PERGRAVIS
Mission Critical Facilities

ASHRAE Data Center Standards: An Overview

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Pergravis is a global mission-critical facility services firm that provides a broad range of consultation, maintenance, design, deployment and migration services throughout North America, the Pacific, the Caribbean and Latin America.

Headquartered in Tampa, FL the firm's client base is highly diverse ranging from Fortune 100 firms and the White House Communications Agency to local small businesses.

Why Worry?

Why Worry About Cooling/Humidity?

Traditional Concerns:

- CPU Performance & Longevity
- Bus Processor and Memory Performance & Longevity
- Prevent Chassis Corrosion and Resulting Potential for Short Circuits
- Prevent Circuit Trace Corrosion
- Prevent Circuit Trace Delamination
- Prevent Circuit Board Delamination
- Hard Drive Longevity
- Fan Longevity

What About Today?

- Hardware much more robust
- Research suggests much wider range of temperature & humidity allowable
- Legacy hardware remains a concern
- Hardware operated beyond warranty a concern (>3 Years)
- Hardware operated beyond $0.00 depreciation a concern (>5 Years)

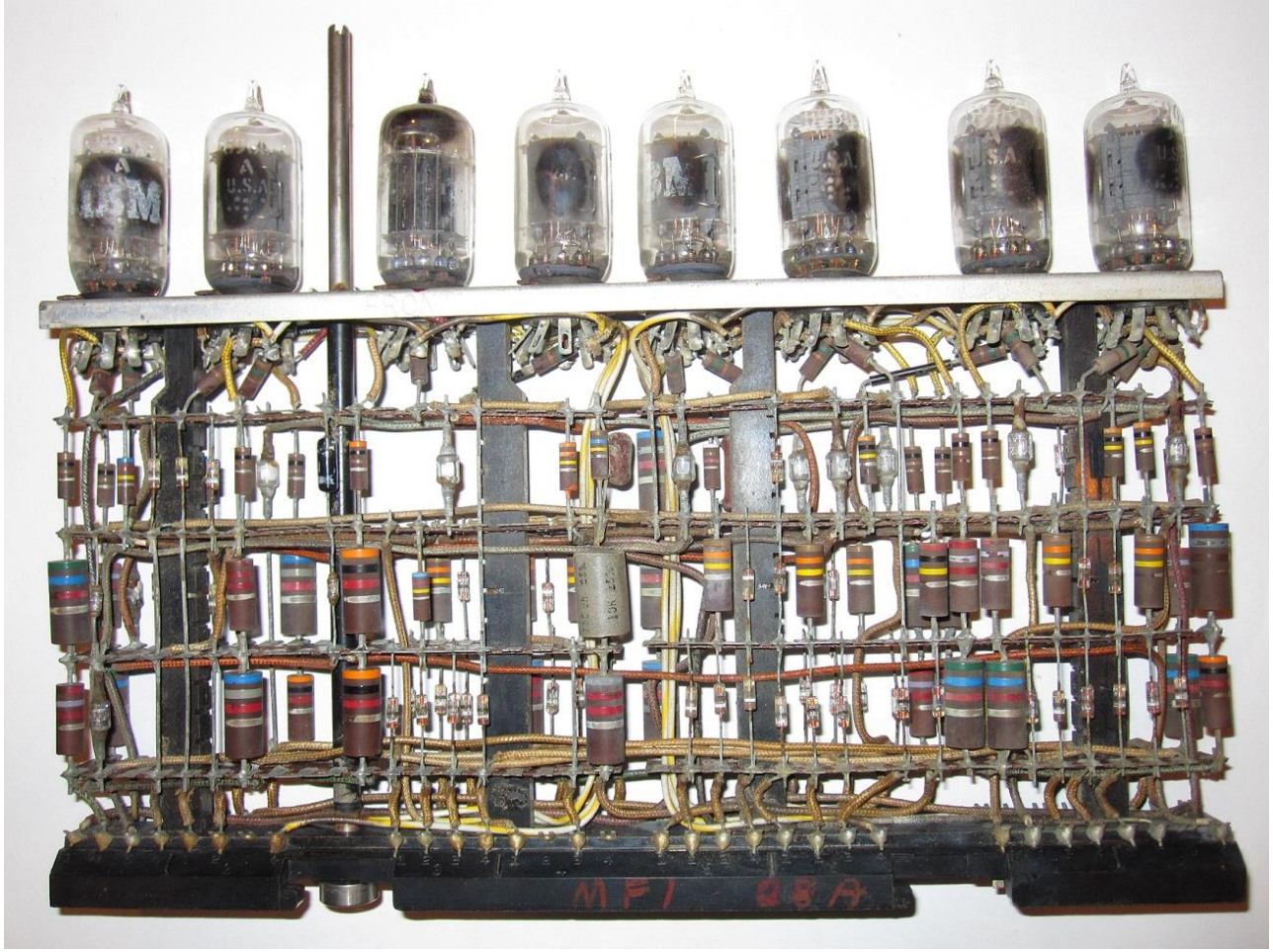
Q. How Did We Get Here?
A. We’ve Always Been Here!

So, How Did We Get Here?

IBM 7090 Circa 1962

Main frame computers, often with vacuum tube components, required cooling to ensure proper operation. Cooling was via integrated chilled water loops.

So, How Did We Get Here?



IBM Model 709 Eight Tube Logic Module
(Each tube has voltages up to 330 Volts!)

So, How Did We Get Here?

RCA IBM Model 709 Installation Cape Canaveral, Florida

CPU Speed:	42k add./sub./sec. or 5k mult./div./sec.
Power Consumption Computer:	113.6 kW/158.9 kVA (0.72 pf)
Power Consumption Air Conditioner:	78.3 kW
Area, Computer:	2,472 sq ft
Area, Air Conditioner:	450 sq ft
Computer Room Dimensions:	39 ft x 56 ft 9 ft x 32 ft
Air Conditioner Room Dimensions:	15 ft x 15 ft 15 ft x 15 ft
Air Conditioner Capacity:	84 Tons (1,008,000 BTU)
Weight, Computer	43,130 lbs.

Facilities Systems Description:

Concrete block building, false floor in machine room for cables, terminal rack for real time inputs and communications, fast acting switch to transfer critical power input to the industrial bank during power fluctuations, and direct expansion system for air conditioning.

Price: Starting from $2,600,000

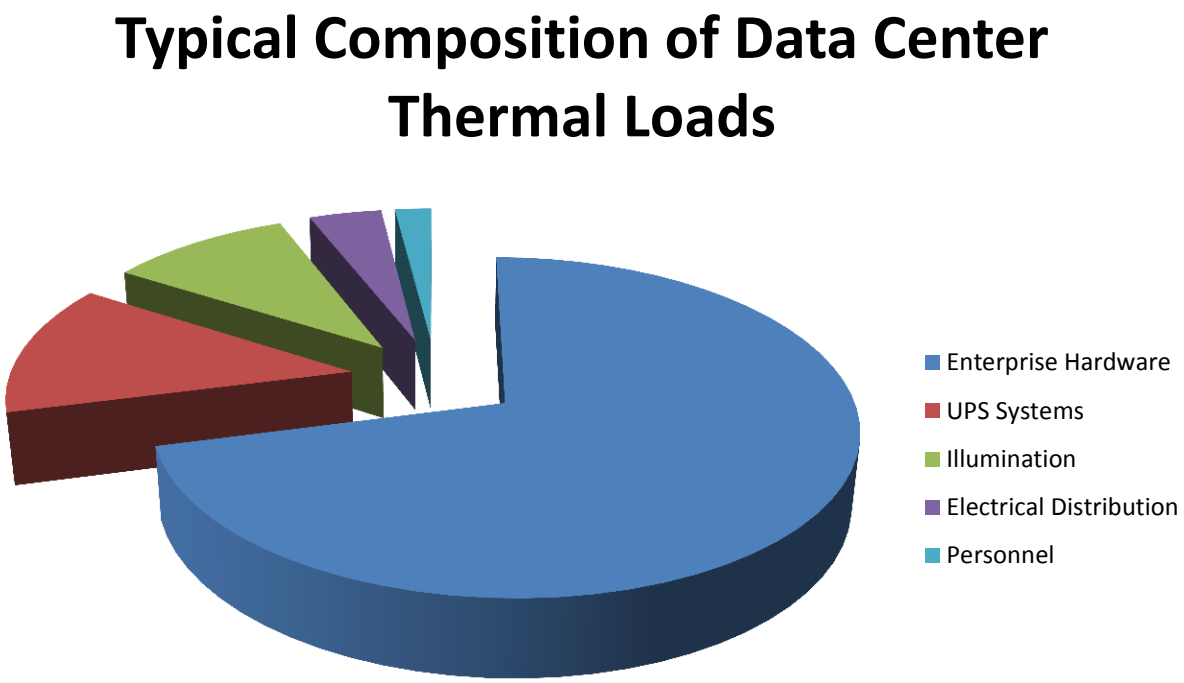
So, How Did We Get Here?

1994: World changes with the introduction of the first rack mount X86 based server family, the Compaq Proliant 1000R, 2000R and 4000R.

So, How Did We Get Here?

2007: Dell M1000e Blade Center. Representative of 21st Century high density rack mount technology. 4 kW to 7 kW per Center depending on configuration.

So, How Did We Get Here?



Who/What is ASHRAE

What is ASHRAE?

American Society of Heating, Refrigerating and Air-conditioning Engineers

www.ashrae.org

- Founded in 1894
- Building technology society
- 50,000 members worldwide
- Focus is on building systems, energy efficiency, indoor air quality and sustainability within the industry.

Mission:
To advance the arts and sciences of heating, ventilating, air conditioning and refrigerating to serve humanity and promote a sustainable world.

Why Did ASHRAE Develop Standards?

Three Primary Goals:

1. **For Consumer Protection**
   Establishing data center environmental standards protected consumers by guarantying that warranty claims would be paid **IF** the data center environment was properly maintained.

2. **For Enterprise Protection & Performance**
   Establishing standards for the data center environment would assure operators that the enterprise would function “as advertised” (processor speed) FSB speed, memory speed, hard drive MTBF, etc.) if the environment was properly maintained

3. **For Energy Efficiency / Cost Savings ($$$)**
   To help minimize OPEX by establishing temperature and humidity specifications that do not over cool or over process the data center environment.

ASHRAE Technical Committee 9.9

TC9.9 Focus:
Mission Critical Facilities, Technology Spaces, & Electronic Equipment

Mission:
To be recognized amongst all areas of the datacom industry as the unbiased engineering leader in HVAC & an effective provider of technical datacom information.

Scope:
All datacom facilities**:** datacom stands for data processing & communication facilities. It includes rooms or closets used for communication, computers, or electronic equipment.

Membership:
- 59 Representatives from Producers of datacom equipment
- 32 Representatives of users of datacom equipment
- 26 General Interest representatives (Government agencies, consultants, etc.)

ASHRAE TC9.9 Cont.

TC9.9 is:
A group of volunteers who provide the Society with expertise in a specific field or subject (Manufacturers, Consultants, Researchers, Universities, Utilities, Regulators, Contractors, and Government).

Participate in Five (5) Areas:

- Standards
- Handbooks
- Program
- Technical Activities
- Review technical papers submitted to the Society

Advise Society on technical matters related to the TC's expertise.

TC 9.9 Website: www.tc99.ashraetcs.org

The ASHRAE TC 9.9 Data Center Recommendations

Before ASHRAE TC 9.9:

The Rule-of-Thumb Conditions - “Colder is Better!”

ASHRAE TC 9.9 Guidelines: Overview

- First established in 2004
- Developed by ASHRAE Technical Committee 9.9 (TC 9.9)
- Prior to ASHRAE, environmental requirements were dictated by manufacturers
- Developed to establish standards for manufacturer's to meet
- Focus was on performance and reliability (uptime), not efficiency
- Would evolve based on hardware characteristics

ASHRAE TC 9.9 Guidelines: 2004

- Standard focuses on enterprise reliability not efficiency
- Establishes a 9°F range between 68°F to 77°F as the acceptable inlet temperatures for enterprise hardware
- Adopted relative humidity (RH) as the metric for humidity measurement
- Established a 15% band between 40% and 55% RH as acceptable

ASHRAE TC 9.9 Guidelines: 2008

- Standard begins to accommodate facility efficiency as well as enterprise reliability
- Established six environmental classes (A1, A2, A3, A4, B, C) to reflect differences in the settings in which IT hardware would be deployed. For most SMB data centers,A3/A4 will be the applicable Class.
- Increased the acceptable temperature range by 7.2°F and establishes the 16.2°F band between 64.4° – 80.6°F as the acceptable inlet temperature range for enterprise hardware
- Utilized both relative humidity and dew point as the basis for humidity measurement

ASHRAE TC 9.9 Guidelines: 2008 Cont.

- Standard begins to accommodate facility efficiency as well as enterprise reliability
- Dew point is introduced as a humidity metric

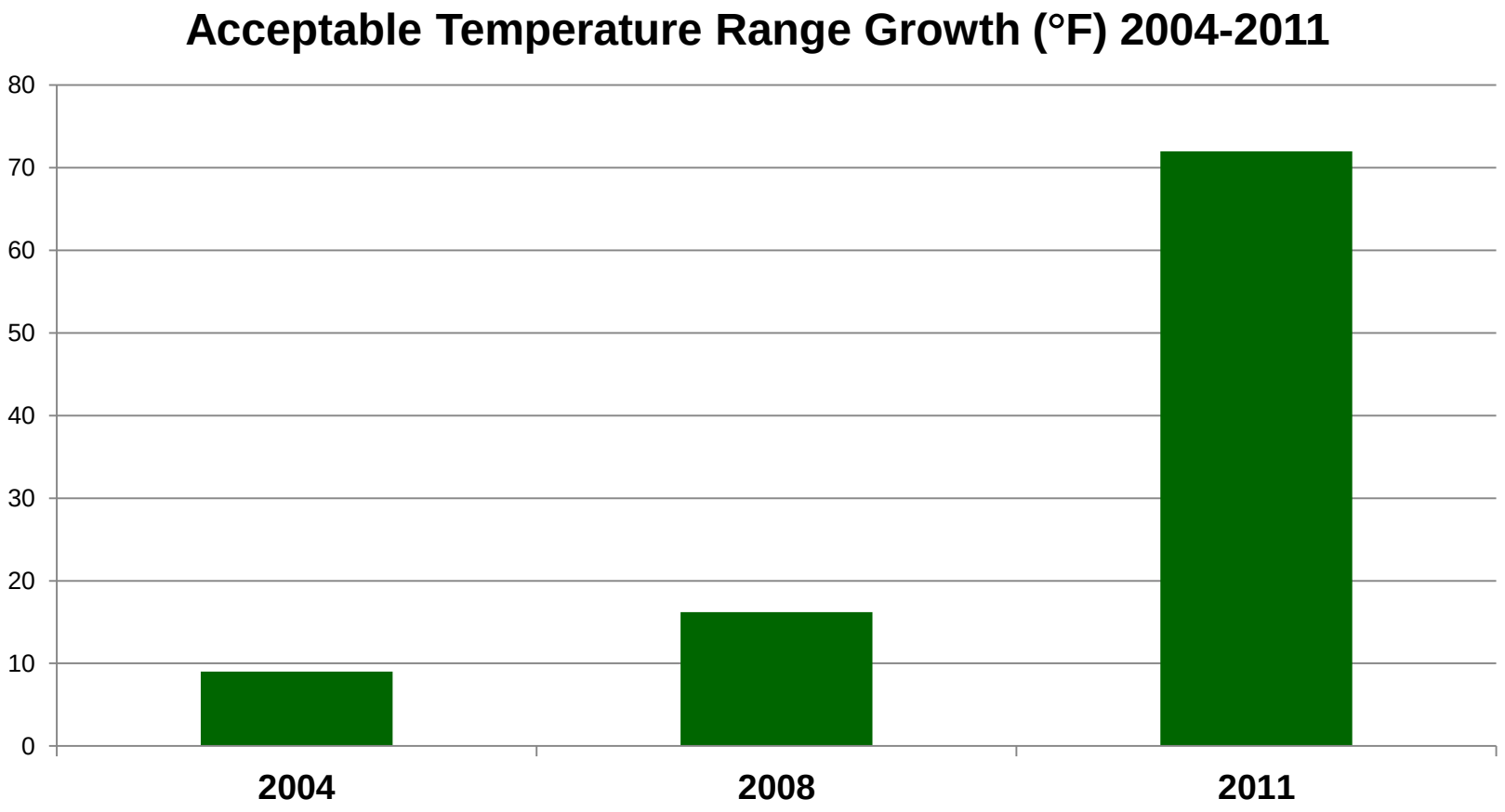
	Hardware in Operation			Hardware Power Off		
Class	**Dry Bulb Temp**	**Humidity Range (Non-condensing)**	**Maximum Dew Point**	**Dry Bulb Temp**	**Relative Humidity Range (%)**	**Maximum Dew Point**
A3*	5 to 40	-12˚C DP & 8% RH to 85% RH	24	5 to 45	8% to 85%	27
A4*	5 to 45	-12˚C DP & 8% RH to 90% RH	24	5 to 45	8% to 90%	27

***A3/A4 Facilities are Data Centers housing Volume servers, storage products, personal computers, workstations and capable of some environmental control.**

ASHRAE TC 9.9 Guidelines: 2011

- TC 9.9 issues a White Paper with a high degree of granularity for environmental conditions based on a number of enterprise factors
- Acceptable temperature range, under certain circumstances, is as wide as 72°F stretching from a low of 41°F to a high of 113°F
- Shifts to absolute humidity (Dew Point) as the preferred method of quantifying humidity levels
- Clearly making an effort to maintain enterprise performance and reliability (uptime) while offering guidance for facility efficiency
- Represents improved hardware performance in a variety of environmental conditions

ASHRAE TC 9.9 Guidelines:



Relative Humidity v. Dew Point: A High Level Description

Relative Humidity v. Dew Point

Relative Humidity

Relative humidity is expressed as a percentage (%). It represents the amount of water vapor contained in a given air mass vs. the amount of water vapor the air mass can ultimately contain (saturation) at a given temperature.

Relative humidity changes inversely with temperature.

Relative Humidity is not an absolute measurement of water vapor content.

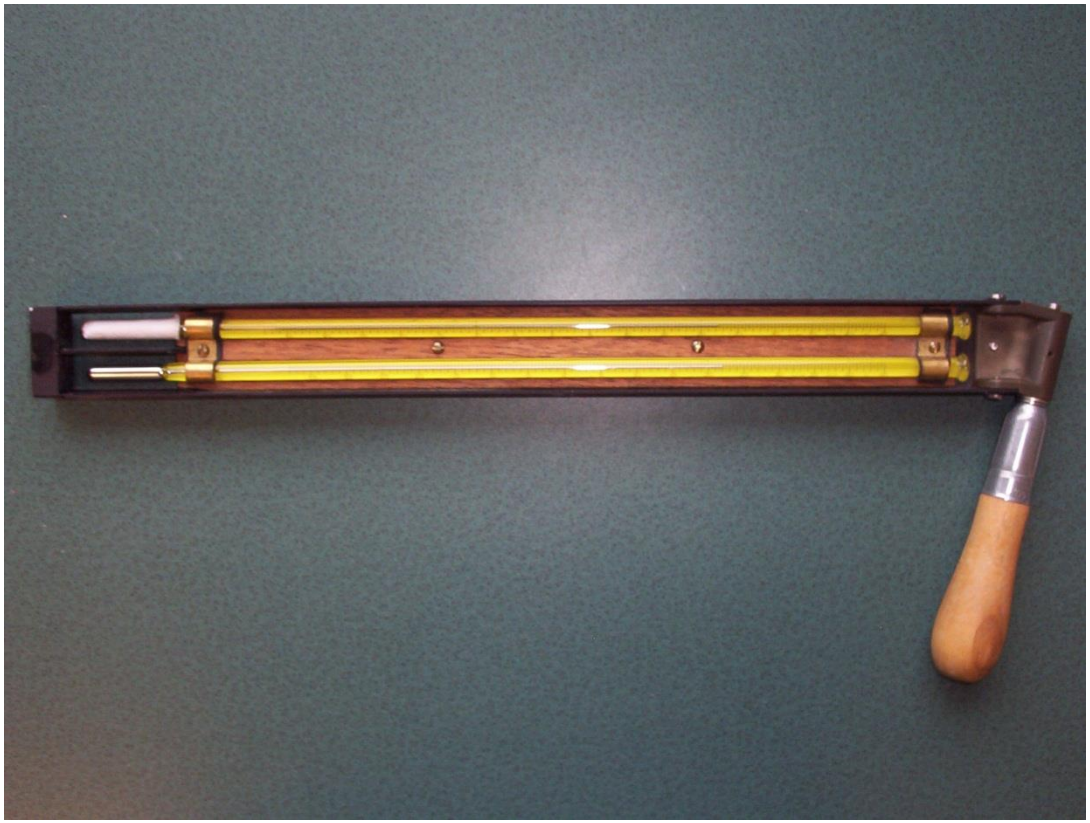
Relative Humidity v. Dew Point

Inverse Relationship Illustration

Temperature	Dew Point	Relative Humidity
Morning: 68°F	60°F	78%
Afternoon: 94°F	60°F	34%

Relative Humidity v. Dew Point

Sling Psychrometer



Relative Humidity v. Dew Point Cont.

Dew Point

Dew point is expressed as a temperature and represents the temperature at which a given air mass will become saturated with water vapor. The term Dew Point is derived from the fact that water vapor will condense out of an air mass (form dew) when that mass becomes saturated.

Dew Point is an absolute measurement of water content for a given air mass at a constant barometric pressure.

The Future of Data Center Facilities

Intel's Research

2007-2008 Environment Test

- 10 Month Test from October 2007 – August 2008
- Compared blade server failures in 500 sq. ft. air conditioned and outside air (economized) test facilities v. a control facility. 448 blades deployed in each room with a power density of 200 Watts per Sq. Ft.(+/-)
- Cooled facility was held at 68°F with no humidity regulation
- Ambient air facility ranged between 64°F and 92°F inlet temperatures and humidity levels of 4% to over 90%.
- Air was lightly filtered with dust and debris allowed to accumulate on enterprise hardware

Intel's Research Cont.

Results

- Energy savings of 74% between the air conditioned facility and the outside air cooled facility.

- Failure Rates
  - Control facility: 3.83%
  - Outside air (economizer) facility: 4.46%
  - Air conditioned test facility: 2.45%

- Conclusions
  - Economization works well in temperate climates
  - Modern hardware is far more temp./humidity tolerant than anticipated
  - Traditional, tightly regulated environments may not be needed for the modern data center

What Does the Future Hold?

Trends in Enterprise Hardware & Facility Systems

- Enterprise hardware much more robust (per Intel and other mfgs)
- Research suggests much wider range of temperature & humidity allowable
- Manufacturers are certifying a wider range of temperatures & humidity levels
- Legacy hardware remains a concern
- Hardware operated beyond warranty period is a concern (>3 Years)

Industry Recommendations

Assuming that the basic data center architecture is sound Gartner recommends:

- Operate the data center at 30°C/86°F
- Target 50% of cooling budget to be provided by outside air.
- Model net energy savings at temps above 30°C/86°F
- Consider operating above 30°C/86°F if modeling shows significant savings
- Use Computational Fluid Dynamics Modeling to predict performance of facility prior to pushing temperatures
- Incrementally raise temps up to 30°C/86°F and let environment stabilize for 90 Days.

Efficiency Recommendations for the Small/Medium Size Business (SMB)

SMB Efficiency Recommendations

Address the Basic/Inexpensive Items First!

Maximize ROI by fixing the basic problems first:

A. Adopt Hot Aisle / Cold Aisle Configuration

B. Deliver Cool Conditioned Air Directly to the Cold Aisle

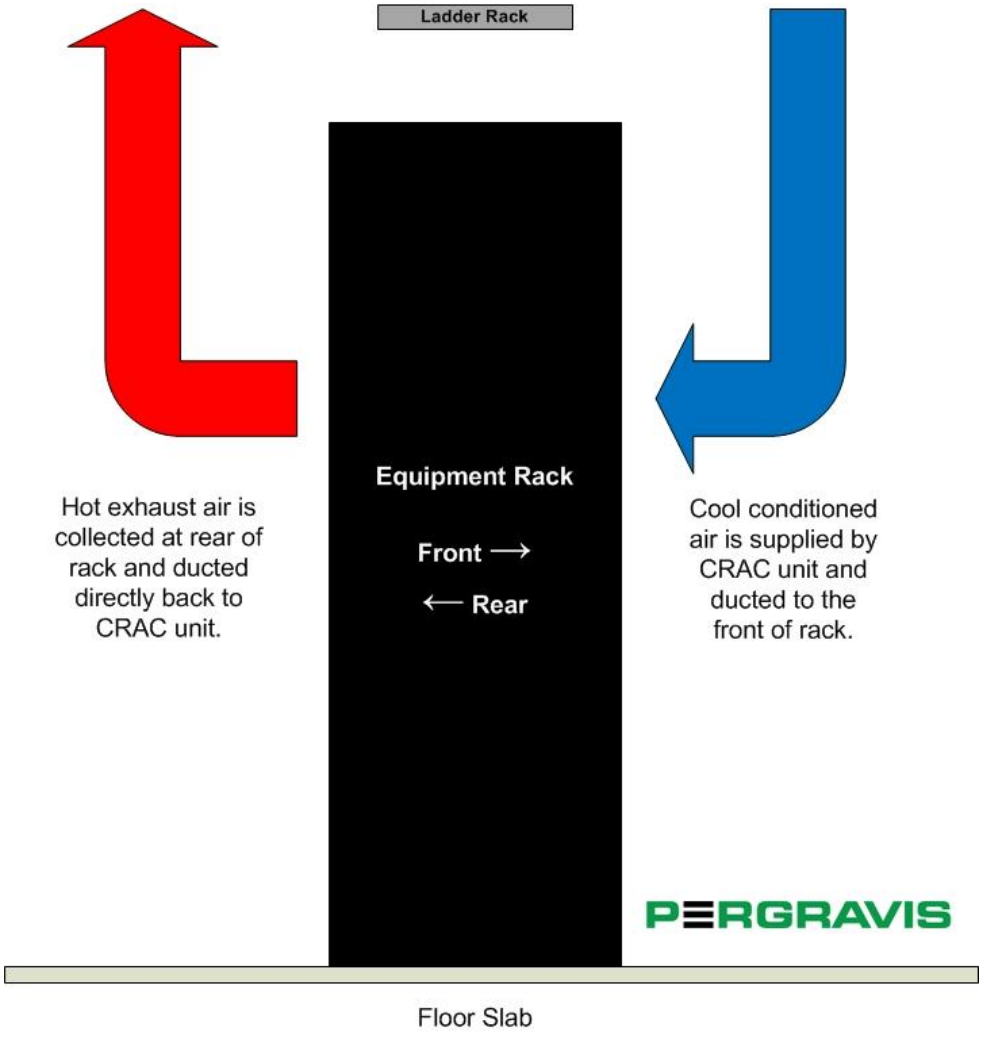
C. Draw Hot Exhaust Air Directly back to the A/C Unit (CRAC)

D. Employ Proper Cable Management Techniques

E. Install Blanking Plates in Empty Rack Spaces

F. Balance Air Delivery in the Data Center

SMB Efficiency Recommendations



SMB Efficiency Recommendations

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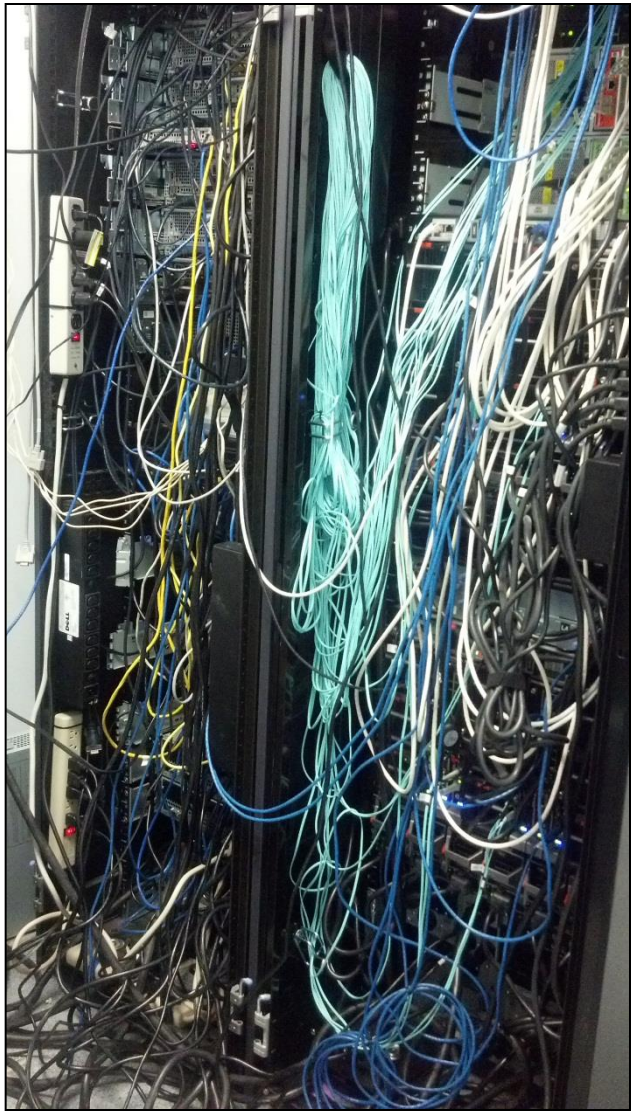
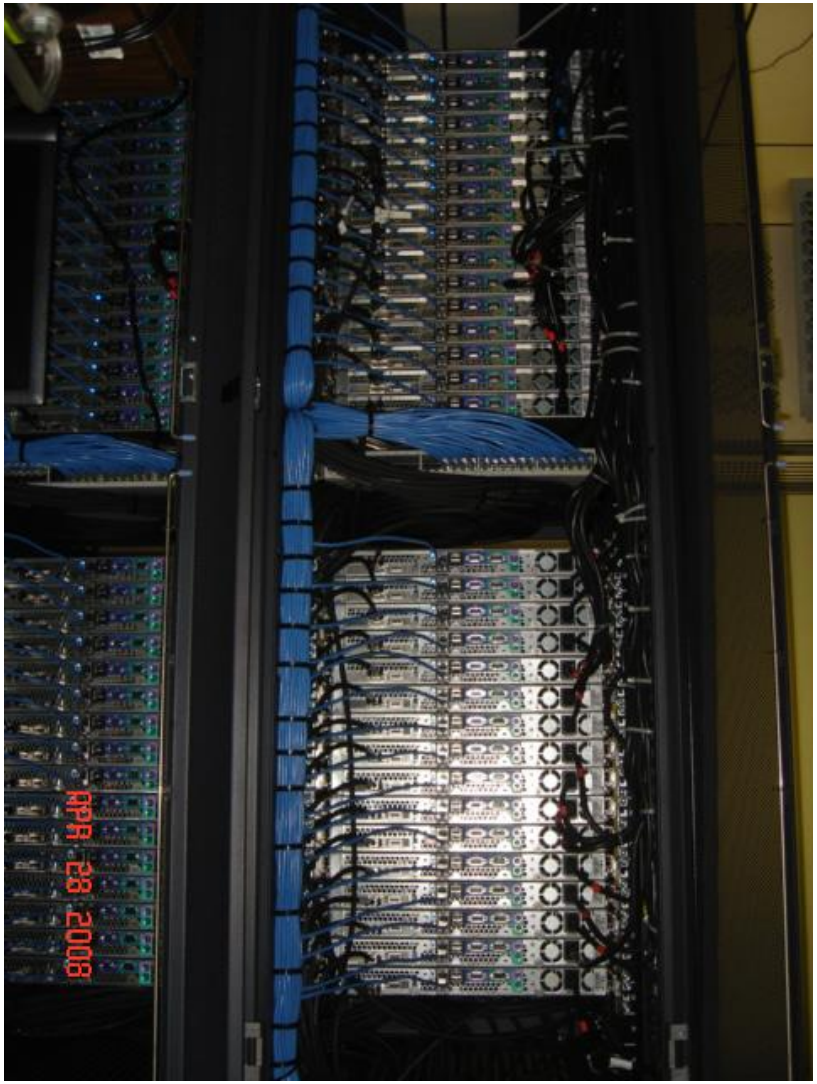


SMB Efficiency Recommendations



SMB Efficiency Recommendations

Once the Basics are Addressed…..

Fine Tune the Data Center Environment

A. Deploy Basic Instrumentation
   i. Temperature Sensors
   ii. Humidity Sensors
   iii. Metered PDU's (Power Strips)
   iv. Record and Trend Collected Data

B. Modify Temperature Set Points & Monitor Performance

C. Implement DCIM – Caution: May not be corresponding ROI!

References:

ASHRAE

- 2008 "ASHRAE Environmental Guidelines for Datacom Equipment"
  By: ASHRAE TC 9.9

- 2011 "Thermal Guidelines for Data Processing Environments"
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- 2008 "Reducing Data Center Cost with an Air Economizer"
  By: Don Atwood and John G. Miner, Intel Corp.

Gartner, Inc.

- 2013 "How to Run the Data Center Effectively at High Temperatures"
  By: Rakesh Kumar, Analyst, Gartner, Inc.

Follow On Questions:

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