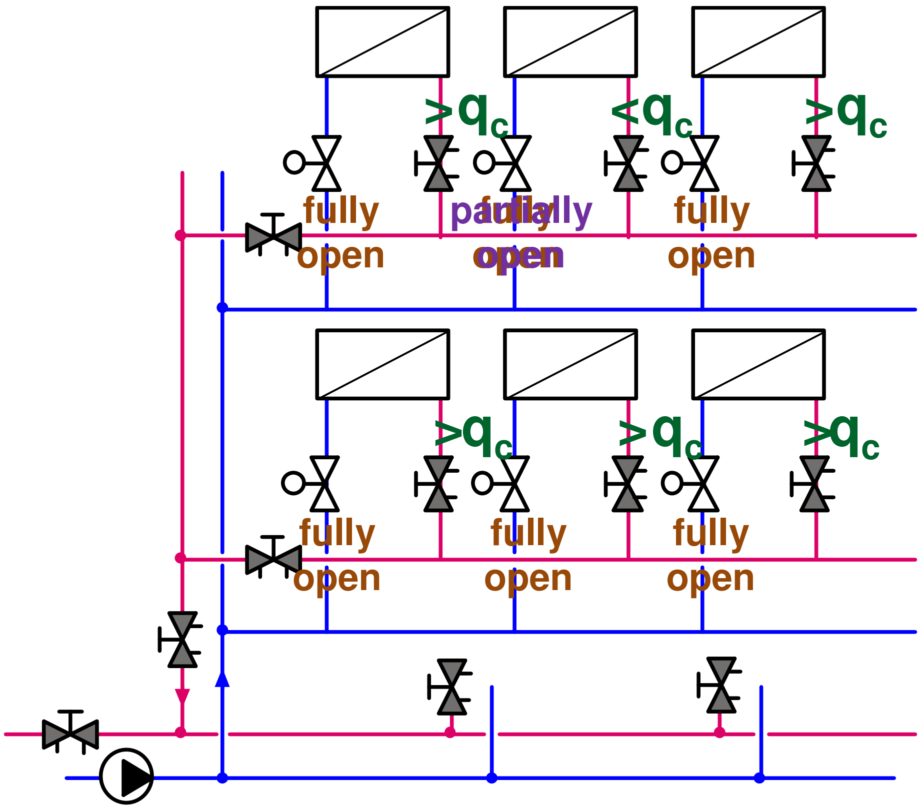




Manual balancing

Adjusting the **design flows** in all terminal units in **design conditions**

- Design conditions are the "worst" plant operating conditions, under which maximum flow is required : control valves are all fully open.
- If design flows are adjusted under design conditions, they can be obtained in all other conditions.



This should be achieved while creating the **absolute minimum amount** of **additional pressure drops**.

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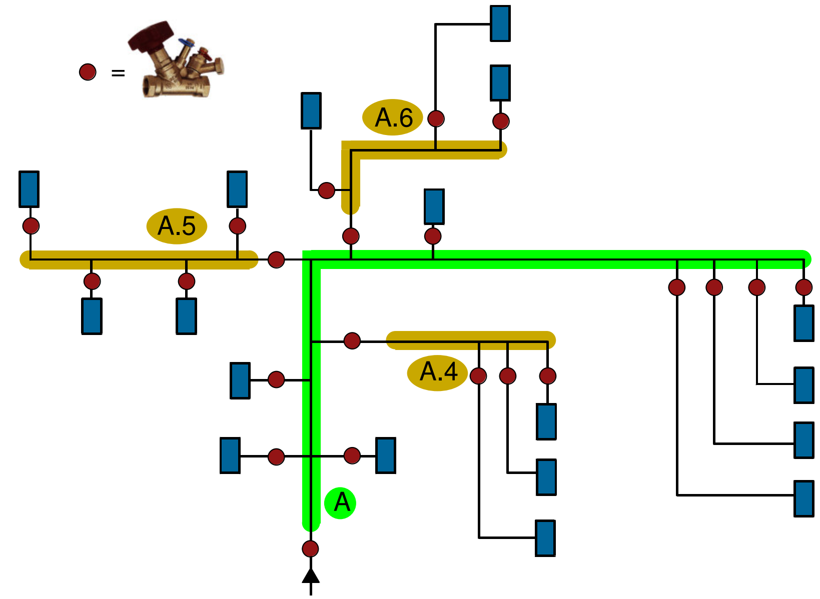
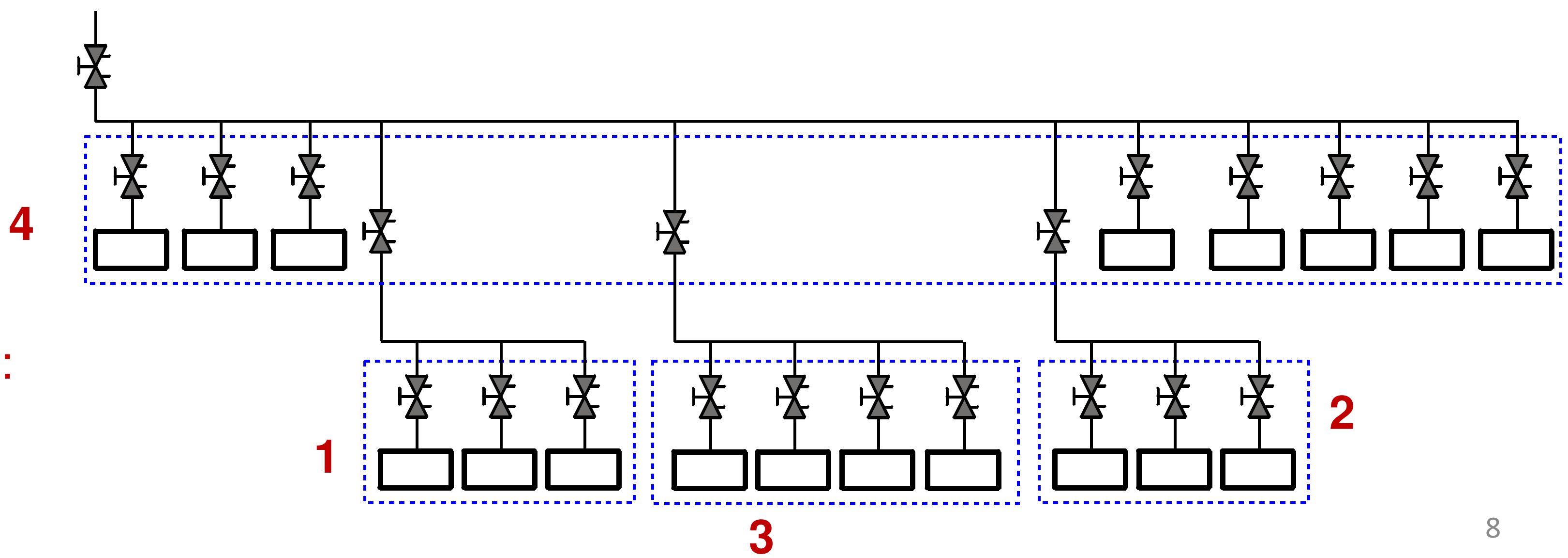
Order for balancing modules

The structure of hydronic modules can be seen as a hierarchical tree.

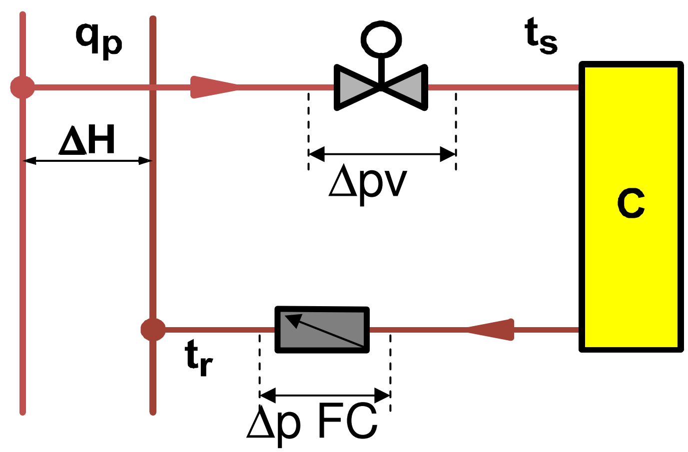
Before a module can be balanced, the whole descent of this module must be balanced.



Balancing order:



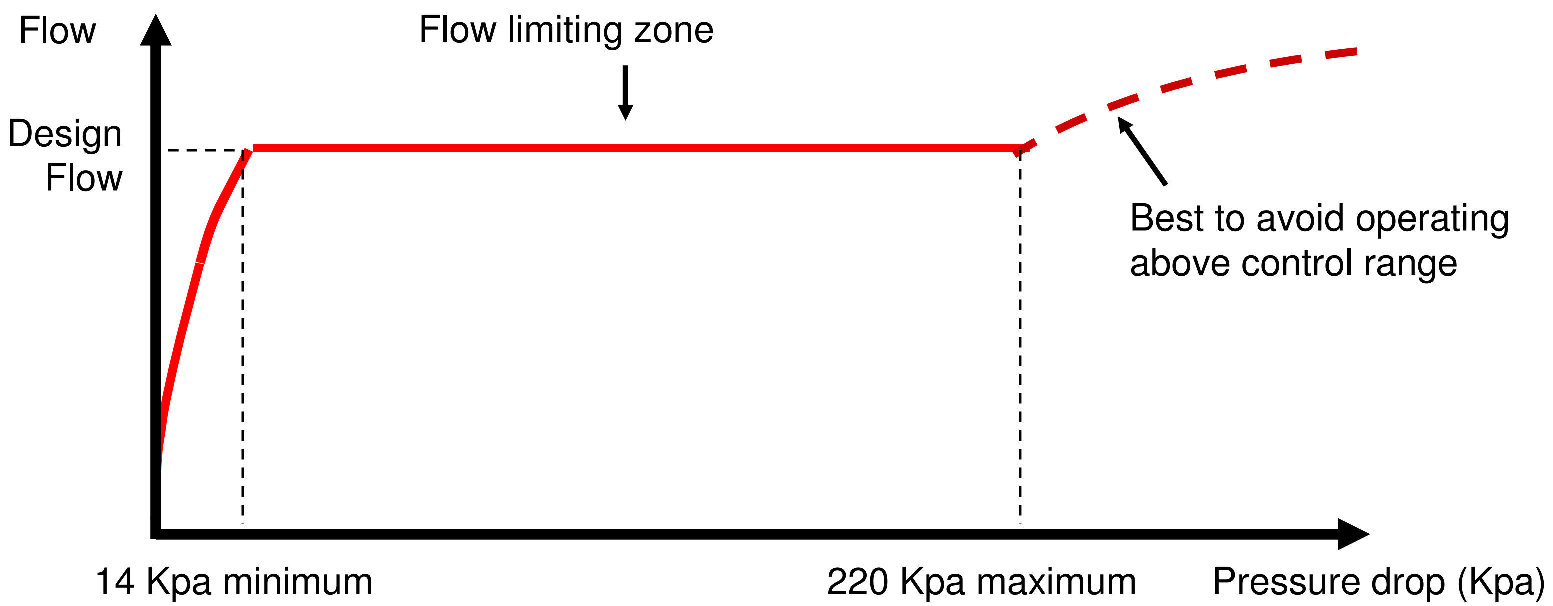
Automatic flow controller - characteristic



Δp FC: 0 to 14 Kpa at flow 0 to 100%

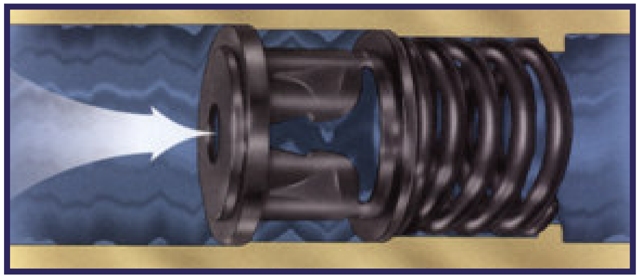
Δp FC: 14 to 220 Kpa at design flow

flow accuracy: ± 5%

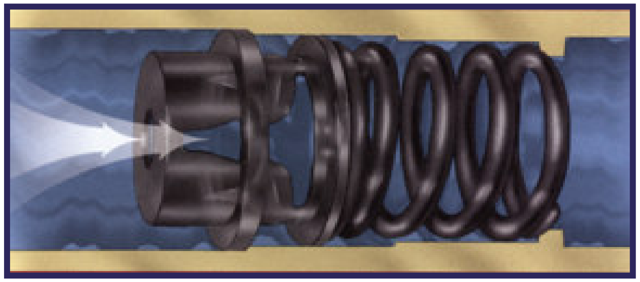


Automatic Flow Control Operation

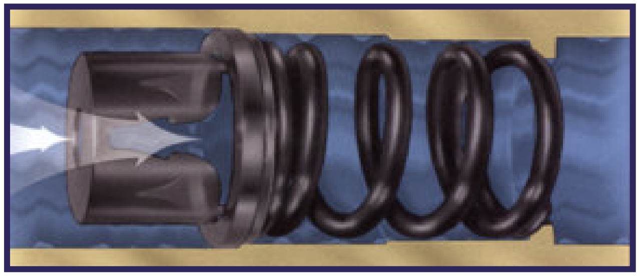
- Example for 14 to 220kPaD range cartridge.



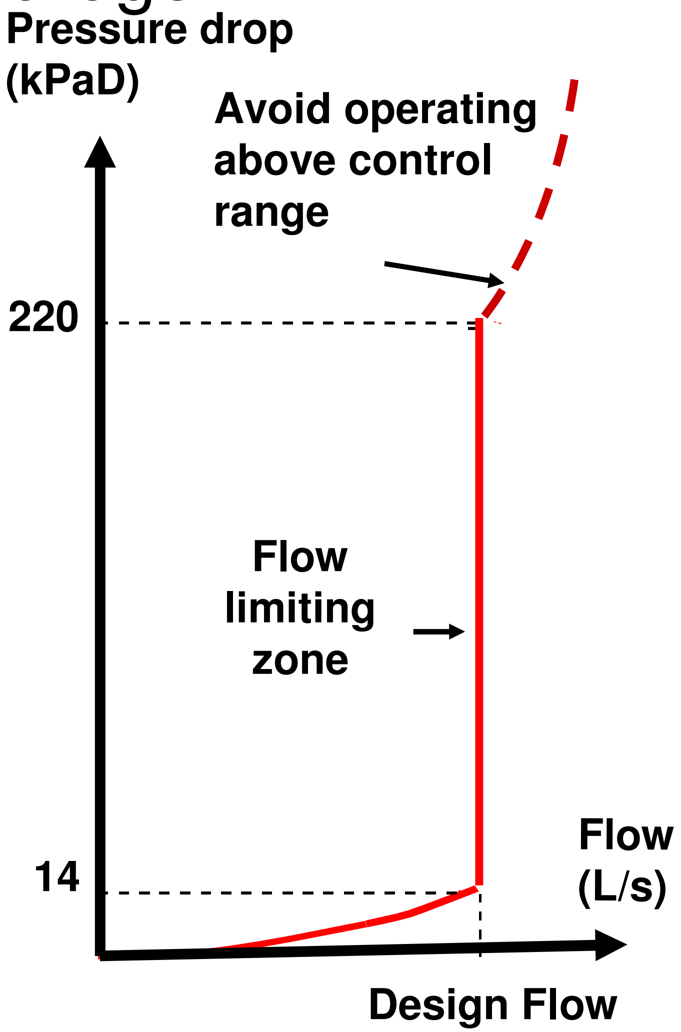
Above maximum differential pressure piston fully compresses & acts as fixed orifice.



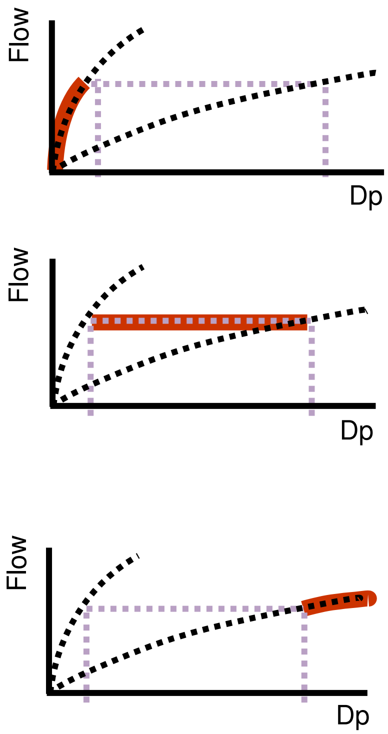
Within differential pressure range, piston responds limit to design flow ±5%.

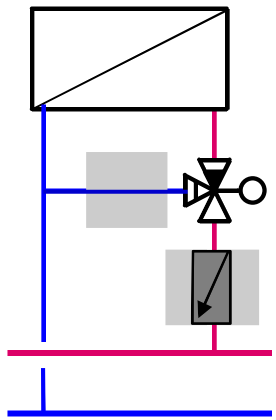


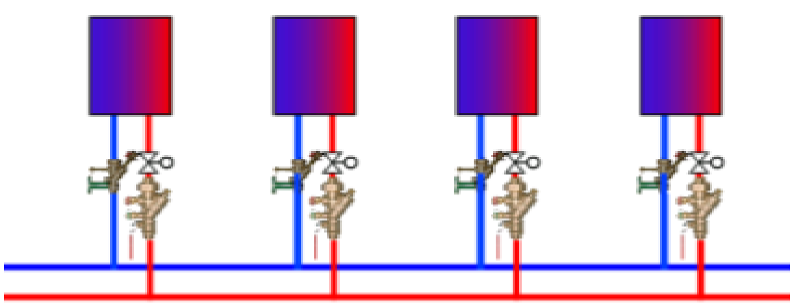
Below minimum differential pressure piston fully extends & acts as a fixed orifice.



Automatic Balancing







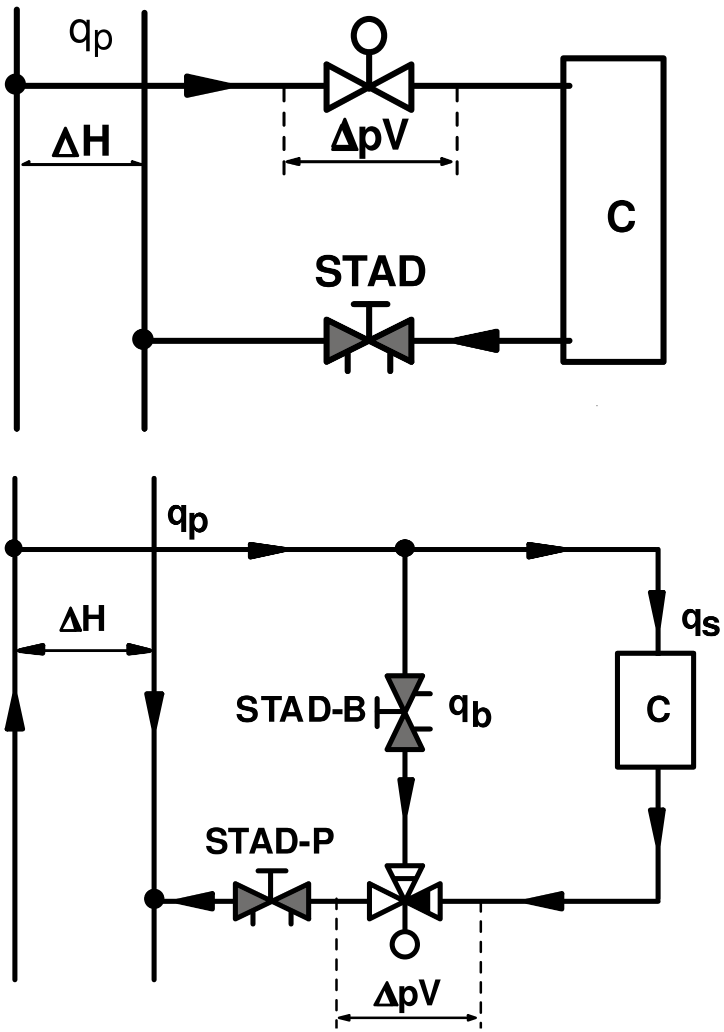
CONSTANT FLOW SYSTEMS

- Good solution to avoid balancing methods
- Technical the same quality as with manual balancing valves due to constant flow and pressure conditions

VARIABLE FLOW SYSTEMS

- Works excellent with ON/OFF control valves
- Valve authority could be poor in modulating control

Control valve authority

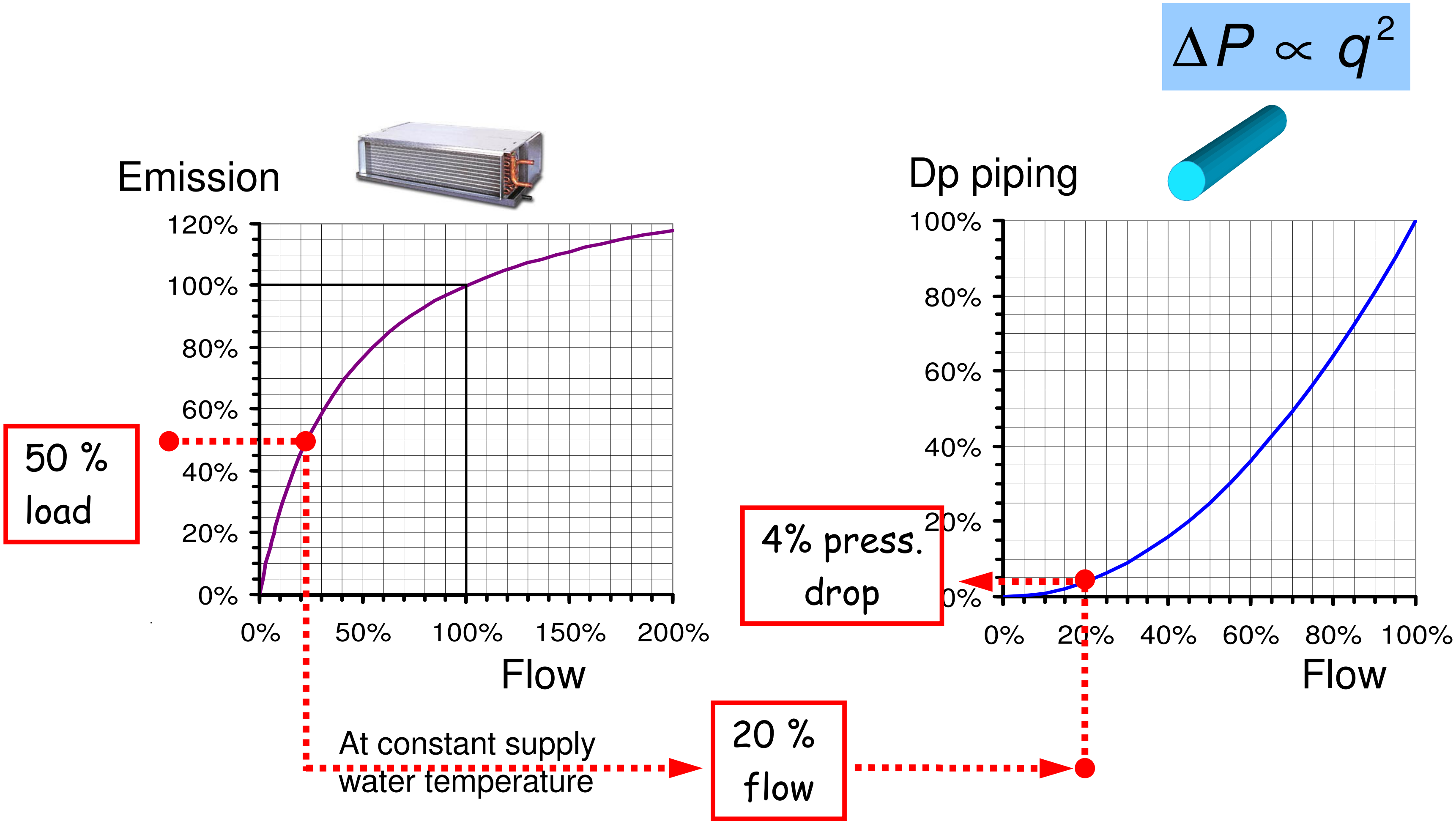


$$\beta = \frac{\Delta P_{\text{Control valve fully open and design flow}}}{\Delta P_{\text{Control valve fully shut}}}$$

The authority formulates how much the differential pressure builds up on the control orifice of a control valve when it is closing

Its value indicates how effectively the control valve can reduce the flow while it is closing.

Differential pressure variations



Pressure drops are reduced to 4% of their design value.

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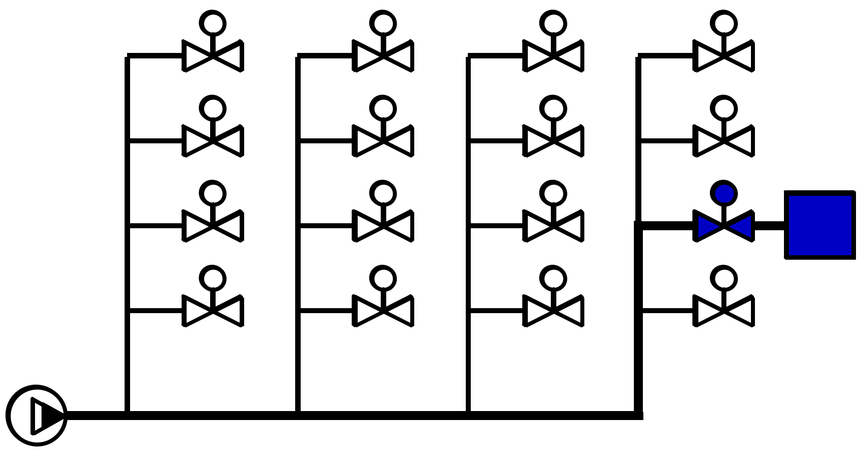
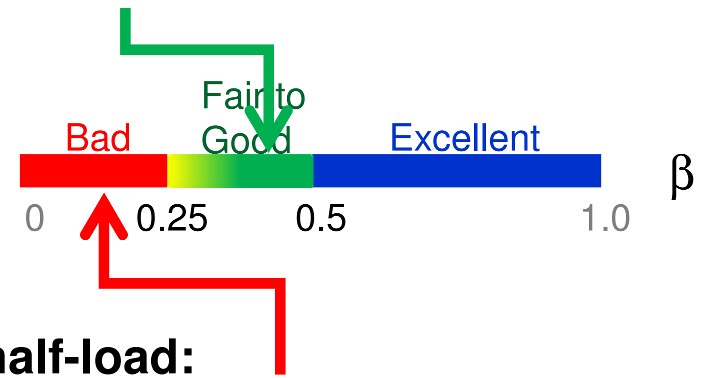
Variable authority of 2-way control valves

Example:



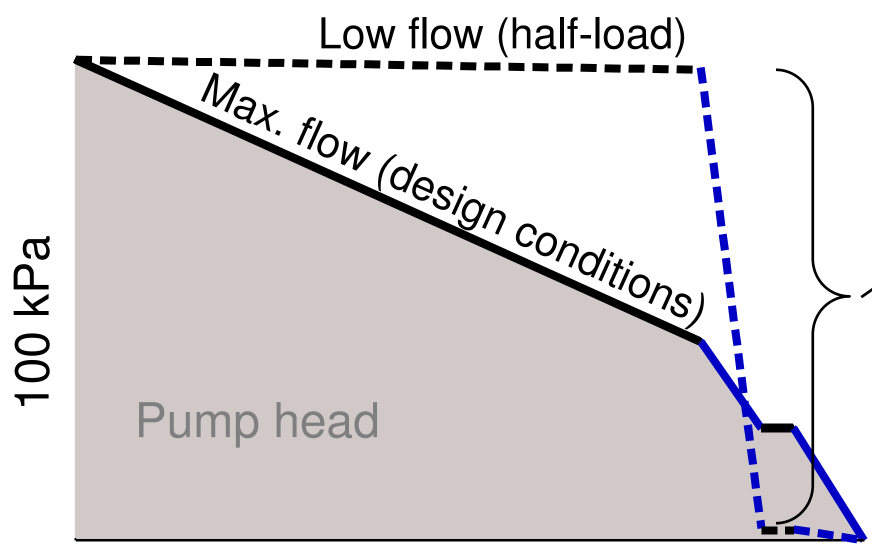
Authority in design conditions:

β ≈ 15/(15+20) = **0.43**



Authority at half-load:

β = 15/(15+20+0.96*65) = **0.15 !**



0.96*65 kPa+0.96*20 kPa ≈ 82 kPa in excess in the valve at half-load

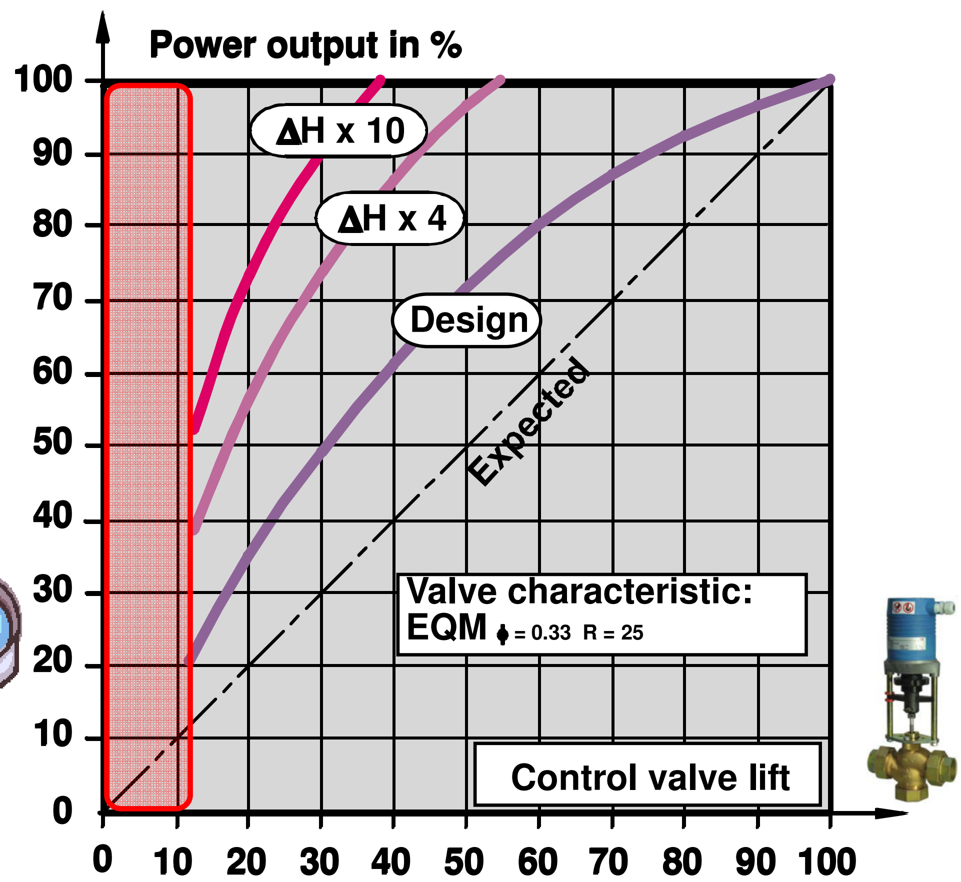
15 kPa in the valve

20 kPa in the circuit

Effect of Dp variations on controlled heat output

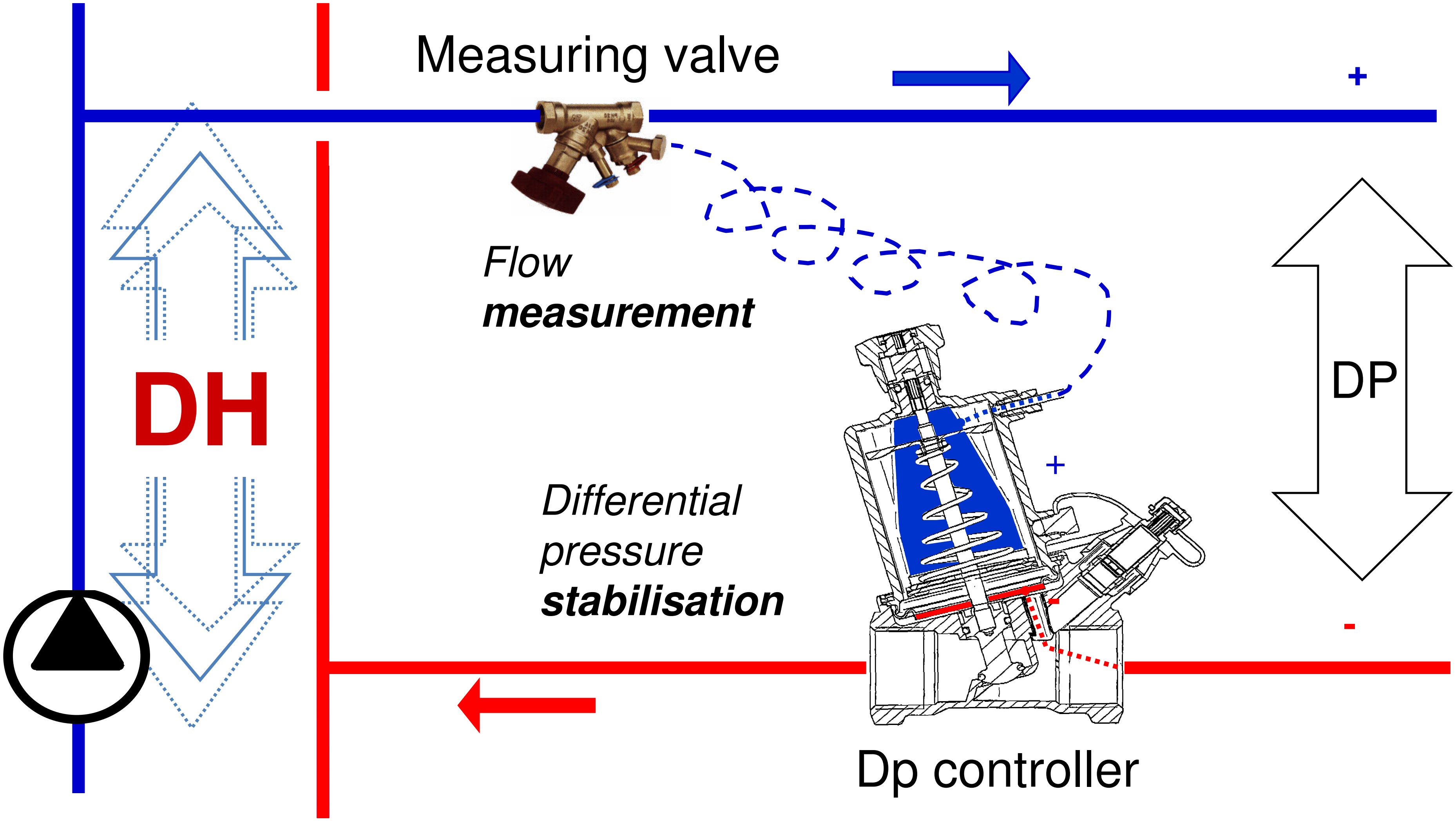
Δp variations distort the characteristic of the control valve

⇨ the nonlinear characteristic of the terminal unit is no longer compensated

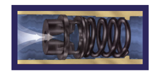
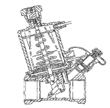


Rangeability
area of the
control valve

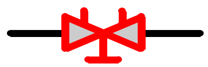
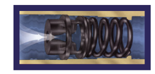
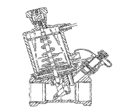
Dp controller operation



Summary

	Manual Balancing 	Automatic Flow Controller 	Dp Controller 
Application	Constant flow, On/Off	Constant flow, On/Off	Variable flow, On/Off or Modulating
Pressure drops calculation	Necessary	Necessary	Necessary
Installation requirement	Before or after terminal unit, several diameters before and after balancing valve	Downstream of terminal units	At water return side
Balancing method	1.Proportional 2.Compensated 3.Computerised	Not necessary	Not necessary

Summary

	Manual Balancing 	Automatic Flow Controller 	Dp Controller 
Equipment	Manometer/computerized balancing instrument	Manometer	Manometer
Flow measurement	Yes	No	Yes
Tolerance	≥ ±5%	± 5%	≥ ±5%
Balancing time	≈ 30min per balancing valve	≈ 3min per AFC (Dp verification only)	≈ 5min per Dp Controller
Change of flow	System level rebalancing	Replace cartridge/canister	Adjust spring pressure

Saving case 1

Pfizer pharmaceutical production unit nearby Tours (France)

- Installed cooling capacity of 5.4 MW (3 chillers in cascade)
- Total design flow: 773 m^3/h = 215 l/s
- Problem: production alarms !
- 80 balancing valves from DN 15 to DN 200

- Audit of plant with TA Select based on a first measurement campaign (presettings calculated, viscosity corrections checked)
- Full balancing performed using TA-Balance on one TA-CBI

Saving case 1

Before balancing

Industrial plant
5,4 MW cooling capacity

889 m³/h=247 l/s
335 kPa pump head

After balancing

773 m³/h=215 l/s (-13%)

No production alarms!

270 kPa pump head (-20%)

Pumping power reduction : 39 kW

Savings : 17200 €/year
13500 £/year

Saving case 2 – HKPU Dean office

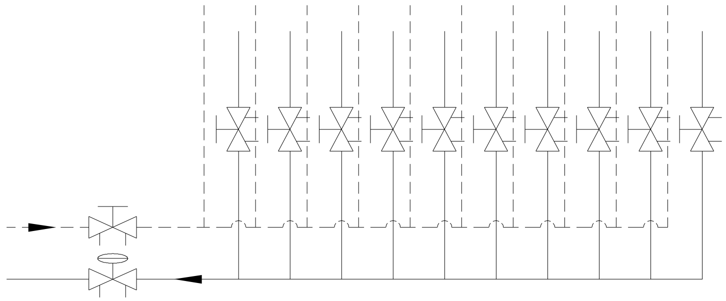
- 10 x STAD DN20 at FCU terminal level, 1 x STAD DN50 and 1 x STAP DN50 in partner pair at distribution piping
- **Without balancing : Total flow 0.9 l/s, ΔT=6°C, output 22.5kW**
- **After balancing : Total flow 0.6 l/s, ΔT=7°C, output 17.5kW**
- Eliminate over-duty 5kW or 22%, total flow down 33%

  Equivalent to 284 sq. ft. of cooling space

  OR

  2 sets of 1HP window type AC

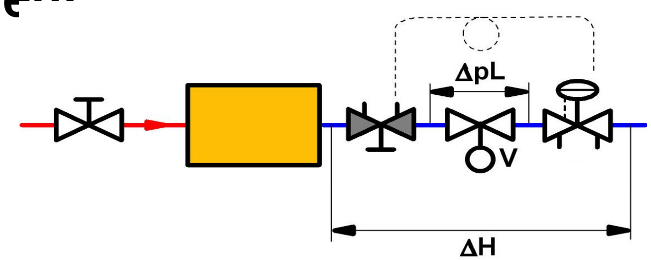
  with Grade 1 energy label



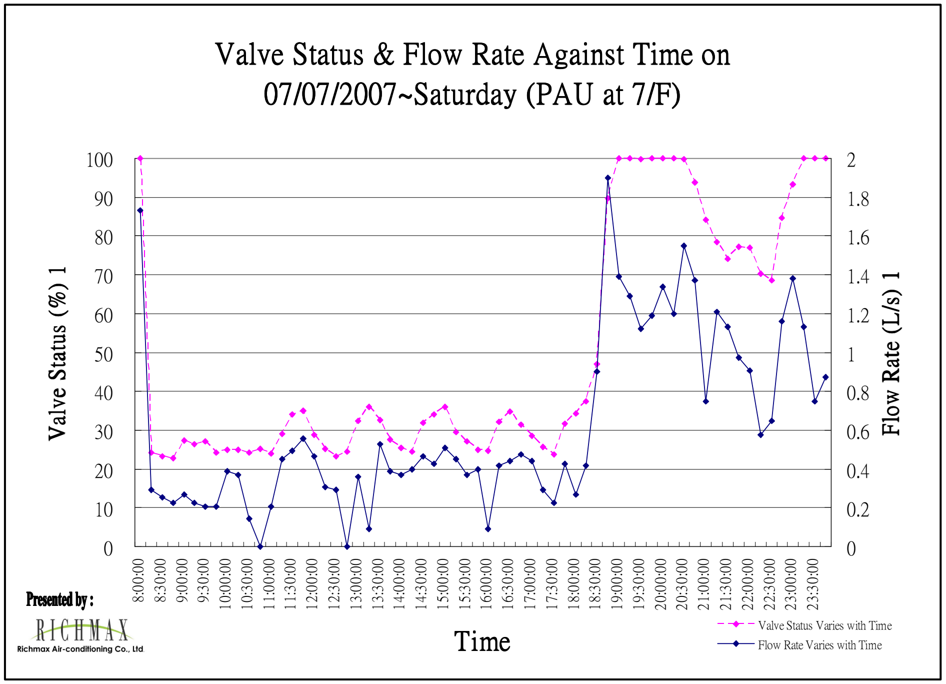
Saving case 3 – HK Polytechnics

<u>Wing P-Q hydronic system improvement at 7/F & 8/F PAUs</u>

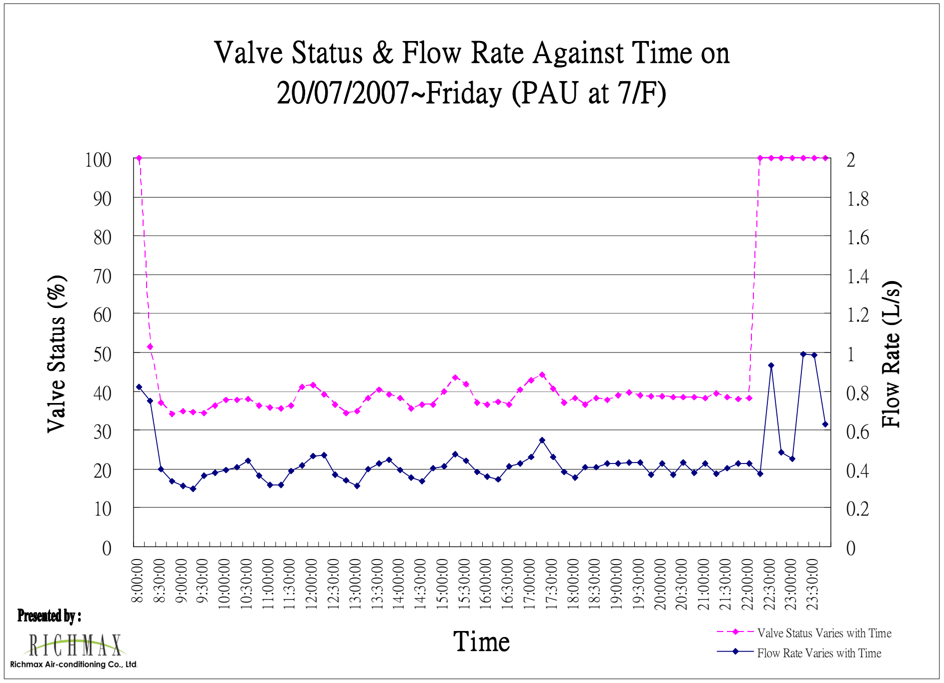
- **Overflow analysis showed 20% overflow at 40% loading**
- **Replace existing balancing valve and add DP controller work in partner pair at PAU piping branch**
- **Re-balance with TA computerized balancing instrument**



Improved controllability



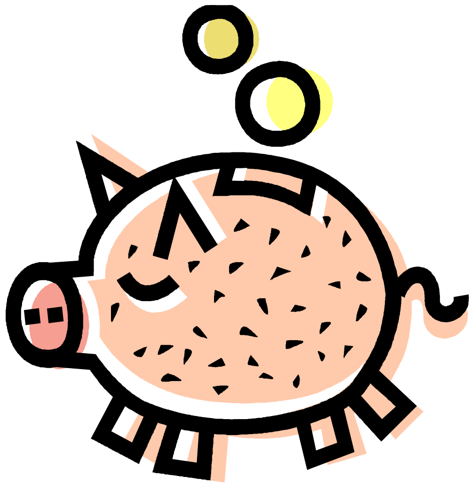
BEFORE



AFTER

Key results

❖ Over-duty reduction	896 kWH/wk
❖ Energy input saving (COP = 2.5)	358 kWH/wk
❖ Saving per month ($0.9/kWH)	$1,450.00/mth
❖ Equipment, installation & balancing	$20,000.00
❖ Payback	13.8 mths

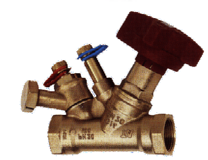


Diagnostic is a key point

Through balancing, many hydronic problems may be detected:

- Filters or valves clogged
- Terminal units or exchangers wrongly mounted
- Pipe damaged or not connected as expected
- Shut-off valves partially shut
- Check valves or pumps installed back-to-front

Balancing exposes these flaws while they can still be cheaply repaired.



Diagnostic is one of the main use of balancing valves.

Thank you for your attention !

Questions ?