Variable Primary
chilled water systems
variable primary chilled water systems

Today’s Topics

- Hyatt Singapore Hotel
- From Primary–Secondary to Variable Primary
- Variable Primary advantages
- Chiller selection for Variable Primary
- More System efficiency
- Reference
- Answers to your questions
Hyatt Singapore Hotel
chilled water systems

From Primary Secondary
Primary–Secondary design

1. 650 tons
   12.0°C
   7.0°C

2. 650 tons
   12.0°C
   7.0°C

3. 650 tons
   12.0°C
   7.0°C

4. 650 tons
   12.0°C
   7.0°C

98 lps (each)

12.0°C

bypass (decoupler)

12.0°C
392 lps

primary pumps

7.0°C 392 lps

secondary pumps

TRANE
Primary–Secondary part load

Primary pumps

Secondary pumps

1. 650 tons, 11.1°C, 7.0°C
2. 650 tons, 11.1°C, 7.0°C
3. 650 tons, 11.1°C, 7.0°C
4. 650 tons, 11.1°C, 7.0°C

98 lps (each) bypass (decoupler)

12.0°C 320 lps

12.0°C 7.0°C 72 lps
Variable Primary design

1. 800 tons
   - 12.0°C to 7.0°C

2. 700 tons
   - 12.0°C to 7.0°C

3. 700 tons
   - 12.0°C to 7.0°C

83 lps (each)

83 lps

12.0°C

12.0°C

12.0°C

12.0°C

7.0°C

7.0°C

7.0°C

7.0°C

331 lps

331 lps

ΔP (typical)

700 tons

700 tons

800 tons

(83 lps (each))
Variable Primary part load

1. 100 lps
2. 100 lps
3. 100 lps

75 lps (each)

12.0°C  12.0°C  12.0°C

7.0°C  7.0°C  7.0°C

300 lps  300 lps

0 lps

ΔP (typical)
Variable Primary
system flow < minimum chiller flow rate

11.1 °C
24 lps

7.0°C

off

11.1 °C

off

7.0°C

20 lps

12.0°C
20 lps

4 lps

ΔP
(typical)
## From primary–secondary to variable primary

### Comparative Summary

<table>
<thead>
<tr>
<th>primary–secondary</th>
<th>variable primary</th>
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<tbody>
<tr>
<td>production pumps (primary)</td>
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<td>• Occupies less space</td>
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<td>• Selected for distribution pressure drop (piping, coil, valve)</td>
<td>• Selected for system pressure drop (coil, piping, valve, plus chiller)</td>
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<tr>
<td>• Controlled from system ΔP sensor</td>
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- Occupies less space
- Requires fewer connections

production pump

control from system ΔP sensor

Selected for system pressure drop

Selected for distribution pressure drop (piping, coil, valve)

1 per chiller

Selected for system pressure drop (coil, piping, valve, plus chiller)
## Comparative Summary

### From primary–secondary to variable primary

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<td>• Control valve</td>
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<tr>
<td><strong>Flow-monitoring</strong></td>
<td><strong>Temperature sensors or flow meter</strong></td>
<td><strong>Flow meter or differential pressure sensors</strong></td>
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Variable Primary chilled water systems

Advantages
variable primary chilled water systems

Advantages

- Reduces capital investment
- Saves mechanical-room space
- Simplifies control
- Improves system reliability
- Improved chiller performance
- Saves energy
Variable Primary advantages

Lower Capital Cost

- Fewer ...
  - Pumps
  - Motors
  - Pump bases
  - Starters and wiring
  - Fittings and piping
  - Controls

- Less labor
Variable Primary advantages

More Available Space

Opportunity to ...

- Add other equipment
- Select larger, more efficient chillers
- Improve service access
Variable Primary advantages

**Simplified Control**

- Unfetters chillers from flow-based control
- Operates distribution pumps to transport water
  ... not to start/stop chillers
Variable Primary advantages

**Improved Reliability**

Provides system with ...

- Fewer pumps and accessories
- Fewer chiller recovery options
- Fewer pump recovery options
- Better balance between pumps and chillers online
Improved Chiller Performance

Part Load

[ARI Relief]

CenTraVac Part Load Performance CTV-1

% Load vs. kW/ton -- using ARI Relief Method

Version 24.08, REVL 55066
Improved Chiller Performance

Part Load  [no ARI Relief]

CenTraVac Part Load Performance CTV-1
% Load vs. kW/ton -- using Constant Condenser Method

Version 24.08, REVL 55066
Variable Primary advantages

Greater Flexibility

any flow rate ...

any $\Delta T$
Variable Primary chilled water systems

Chiller selection considerations
chiller selection

Considerations

- Evaporator flow limits
- Rate-of-change tolerance
- Flow “range-ability”
  - Difference between design flow rate and evaporator’s minimum flow limit
Evaporator Flow Limits

Flooded or falling-film evaporators ...

- Refrigerant circulates around tubes
- Water flows through tubes
- Water velocity delimits acceptable flow rates
### Chiller Selection Considerations

#### Evaporator Flow Limits

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<th>flooding \ falling-film evaporators</th>
<th>water velocity, m/s (fps)</th>
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<tbody>
<tr>
<td></td>
<td>minimum</td>
</tr>
<tr>
<td><strong>traditional limits</strong></td>
<td>0.92(3.0)</td>
</tr>
<tr>
<td><strong>revised limits:</strong></td>
<td></td>
</tr>
<tr>
<td>standard tubes</td>
<td>0.46(1.5)</td>
</tr>
<tr>
<td>high-performance tubes</td>
<td>0.61(2.0)</td>
</tr>
</tbody>
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### Rate-of-Change Tolerance

<table>
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<tr>
<th>Chiller (Compressor) Type</th>
<th>Allowable Flow-Rate Change* (% of Design Flow Per Minute)</th>
</tr>
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<tbody>
<tr>
<td>Centrifugal</td>
<td>10% for process cooling&lt;br&gt;30% for comfort cooling</td>
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* Tolerances pertain specifically to Trane chillers.
chiller selection considerations

Rate-of-Change Tolerance

New chiller control technology:

- Centrifugal ... Control
  - “feed forward”
  - flow compensation
  - 50% per minute, all applications
Minimum Flow Rate

Evaporator

\[
\frac{\text{design flow}}{\text{minimum flow}} = \text{greater than 2}
\]

Condenser

minimum flow = 1 meter per second
unsuited for

Variable Primary

- Inadequate control capability
  - Reciprocating chillers
  - Return-water thermostats
  - Insufficient chiller unloading
  - Vintage chiller controls

- Poor financial return
  (Consider chilled water reset instead)
Variable Primary Chilled Water System in Hyatt Singapore Hotel
Saving 30% Kwhr
Reduce 25% KW Demand
Variable Primary Chilled Water System in Another Singapore Hotel

SHANGRI-LA HOTEL CHILLED WATER PIPING SCHEMATIC
Advantages

- Reduces capital investment
- Saves mechanical-room space
- Simplifies control
- Improves system reliability
- Improved chiller performance
- Saves energy
System Efficiency in Hotel

More

- Increase chilled water supply temperature difference to 7°C (5°C/12°C)
- Increase range of cooling tower to 7°C (30°C/37°C)
- Side stream heat recovery
- Stepless FCU
Chilled Water Range
(5.0°C / 12.0°C)

1. 800 tons
   - 12.0°C (typical)
   - 5.0°C

2. 700 tons
   - 12.0°C
   - 5.0°C

3. 700 tons
   - 12.0°C
   - 5.0°C

60 lps (each)

240 lps

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Chilled Water Range
(from 414 l/s, 30°C/35°C)
(to 300 l/s, 30°C/37°C)

1. 800 tons
   30.0°C → 37.0°C

2. 700 tons
   30.0°C → 37.0°C

3. 700 tons
   30.0°C → 37.0°C

cooling tower
cooling tower
cooling tower

ΔP (typical)

37.0°C
300 lps

30.0°C
300 lps
Side stream
Heat recovery design

1. 800 tons

2. 700 tons

3. 700 tons

12.0°C  5.0°C

240 lps

heat-recovery chiller

12.0°C

800 tons

700 tons

700 tons

5.0°C

ΔP
(typical)
Reference

• VARIABLE PRIMARY FLOW CHILLED WATER SYSTEMS: POTENTIAL BENEFITS AND APPLICATION ISSUES
  Final Report Volume 1, March 2004, ARI CR21

• Variable Primary Flow Systems by Mick Schwedler, P.41-44, HPAC April 2000

Variable Primary
chilled water systems

Answers to your questions