EmiratesGBC Technical Workshop

Delta T problem in chilled water systems

Low delta T syndrome in commercial buildings - prevention and solutions

Facilitator	Company	Date
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Low delta T syndrome

- The difference between supply and return chilled water temperature goes under the design value causing the cooling plant to work less efficiently during more than 90 percent of the years since the full load condition only happens at pick load during summer day time.
- Low delta T syndrome is forcing the plant to consume more energy and building side end users to pay surcharges or penalties.

Reasons of Low delta T syndrome

Main reasons: Design & selection, commissioning, maintenance & operation.

1. Design & selection: Oversized or undersized cooling coils & control valves will cause overflows and reduce exchange efficiency resulting in low return temperature.

2. Lack of maintenance of the equipment eg. Dirty air filter or coils (outside fins or inside the coil) with reduce the exchange efficiency and cause low return temperature.

3. Commissioning: wrong hydronic balancing and pump optimization will result in over pumping during part load causing low return temperature.

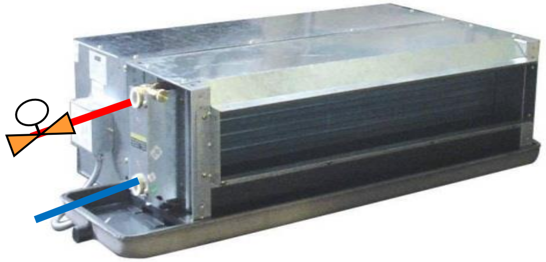
……………………Example of the above listed below………………………………

Design & Selection

Common cases: valve size = pipe size

This will cause the valve to have lower pressure drop and reduced authority that will directly affect the flow control range and the valve will work as ON/OFF instead of Modulating.

Cooling coil: oversized cooling coil might lead to bigger tube when modulating and the water velocity will be less than the minimum of 0.3m/s (min 0.3m/s & max 1.5m/s) below 0.3m/s the flow will not be turbulent for proper exchange and lead to reduced return temperature.



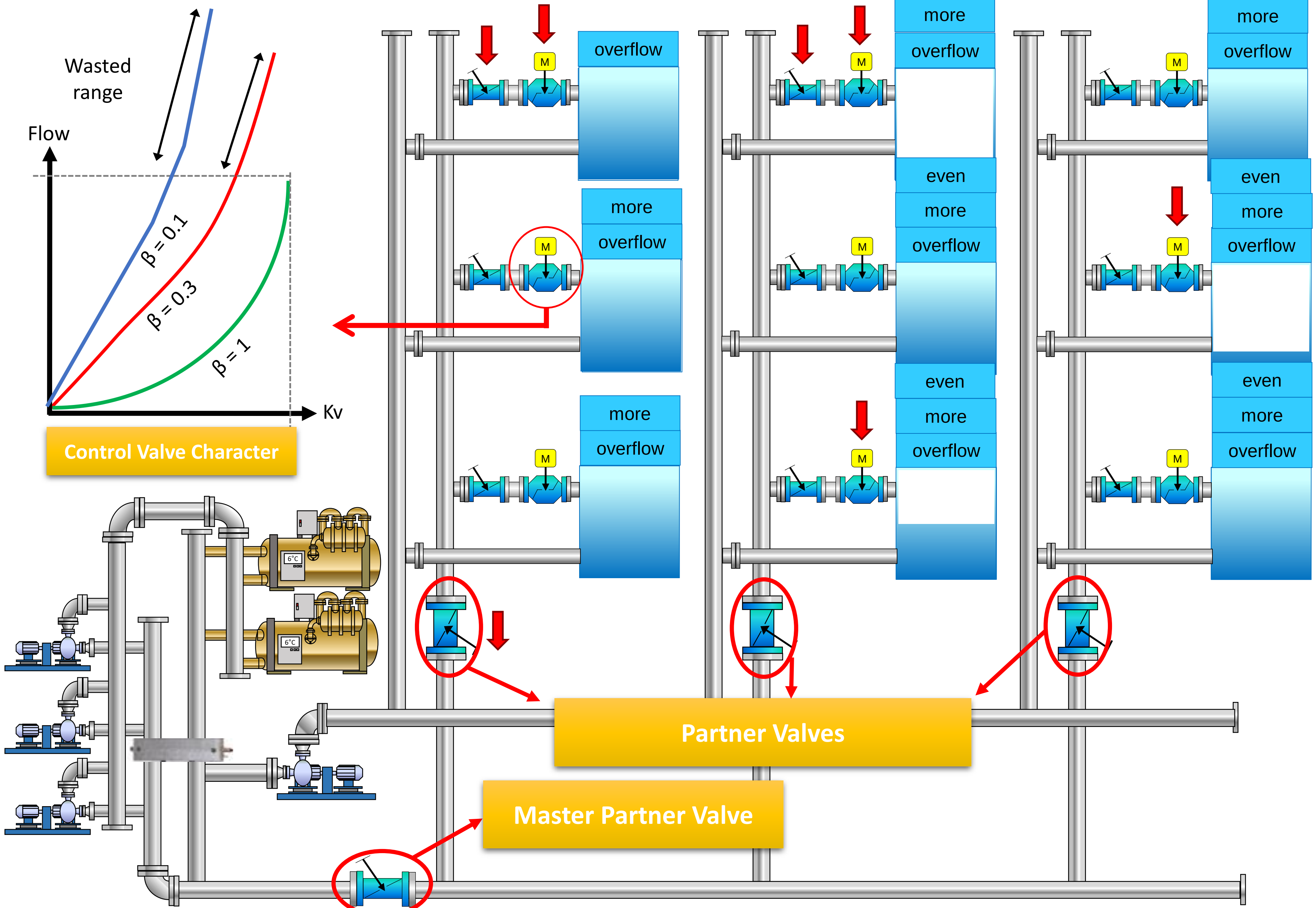
Maintenance

Poor maintenance lead to lower exchange and discomfort

Dirty air filter lead to inefficient exchange & low return chilled water temperature.

Blocked strainer lead to less flow which will push the controller to open the valve further and cause overflow.

HYDRONIC SYSTEMS – VARIABLE FLOW



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CONTROL VALVE SIZING CONVENTIONAL

$Q = Kv \sqrt{\Delta P}$

$Kv = Q / \sqrt{\Delta P}$

Where

Q : flow rate m^3/hr

ΔP : pressure drop across the control valve in bar

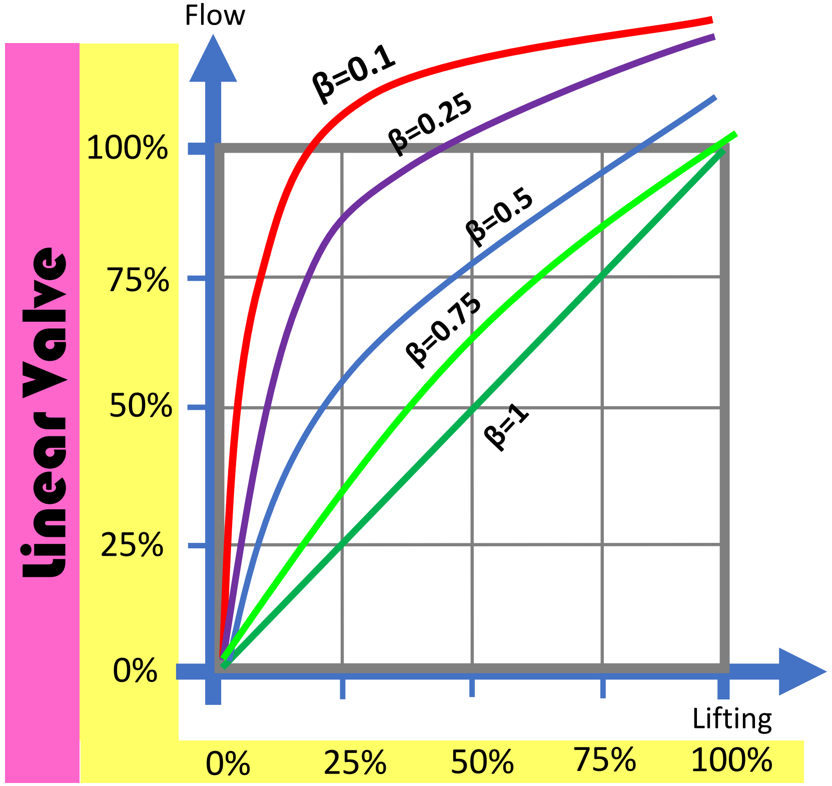
Kv : flow coefficient of the control valve

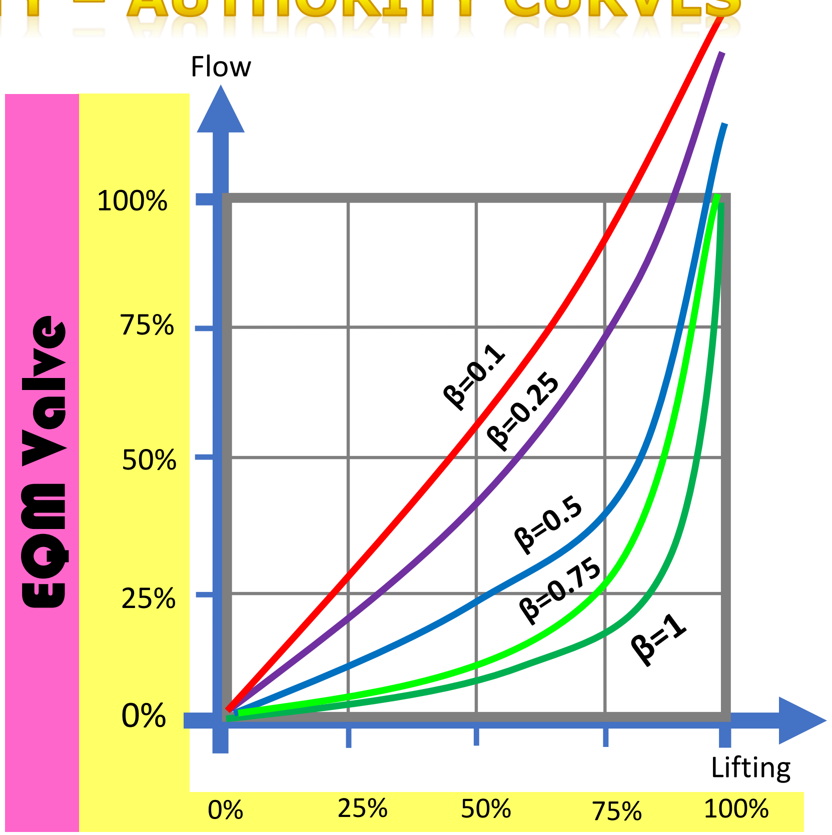
CONTROL VALVE AUTHORITY

- A calculation done to determine the performance of the control valve's characteristic & capability to control against system pressure.

$$\beta = \frac{\Delta p \text{ open valve}}{\Delta p \text{ open valve} + \Delta p \text{ system}} \; (\text{x } 100\%)$$

CONTROL VALVE AUTHORITY – AUTHORITY CURVES





Accuracy & Stability Table

Excellent	Good	Moderate	Poor	Unacceptable
1 – 0.76	0.75 – 0.51	0.5 – 0.26	0.25 – 0.11	0.1 - 0

Pipe pressure drop

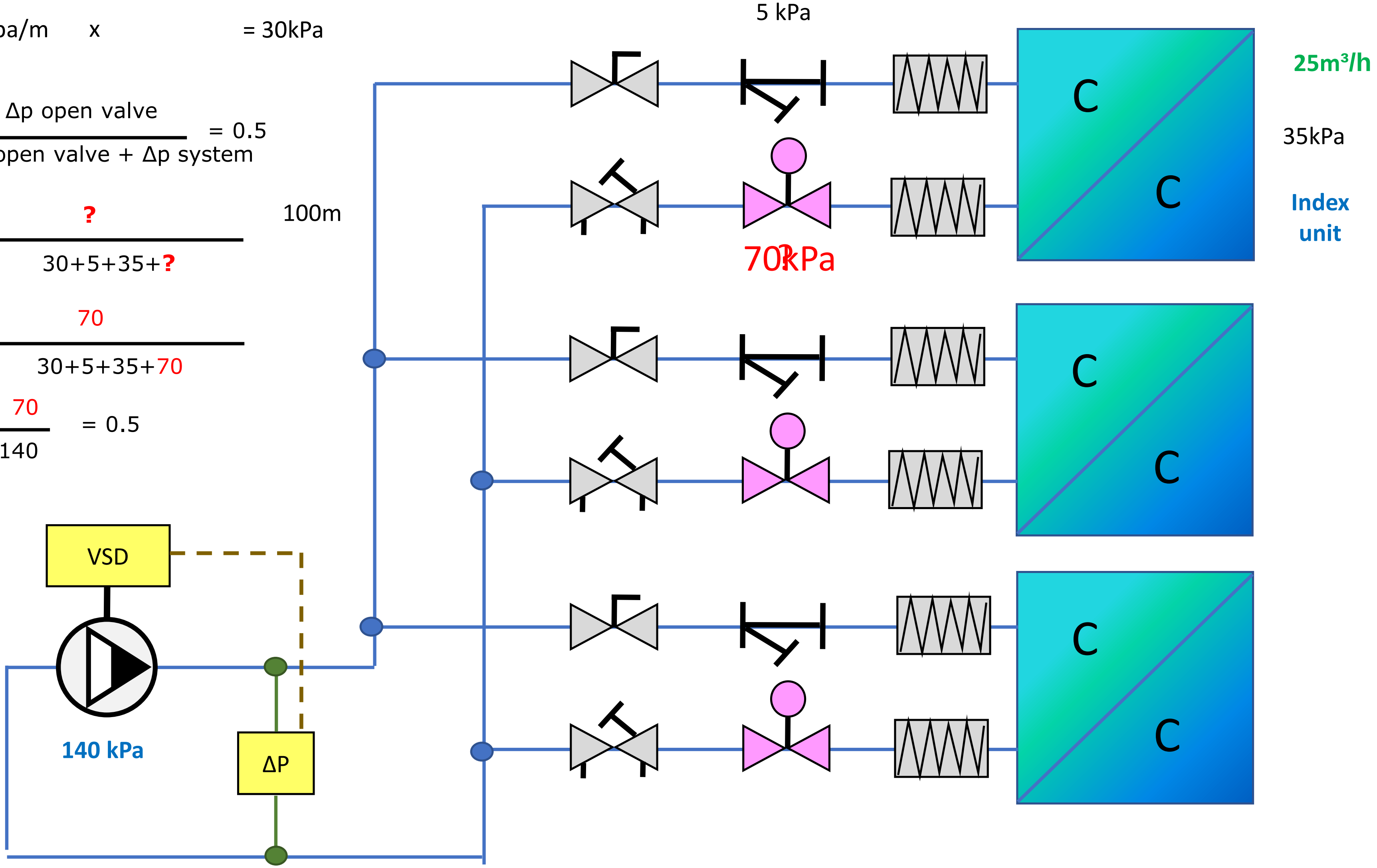
300pa/m x = 30kPa

$$\beta = \frac{\Delta p \text{ open valve}}{\Delta p \text{ open valve} + \Delta p \text{ system}} = 0.5$$

$$\beta = \frac{?}{30+5+35+?}$$

$$\beta = \frac{70}{30+5+35+70}$$

$$\beta = \frac{70}{140} = 0.5$$



Control Valve Selection

$$Kv = \frac{q}{\sqrt{\Delta p}}$$

Where: -

$$\Delta P = Bar$$

$$q = m^3/h$$

$$Kv = m^3/h$$

Valve Authority Requirement

$$\beta = \frac{70}{30+5+35+70} = 0.5$$

$$\beta = \frac{70}{140} = 0.5$$

Control Valves sizes

1.8 Kvs = DN10
4.0 Kvs = DN15
6.3 Kvs = DN25
10 Kvs = DN32
16 Kvs = DN40
25 Kvs = DN50
40Kvs = DN65
63Kvs = DN80

$$Kv = \frac{25}{\sqrt{0.7}} = \frac{25}{0.84} = 29.7$$

$$\Delta p = \left(\frac{q}{Kv}\right)^2$$

$$\Delta p = \left(\frac{25}{40}\right)^2 = 0.625^2 = 0.4$$

$$\beta = \frac{40}{140} = 0.28$$

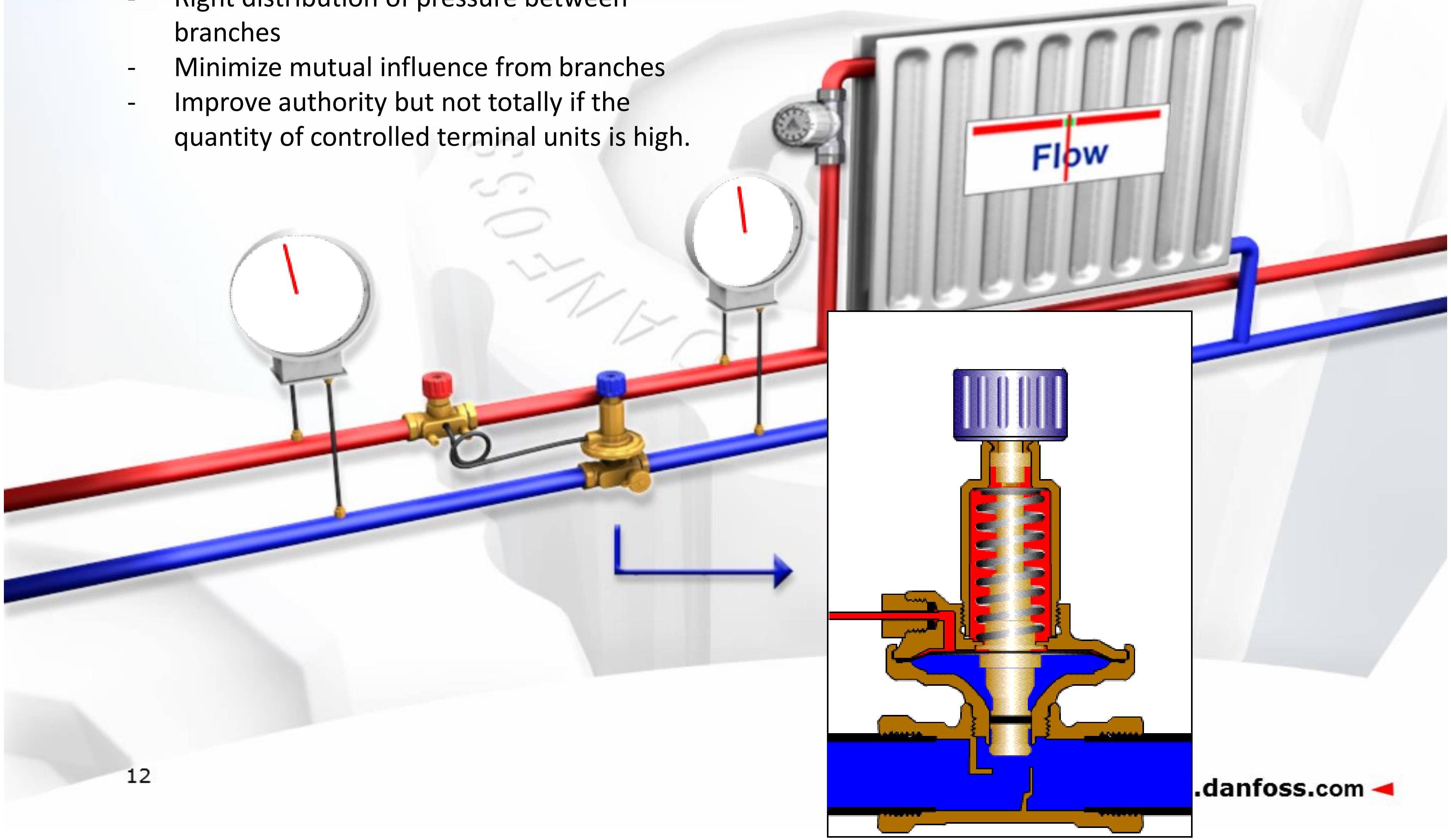
Authority not optimum

Recommended = 0.5

Mechanical DP Controllers: Diffirential Pressure Control Valve (DPCV)

Automatic Balancing Valves ASV – how they work

- Right distribution of pressure between branches
- Minimize mutual influence from branches
- Improve authority but not totally if the quantity of controlled terminal units is high.



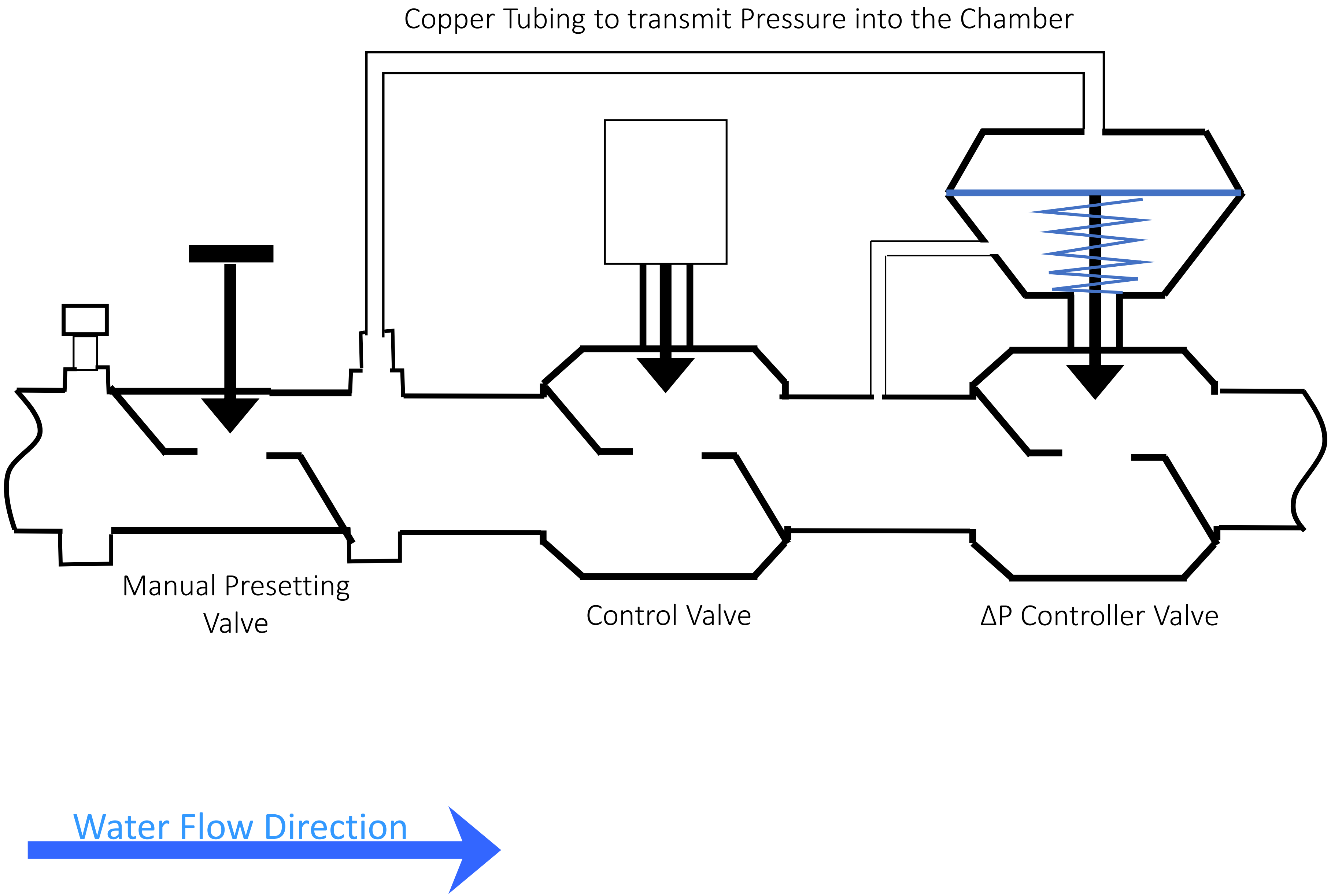
SUMMARY:

For Optimum HVAC system performance and energy efficiency/ savings we need the below:

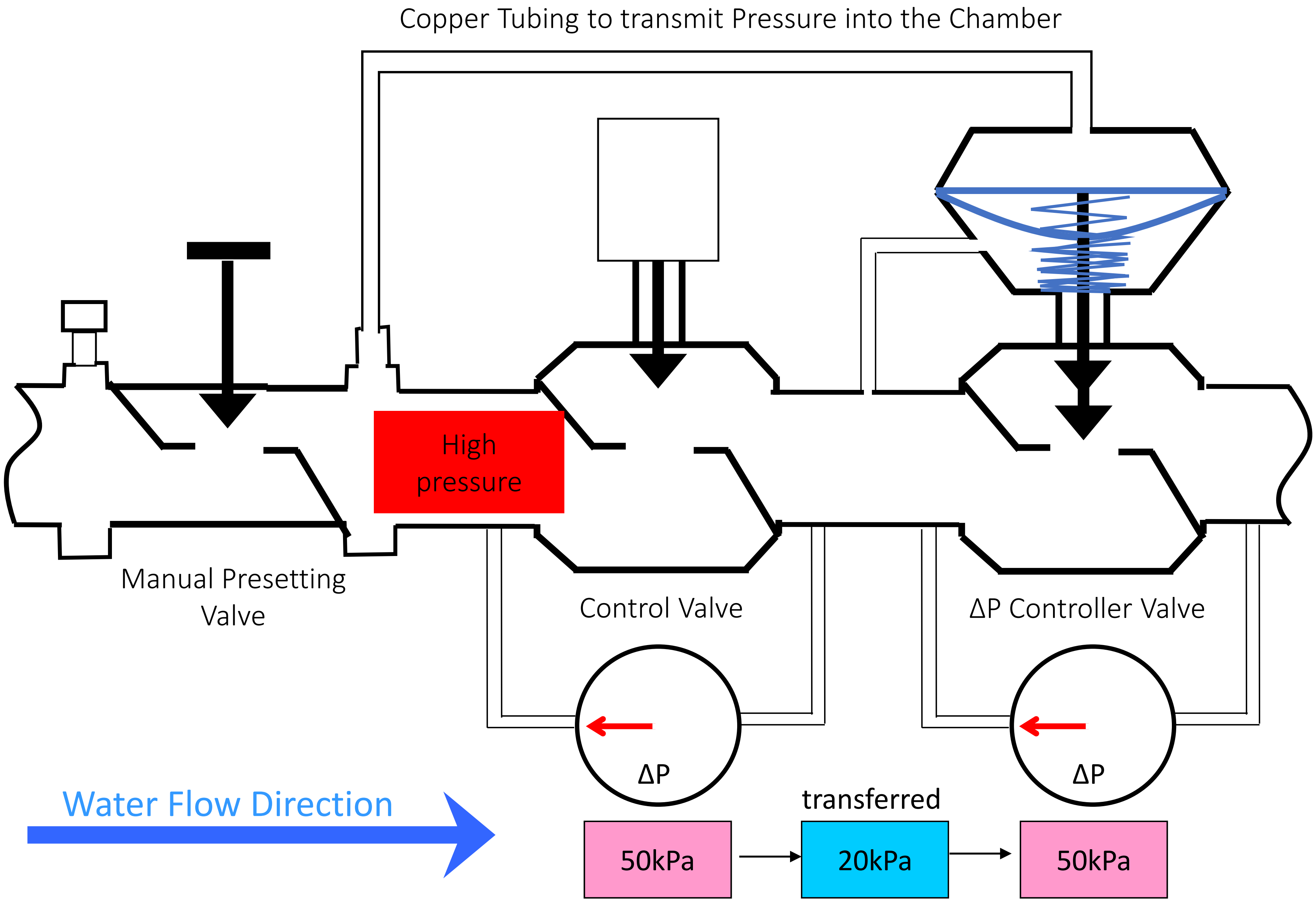
-The chilled water system to be hydronically balanced at full load (DRV or manual balancing) at partial load (DPCV).

-Improving control valve characteristic with optimum authority for high efficiency exchange between water & air thus bringing delta T to the design value this will only be achieved by eliminating system pressure fluctuation effect on the control valve throttle / stem.

In order to have all above features combined in one valve we need a **PRESSURE INDEPENDENT BALANCING & CONTROL VALVE**.



Copper Tubing to transmit Pressure into the Chamber
Manual Presetting Valve
Control Valve
ΔP Controller Valve
Water Flow Direction



Copper Tubing to transmit Pressure into the Chamber
High pressure
Manual Presetting Valve
Control Valve
ΔP Controller Valve
ΔP
ΔP
transferred
50kPa
20kPa
50kPa
Water Flow Direction

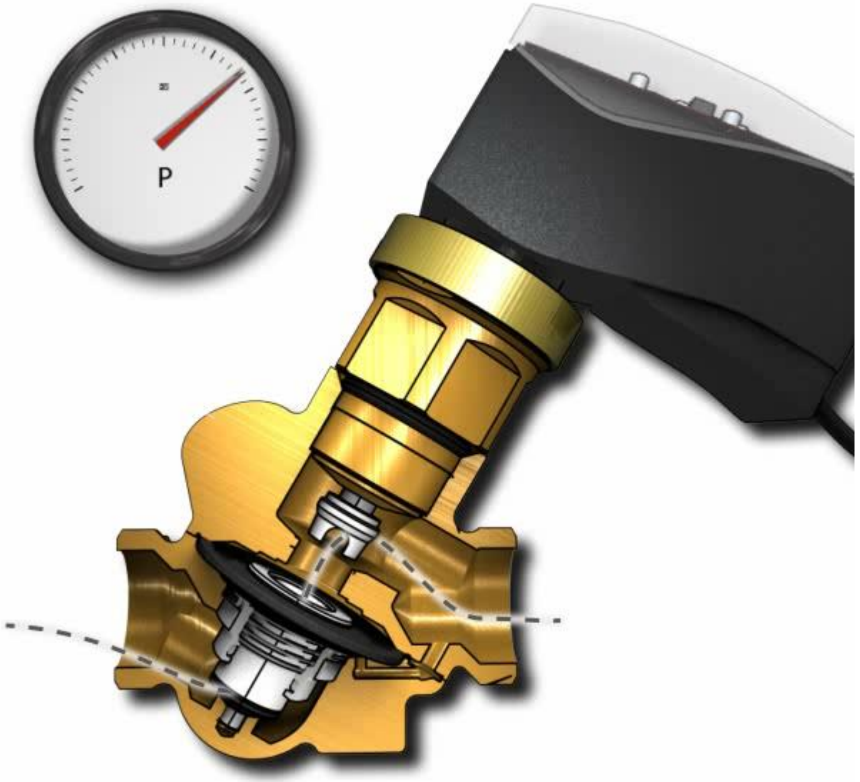
What is the AB-QM?

The AB-QM is a **P**ressure **I**ndependent **B**alancing and **C**ontrol **V**alve (PIBCV):

- Control valve
- Automatic balancing function

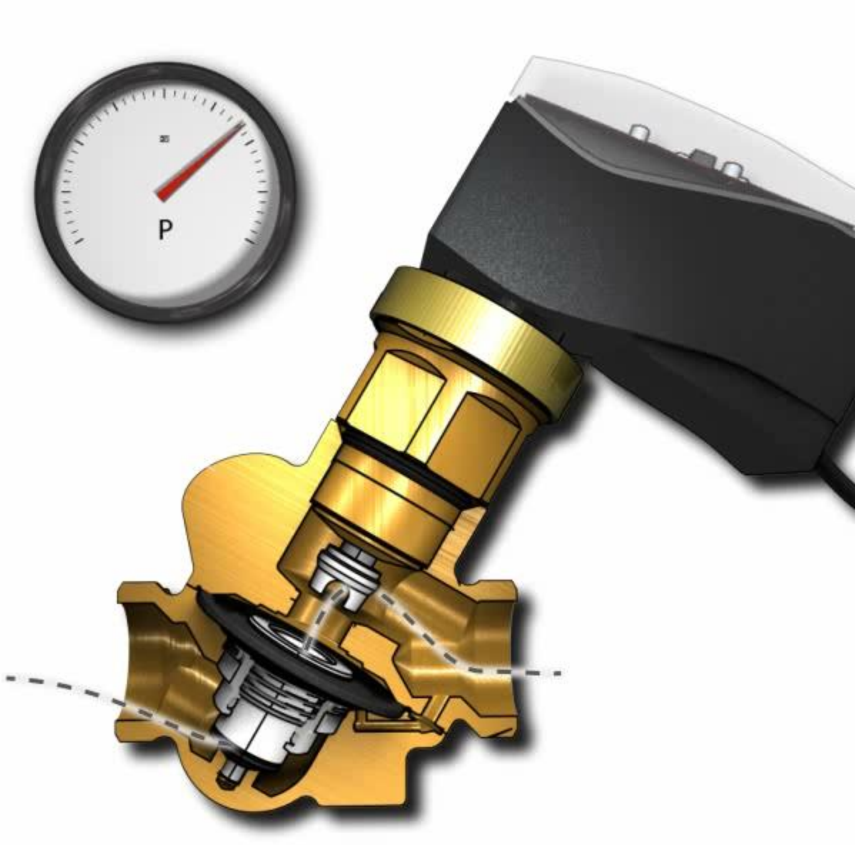
How does the AB-QM work

- The top part of the AB-QM is a control valve



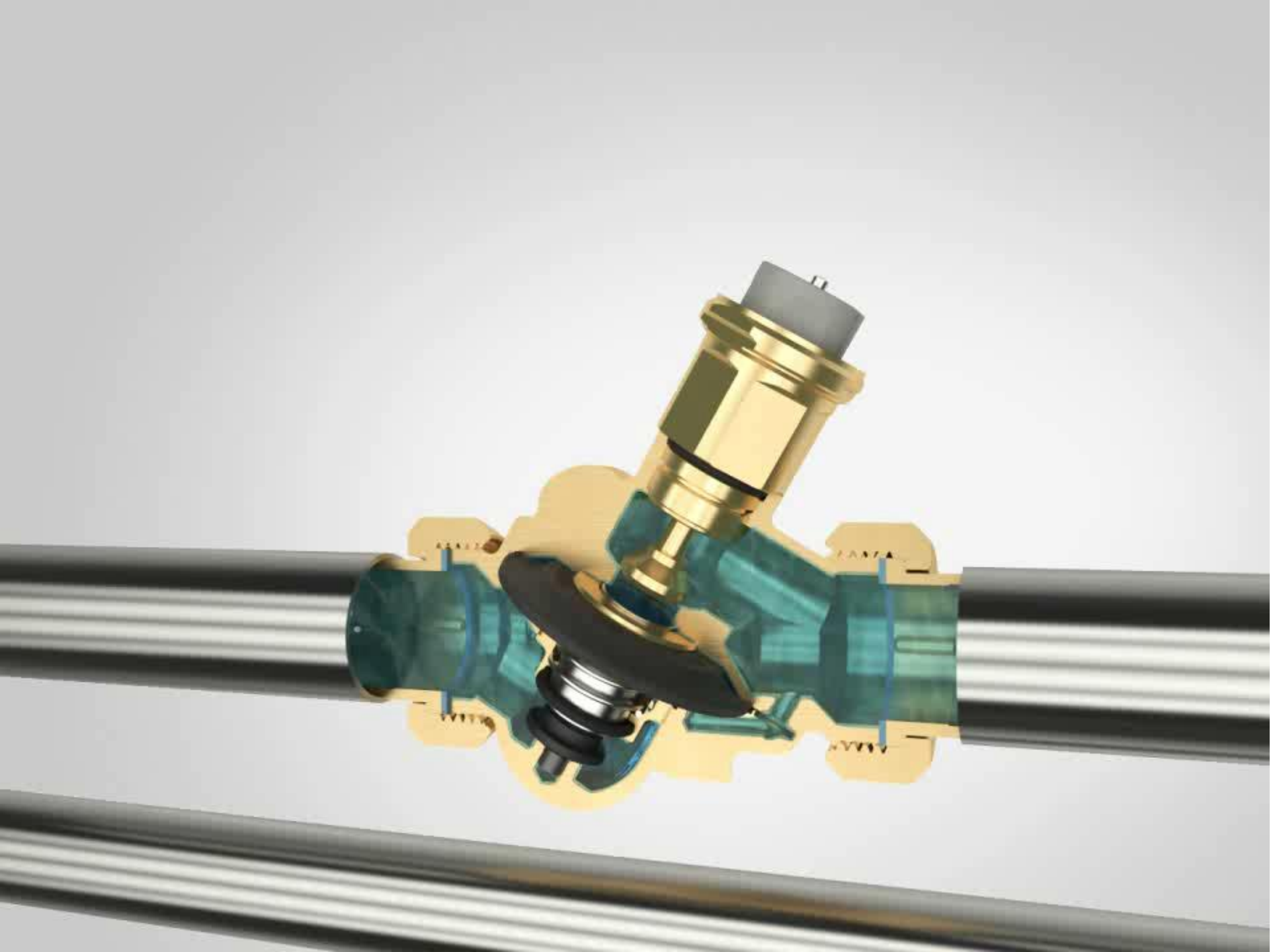
How does the AB-QM work

- The bottom part of the AB-QM is a differential pressure controller that keeps a constant differential pressure across the control valve independent of pressure fluctuations in the system



How does the AB-QM work

- The pressure controller keeps a constant differential pressure across the control valve
- $Q = Kv \times \sqrt{\Delta P}$
- Constant differential pressure means:
  - Constant flow
  - Full authority



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Product range

AB-QM & TWA-Z /HF

AB-QM & ABN/M A5 LOG/LIN

AB-QM & AME/V 110/120 NL/X

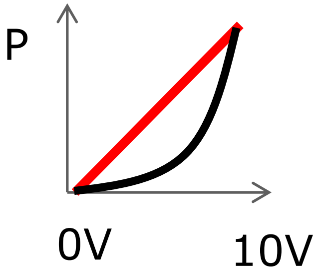
AB-QM & AME 435QM

AB-QM & AME 55QM

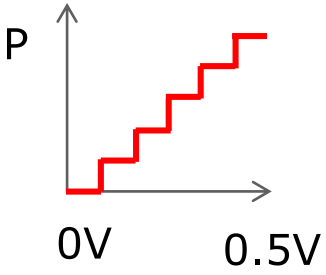
AB-QM & AME 85QM

The AB-QM can be combined with a large range of actuators

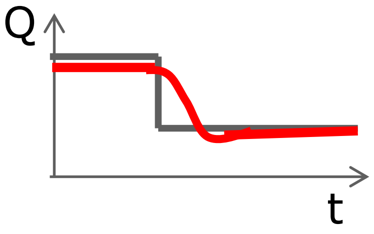
- For superb control performance use gear actuators with the following unique features:
  - Self calibration to the stroke of the AB-QM
  - Lin/Log/alpha setting to make the same valve/actuator combination linear or logarithmic
  - High rangeability (256 steps at any preset)
  - Instant response to change in control signal



calibration
Lin/Log/alpha



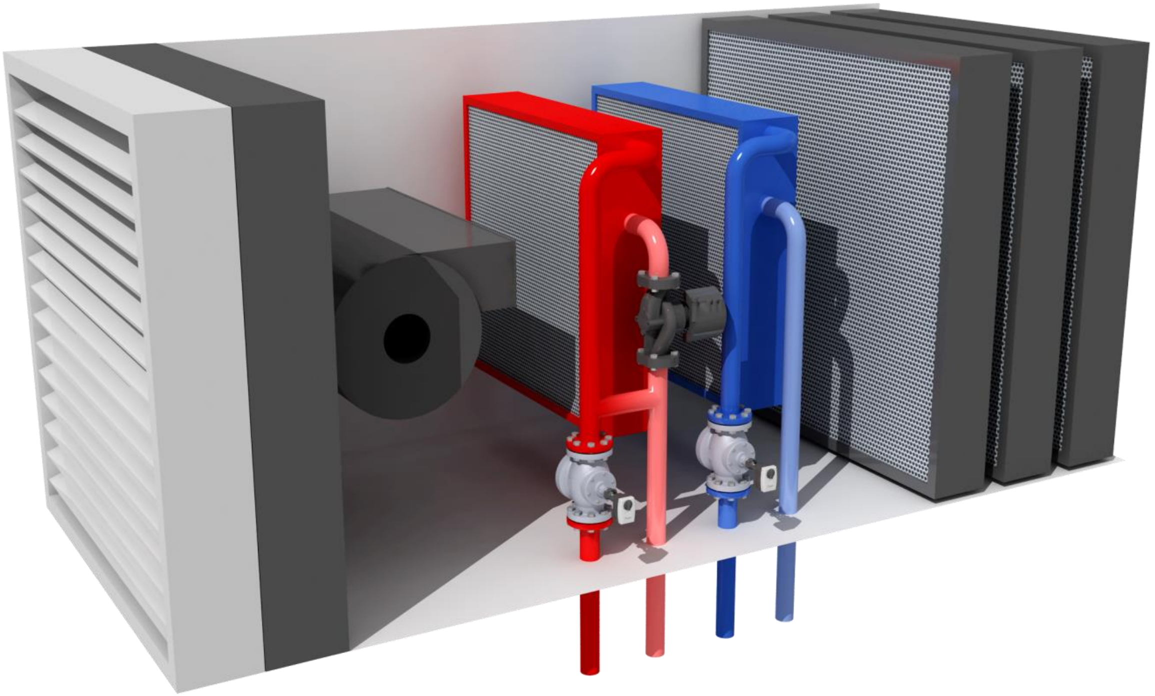
high
rangeability



instant
response

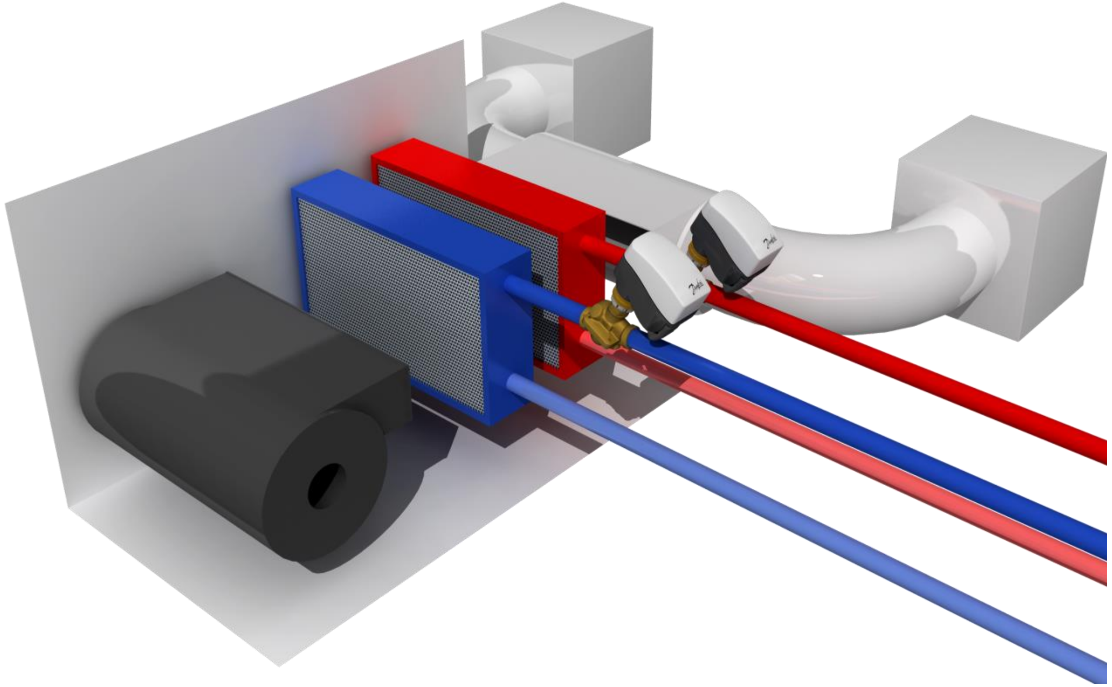
Applications

- AHU, Heating/Cooling



Applications

- Fancoil unit, Heating/Cooling



Applications

- Heat Exchangers

Less calculations

Selection of the AB-QM is based purely on

the flow:

- No KV calculations
- No need to calculate authority

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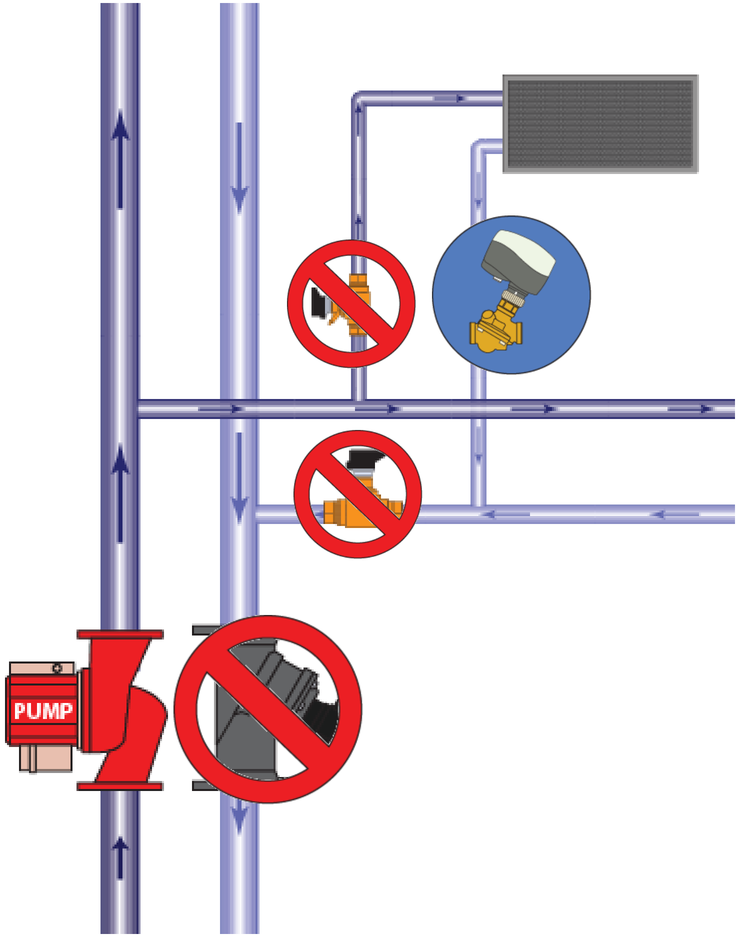
Less Mounting/Installation

Mounting cost

- Installation time DN15 valve approx. 70 minutes
- Installation time DN40 approx. 80 minutes
- Installation time DN80 approx. 120 minutes

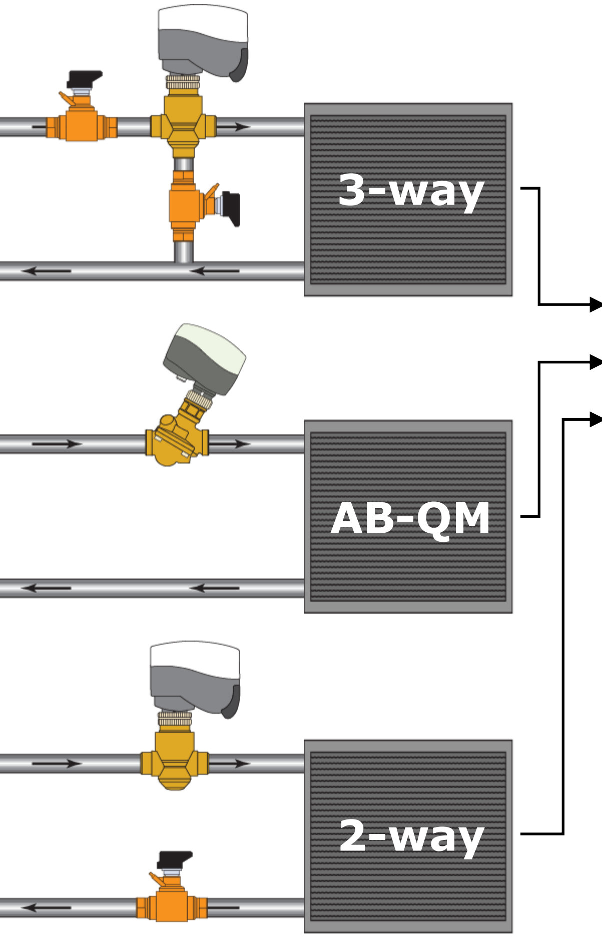
- Less commissioning time (normally at least 30 min./valve)
- No delay of handover
- Phased handovers



How does the AB-QM save energy

- Potential savings
  - pumping
  - ΔT to chiller
  - Temperature setting

Energy savings on pumping



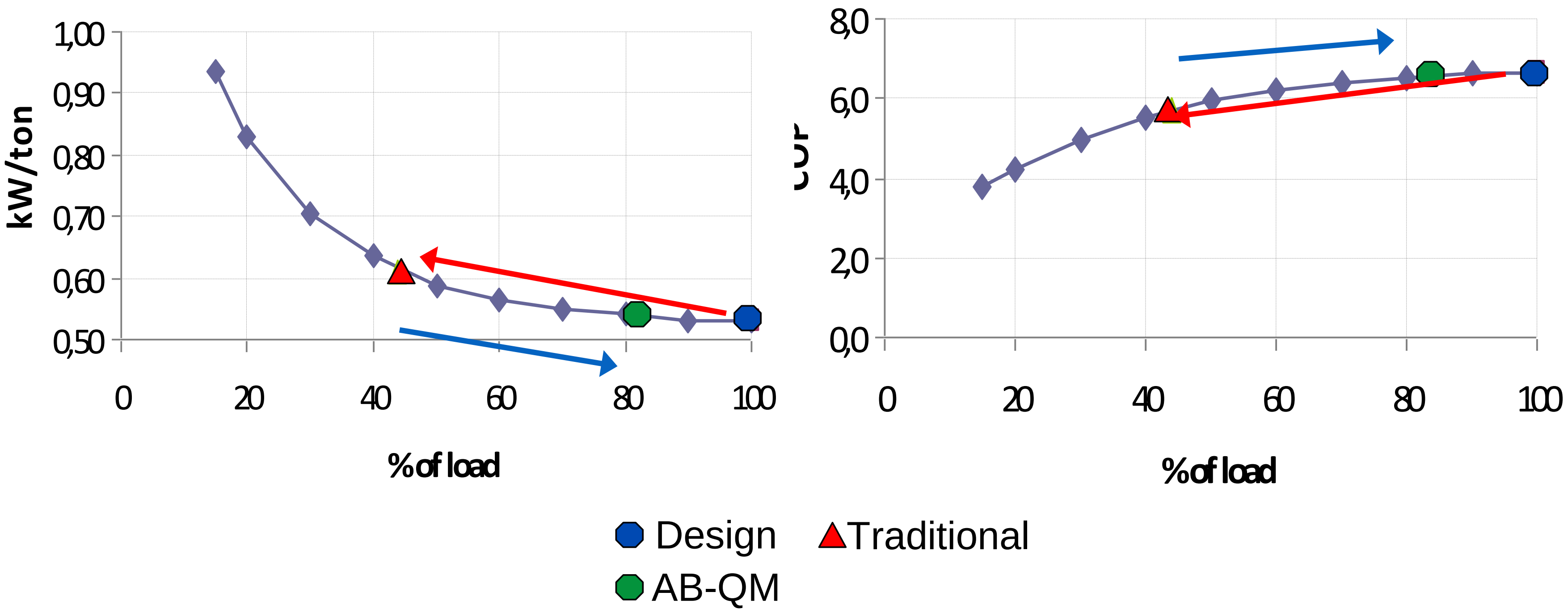
Pump head (Bar)	Flow (m3/h)	Days per year	Load profile	Energy per year	Energy cost per valve per year (€)
0,8	120	285	Full load	31000	15,5
0,8	100	285	Standard	9900	5,0
1,6	120	285	Standard	22900	11,5

- 3-way valves require full load all the time
- PICV allows more precise flow limitation
- Traditional control requires bigger pump head to achieve sufficient authority

NB: Calculations based on an average installation with 100m3/h and 200 DN20 valves with a flow of 500 l/h. 1 kW = 0,1 Euro

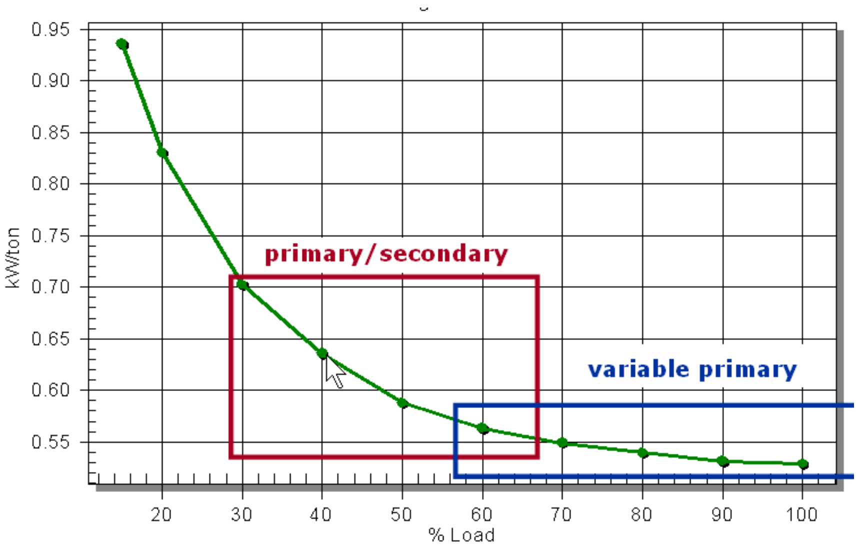
Energy saving on chiller

- A chiller is designed for 100% load but operates mostly (in case of traditional control valve) at 40% due low ΔT syndrome. Consequently additional chillers will be started by the control system to achieve requested cooling.
- AB-QM will increase chiller performance significantly, as we avoided overflow and thus are we able to increase ΔT



Energy saving on Chiller

- Higher (designed) return allows chiller to run more efficeint
- Variable primary hydronics
  - allow to run chillers in so called maxCap
  - more demanding to control valves
- To ensure maximum efficiency make sure to maximize ΔT

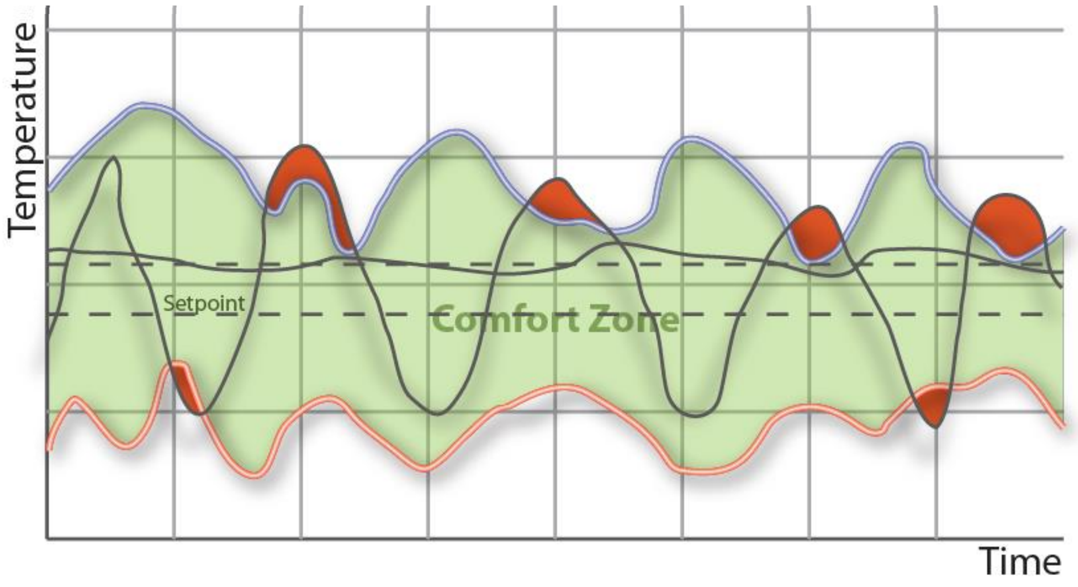


Increasing ΔT leads to higher energy efficiency

- Higher return temperature (with 3 K) for chillers (cooling system) results >10% energy saving
- Lower return temperature (< 60ºC) for condensing boilers (heating system) results in ~10% energy saving

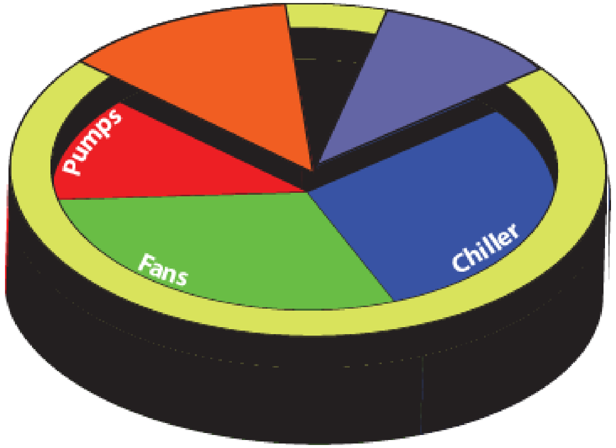
Energy saving on the temperature setting

- What constitutes a comfortable temperature is individual and varies through the day
- Imprecise control increases the chance of discomfort
- Discomfort causes complaints and increased use of energy
- By stabilizing the control the temperature can be optimised
- increasing the setting with 1K saves 10 to 16% of energy (Cooling)



Energy saving summary

- By reducing overflows the pump can run on a lower speed
- By improving the DT of the installation the efficiency of the chiller can be improved
- By increasing the performance of the control the temperature setting can be optimised



Danfoss NovoCon® smart actuator concept

The best way to cut back on installation costs

Next step

Based on extensive customer feedback:

- More efficient builidng process
- More automation (data)
- Higher demands
  - Comfort
  - Energy efficiency

The result:

Smart actuator NovoCon®

4 system components combined in 1

Actuator
NovoCon® is a highly accurate multi-functional actuator

Flow indicator
NovoCon® indicates flow through the AB-QM valve

Bus communication device
NovoCon® enables more than flow control via Fieldbus

Online Data info

to compare building performance

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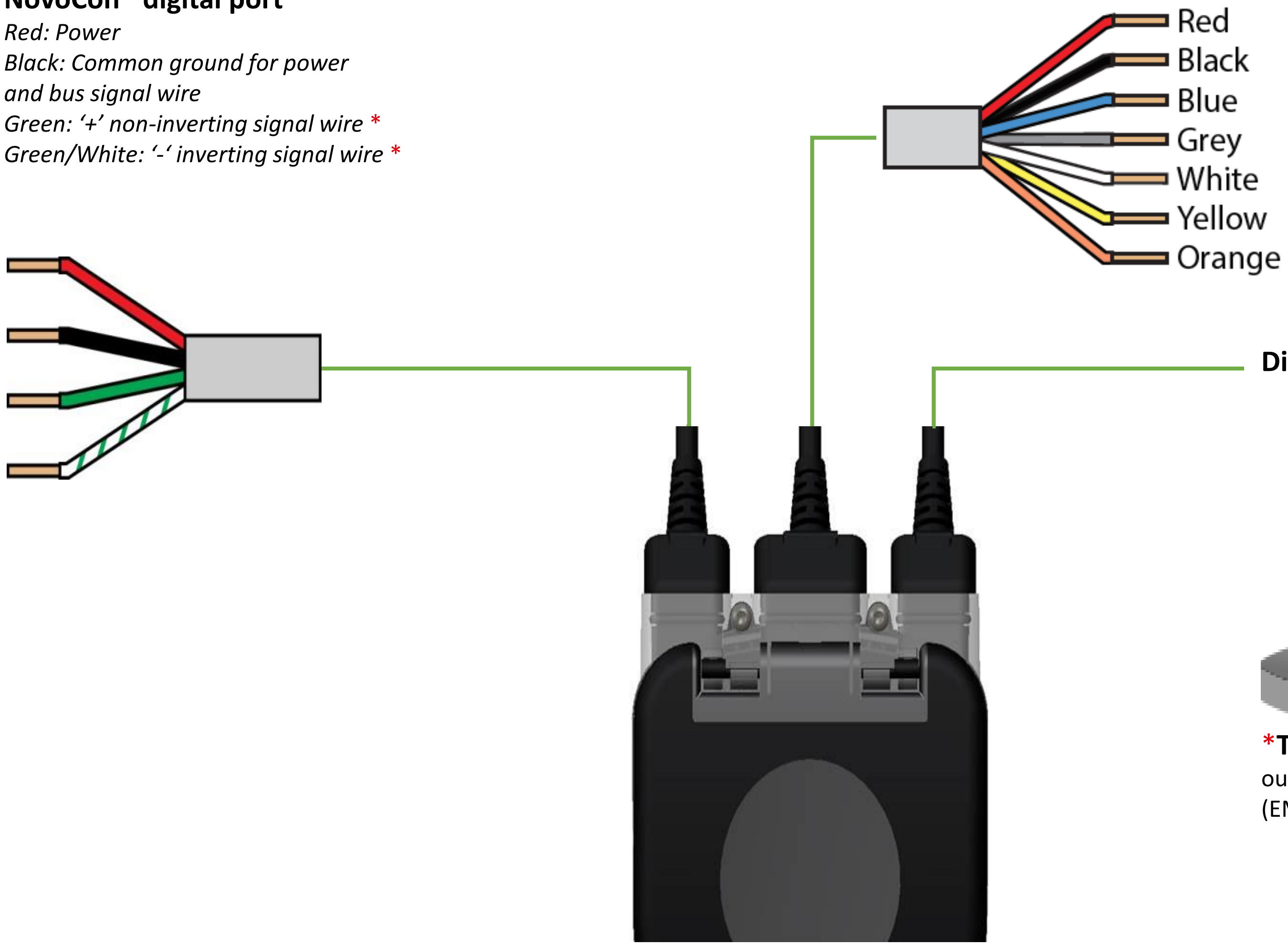
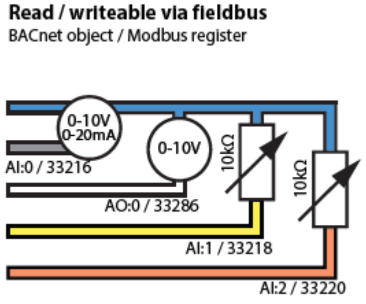
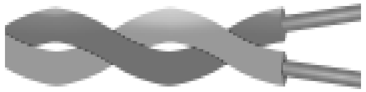
Flexibility in connections

NovoCon® digital port
Red: Power
Black: Common ground for power and bus signal wire
Green: '+' non-inverting signal wire *
Green/White: '-' inverting signal wire *





Digital port for daisy chain

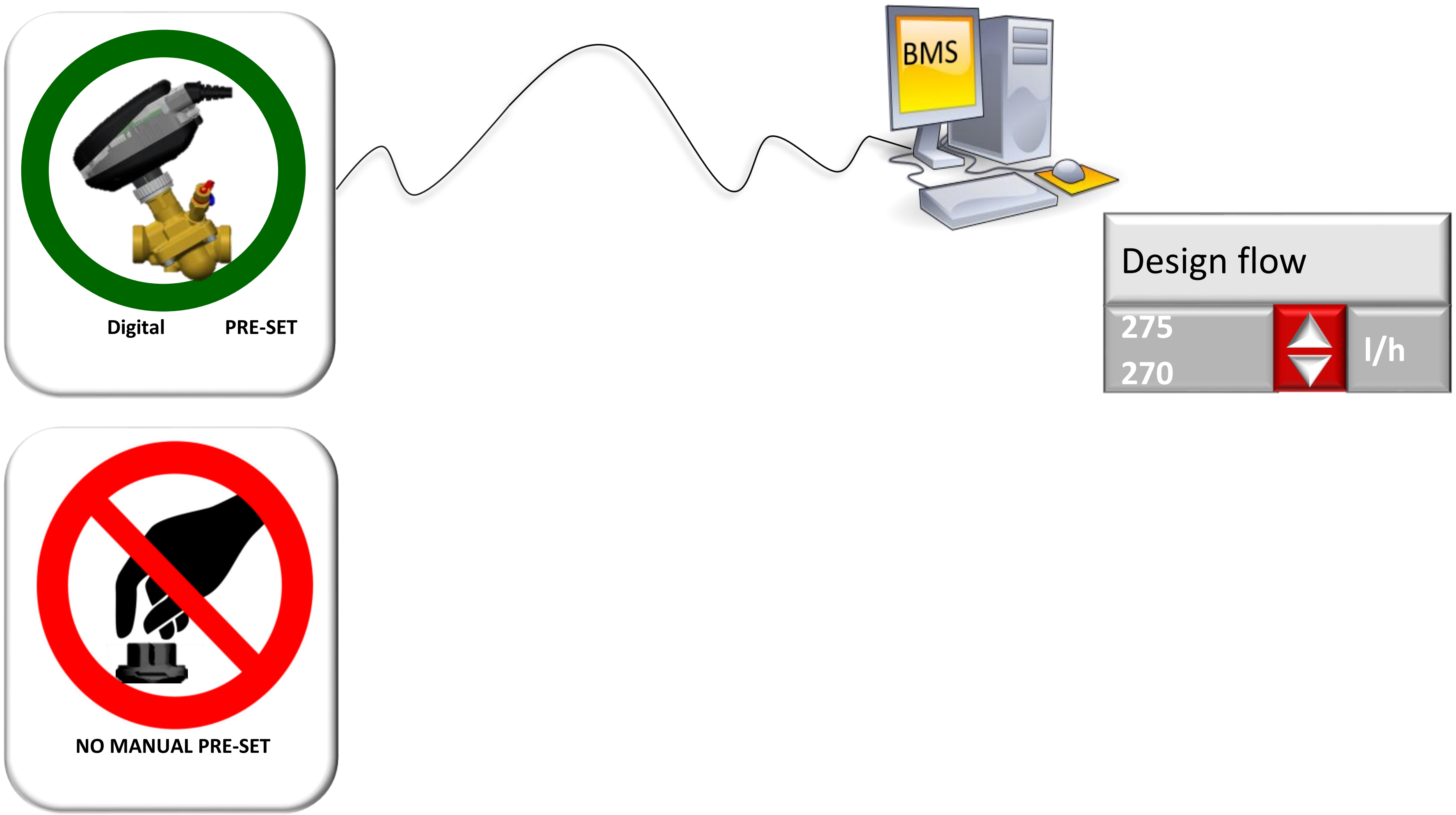


***Twisted pair cabling** canceling out electromagnetic interference (EMI)

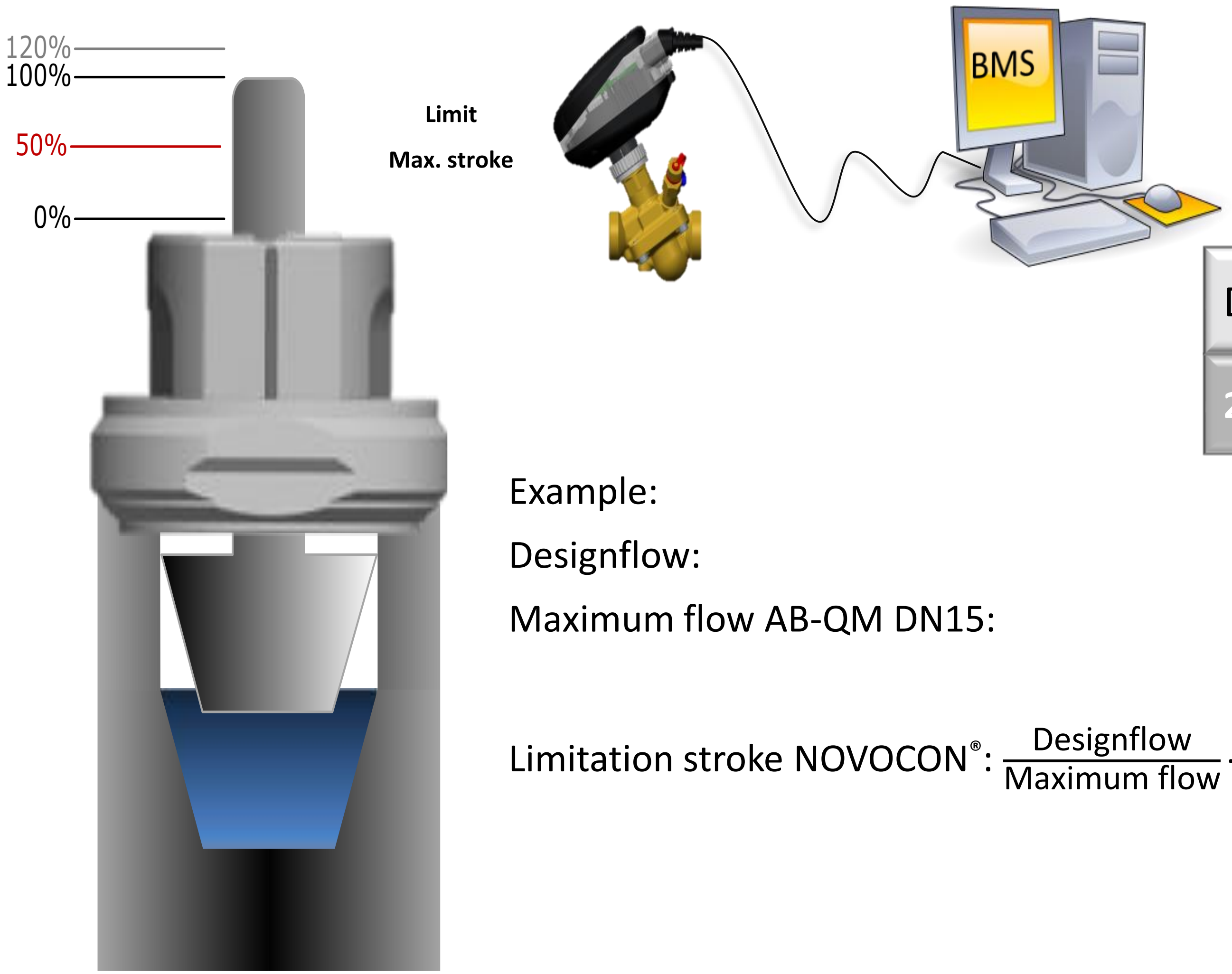
Flexibility in connections:

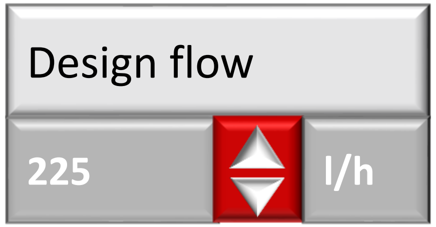
- BACnet™/Modbus datacommunication
- 24 V connection
- Daisy chaining
- Analog signal input / output
- Temperature sensor wired or direct sensor

Remote setting design flow



Remote setting design flow





Example:

Designflow: 225 [l/h]

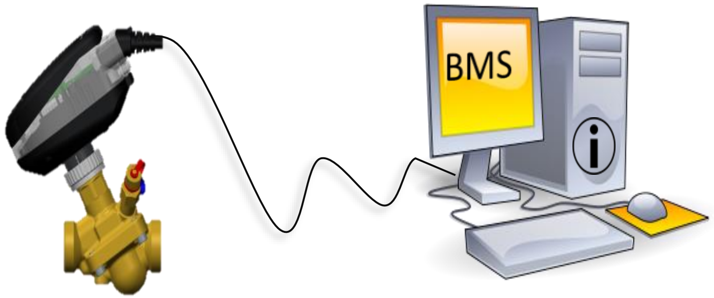
Maximum flow AB-QM DN15: 450 [l/h]

Limitation stroke NOVOCON®: $\frac{\text{Designflow}}{\text{Maximum flow}} \cdot 100 \ \ [\%]$

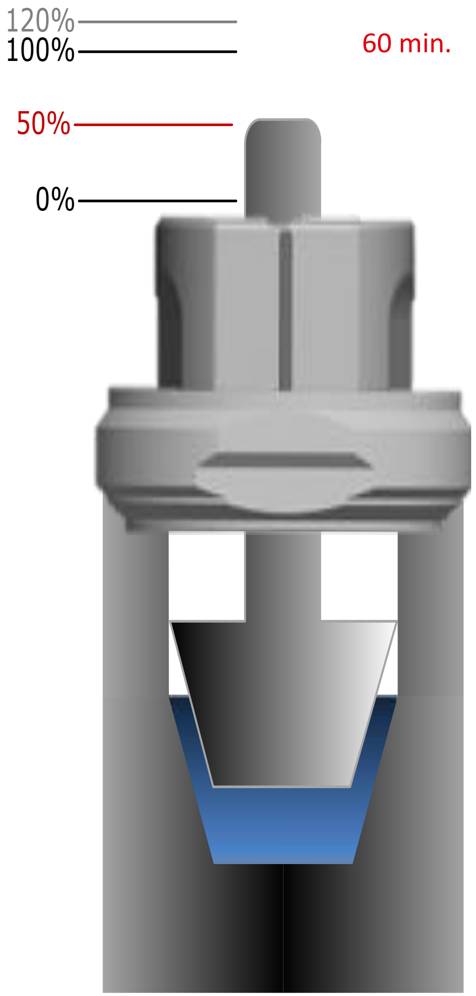
Remote features

- Flushing program

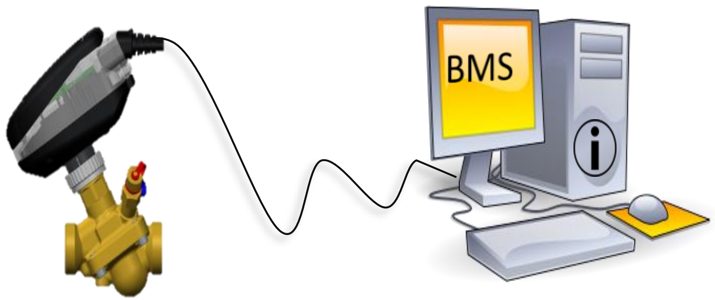
- De-air program



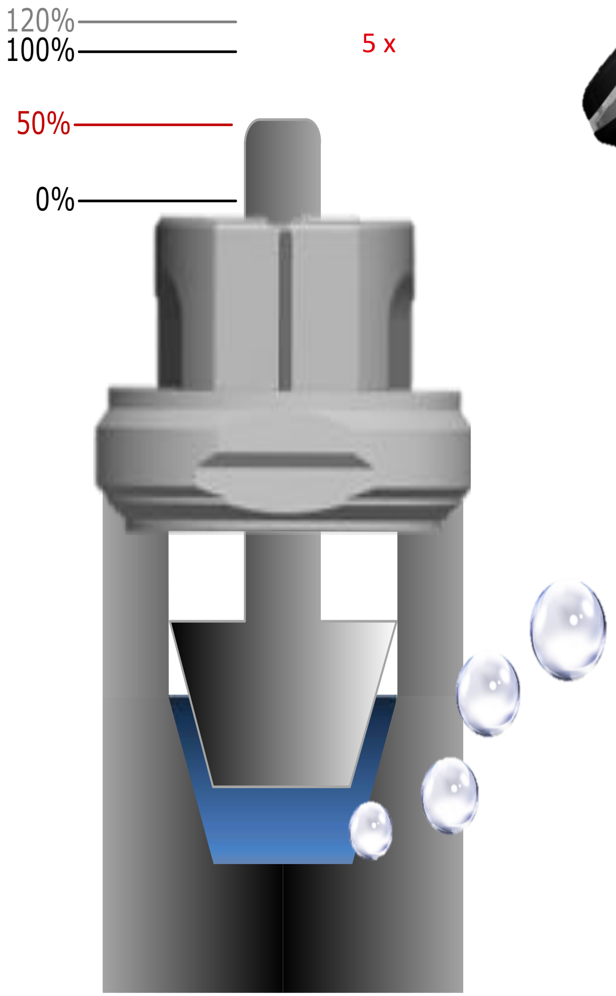
Remote feature:Flushing program

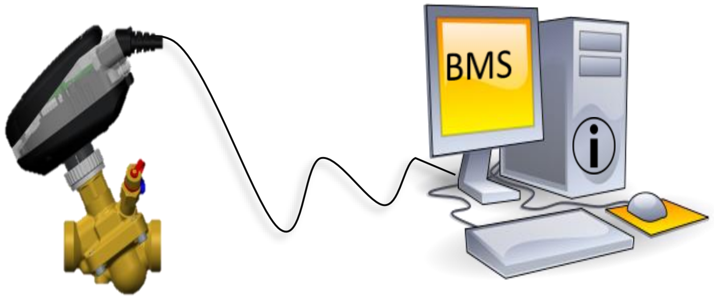


60 min.



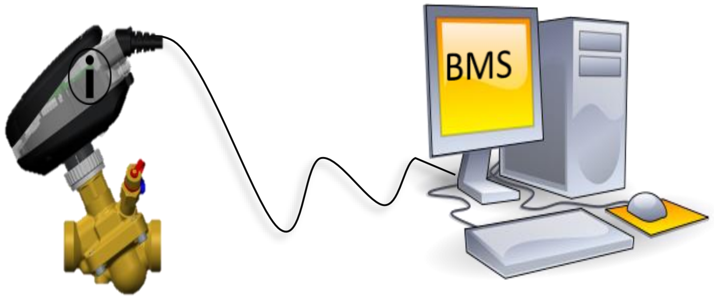
Remote feature:De-air program





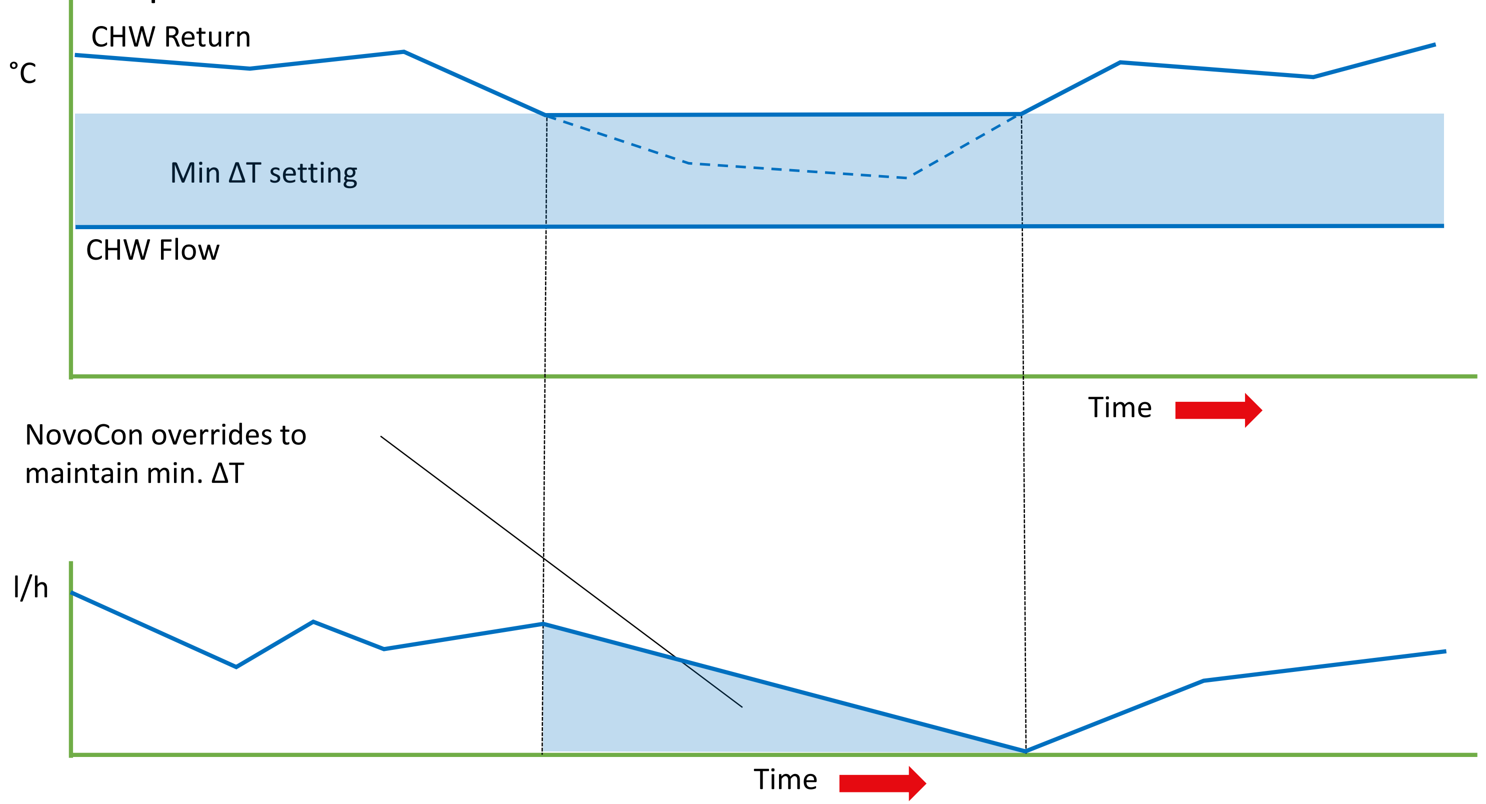
Remote status feedback

- Error: No signal
- Error: Calibration
- Warning high temperature electronics
- Warning abnormal supply voltage
- Closing error due to obstruction
- No 0-10V control signal

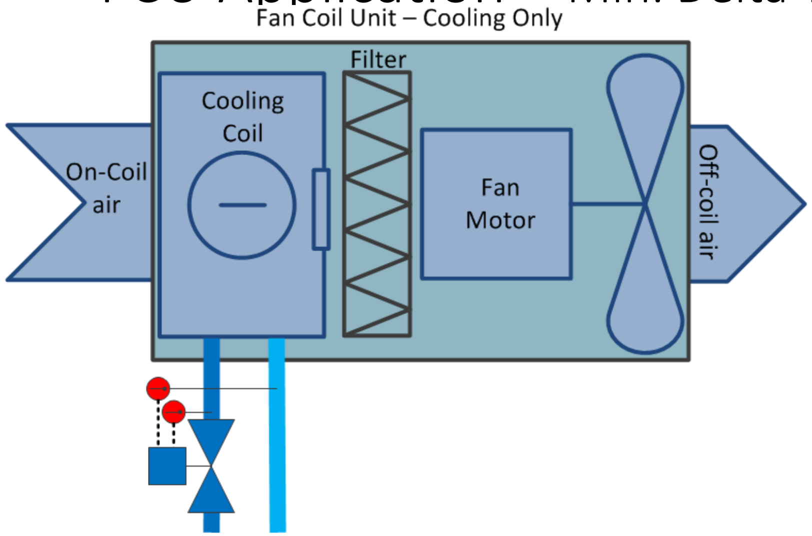


Energy Management
Min. Delta T Management

Description:
Smart actuator overrides the DDC control signal and maintains a minimum temperature difference between the flow and return temperatures by closing the valve when the user defined minimum is not achieved. When the flow temperature increases/decreases, so will the calculated minimum setpoint for the return temperature. This always ensures a minimum energy transfer to the FCU irrespective of the flow temperature.



FCU Application – Min. Delta T Management



Description:

- Actuator being primarily controlled by a DDC bus control signal in % valve opening.
- Actuator will override the DDC control signal when the user defined delta T is not achieved and the valve will begin to close.
- Actuator is gathering energy information about the FCU via 2 PT1000 pipe sensors.

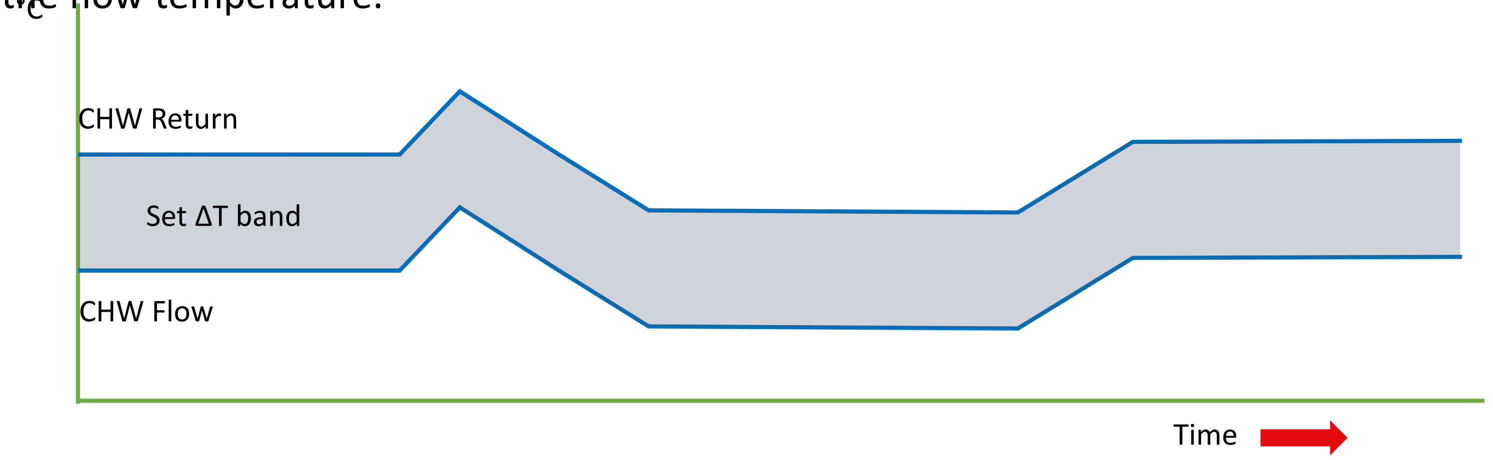
Note:

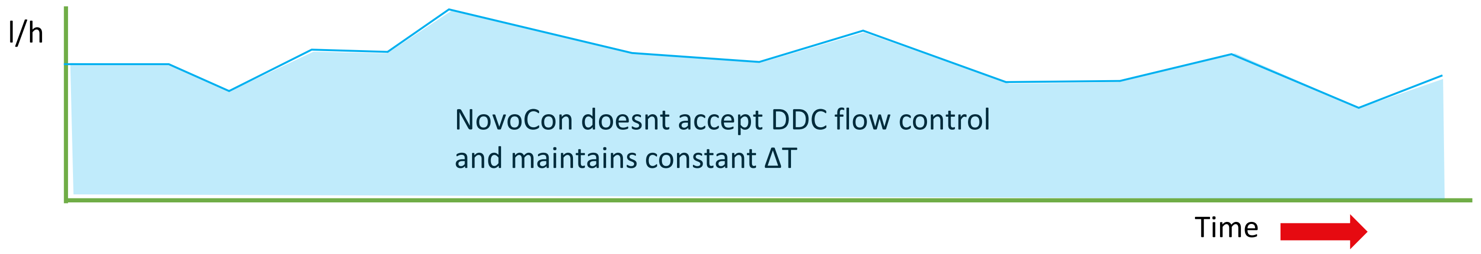
- BV:22 will be activated if the sensors are missing or not connected properly.
- BV:23 will be activated to alert the user the user that this override function is active.
- BV:24 will be activated to alert the user if the user defined min. ΔT is out of the achieveable range.
- ΔT & temperature sensing units may be changed to °F via MSV:23.
- Logged Energy kWh may be changed to MJ or kBTU via MSV:27.

Energy Management
Set Delta T Control

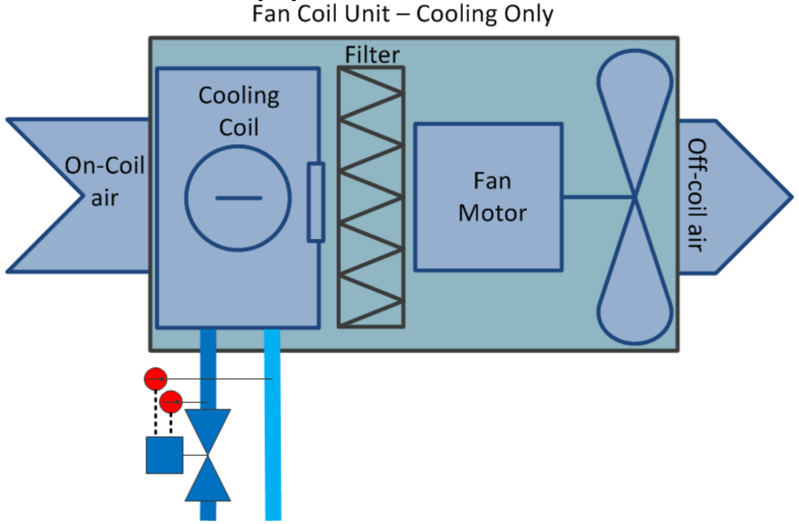
Description:

The smart actuator overrides the DDC control signal and maintains a constant temperature difference between the flow and return temperatures by opening and closing the valve when the user defined ΔT is exceeded or not achieved. When the flow temperature increases/decreases, so will the calculated ΔT setpoint for the return temperature. This always ensures a constant ΔT accross the FCU irrespective of the flow temperature.





FCU Application – Set Delta T Control



Description:

- Actuator is primarily controlling itself and overwriting DDC bus control signal in % valve opening.
- Actuator will open and close accordingly in maintaining the user defined set ΔT value.
- Actuator is gathering energy information about the FCU via 2 PT1000 pipe sensors.

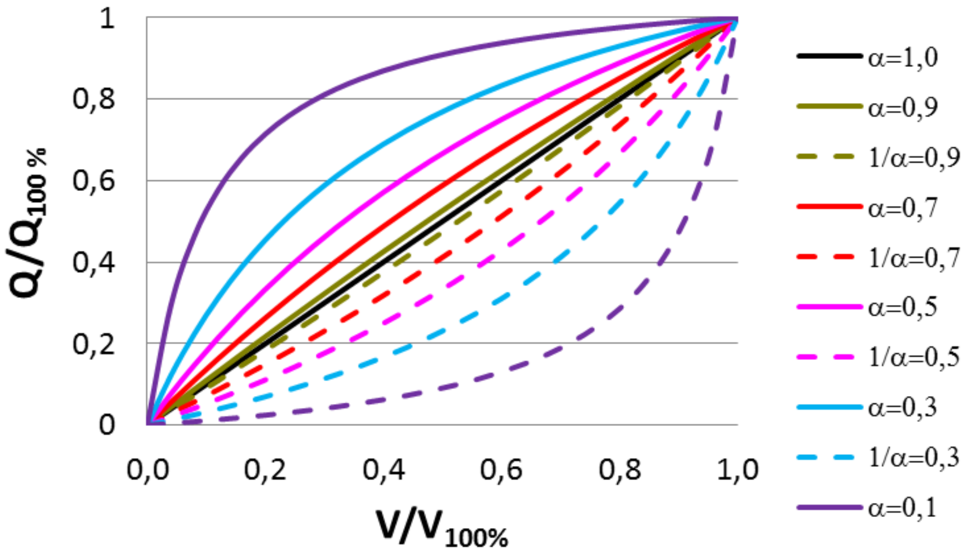
Note:

- BV:22 will be activated if the sensors are missing or not connected properly.
- BV:23 will be activated to alert the user the user that this override function is active.
- BV:24 will be activated to alert the user if the user defined set ΔT is out of the achieveable range.
- ΔT & temperature sensing units may be changed to °F via MSV:23.
- Logged Energy kWh may be changed to MJ or kBTU via MSV:27.

Remote alpha setting for optimal control

- Optimal control is possible, if we have linear response of system. Characteristic of HEX can be compensated with characteristic of actuator by appropriate α value.
- On NovoCon you can set the value remotely using BACnet command.
- α=0.2 (logarithmic), α=1 (linear).

Relationship between HEX (full line) and valve+actuator (dashed line) characteristic



LED bar on NovoCon^{TM}

Network status
BACnet(RS485) activity

Movement
LED's show if Novocon^{TM} is opening or closing

Valve position
Indication of valve position

Errors
Abnormal voltage supply, internal temperature, obstruction during closing

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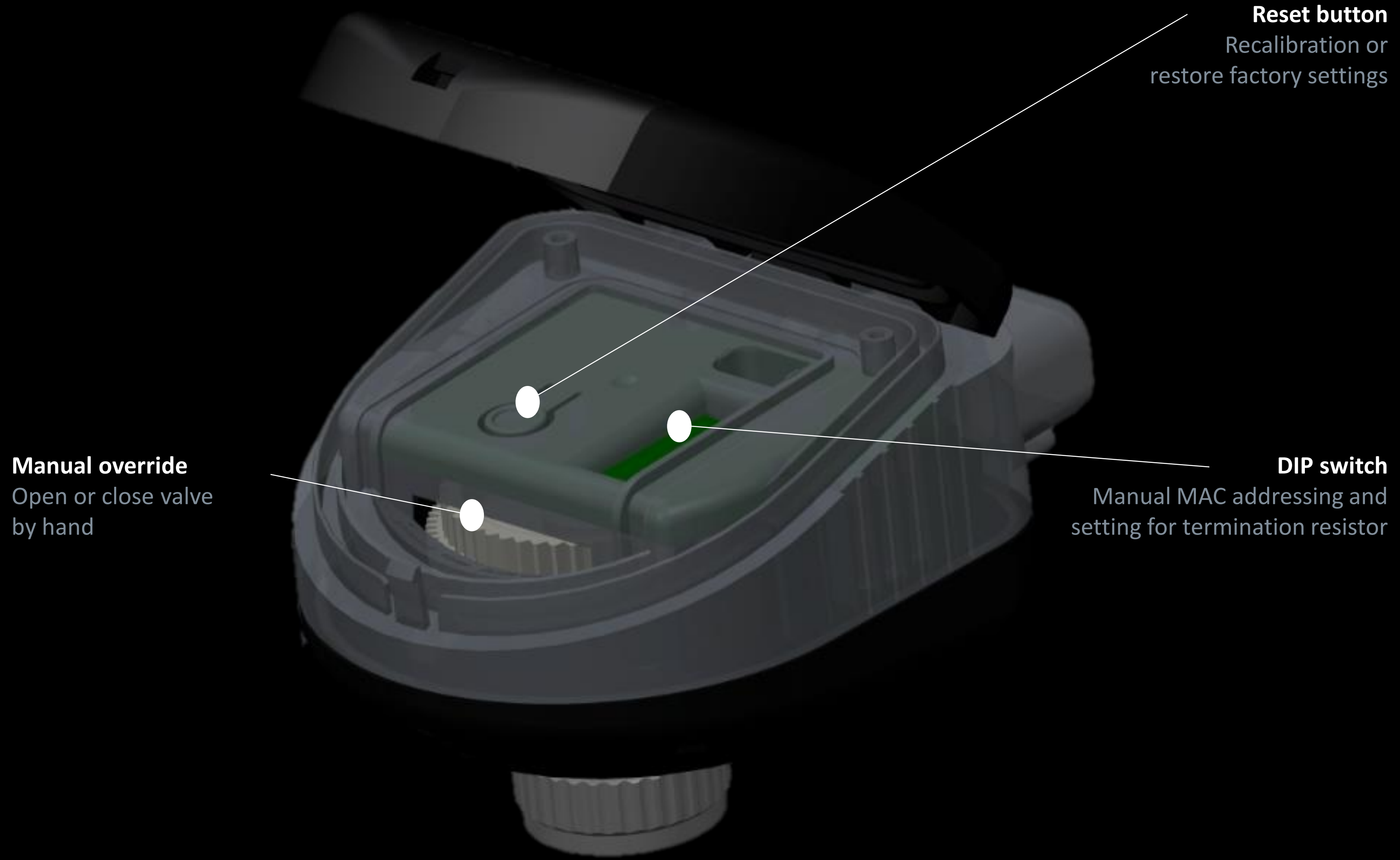
Local control options



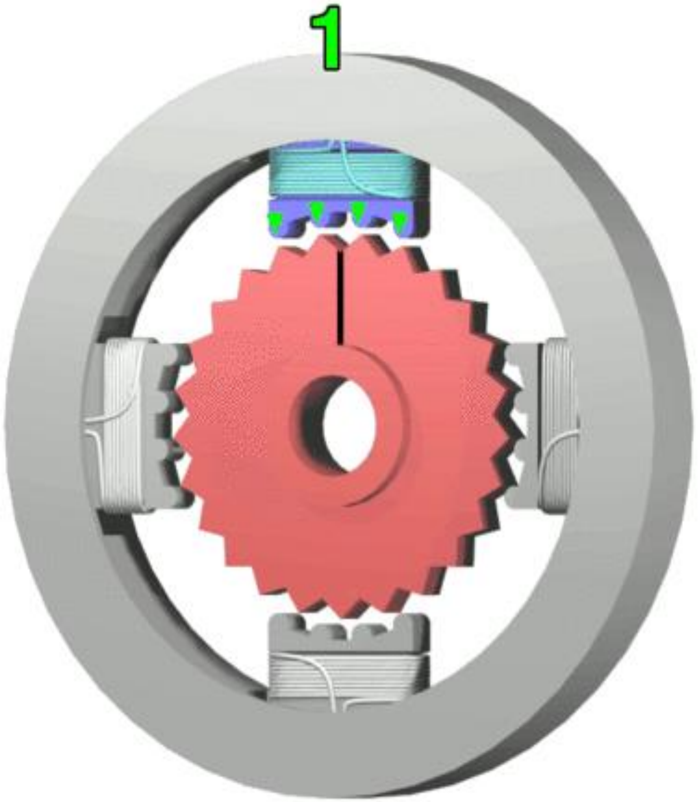
Flow indication

How is it possible ?

Precision stepper motor for precise spindle position

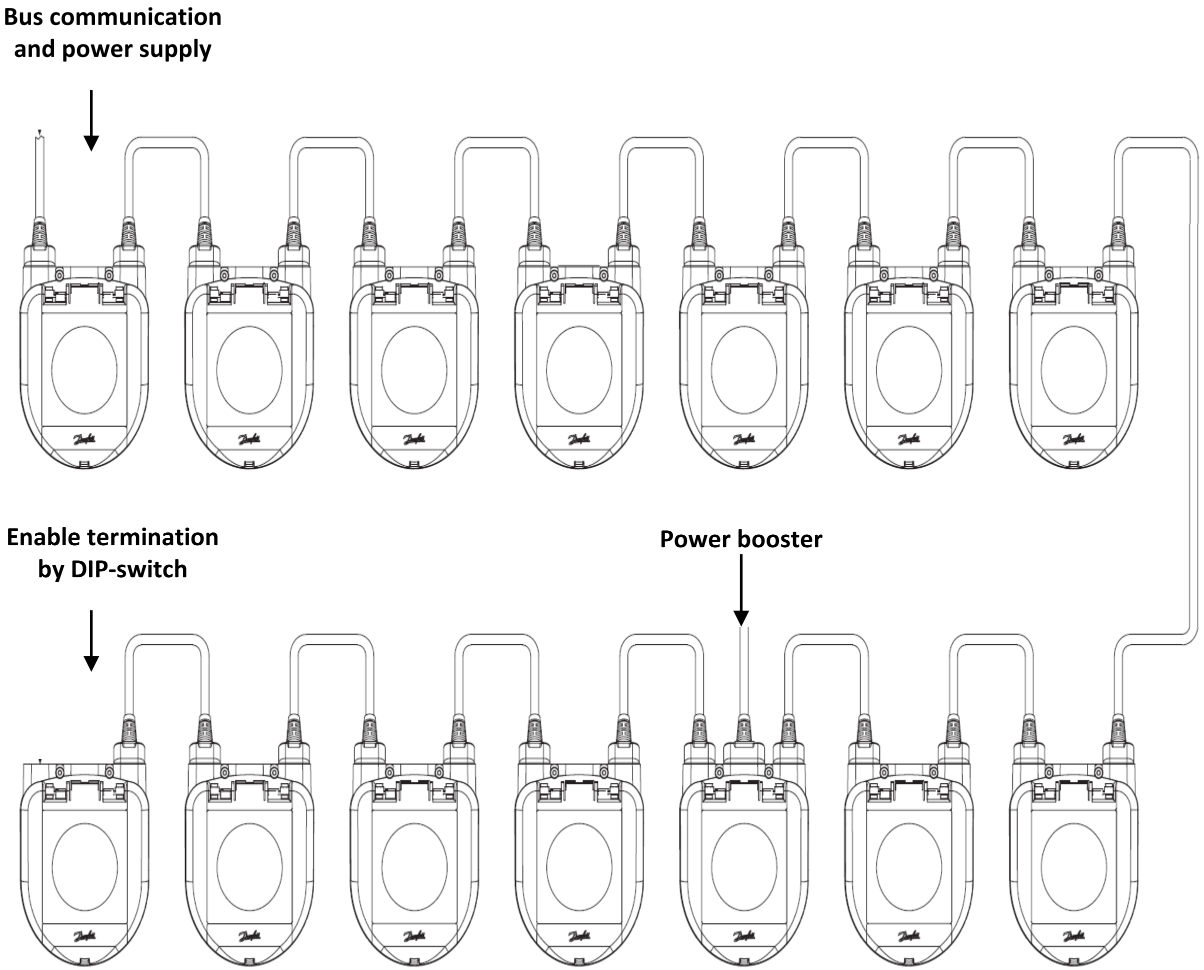
Maintaining constant differential pressure

$$q_v = Kv \times \sqrt{\Delta P}$$

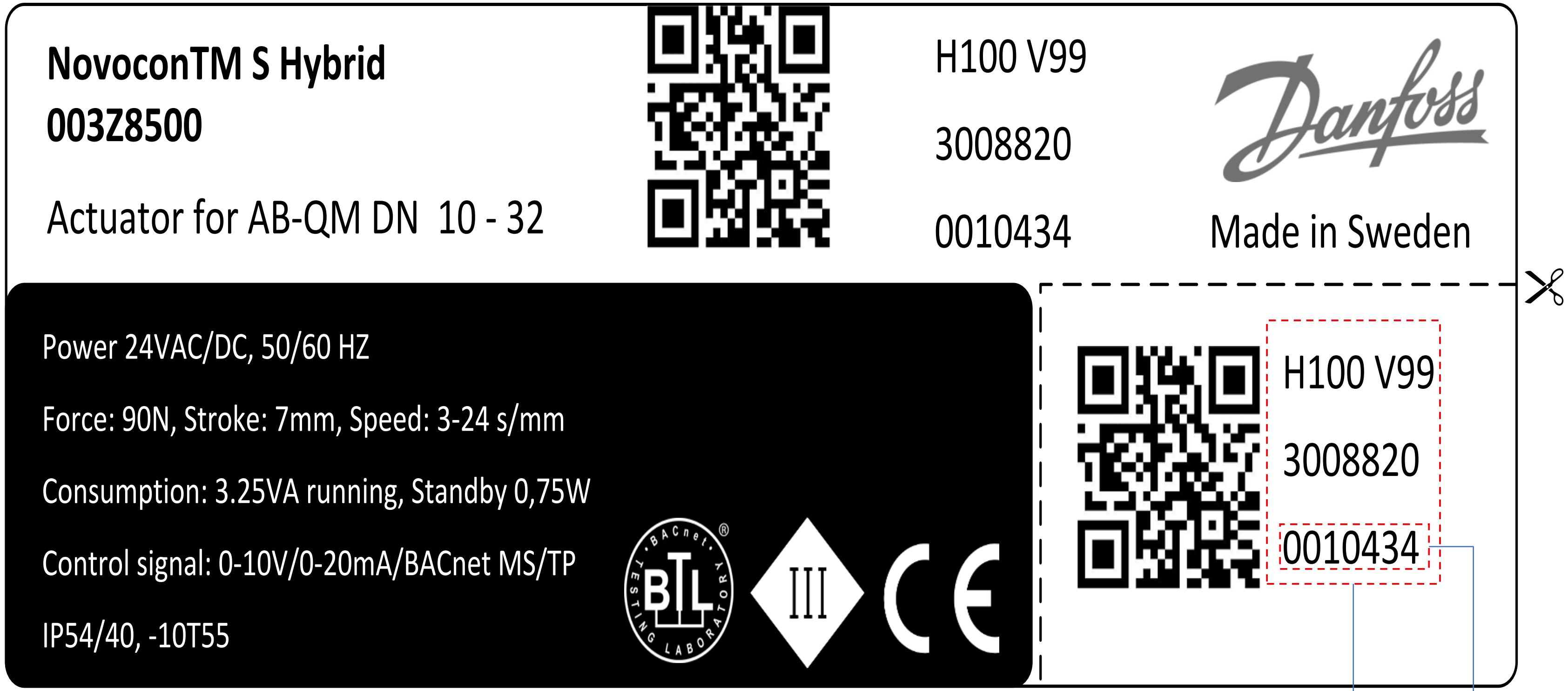


Daisy-chaining
Select and adapt the Smart actuator

- Additional voltage booster each 7 – 11 NovoCon’s.
- Chain max. 64 pcs



Sticker on the smart actuator



Serial Number of NovoCon S actuator

Unique ID (last 7 digits)

Conclusions

- Faster design with AB-QM
- Faster installation
- Faster, remote commissioning
- Energy optimisation
- Faster problem location
- Faster remote maintenance

1 click

to flush hundreds of AB-QM valves

Time is the biggest saving

Alarms and status are feedback to the Building Automation System via Fieldbus

Remote system verification:

- ✓ wiring to actuator
- ✓ connection to valve
- ✓ valve pre-setting
- ✓ valve operation

No need to visit site

LEDs on the side of the smart actuator give local status feedback

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Thank You