EmiratesGBC Technical Workshop
Delta T problem in chilled water systems
Low delta T syndrome in commercial buildings - prevention and solutions

Facilitator
Anis Ben Ali
OUERGHI

Company
Danfoss

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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

Flow

Wasted range

Kv

Control Valve Character

Master Partner Valve

Partner Valves
Q = Kv VΔP
Kv = Q/ VΔP
Where
Q : flow rate m³/hr
ΔP : pressure drop across the control valve in bar
Kv : flow coefficient of the control valve
• A calculation done to determine the performance of the control valve’s characteristic & capability to control against system pressure.

\[ \beta = \frac{\Delta p \text{ open valve}}{\Delta p \text{ open valve} + \Delta p \text{ system}} \times 100\% \]
Pipe pressure drop

\[300 \text{pa/m} \times \text{x} = 30 \text{kPa}\]

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

\[\beta = \frac{?}{30+5+35+?}\]

\[\beta = \frac{70}{30+5+35+70}\]

\[\beta = \frac{70}{140} = 0.5\]

\[\Delta p \text{ open valve} + \Delta p \text{ system}\]

\[\text{Index unit}\]

\[35 \text{kPa}\]

\[25 \text{m}^3/\text{h}\]

\[140 \text{kPa}\]

\[\text{VSD}\]

\[\Delta P\]
Control Valve Selection

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
- 40 Kvs = DN65
- 63 Kvs = DN80

\[ K_v = \frac{q}{\sqrt{\Delta p}} \]

Where:

\[ \Delta P = \text{Bar} \]

\[ q = m^3/h \]

\[ K_v = m^3/h \]

Plan Area

\[ \frac{25}{\sqrt{0.7}} = \frac{25}{0.84} = 29.7 \]

\[ \Delta p = \left( \frac{q}{K_v} \right)^2 \]

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

\[ \beta = \frac{40}{140} = 0.28 \]

Authority not optimum

Recommended = 0.5
Mechanical DP Controllers: Differential 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.
Water Flow Direction

Copper Tubing to transmit Pressure into the Chamber

Manual Presetting Valve

Control Valve

ΔP Controller Valve
Copper Tubing to transmit Pressure into the Chamber

Manual Presetting Valve

Control Valve

ΔP Controller Valve

ΔP

High pressure

Water Flow Direction

50kPa

20kPa

50kPa

transferred
What is the AB-QM?

The AB-QM is a Pressure Independent Balancing and Control Valve (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

• $Q = K_v \times \sqrt{\Delta P}$

• Constant differential pressure means:
  • Constant flow
  • Full authority
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

![](image1.png)
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
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

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

- 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 ∆T 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 ∆T
Energy saving on Chiller

- Higher (designed) return allows chiller to run more efficient
- Variable primary hydronics
  - allow to run chillers in so called maxCap
  - more demanding to control valves
- To ensure maximum efficiency make sure to maximize $\Delta T$
Increasing $\Delta T$ leads to higher energy efficiency

- Higher return temperature (with 3 K) for chillers (cooling system) results in $>10\%$ energy saving
- Lower return temperature ($< 60^\circ C$) for condensing boilers (heating system) results in $\sim 10\%$ 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 building 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

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

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

**Online Data info**
To compare building performance
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

*Twisted pair cabling cancels out electromagnetic interference (EMI)
Flexibility in connections:

• BACnet™/Modbus data communication

• 24 V connection

• Daisy chaining

• Analog signal input / output

• Temperature sensor wired or direct sensor
Remote setting design flow

Digital PRE-SET

NO MANUAL PRE-SET

Design flow

275
270

l/h
Remote setting design flow

Example:
Designflow: 225 [l/h]
Maximum flow AB-QM DN15: 450 [l/h]

Limitation stroke NOVOCON®: \[
\frac{\text{Designflow}}{\text{Maximum flow}} \times 100 \quad [\%]
\]
Remote features

- Flushing program
- De-air program
Remote feature: Flushing program

120%
100%
50%
0%

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 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 achievable 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 $\Delta T$ is exceeded or not achieved. When the flow temperature increases/decreases, so will the calculated $\Delta T$ setpoint for the return temperature. This always ensures a constant $\Delta T$ across the FCU irrespective of the flow temperature.

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**NovoCon doesn't accept DDC flow control and maintains constant $\Delta T$**
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 ∆T 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 that this override function is active.
• BV:24 will be activated to alert the user if the user defined set ∆T is out of the achievable range.
• ∆T & 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 $\alpha$ value.

- On NovoCon you can set the value remotely using BACnet command.

- $\alpha=0.2$ (logarithmic), $\alpha=1$ (linear).

Relationship between HEX (full line) and valve+actuator (dashed line) characteristic
LED bar on NovoCon™

Network status
BACnet (RS485) activity

Movement
LED’s show if Novocon™ is opening or closing

Valve position
Indication of valve position

Errors
Abnormal voltage supply, internal temperature, obstruction during closing
Local control options

- **Manual override**: Open or close valve by hand.
- **DIP switch**: Manual MAC addressing and setting for termination resistor.
- **Reset button**: Recalibration or restore factory settings.
Flow indication

How is it possible?
  Precision stepper motor for precise spindle position
  Maintaining constant differential pressure

\[ q_v = K_v \times \sqrt{\Delta P} \]
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

NovoconTM S Hybrid
003Z8500
Actuator for AB-QM DN 10 - 32

Power 24VAC/DC, 50/60 HZ
Force: 90N, Stroke: 7mm, Speed: 3-24 s/mm
Consumption: 3.25VA running, Standby 0,75W
Control signal: 0-10V/0-20mA/BACnet MS/TP
IP54/40, -10T55

Serial Number of NovoCon S actuator
Unique ID (last 7 digits)

Made in Sweden

H100 V99
3008820
0010434
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
Thank You