Achieving High Chilled Water Delta T in District Cooling Plants

Zhan Wang, Gang Wang, Ke Xu, Yuebin Yu, Mingsheng Liu
Energy Systems Laboratory
Department of Architectural Engineering
University of Nebraska-Lincoln
Nov. 1, 2007
Outline

✓ Introduction
✓ Conventional Method
✓ Improved Method
✓ Case Studies
✓ Conclusions
Objectives of District Chilled Water Plant

- To ensure that every building in the district cooling system receive enough chilled water.
- To save pump power in both the central plant and buildings.
- To avoid chilled water penalty
Conventional Connections (systems)

District Cooling Plant
CHWS CHWR

Pressure reducing valve

Temperature control valve

Circulating pump

Blending Station

AHU Cooling coil

EnerSys Lab
Basic Operation

When $T_{CHWS}$ is lower than the set point

Blend return chilled water with primary supply chilled water from the central plant to **achieve high chilled water $\Delta T$**.
Issues

- $T_{CHWS} > 48^\circ F$
- $T_{SA} > 60^\circ F$

- Blend return chilled water
- Circulating pump power
- Temperature, Humidity problem
- Extra fan power (VAV)
- Extra cooling load added

CONVENTIONAL METHOD
IMPROVED METHOD

Science and Good Practices

- **Science**
  - Coils produce higher chilled water return temperatures ($T_{CHWR}$) at partial loads

- **Good Practices**
  - Convert 3-way control valves by 2-way
  - Keep coils clean
  - Balance the chilled water system
IMPROVED METHOD

Recommended Connection

District Cooling Plant

CHWS CHWR

Pressure reducing valve

Circulating pump

VFD

T1

T2

P1

P2

T3

ΔP2

2-way valve

2-way valve

AHU Cooling coil

ΔP2

T

ΔP2

T

Energy Systems Laboratory
CASE STUDIES

Three Case Studies

Session 8, ICEBO 2007
Nov. 1-2, 2007 San Francisco, California

Achieving High Chilled Water Delta T in District Cooling Plants

Central Plant

Energy System Company (ESC)

Building #1

Building #2

Building #3
**System Information in Building #1**

<table>
<thead>
<tr>
<th>Type of building</th>
<th>Museum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of construction</td>
<td>1931/1994</td>
</tr>
<tr>
<td>Area (ft²)</td>
<td>213,000</td>
</tr>
<tr>
<td>Operation schedule</td>
<td>24/7</td>
</tr>
<tr>
<td>CHW consumption in Aug. 2007 (ton·hrs)</td>
<td>99,230</td>
</tr>
<tr>
<td>Number of blending station</td>
<td>2</td>
</tr>
<tr>
<td>Circulating pump configuration for each station</td>
<td>1 with a VFD</td>
</tr>
<tr>
<td>Circulating pump power (HP)</td>
<td>20</td>
</tr>
<tr>
<td>Cooling coil valve configuration</td>
<td>2-way</td>
</tr>
<tr>
<td>CHWS, T2 range (°F)</td>
<td>42~45</td>
</tr>
<tr>
<td>Humidity problem</td>
<td>No</td>
</tr>
</tbody>
</table>
Session 8, ICEBO 2007
Nov. 1-2, 2007 San Francisco, California

CASE STUDIES

Building #1

South Building Loop

AHU-5,6
AHU-8
North FCUs
South FCUs
Hall Way Education FCUs
AHU-1,2,3,4
AHU-7

Circulating pump

2-way Valve

Sever Room
Rest Room
FCUs

Office & Generator FCUs

2D, 3D & Special Storage

Liebert Unit
Western Studies

Circulating pump

North Building Loop

PRV
TCV

Energy Systems Laboratory
Basic Improved Operation in Building #1

Variable speed circulating pump

1.1 Disable circulating pump
1.2 Modulate PRV to maintain $\Delta P$

If PRV is 100% open
$\&$ $\Delta P$ is less than the set point

2.1 Maintain PRV 100% open
2.2 Enable circulating pump and modulate it to maintain $\Delta P$
achieving high chilled water delta T in district cooling plants

Case Studies

Chilled Water ΔT in Building #1 after CC®

Energy Systems Laboratory
RESULTS

Comparison of $\Delta T$ in Building #1

<table>
<thead>
<tr>
<th></th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002-2006 average (Pre-CC®)</td>
<td>12.3</td>
<td>12.0</td>
<td>13.2</td>
<td>12.7</td>
</tr>
<tr>
<td>2007 (Post-CC®)</td>
<td>15.8</td>
<td>14.8</td>
<td>14.5</td>
<td>14.2</td>
</tr>
</tbody>
</table>
CASE STUDIES

Building #2 System Information

<table>
<thead>
<tr>
<th>Type of building</th>
<th>Office</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of construction</td>
<td>1970’s</td>
</tr>
<tr>
<td>Area (ft²)</td>
<td>230,000</td>
</tr>
<tr>
<td>Operation schedule</td>
<td>60hrs/week</td>
</tr>
<tr>
<td>CHW consumption (ton·hrs) Aug. 2007</td>
<td>193,000</td>
</tr>
<tr>
<td>Number of blending station</td>
<td>1</td>
</tr>
<tr>
<td>Circulating pump configuration</td>
<td>3 constant</td>
</tr>
<tr>
<td>Circulating pump power (HP)</td>
<td>40 each</td>
</tr>
<tr>
<td>Cooling coil valve configuration</td>
<td>2-way &amp; 3-way</td>
</tr>
<tr>
<td>CHWS, T2 range (°F)</td>
<td>42~50</td>
</tr>
<tr>
<td>Humidity problem</td>
<td>Yes</td>
</tr>
</tbody>
</table>

![Diagram of District Cooling Plant](image-url)
CASE STUDIES WITH RETROFITS

Basic Improved Operation in Building #2

Constant speed circulating pump

1.1 Disable circulating pump
1.2 PRV maintain $T_{CHWR}$

If PRV is 100% open
& $T_{CHWR}$ is higher than the Stpt

2.1 Maintain PRV 100% open
2.2 Enable circulating pump(s) and modulate it to maintain $T_{CHWR}$
✓ RESULTS

Comparison of $\Delta T$ in Building #2

<table>
<thead>
<tr>
<th></th>
<th>June</th>
<th>July</th>
<th>August</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006 (Pre-CC®)</td>
<td>12.2</td>
<td>12.6</td>
<td>14.1</td>
</tr>
<tr>
<td>2007 (Post-CC®)</td>
<td>14.1</td>
<td>15.8</td>
<td>15.5</td>
</tr>
</tbody>
</table>
**CASE STUDIES**

**Building #3**

<table>
<thead>
<tr>
<th>Type of building</th>
<th>Office</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of construction</td>
<td>1970's</td>
</tr>
<tr>
<td>Area (ft²)</td>
<td>71,500</td>
</tr>
<tr>
<td>Operation schedule</td>
<td>70hrs/week</td>
</tr>
<tr>
<td>CHW consumption (ton·hr)</td>
<td>36950</td>
</tr>
<tr>
<td>Aug. 2007</td>
<td></td>
</tr>
<tr>
<td>Number of blending station</td>
<td>1</td>
</tr>
<tr>
<td>Circulating pump configuration</td>
<td>3 constant</td>
</tr>
<tr>
<td>circulating pump power (HP)</td>
<td>10 each</td>
</tr>
<tr>
<td>Cooling coil valve configuration</td>
<td>2-way &amp; 3-way</td>
</tr>
<tr>
<td>CHWS, T2 range (°F)</td>
<td>42~50</td>
</tr>
<tr>
<td>Humidity problem</td>
<td>Yes</td>
</tr>
</tbody>
</table>

![Diagram of District Cooling Plant](image-url)
**RESULTS**

**Comparison of ΔT in Building 3**

<table>
<thead>
<tr>
<th></th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006 (Pre-CC®)</td>
<td>12.0</td>
<td>13.9</td>
<td>14.9</td>
<td>15.4</td>
</tr>
<tr>
<td>2007 (Post-CC®)</td>
<td>14.4</td>
<td>15.1</td>
<td>13.2</td>
<td>14.5</td>
</tr>
</tbody>
</table>

**Graph:**
- **3-way Valves**
- **2-way Valves**

Monthly Average ΔT (°F)

Energy Systems Laboratory
Conclusions

- Building blending station is not necessary to maintain the required $T_{CHWR}$ or $\Delta T$ temperature.
- Without blending station, building pump power is eliminated.
- Without blending station, thermal comfort is improved by ensuring good control for space humidity and temperature.
Questions?

Thank You!