Flipping Chilled Water Optimization: Train Operators First

Princeton and MIT Case Studies
CHILLED WATER PLANT OPTIMIZATION

- Chilled Water plant optimization finds lowest energy balance of all components

- Typically training occurs at end of project

- We recommend training first
WHY TRAIN FIRST?
REASON #1: MUST UNDERSTAND THE SYSTEM

• Most often simple issues keep system from working properly, that can only be found through survey

• Tribal knowledge can be key to success

• Training facilitates dialogue between operators
EXAMPLE: MIT SYSTEM BOTTLENECKS
MORE CLOGGED STRAINERS

10# DROP

60#

48#

38#

112#

118#

78#

126#

122#

10# DROP

6.9#
NORMALIZE 48# TO BASEMENT
48# + (10’ / 2.31) = 52#

THEREFORE: PRESSURE DROP
FROM CHILLER OUTLET TO
STRAINER INLET IS:
52# - 40# = **12# PRESSURE DROP**

READING PRESSURE GAUGES AT ELEVATION
REASON #2: COMPLEX PLANTS PARTIAL AUTOMATION

• Many plants do not want full automation

• Especially plants with mix of steam and electric assets

• Steam turbine chillers
STEAM TURBINE CHILLERS

MIT: 5000 Ton York OM500

Princeton: 4500 Ton Carrier 17DA
EXAMPLE: MIT COOLING TOWERS

• Uneven cooling tower basin levels
REASON #3: GAIN OPERATOR’S TRUST AND ADDRESS MISCONCEPTIONS

• If operators do not trust the optimization, THEY WILL OVERRIDE IT

• There are common misconceptions that are counter to principles of optimization
EXAMPLE: CW TEMPERATURE ON TRANE CHILLERS

PU CW Operation – CW Control Valve – CH-2

Guidelines for CenTraVac Chillers with Tracer AdaptiView Controls

Operating Recommendations

All chillers require a minimum pressure difference between the condenser and evaporator refrigerant circuits to assure proper management of oil and refrigerant, as well as hermetic motor cooling (when applicable).

Following are specific guidelines for CenTraVac™ condenser refrigerant pressure with Tracer AdaptiView controls.

At start-up ...

- The chiller should reach the required minimum pressure differential within 15 minutes of starting the chiller. This means that the entering condenser water can be very cold at the start (e.g., –40°F–50°F). The chiller can start in an inverted mode where the condenser water is colder than the evaporator chilled water temperature.
- Running the chiller continuously for 30 minutes at the required minimum refrigerant pressure differential will assure that the oil returns to the oil tank via the oil reclaim system.

When running ...

- The chiller can run steady state with very cold entering tower water. It is important to maintain a minimum 3 psig (20.7 kPa) pressure differential as shown in Figure 2. The 3 psig (20.7 kPa) minimum at all loads is nominally equivalent to a 15°F differential between leaving chilled water temperature and leaving condenser water temperature. For example, a chiller running at 40°F chilled water could operate with an entering condenser water temperature below 50°F, as long as the leaving condenser water temperature is greater than or equal to 55°F if you have chillers with older controls, refer to previous revisions of this bulletin for pressure differential minimums.
EXAMPLE: CHILLER SURGE

Ways to get out of surge:

1. Increase CW Flow
2. Lower CWST
3. Increase Evap Flow
4. Raise CHWST (sometimes)
CHILLER FUNDAMENTALS

- 90F OA 70% RH
- 55F AIR 100% RH
- 120F HOT GAS
- 78F WB AIR 90F DB AIR
- 95F CWR
- 85F CWS
- 90F AIR
- 50F COOL GAS
- 54F CHWS
- 54F CHWR
- 44F CHWS
- 42F COLD LIQUID
- 97F WARM LIQUID
- COMPRESSOR
- EVAPORATOR
- CONDENSER
- EXPANSION VALVE
- SMITH ENGINEERING

www.smith-eng.com
CHILLER FUNDAMENTALS – APPROACH AND LIFT

Cond Approach = Cond Refrig Temp - Leaving CW Temp
97F-95F = 2F

Evap Approach = Leaving CHW Temp - Evap Refrig Temp
44F – 42F = 2F

Lift =
Cond Pressure – Evap Pressure
118.3 – 36.6 = 81.7psig

Or
Cond Temp – Evap Temp
97F – 42F = 55F
EXAMPLE: MIT HAND VALVE OPTIMIZATION
OPTIMIZATION – STEAM CHILLER

All hand valves open: Inefficient

Leaving all valves open

One hand valve closed: Better
OPTIMIZATION – STEAM CHILLER

Two hand valves closed: Even Better

Three hand valves closed: Best
Over 3,500 lb/hr reduction
The hand valves cannot be used as throttling valves. They should be either fully opened or fully closed. A valve that is partly open will soon have a damaged seat due to steam erosion. This condition is better known as “wire drawing”. However, when putting the unit into operation, do not close a valve tightly until the turbine is up to operating temperature and all parts are evenly heated.
REASON #4: GET SAVINGS WITH PARTIAL OPTIMIZATION

- An operator “Cheat Sheet” can often get you half the way to fully optimized
REASON 5: OPERATOR INTERFACE MUST HAVE BUY-IN

The pump control sequence is designed to automatically control the number of running pumps and the speed that the pumps run to:

A. Maintain the differential pressure at the plant wall, and

Stage the number of pumps running so that the pumps are close as possible to their best efficiency point.
REASON #6: POST OPTIMIZATION DRIFT

• Systems **change over time.** Operators must know how to respond

• Getting operator buy-in so that they see the process and understand, allows them to
EXAMPLE: PRINCETON PUMP STAGING
PUMP PRINCIPLES

LARGE CAMPUS CHILLED WATER PUMP

\[ HP = \frac{Flow \times Head}{3960 \times \eta} \]

1. Flow: Campus dictates \(\Delta T\) and thus flow

2. Head: Too many valves to poll to perform DP reset; therefore hydraulically remote DPT determines pump head

3. \(\eta\) can never be greater than pump+motor+VFD BEP \(~80\%\)

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3 CHW Pumps

TDH: 135'
Total FLOW: 7,863 GPM
Ƞ: 56%
Total kW: 375
4 CHW Pumps

TDH: 133’
Total FLOW: 7,863 GPM
Ƞ: 76%
Total kW: 259
kW Reduction: 115
### CHW PUMP OPTIMIZATION

#### Campus TES CHW Distribution Pumps – (4) 400hp Pumps

<table>
<thead>
<tr>
<th></th>
<th>Pre-Optimization</th>
<th>Cx and Operator Training</th>
<th>Stable Optimized Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak (kW)</td>
<td>609</td>
<td>350</td>
<td>215</td>
</tr>
<tr>
<td>Kwh Per day</td>
<td>7,701</td>
<td>4,583</td>
<td>2,525</td>
</tr>
</tbody>
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![Graph showing energy consumption over time](image-url)
SUMMARY: WHY TRAIN FIRST?

1. Must understand the system and capture **tribal knowledge**
2. Complex plants likely **do not want full automation**
3. Process must gain **operator’s trust**
4. **Partial Optimization** can be achieved with operator cheat sheet
5. **Operator Interface** must have operator buy-in and context
6. Optimization will **drift** if operators are not on board
Thank You

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