



# Liquid Cooling Guidelines

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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.



Ice Cooled System  
(Circa 1890)



General Electric Room Cooler  
(Circa 1932)



Computer Room Air Conditioner  
(Circa 1970)

What's  
Next?

# 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.**

Thermal Guidelines  
for Data Processing  
Environments

Datacom Equipment  
Power Trends and  
Cooling Applications

Design Considerations  
for Datacom  
Equipment Cen

Liquid Cooling  
Design Considerations for  
Data and Communications  
Equipment Centers

High Density Data Center:  
Case Studies and Other  
Considerations

Structural and Vibration  
Guidelines for Datacom  
Equipment Centers

Best Practices for  
Datacom Facility  
Energy Efficiency

ASHRAE Datacom Series

ASHRAE Datacom Series

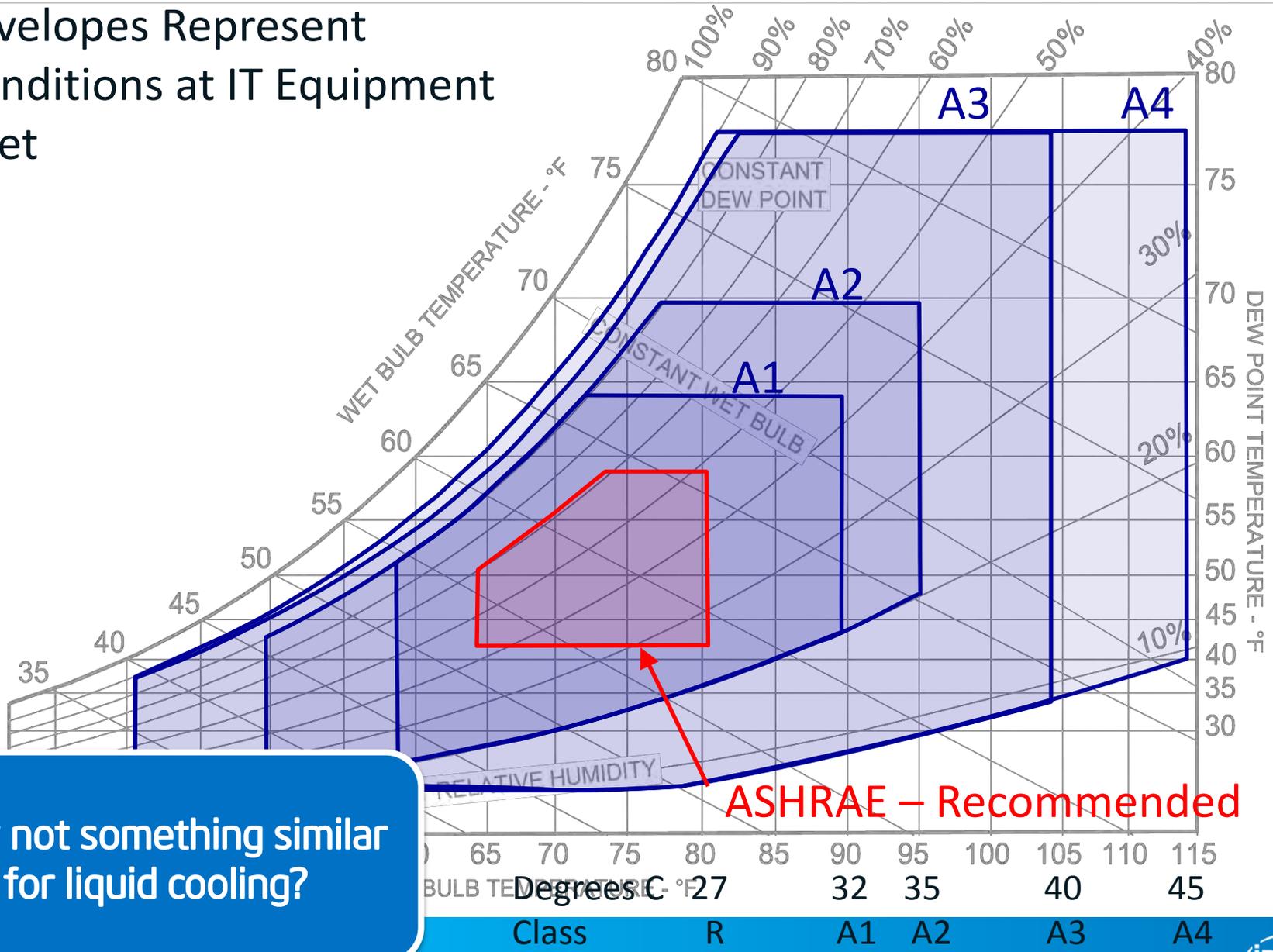
ASHRAE Datacom Series

ASHRAE  
Datacom  
Book Series



# 2011 ASHRAE Air-Cooled Thermal Guidelines

\*Envelopes Represent  
Conditions at IT Equipment  
Inlet



ASHRAE - Recommended

Why not something similar  
for liquid cooling?

Class	Dry Bulb Temperature (°F)	Dry Bulb Temperature (°C)
R	80	27
A1	90	32
A2	95	35
A3	105	40
A4	115	45



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ASHRAE TC 9.9

# 2011 Thermal Guidelines for Liquid Cooled Data Processing Environments

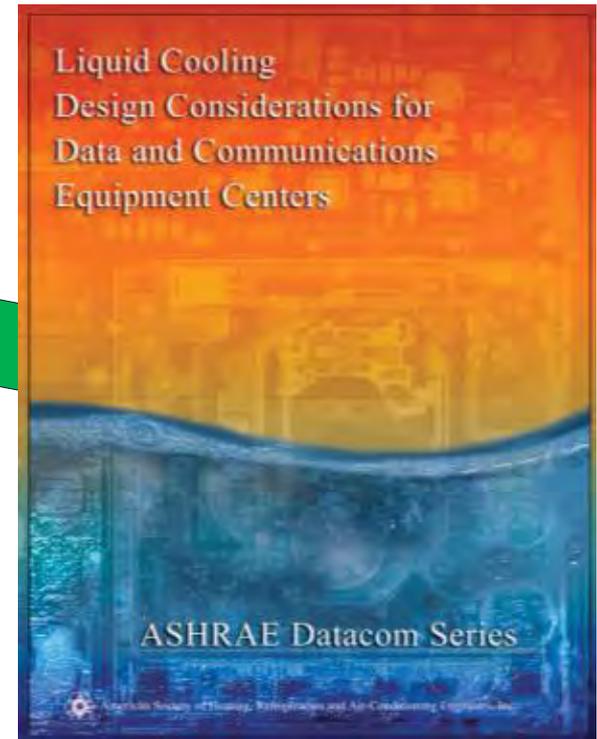
Whitepaper prepared by ASHRAE Technical Committee (TC) 9.9 Mission Critical  
Facilities, Technology Spaces, and Electronic Equipment

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**2006 book now  
supplemented by  
2011 WP**

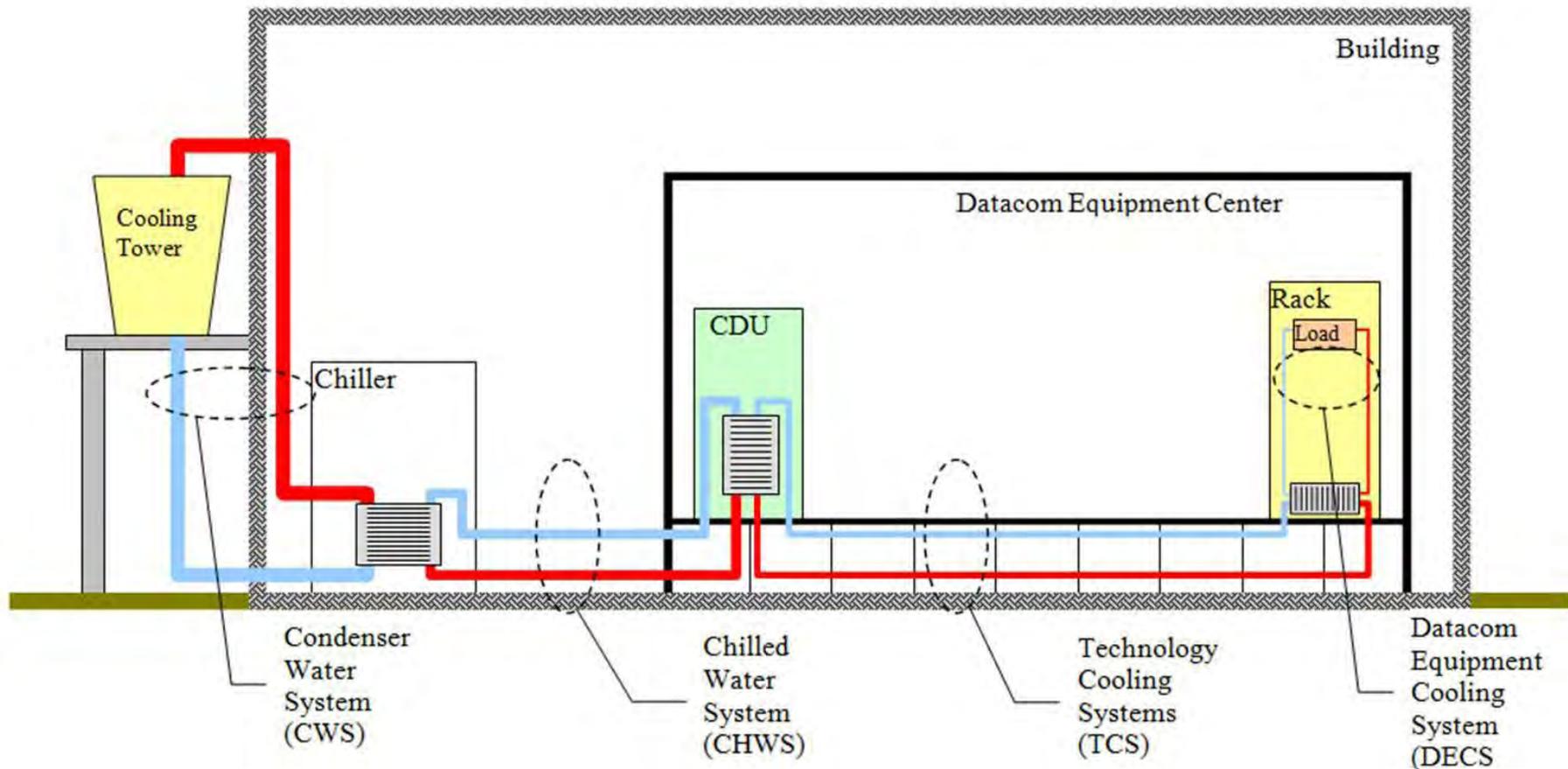


# 2011 ASHRAE Liquid Cooling Guidelines

- **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

Classes	Typical Infrastructure Design		Facility Supply Water Temp (C)	IT Equipment Availability
	Main Cooling Equipment	Supplemental Cooling Equipment		
<b>W1</b>	Chiller/Cooling Tower	Water-side Economizer Chiller	2 – 17	Now available
<b>W2</b>			2 – 27	
<b>W3</b>	Cooling Tower	Chiller	2 – 32	Not generally available, dependent on future demand
<b>W4</b>	Water-side Economizer (with drycooler or cooling tower)	Nothing	2 – 45	
<b>W5</b>	Building Heating System	Cooling Tower	> 45	Specialized systems

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

# ASHRAE Classes

Figure 3a. Class W1/W2/W3

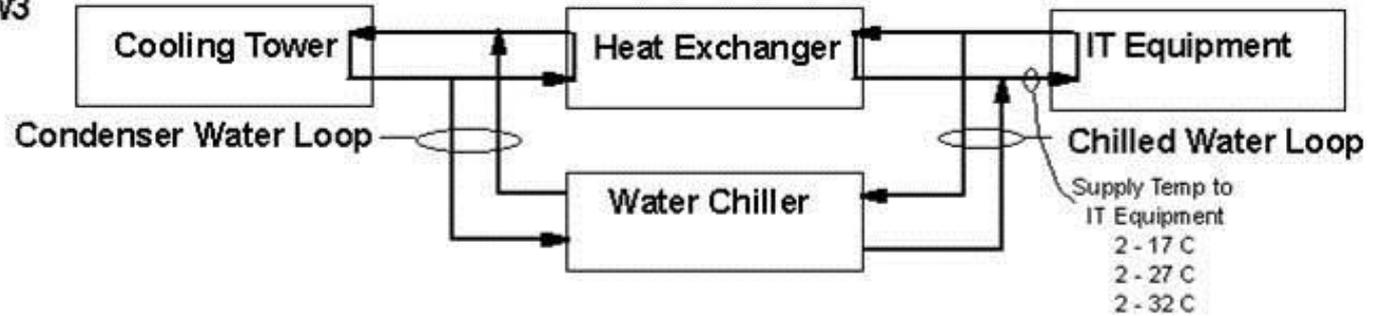


Figure 3b. Class W4

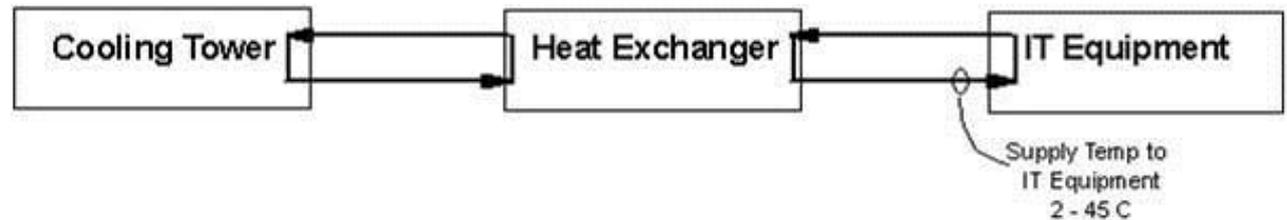
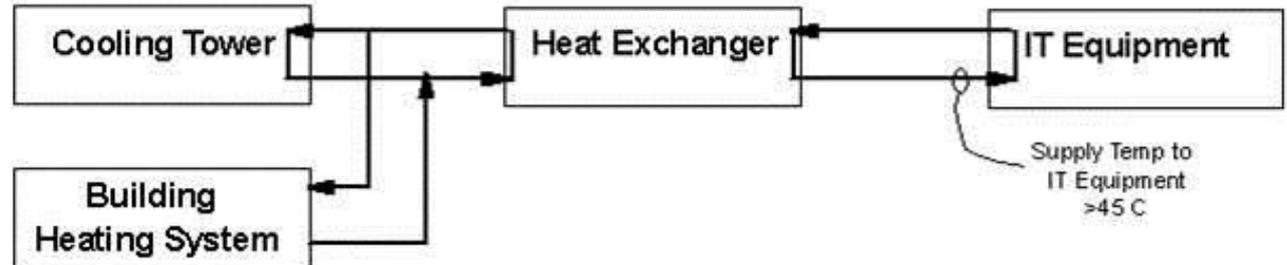


Figure 3c. Class W5



# 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"

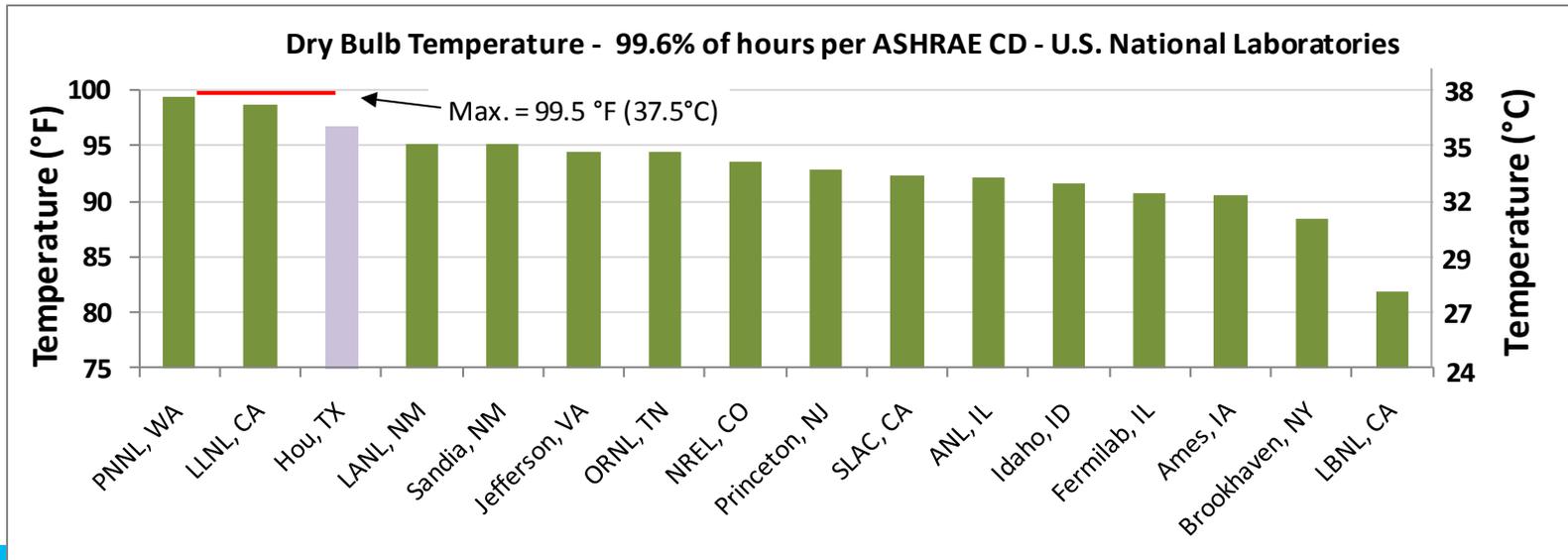
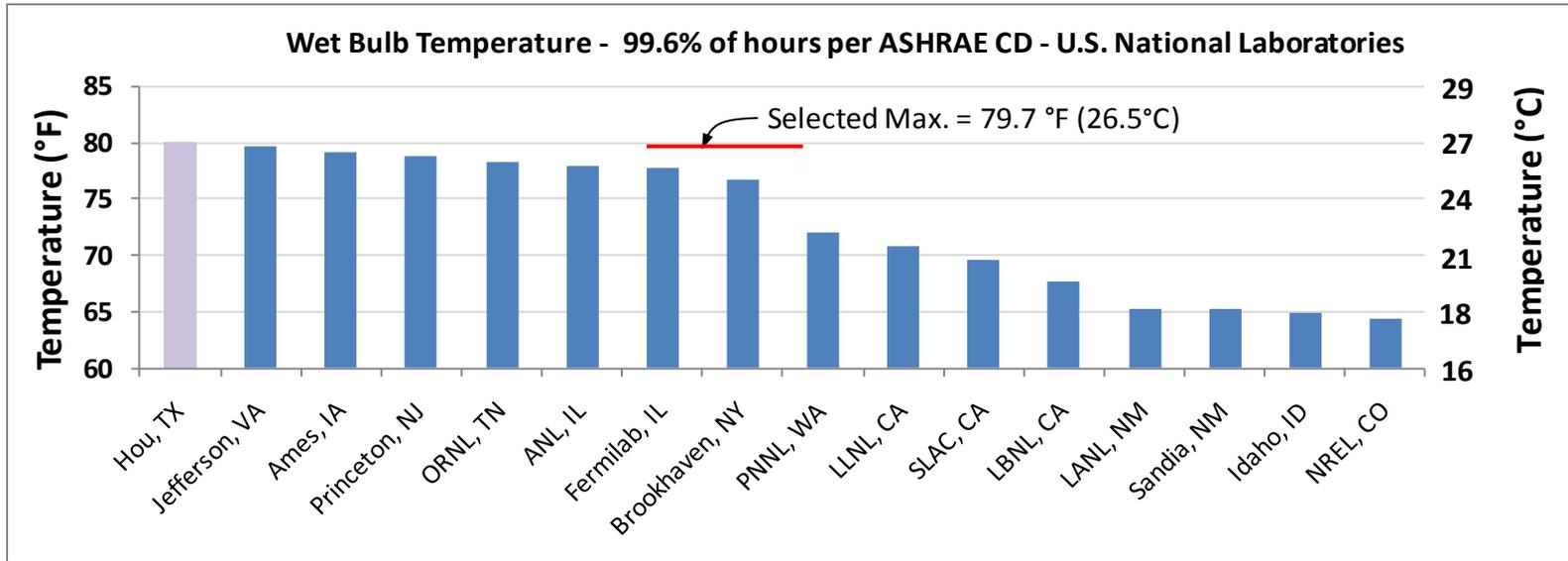
- Tuesday, 5:30-7:00PM WSCC 613/614

## 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.



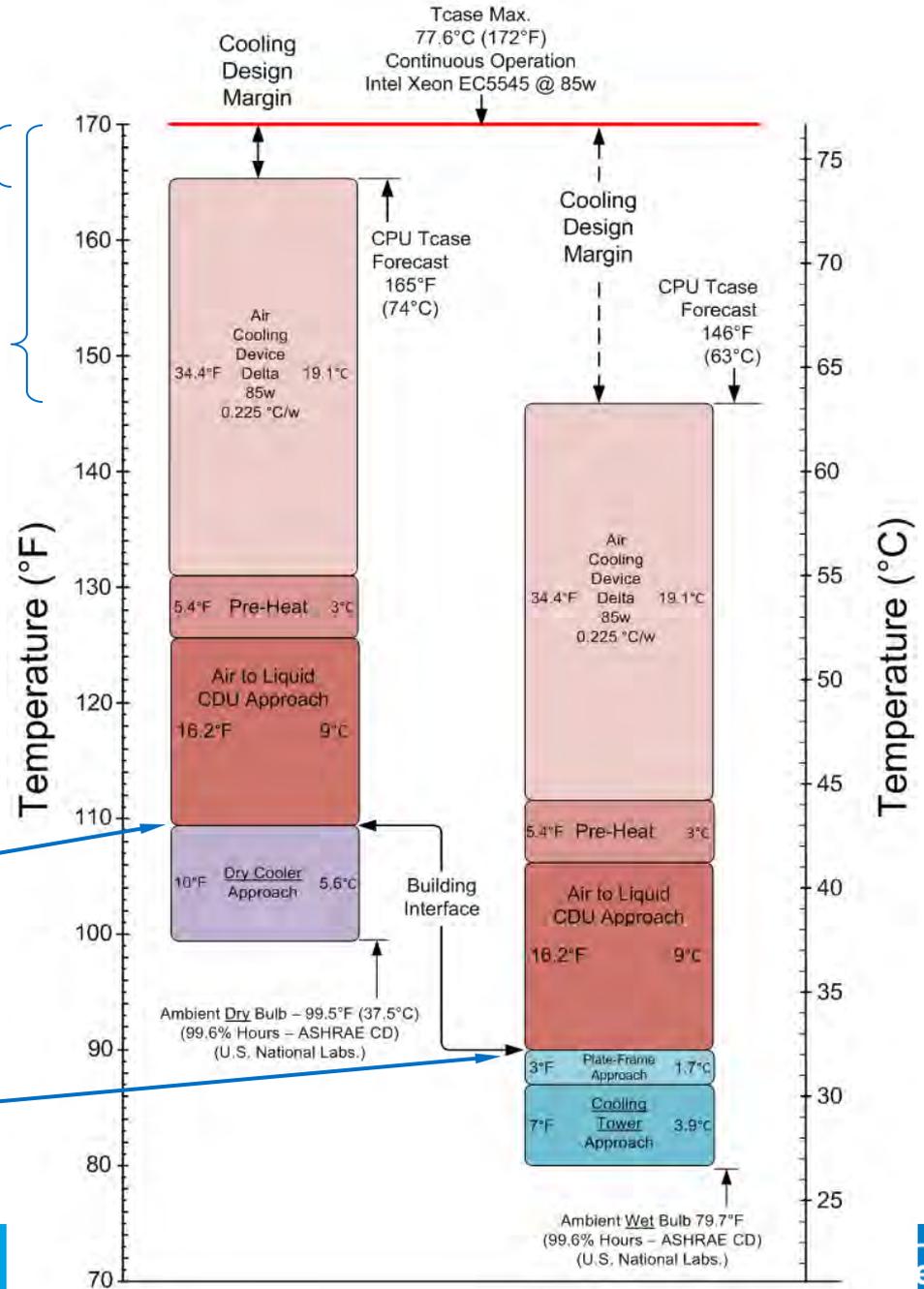
# Air Cooled Server Dry Cooler or Cooling Tower

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

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

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

Using Cooling Tower Only  
Water Temp. Supply to Building  
89°F (32°C)





**Two liquid cooling activities meeting in the middle**

	EEHPCWG		ASHRAE	
L1	17 °C	Legacy systems w/ chiller	2-17 °C	W1
		Cooling tower & Chiller based Rack level cooling	2-27 °C	W2
L2	32 °C	Cooling tower & Chiller based Rack/Component level cooling	2-32 °C	W3
L3	43 °C	Dry cooler based Component level cooling	2-45 °C	W4
		Heat re-use opportunity Component level cooling	>45 °C	W5

Thank You!

Questions?



