Reducing Energy Usage in High Rise Office Buildings

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1. Understand the Effect of Chilled Water Delta T on Energy in Buildings

2. Understand the Effect of Chilled Water Delta T on Chiller Based HVAC Systems

3. Understand the Effect of Chilled Water Delta T on District [Deep Lake] Cooling Based HVAC Systems

4. Add Delta T improving Strategies to your design toolbox
Importance of Controlling Building Delta T

Low Delta T Syndrome!!!
Importance of Controlling Building Delta T

What is Delta T?

Chilled Water Delta T

- Supply Air Delta T
  - 75°F
  - 53°F

- DT
  - 16°F
  - 41°F

- 57°F
Importance of Controlling Building Delta T

Power Formula
\[ \text{BTU/h} = \text{GPM} \times \Delta T \times 500 \]

\[ 500,000 \text{ BTU/h} = 100 \text{ GPM} \times 10^\circ \text{F} \times 500 \]

\[ 500,000 \text{ BTU/h} = 200 \text{ GPM} \times 5^\circ \text{F} \times 500 \]
Importance of Controlling Building Delta T

Major Causes of Low Delta T

1. Coil overflowing

2. Supply chilled water bypassed to return
Case Study on the Impact of Chilled Water Delta T on Building Operation

Existing 23 Storey Downtown Toronto Office Building

HVAC System Cooling System Conversion

from Chiller Based Cooling
to District [Deep Lake] Cooling
Importance of Controlling Building Delta T

Effect of Low Delta T on:

Chiller Based Systems

Vs

District Cooling Based Systems
Importance of Controlling Building Delta T

Effect of Low Delta T on Chiller Based Systems (fixed supply water temperature):

Eg. Design delta T = 16°F, Actual Delta T = 8°F (50% of design)

1. Flow will be doubled
2. Low delta T does not affect supply water temperature
3. System must be oversized in order to meet building load on peak days.
4. More chillers operating at 50% load will be required
Importance of Controlling Building Delta T

System Operating at 50% Load
at Design DT of 16 degF

42°F

CHWS

CHWR

58°F

Chiller
430 tons
645 gpm

Chiller
430 tons
0 gpm

One pump at full flow
1 x 645gpm = 645 gpm

[Tons x 12,000 = Btuh]
Importance of Controlling Building Delta T

System Operating at 50% Load at DT of 8 degF

Chiller 215 tons

CHWS 42°F

CHWR 50°F

Two pumps at full flow
2 x 645gpm = 1290 gpm

Tons x 12,000 = Btuh
Importance of Controlling Building Delta T

Effect of Low Delta on District Cooling Based Systems Controlling to Return Water Temperatures
(Fixed Delta T on District Cooling Side):

Eg. Design Delta T = 16°F; Actual Delta T = 8°F (50% of design)

1. Flow will be doubled
2. Building chilled water supply temperature will be warmer
3. Warmer supply air temperature means less dehumidification – poor occupant comfort
4. Building fan systems will have warmer supply air temperature requiring fan VFDs to speed up and supply more – more fan energy
5. System must be oversized in order to meet building load on peak days
Importance of Controlling Building Delta T

So…Low Delta T means:

**Chiller Based Systems**
- More flow
- More chillers
- More chiller and pump energy
- System must be oversized in order to meet building load on peak days (or more Chillers)

**District Cooling-Based Systems**
- More flow
- Higher chilled water supply temperature
- Warmer supply air (less dehumidification)
- More fan and pump energy
- More difficulty meeting building loads
- May not meet peak load unless District Cooling lowers return water temperature
The Building’s Existing Cooling System Design
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The Building’s Existing Cooling System Design

• Two chillers in series, 2 pumps – Duty/Standby – on 23rd floor

Chiller 1, 60°F – 50°F (10°F Delta T)(480 tons)
Chiller 2, 50°F - 42°F (8°F Delta T)(375 tons)
(Total – 855 tons)

• The design of the original system Delta T is also in series – Total Delta T = 18°F

• Primary Chilled Water System (provides AHU cooling)

• Secondary Chilled Water System (provides cooling to perimeter fan coils units)

• Return chilled water from the Primary system supplies the Secondary system

• The Primary system AHU coil design is based on an 11°F Delta T

• Secondary System has a 7°F Delta T
The Building’s Existing Cooling System Design

- Primary Pump – constant flow of 1140 gpm with 3 way valves on CU’s
- Secondary Pump – variable flow of 1280 gpm with 2 way valves on perimeter fan coils
- Tenant cooling system design load was 100 tons
- Tenant pump – constant flow of 500 gpm with 2 way valves on tenant equipment and no pressure control
- Tenant system cooling is from the Cooling Tower system with a design delta T of 10°F
- Tenant Delta T was approximately 3°F
Existing Cooling System Design vs Converted System Design

- Existing building design tons = 855 tons plus 100 tons Tenant cooling from separate Cooling Tower loop
- Actual operating tons = 550 tons
- Existing design Delta T = 18°F
- Actual operating Delta T = 6°F-10°F (usually around 7°F)

- District Cooling design tons = 600 tons plus 100 tons (Tenant cooling) 700 Tons Total
- System designed to handle 50% spare capacity = 1050 tons
- District Cooling design Delta T = 16°F (40°F – 56°F)
- Converted building design Delta T = 16°F (41.5°F - 57.5°F)
Converted System
Converted System
Converted System

Primary Chilled Water
Energy Savings Strategies Incorporated into Converted Primary System

1. System was designed with 50% future capacity; 3 pumps and 3 HEXs were provided in lieu of 2 oversized pumps.

2. Variable Volume Smart Pumps with Parallel Pump Controller.

3. Constant Volume system converted to Variable Volume – existing 3-way valves converted to 2-way valves by closing common port isolation valve.

4. HEXs controlled by flow instead of HEX connected to associated pump. HEXs insulated with removable insulation jackets with vapor barrier and no insulation pins (thermally broken).
Converted System

Energy Savings Strategies Incorporated into Converted Primary System (cont’d)

5. Minimum flow control valve added to District Cooling side of HEXs, to allow stable after hours control of low tenant load (200 gpm)

6. Piping design of pumps and HEXs used hydraulically-separated headers to reduce water pressure drop and balance flow through pumps and HEXs

7. Numerous sensors and meters were added and displayed on BAS graphics to allow accurate assessment of system
Converted System
Secondary Chilled Water
Converted System

Energy Savings Strategies Incorporated into Converted Secondary System

1. Existing pumps had VFDs with DP sensor across the pumps. A DP sensor was added near the end of the piping system on the 3rd floor.

2. Existing Secondary loop was piped in series with the Primary loop. This was changed to a hydraulically-separated connection with a smart valve on the return to the Primary loop.

3. Several extremely poor pipe fittings were replaced with pipe fittings with improved flow dynamics.

4. Numerous sensors and meters were added and are now displayed on BAS graphics to allow accurate assessment of system.
Converted System

Tenant Chilled Water Cooling System
Converted System

Energy Savings Strategies Incorporated into Converted Tenant Cooling System

1. Existing constant volume pump was converted to Variable Volume.

2. DP sensor was added to the 3rd floor. The pump flow is now less than half of the original.


4. Numerous sensors and a meter were added and are now displayed on BAS graphics to allow accurate assessment of system.
System Operation after Conversion

Phase 1

- Existing chillers and pumps were disconnected.
- The Cooling System was connected to District Cooling HEX’s and pumps.
- Tenant Cooling system was left operational from the existing cooling towers.

Observations after Phase 1: Delta T was only 4°F (Insufficient Cooling)

Causes:

- Isolation valves on 3 way valve common port were leaking.
- Water was bypassing through the existing chiller isolation valves (7).
- System cooling coils were overflowing.
System Operation after Conversion

Phase 1 (Cont’d)

Remediation:

1. Capped all common ports on 3-way valves on CUs.

   Result: increased Delta T by 2.0°F
   Delta T was 6.0°F (Still Insufficient Cooling)

2. Disconnect chiller piping physically isolating the two systems.

   Result: System flow reduced by 150 gpm (bypass through chiller).
   System Delta T increased by 1°F
   Delta T was 7.0°F (Still Insufficient Cooling)
System Operation after Conversion

Phase 2

- Existing Cooling Towers were decommissioned.
- Tenant Cooling was connected to District cooling.

- **Observation after Phase 2: Delta T increased by 1°F**
- Tenant cooling was now extremely stable: operating at 70°F and approx. 235 gpm (half the flow)
- Tenant system Delta T = 6°F (Previously 3°F)
- **Delta T was now 8.0°F DT (Still Insufficient)**
System Operation after Conversion

1. Smart Valve added to Building MAU unit in basement
2. Pressure
   Independence
   Smart Valve added to Electrical Room (3-way valve was passing water; Electrical Room was at 65˚F)

3. All remaining 3-way valve common ports in the basement were capped

Results:
- System Delta T increase by 1.5˚F
- Total system Delta T = 9.5˚F (Still Insufficient)

Phase 2 (cont’d)

Remediation to Further Improve Delta T
Observation:

Building pumps overflow every morning from 7 am to 12 pm. This is due to remaining 2-way valves and oversized coils overflowing.

Solution:

Install Pressure Independent or Smart Valves
Solutions to Further Improve Delta T

Testing:
• Tested improvements from cleaning and existing compartment unit cooling coil with probiotic coil cleaner.
• Installed M+V devices on a cleaned coil and on a non-treated coil. Delta T improvement from cleaning was 2˚F.
• Installed Smart control valves to improve Delta T of AHUs. 2˚F-3˚F DT improvement.

Future Remediation:
• Clean Cooling Coils with Probiotic Coil Cleaner
• Install Smart Valves
Solutions to Further Improve Delta T

Delta T Future Testing:

• Present fan coil system Delta T is 4.5°F

• Test Delta T Improvements from Probiotic Coil Cleaning of fan coil system

• M+V Test of standard coil cleaning vs probiotic cleaning
Summary

• Effect of Delta T (Chillers vs District Cooling)
• Ways to improve Delta T
• Do We Want More Delta T??
What is the secret to eternal happiness?

To not argue with fools.

I disagree.

Yes, you are right.