Liquid Cooling Guidelines

Michael K Patterson, PhD, PE, DCEP
Data Center and Connected Systems Group
ASHRAE Overview

1. ASHRAE (American Society of Heating Refrigerating, & Air conditioning Engineering) formed in 1894 is a technical society; specializing in cooling.

2. ASHRAE has over 50,000 members & has members in 135 countries.

3. ASHRAE focuses on maintaining an unbiased role within the industry.

4. ASHRAE actively writes standards, guidelines, model codes, etc.

What’s Next?

- Ice Cooled System (Circa 1890)
- General Electric Room Cooler (Circa 1932)
- Computer Room Air Conditioner (Circa 1970)
ASHRAE and Datacenters

• ASHRAE – American Society of Heating, Refrigeration and Air-conditioning Engineers

• Technical Committee 9.9 – Mission Critical Facilities, Technology Spaces and Electronic Equipment
  - Datacom Equipment producers,
    (manufacturers of computer hardware, HVAC equipment, software vendors, etc)
  - User of Datacom Equipment
    (facility owners, operators, managers, etc)
  - General Interest
    (government agencies, utilities, consultants, academia, testing laboratories, etc.)

• Mission Statement: To be recognized by ALL areas of the datacom industry as the unbiased engineering leader in HVAC and an effective provider of technical information for the datacom industry.
2011 ASHRAE Air-Cooled Thermal Guidelines

*Envelopes Represent Conditions at IT Equipment Inlet

<table>
<thead>
<tr>
<th>Degrees C</th>
<th>27</th>
<th>32</th>
<th>35</th>
<th>40</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td>R</td>
<td>A1</td>
<td>A2</td>
<td>A3</td>
<td>A4</td>
</tr>
</tbody>
</table>

Why not something similar for liquid cooling?
2011 Thermal Guidelines for Liquid Cooled Data Processing Environments

Whitepaper prepared by ASHRAE Technical Committee (TC) 9.9 Mission Critical Facilities, Technology Spaces, and Electronic Equipment

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2011 ASHRAE Liquid Cooling Guidelines

• Drivers for More Detailed Liquid Guidelines – Improve and Increase Liquid Cooling Use and Reduce Confusion among users and suppliers

• HPC Challenges with more and more power per node and per rack, pushing to and past air-cooling limits

• Range of cooling architectures not well aligned to IT requirements

• ASHRAE TC 9.9 Response – Enable Opportunity for Innovation

• Defined liquid cooling classes with temperature ranges

• Created guidance to effectively implement liquid cooling through new White Paper

• ASHRAE TC 9.9 IT Subcommittee: Bull, Cisco, Cray, Dell, EMC, Fujitsu, HP, IBM, Intel, Juniper, Lucent, Nortel Networks, Oracle/Sun, Seagate, SGI, Teradata

Cross HPC-IT Team collaboratively authors WP on liquid cooling
What is liquid cooling? Which liquid are we talking about?
## 2011 ASHRAE Liquid-Cooled Thermal Guidelines

<table>
<thead>
<tr>
<th>Classes</th>
<th>Typical Infrastructure Design</th>
<th>Facility Supply Water Temp (°C)</th>
<th>IT Equipment Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Main Cooling Equipment</td>
<td>Supplemental Cooling Equipment</td>
<td></td>
</tr>
<tr>
<td>W1</td>
<td>Chiller/Cooling Tower</td>
<td>Water-side Economizer Chiller</td>
<td>2 – 17</td>
</tr>
<tr>
<td>W2</td>
<td></td>
<td>2 – 27</td>
<td></td>
</tr>
<tr>
<td>W3</td>
<td>Cooling Tower</td>
<td>Chiller</td>
<td>2 – 32</td>
</tr>
<tr>
<td>W4</td>
<td>Water-side Economizer (with drycooler or cooling tower)</td>
<td>Nothing</td>
<td>2 – 45</td>
</tr>
<tr>
<td>W5</td>
<td>Building Heating System</td>
<td>Cooling Tower</td>
<td>&gt; 45</td>
</tr>
</tbody>
</table>

**Required Cooling Infrastructure: Balance of Silicon/Datacenter**
ASHRAE Classes

Figure 3a. Class W1/W2/W3

Cooling Tower -> Heat Exchanger -> IT Equipment
Condenser Water Loop

Water Chiller

Chilled Water Loop

Supply Temp to IT Equipment
2 - 17 C
2 - 27 C
2 - 32 C

Figure 3b. Class W4

Cooling Tower -> Heat Exchanger -> IT Equipment

Supply Temp to IT Equipment
2 - 45 C

Figure 3c. Class W5

Cooling Tower -> Heat Exchanger -> IT Equipment

Building Heating System

Supply Temp to IT Equipment
>45 C
More from the White Paper

Operational Considerations
• Condensation
• Flow and differential pressure limits
• Class specific limits

Water flow rates vs capacity

Velocity Limits
• By size / material

System Design
• Materials
• Connections
• Heat Rejection devices

Water Quality
• Corrosion
• Fouling
• Scaling
• Micro

Bibliography
As advertised earlier... don’t miss these

Birds of Feather: “‘Hot’ for Warm Water Cooling”
• Tuesday, 5:30-7:00PM  WSCC 613/614

State of the Practice: “‘Hot’ for Warm Water Cooling”
• Wednesday, 4:00-4:30PM   TC 202
Wet and Dry Bulb Temperatures
ASHRAE CD, 99.6% of yearly hours, National Laboratory HPC Locations.

**Wet Bulb Temperature**
- 99.6% of hours per ASHRAE CD - U.S. National Laboratories
- Selected Max. = 79.7 °F (26.5°C)

**Dry Bulb Temperature**
- 99.6% of hours per ASHRAE CD - U.S. National Laboratories
- Max. = 99.5 °F (37.5°C)
Air Cooled Server
Dry Cooler or Cooling Tower

Chip Thermal Margin
7°F (4°C)
Using Dry Cooler Only

Using Dry Cooler Only
Water Temp. Supply to Building
109°F (43°C)

Chip Thermal Margin
26°F (15°C)
Using Cooling Tower Only

Using Cooling Tower Only
Water Temp. Supply to Building
89°F (32°C)
<table>
<thead>
<tr>
<th>EEHPCWG</th>
<th>ASHRAE</th>
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<tbody>
<tr>
<td>L1 17 °C</td>
<td>Legacy systems w/ chiller</td>
</tr>
<tr>
<td>Cooling tower &amp; Chiller based Rack level cooling</td>
<td>2-27 °C</td>
</tr>
<tr>
<td>L2 32 °C</td>
<td>Cooling tower &amp; Chiller based Rack/Component level cooling</td>
</tr>
<tr>
<td>L3 43 °C</td>
<td>Dry cooler based Component level cooling</td>
</tr>
<tr>
<td>Heat re-use opportunity Component level cooling</td>
<td>&gt;45 °C</td>
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</tbody>
</table>
Thank You!  Questions?