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Thermal Design of Data Centers to Safeguard Electronic Equipment

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Advanced Indoor Environmental and Energy Solutions for Mission-Critical Facilities

Outline

- ❑ **The Thermal Interface**

- ❑ **Air Management**

- ❑ **Environmental Requirements**

- ❑ **Show Compliance**

- ❑ **Thermal Design Examples**

- ❑ **Live Software Demo**

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Different Responsibilities
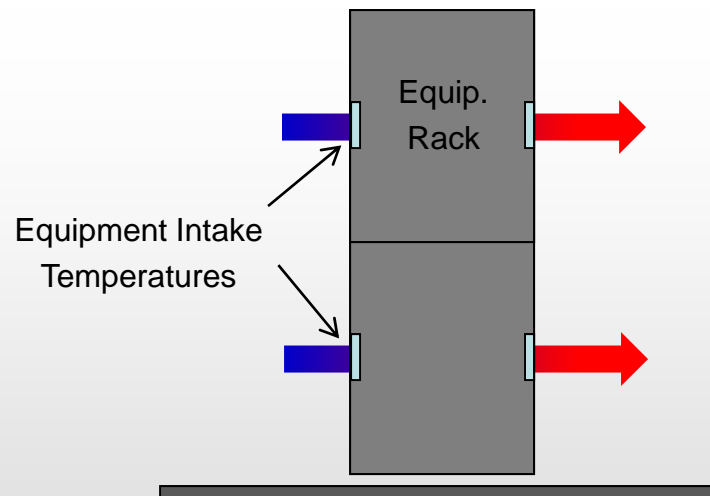
Equipment Vendor

# Box vs. Rack vs. Room

End User

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The Thermal Interface

Air-cooled electronic equipment depends exclusively on the *intake* air temperature for effective cooling. Today, most (but not all) environmental specifications refer to the intake conditions.

Equipment Intake Temperatures

Equip. Rack

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Air Management

The goal of Air Management is to minimize mixing of hot and cold air streams by minimizing air *recirculation* of hot air and minimizing *by-pass* of cold air in the data center room. Successfully implemented, both measures result in energy savings and better thermal conditions.


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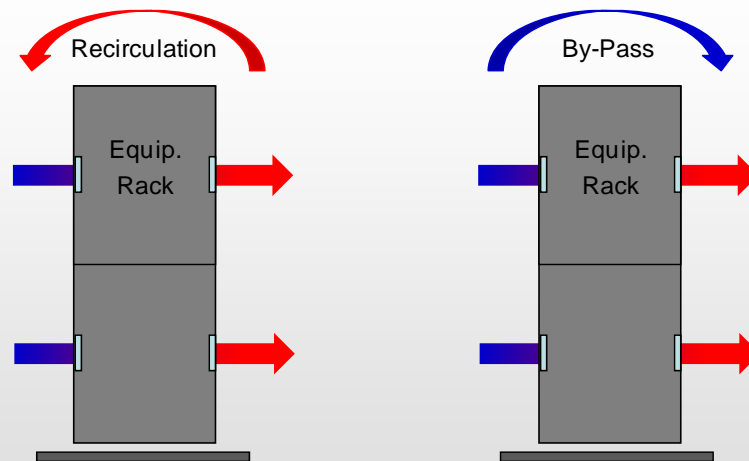
Importance of Air Management

Thermal Management. Adequate thermal conditions (server intake temperatures) are important for the reliability and longevity of electronic equipment.

Energy Management. Air Management helps reduce operating costs by enhancing economizer utilization, improving chiller efficiency, and reducing fan energy.

Capital Management. Improved energy efficiency also results in reduced capital investments for cooling equipment, air-moving equipment, and real estate.

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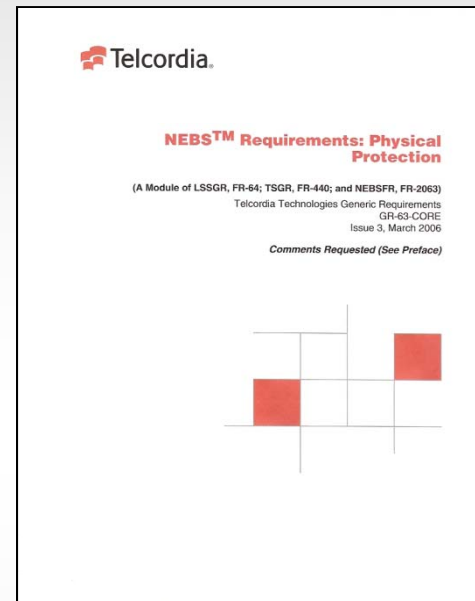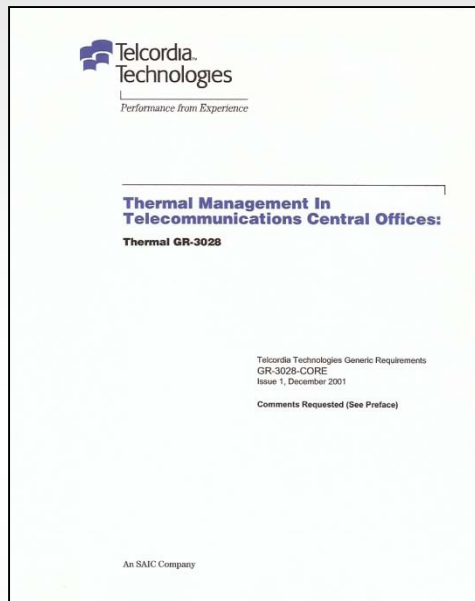
Telcordia NEBS

NEBS is the de-facto standard for
telecom equipment and facilities;
END USER CENTRIC

Telcordia. 2001. (Herrlin, M.) Generic Requirements GR-3028-CORE, *Thermal Management in Telecommunications Central Offices*, Issue 1, December 2001, Telcordia Technologies, Inc., Piscataway, NJ.

Telcordia. 2006. (Kluge, R.) Generic Requirements NEBS GR-63-CORE, *NEBS Requirements: Physical Protection*, Issue 3, March 2006, Telcordia Technologies, Inc., Piscataway, NJ.

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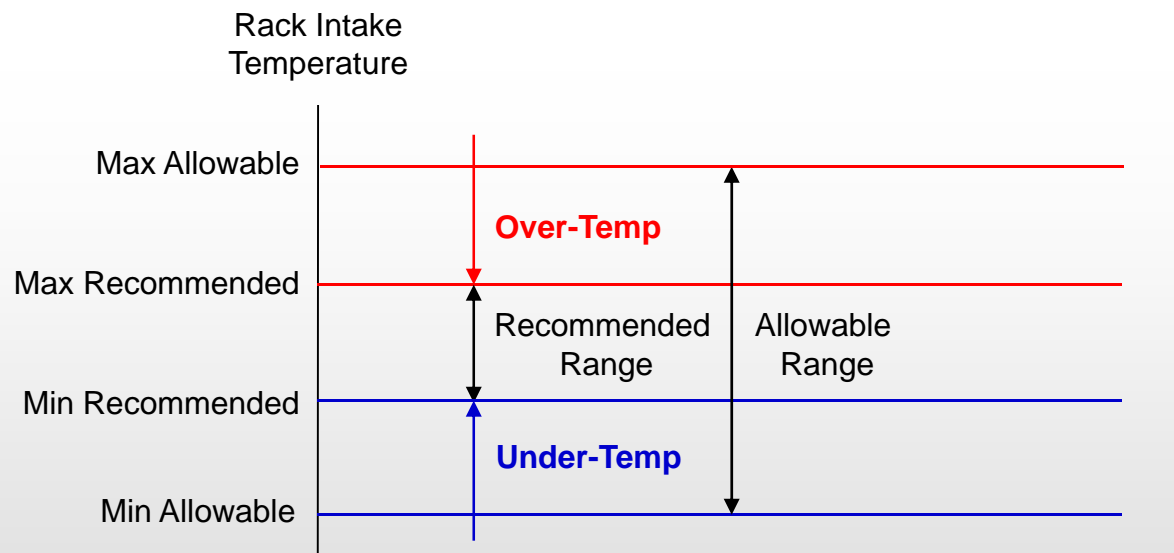INCORPORATED
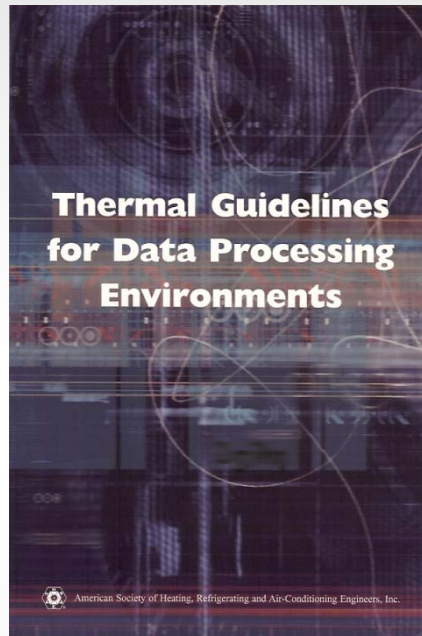
ASHRAE

Many concepts taken
from NEBS GR-63 and
NEBS GR-3028

The ASHRAE guideline is primarily for
data-center equipment and facilities;
EQUIPMENT VENDOR CENTRIC

Key Nomenclature

Recommended range (statement of reliability):
Preferred facility operation; <u>most</u> values should be within this range.

Allowable range (statement of functionality):
Robustness of equipment; <u>no</u> values should be outside this range.

Rack Intake
Temperature

Max Allowable

Over-Temp

Max Recommended

Recommended
Range

Allowable
Range

Min Recommended

Under-Temp

Min Allowable

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Temperature Specifications

(@ Equipment Intake)	Min and Max <u>Recommended</u> (Statement of Reliability)	Min and Max <u>Allowable</u> (Statement of Functionality)
Temperature (°C)		
Data Centers ASHRAE	18° – 27°C	15° – 32°C
Telecom NEBS	18.33° – 26.67°C	5° – 40°C
Temperature (°F)		
Data Centers ASHRAE	64.40° – 80.60°F	59° – 89.60°F
Telecom NEBS	65° – 80°F	41° – 104°F

ASHRAE (2009) Special Publication, *Thermal Guidelines for Data Processing Environments*; Telcordia (2001) *Generic Requirements NEBS GR-3028-CORE*; Telcordia (2006) *Generic Requirements NEBS GR-63-CORE*.

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Determining Compliance

The **Rack Cooling Index (RCI)^{TM}** is a performance metric designed to gauge compliance with the thermal guidelines of ASHRAE/NEBS.

❑ RCI$_{HI}$ (100% mean no temperatures above max recommended)
❑ RCI$_{LO}$ (100% mean no temperatures below min recommended)

Both at 100% mean that all temps are within the recommended range, i.e., absolute compliance. The lower the numbers, the greater probability intake temperatures are outside the allowable range.

The Rack Cooling Index (RCI) is a trademark of ANCIS Incorporated

ASHRAE (2008) Special Publication, *Thermal Guidelines for Data Processing Environments.*

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Rack Cooling Index (RCI$_{HI}$)
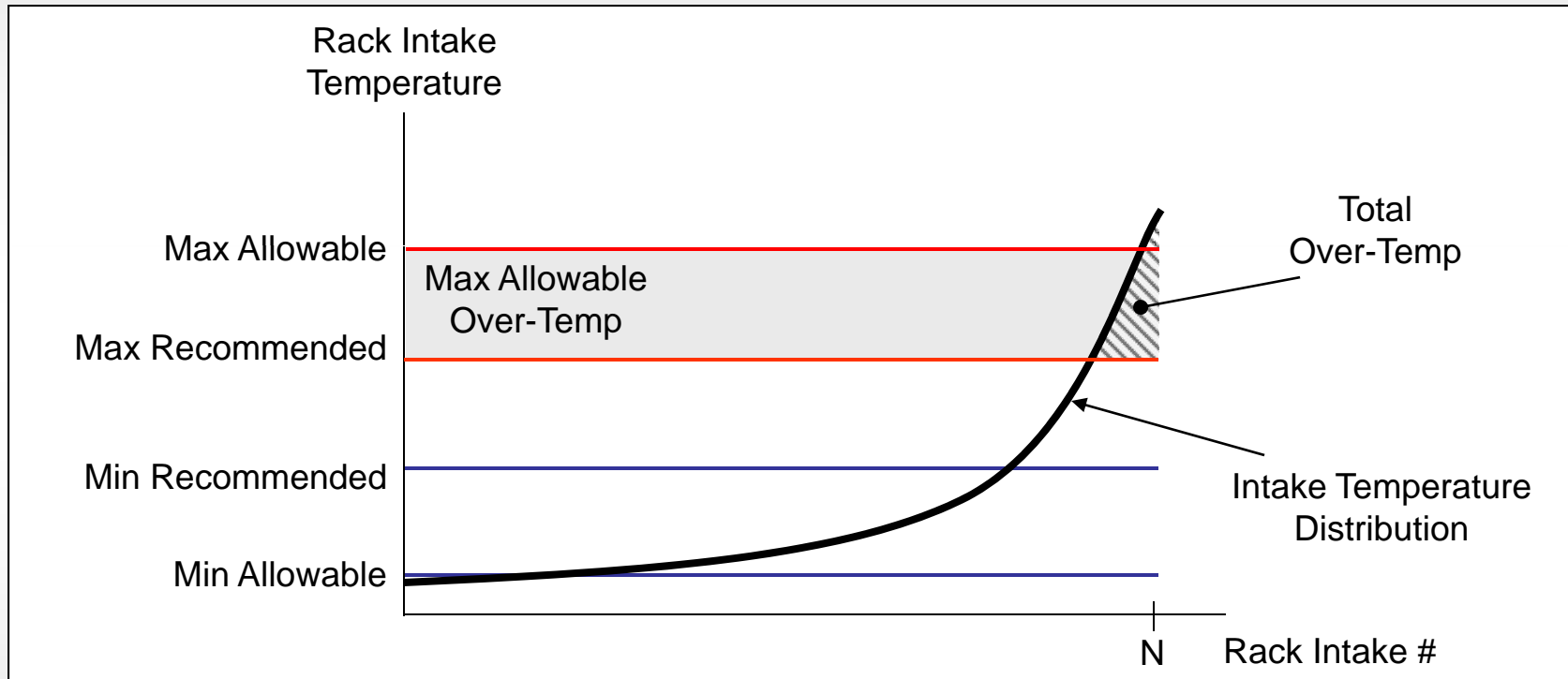
Herrlin, M. K. 2005. Rack Cooling Effectiveness in Data Centers and Telecom Central Offices: The Rack Cooling
Index (RCI). ASHRAE Transactions, Volume 111, Part 2

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Rack Cooling Index (RCI$_{HI}$)

Measure of how well the IT/network equipment is cooled within industry guidelines

$$RCI_{HI} = [1 - \frac{\text{Total Over-Temp}}{\text{Max Allowable Over-Temp}}] \ 100\%$$

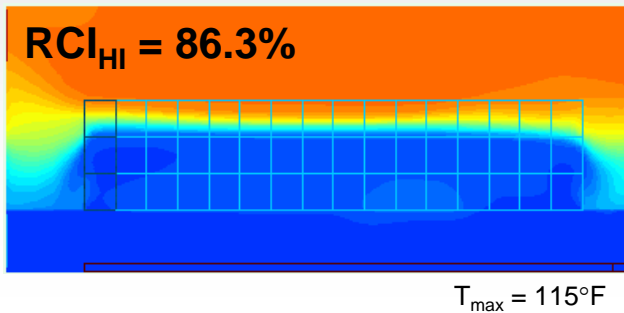Total Over-Temp: Summation of all temperatures above Max recommended
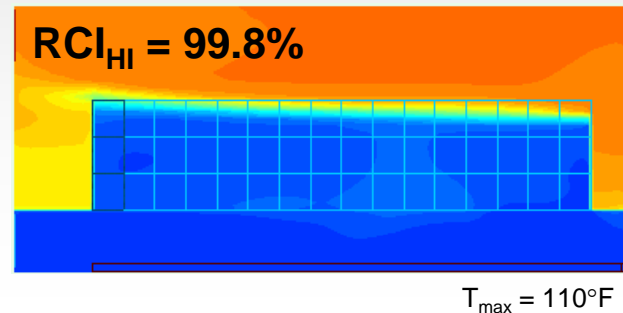Max Allowable Over-Temp: Suitable reference [(Max All - Max Rec)*(Number of Intakes)]

Suggested Rating	RCI
Ideal (max)	100 %
Good	≥95 to <100
Acceptable	≥90 to <95
Poor	<90

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LBNL Supercomputer Facility

Open Architecture

$RCI_{HI} = 86.3\%$

$T_{max} = 115°F$

Doors

$RCI_{HI} = 99.8\%$

$T_{max} = 110°F$

Open, +20% Supply Air

$RCI_{HI} = 99.9\%$

$T_{max} = 107°F$

Doors, +20% Supply Air

$RCI_{HI} = 100\%$

$T_{max} = 100°F$

Section Views

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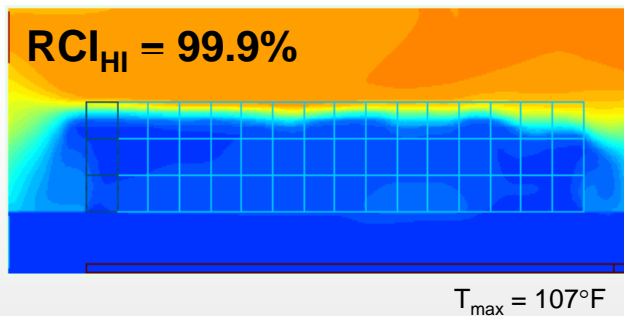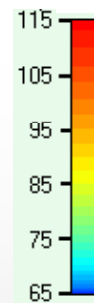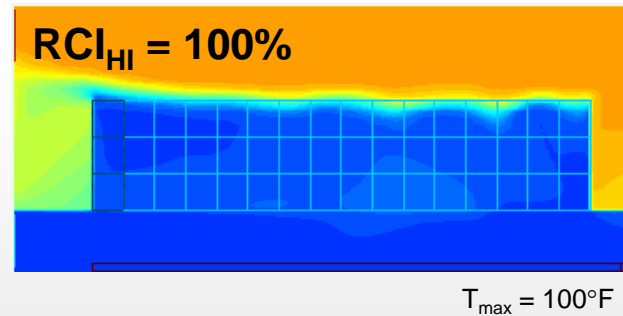
Advanced Data Centers (ADC)

Legend:
- Servers
- Tape Machines
- Network
- PDUs
- Enclosures
- Chimneys
- Returns
- Fan Wall
- Cable Racks

@ Server Mid Level

Temperature (degF)
100
95.3
90.7
86
81.3
76.7
72

RCI_{HI}=100%
RCI_{LO}=100%

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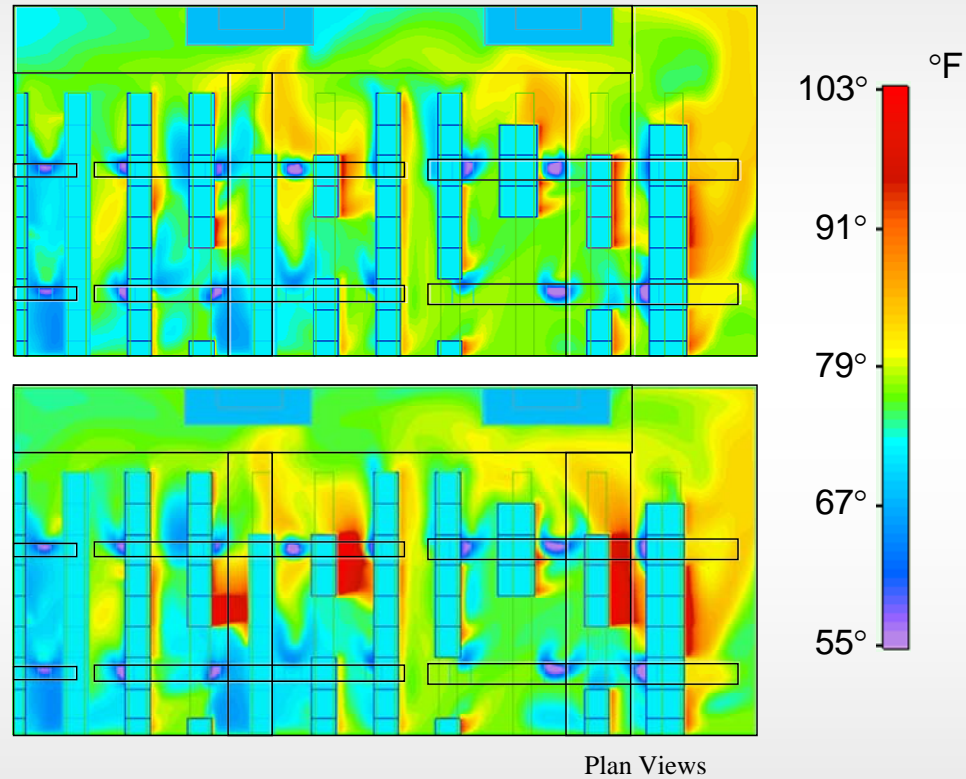
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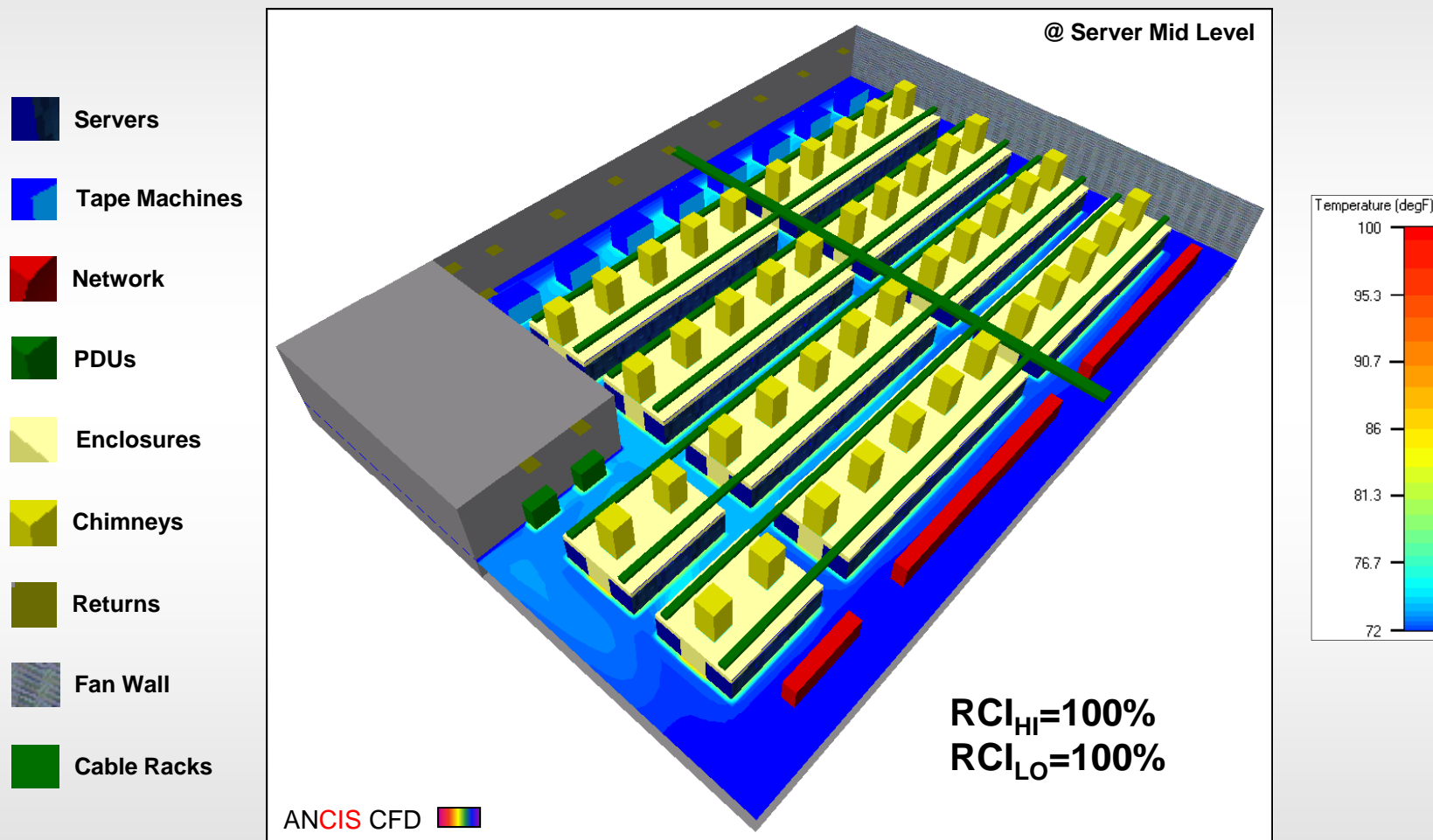
Verizon Wireless Telecom Facility

With exhaust
deflection devices;
$RCI_{HI}=99\%$

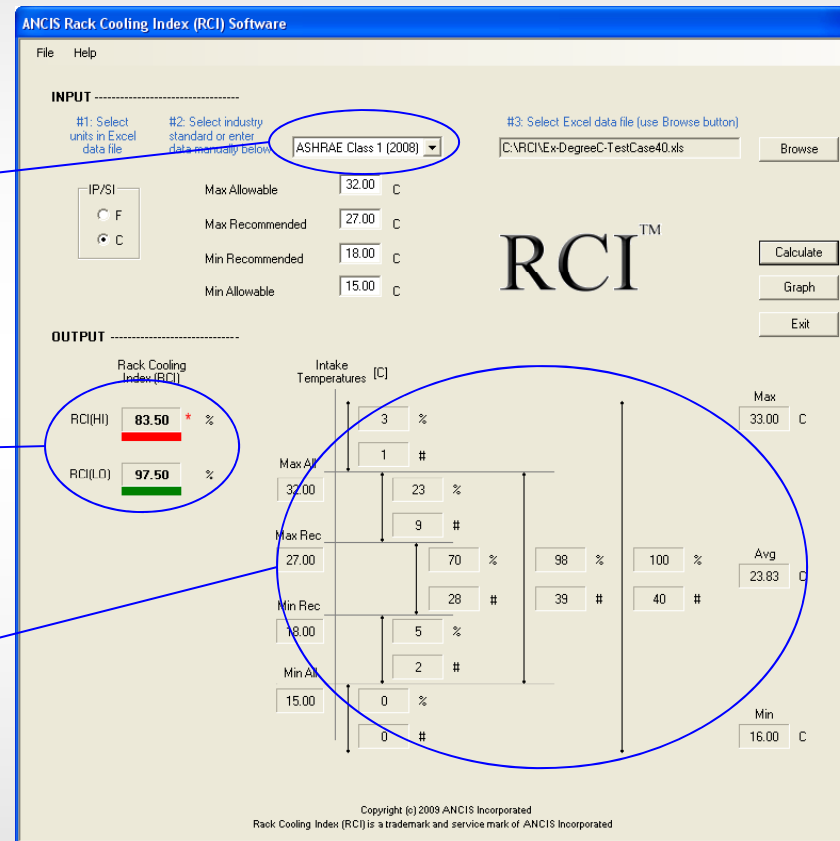Without exhaust
deflection devices;
$RCI_{HI}=95\%$

Plan Views

Herrlin, M. K. and Quirk, D. 2008. Placing High-Density Point Loads in Existing Telecom Switching Centers.
ASHRAE Journal, January 2008

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Rack Cooling Index (RCI)^{TM} Software

Industry Standards

RCI$_{HI}$ and RCI$_{LO}$

Temperature Statistics

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Rack Cooling Index (RCI)™ Software

Temperature Plots
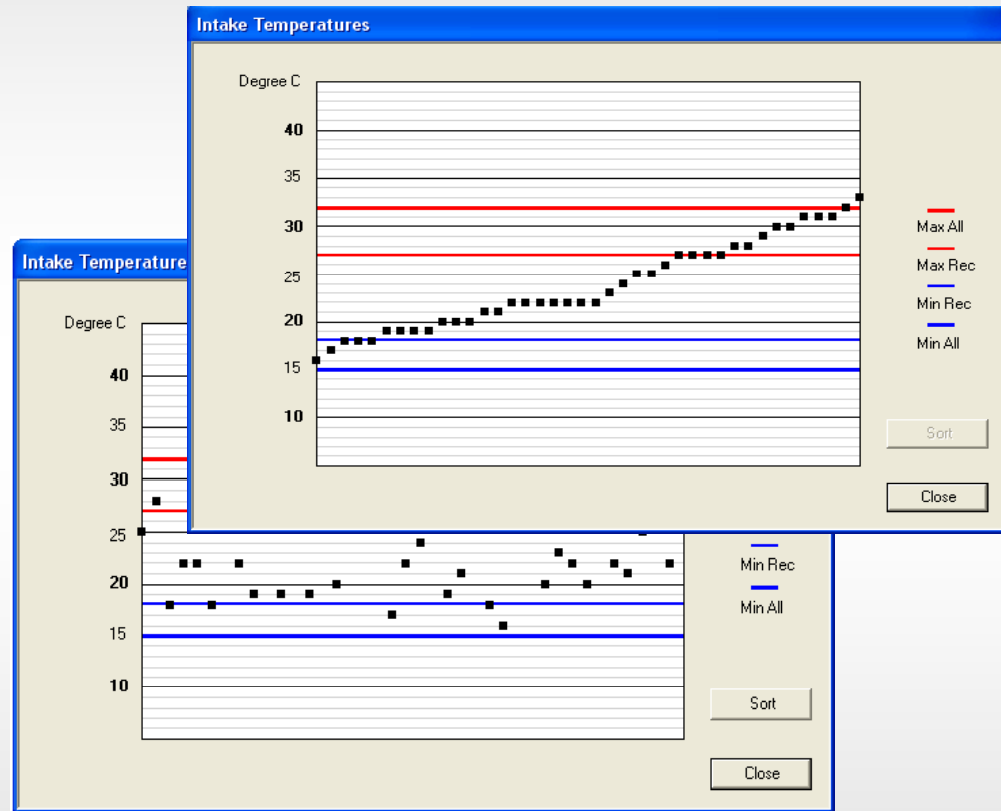
More Rack Cooling Index (RCI) Software information at www.ancis.us

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Live Software Demo

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Thermal-Energy Certification

DOE is partnering with industry to develop a Data Center Certified Energy Practitioner (DC-CEP) Program to accelerate energy savings in data centers.

The Practitioners will be qualified to identify and evaluate energy efficiency opportunities in data centers. The candidates must pass minimum qualifications and a certification exam.

Read more at:

http://www1.eere.energy.gov/industry/saveenergynow/cep_program.html

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Summary

❑ Understand the thermal interface between equipment-room

❑ Be familiar with the wider temperature ranges

❑ Recognize metrics for demonstrating compliance

❑ Be aware of software for calculating the RCI metric

❑ DOE Certified Energy Practitioners (DC-CEPs) will help improve the thermal conditions and energy efficiency of data centers.

THANK YOU

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