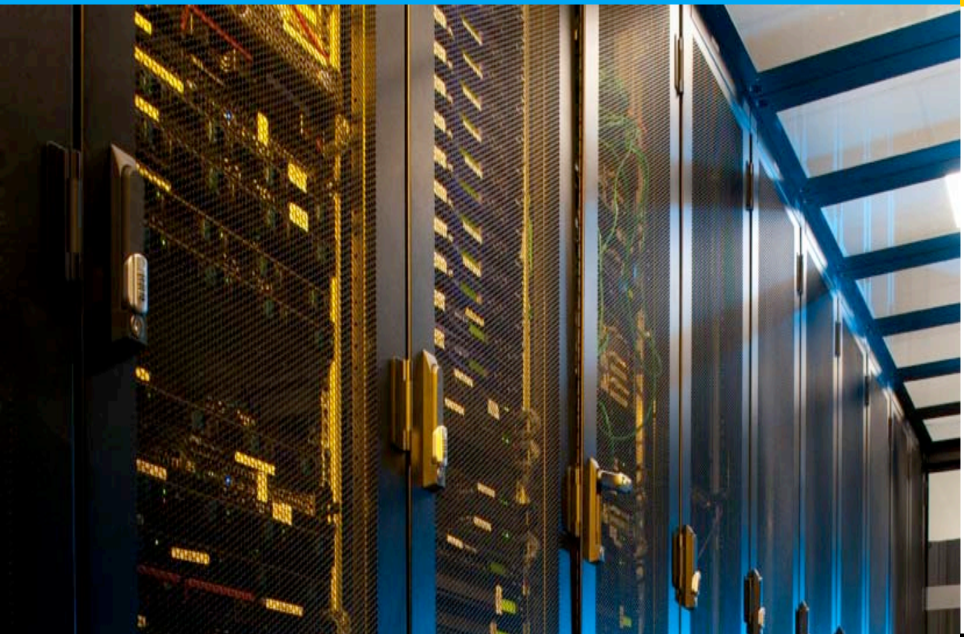
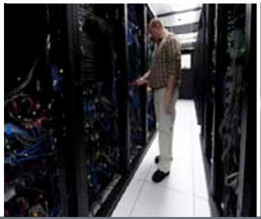


Achieving Energy-Efficient Data Centers with New ASHRAE Thermal Guidelines

FEMP FIRST THURSDAY SEMIN@RS



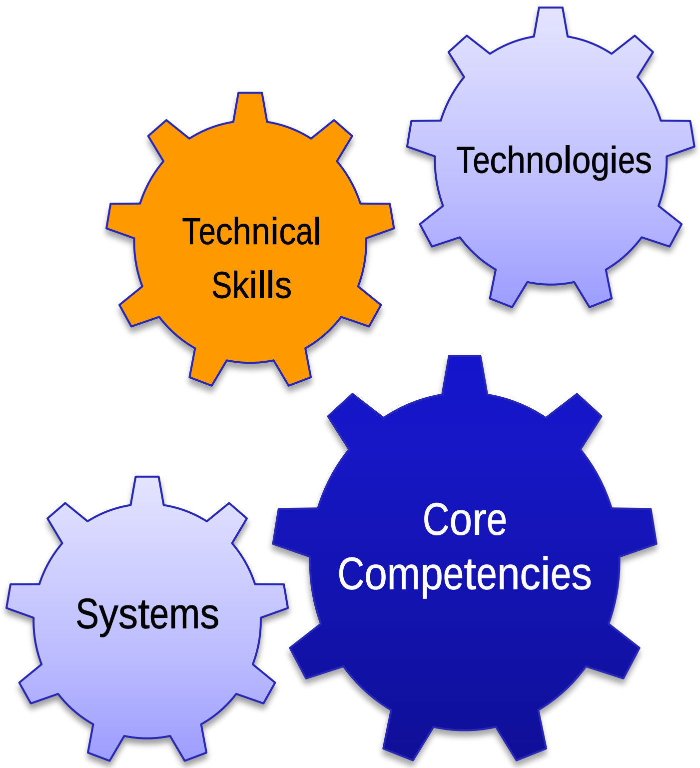
Presented by:
Don Beaty, DLB Associates
Will Lintner, FEMP

FEMP Federal Energy Management Program

Core Competencies Addressed in this Seminar

Energy/Sustainability Managers and Facility Managers
- Building Technologies
- Operations and Maintenance

Operating Engineers/Building Technicians
- Building Cooling Systems
- Building Heating System
- HVAC Systems
- Operations and Maintenance



Results Expectations

Develop plans to plan for and implement processes to control temperature and air volume in high-intensity data centers based on new ASHRAE TC 9.9 information.

Presentation Objectives

Arm yourself with the knowledge to improve energy performance in Federal data centers and research facilities <u>WITHOUT</u> compromising reliability, voiding warranties or increasing the risk of failure.

Learn about:

1) The latest ASHRAE TC9.9 standards with regards to allowable and recommended temperature and humidity ranges.
2) The real impact on IT equipment failures from operating at higher temperatures (based on IT OEM actual data).
3) The increased potential for data centers WITHOUT any mechanical refrigeration (i.e. NO CHILLERS, COMPRESSORS, ETC.).
4) Resource materials from the major IT OEMs and data center industry thought leaders.

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Opening Comments

Common reasons for reluctance to increase temperature and humidities

1) Concern over increased outage potential
2) Concern over voiding IT manufacturer’s warranty’s
3) Concern over having less safety margin & / or resilience

ASHRAE’s TC 9.9 IT Subcommittee is comprised of the major IT OEM’s.
The ASHRAE temperatures and humidities were produced by the IT OEMs

Opening Comments (continued)

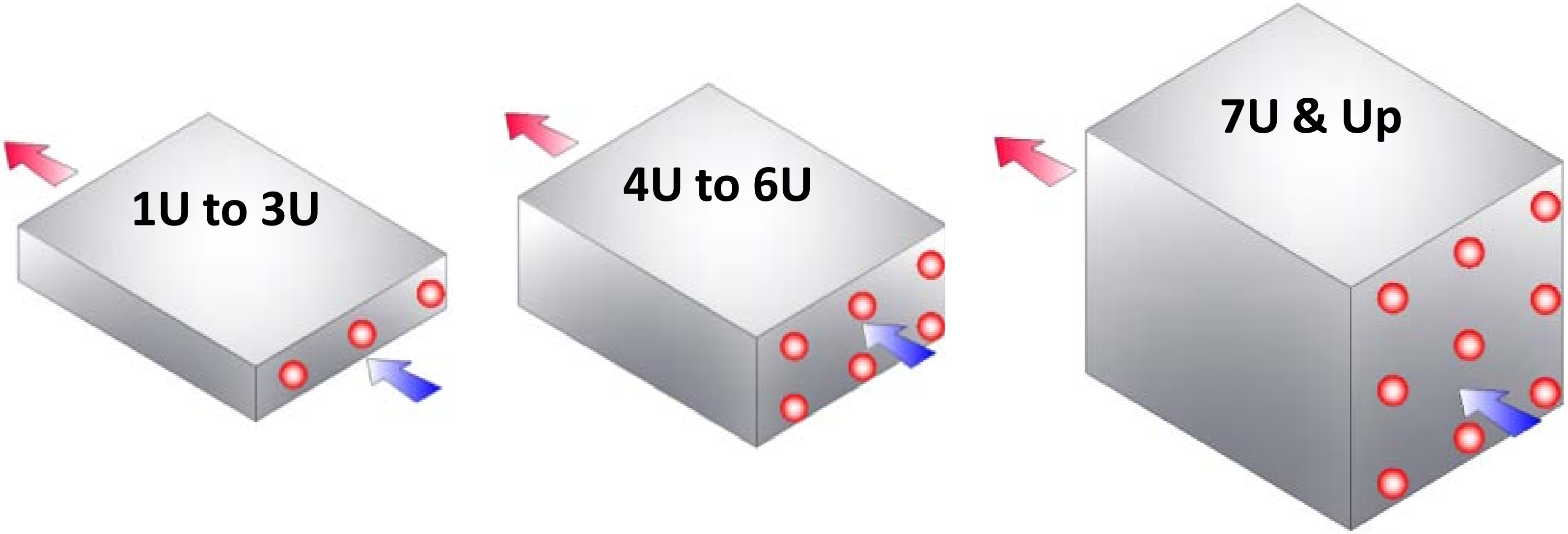
In 2004, ASHRAE TC 9.9 standardized temperature (68 F to 77 F) & humidity by publishing vendor NEUTRAL guidelines approved by the IT OEMs and within their WARRANTIES.

In 2008, ASHRAE TC 9.9, widened the temperature range (64.4 F to 80.6 F) while still being within WARRANTY requirements (including LEGACY equipment).

In 2011, ASHRAE TC 9.9 White Paper provides scenarios for ranges as wide as 41 F to 113 F. These wider ranges are NOT compliant with LEGACY equipment warranties.

THE OPPORTUNITIES FOR COMPRESSORLESS COOLING (NO REFRIGERATION) ARE HIGH

ITE Environment – Measurement Points



Server Troubleshooting

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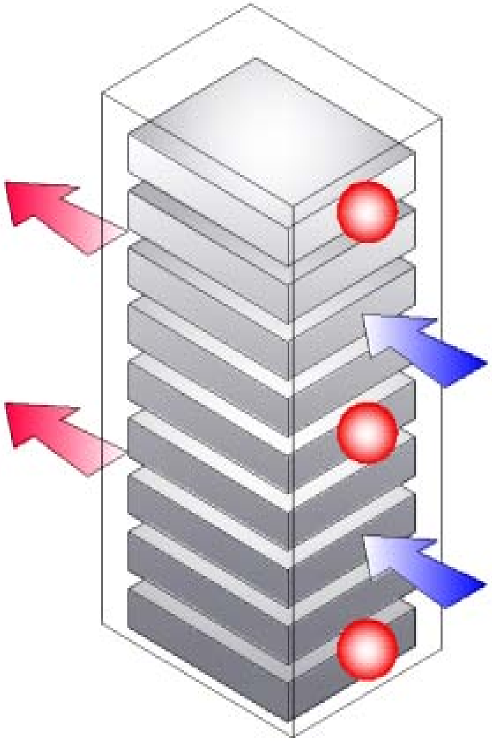
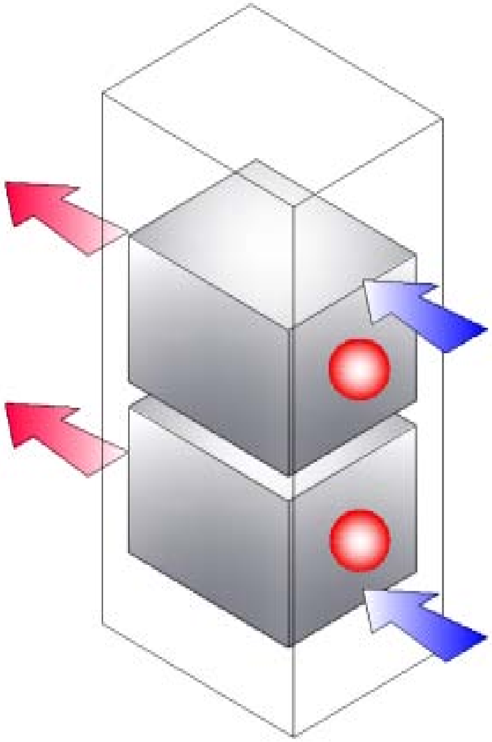
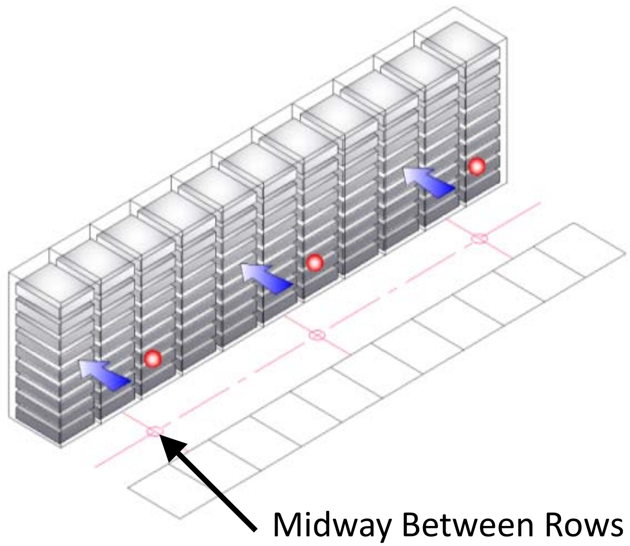
ITE Environment – Measurement Points



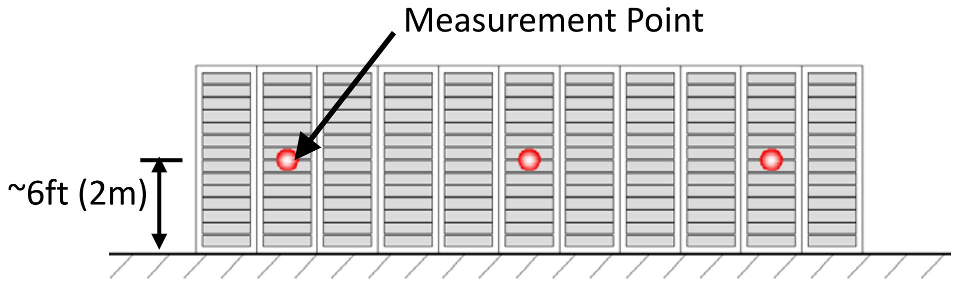


Rack Troubleshooting

ITE Environment – Measurement Points



Every 4th Cabinet or 10-30ft (3-9m) of Aisle



Facility Health

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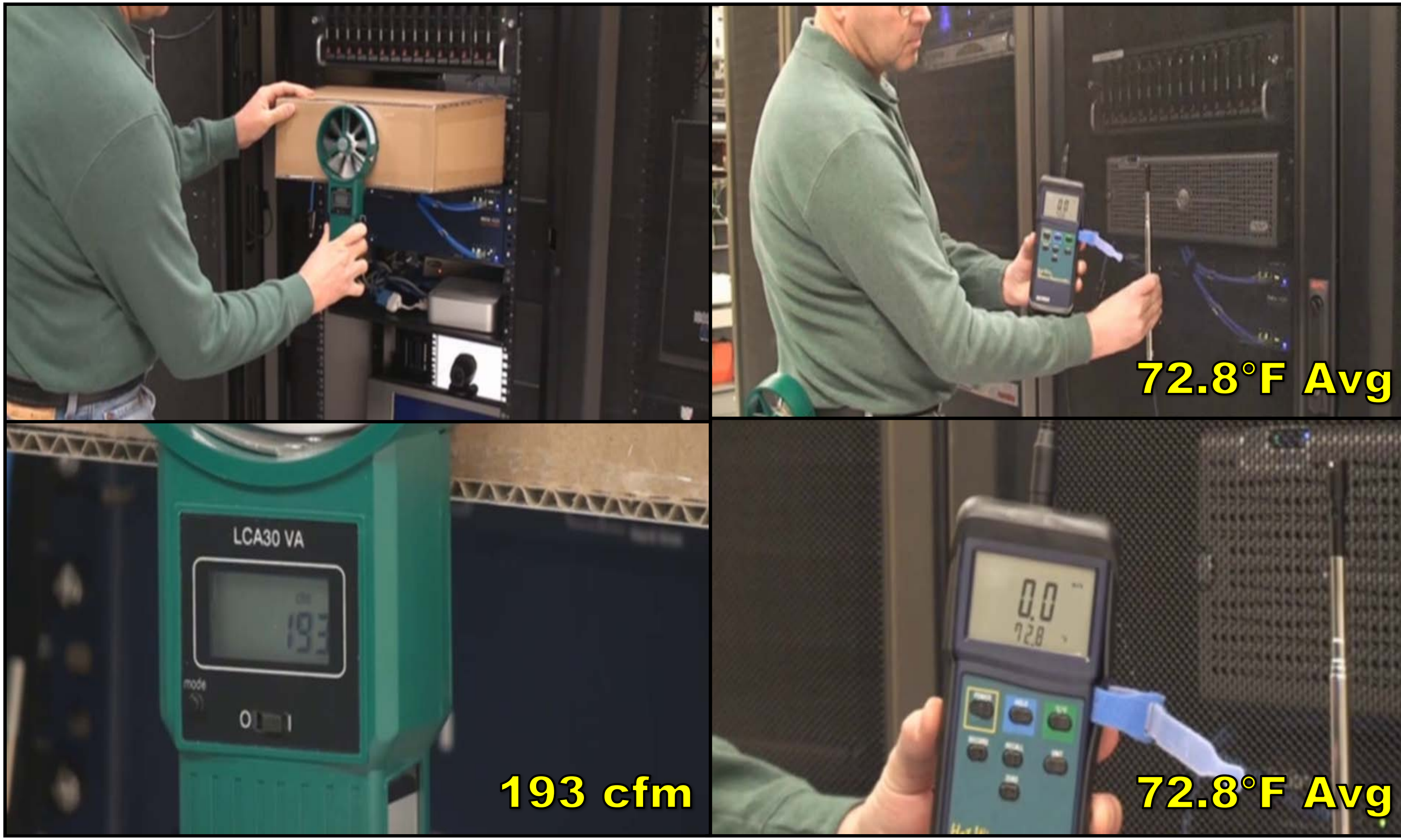
ITE Environment – Measurement Points



ITE Environment – Envelope

Recommended – The purpose of the Recommended Envelope is to give guidance to operators on the combination of maintaining high reliability and energy efficiency.

The recommended envelope is based on IT OEM's expert knowledge of server power consumption, reliability & performance vs. ambient temp.

Allowable – The Allowable Envelope is where the IT manufacturers test their equipment in order to verify that the equipment will function within those ENVIRONMENTAL BOUNDARIES.

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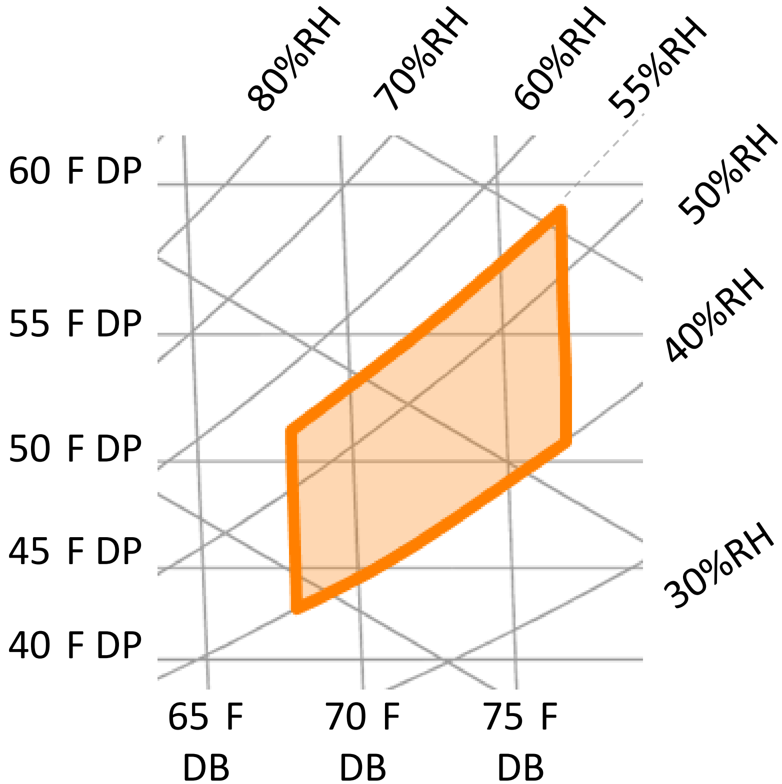
ITE Environment – Envelope



Envelope

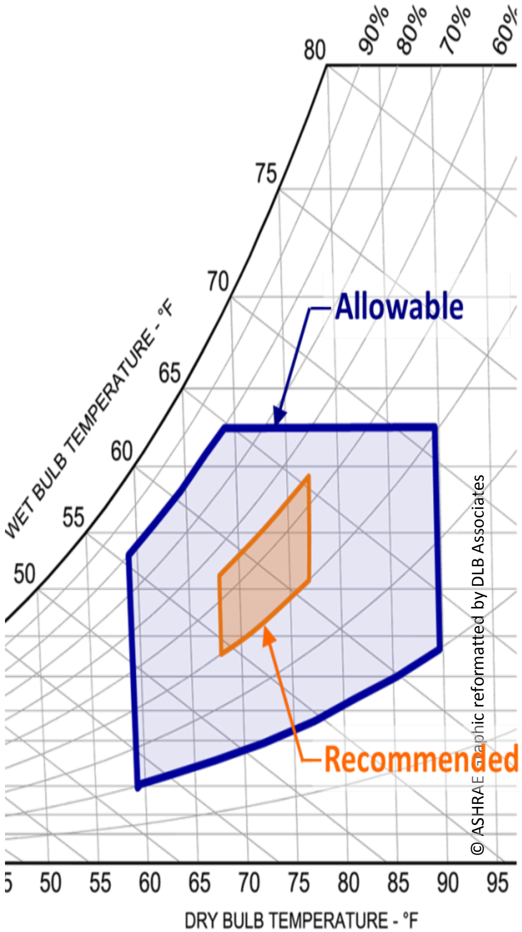
ITE Environment – Envelope

Prior to ASHRAE; single operating point, say 68 F, 50% RH

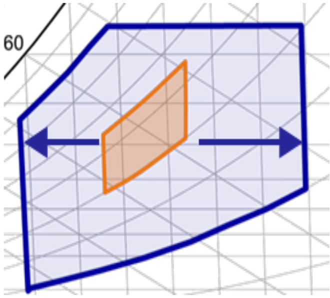
2004 Recommended Envelope – Many Operating Points (160)

Dry Bulb	% Relative Humidity																
	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	
68	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	=16
69	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	=16
70	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	=16
71	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	=16
72	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	=16
73	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	=16
74	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	=16
75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	=16
76	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	=16
77	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	=16
	=10	=10	=10	=10	=10	=10	=10	=10	=10	=10	=10	=10	=10	=10	=10	=10	=160

ITE Environment – ASHRAE Psychrometric Chart



2004 Recommended & Allowable Envelope



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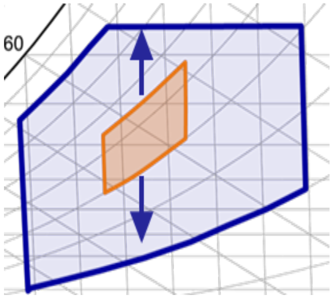
Temperature Excursion



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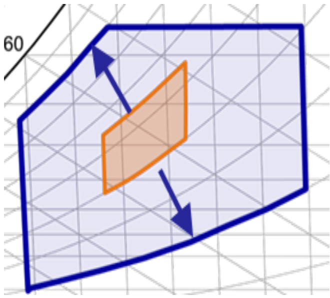
Humidity Excursion



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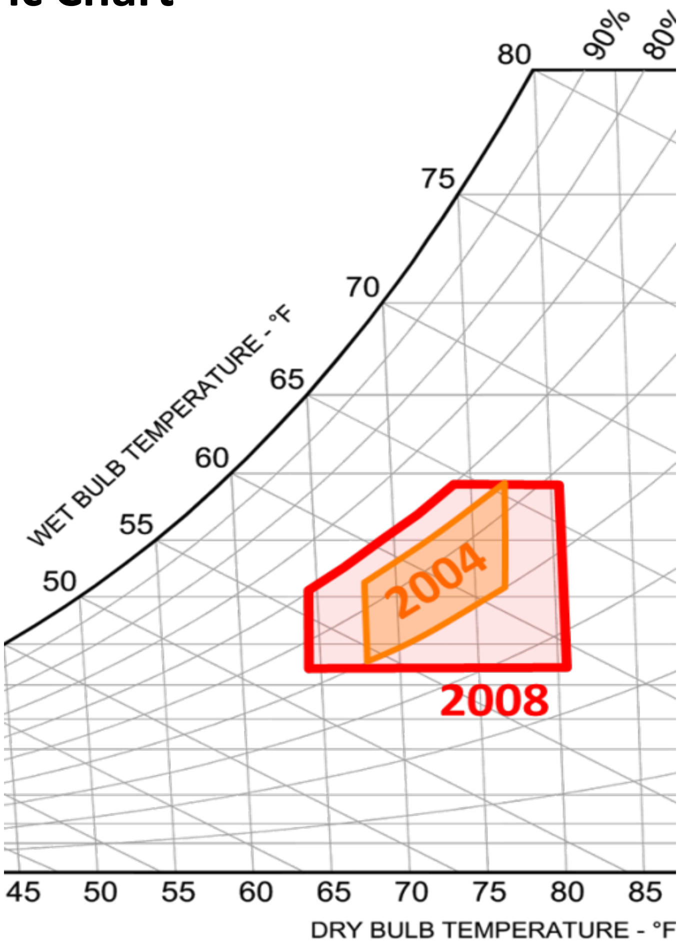
Temp. & Humidity Excursion

ITE Environment – ASHRAE Psychrometric Chart – 2004 / 2008 Recommended

Criteria	2004	2008
Low End Temp.	68°F	64.4°F
High End Temp.	77°F	80.6°F
Low End Moisture	40% RH	41.9°F DP
High End Moisture	55% RH	60% RH & 59°F DP



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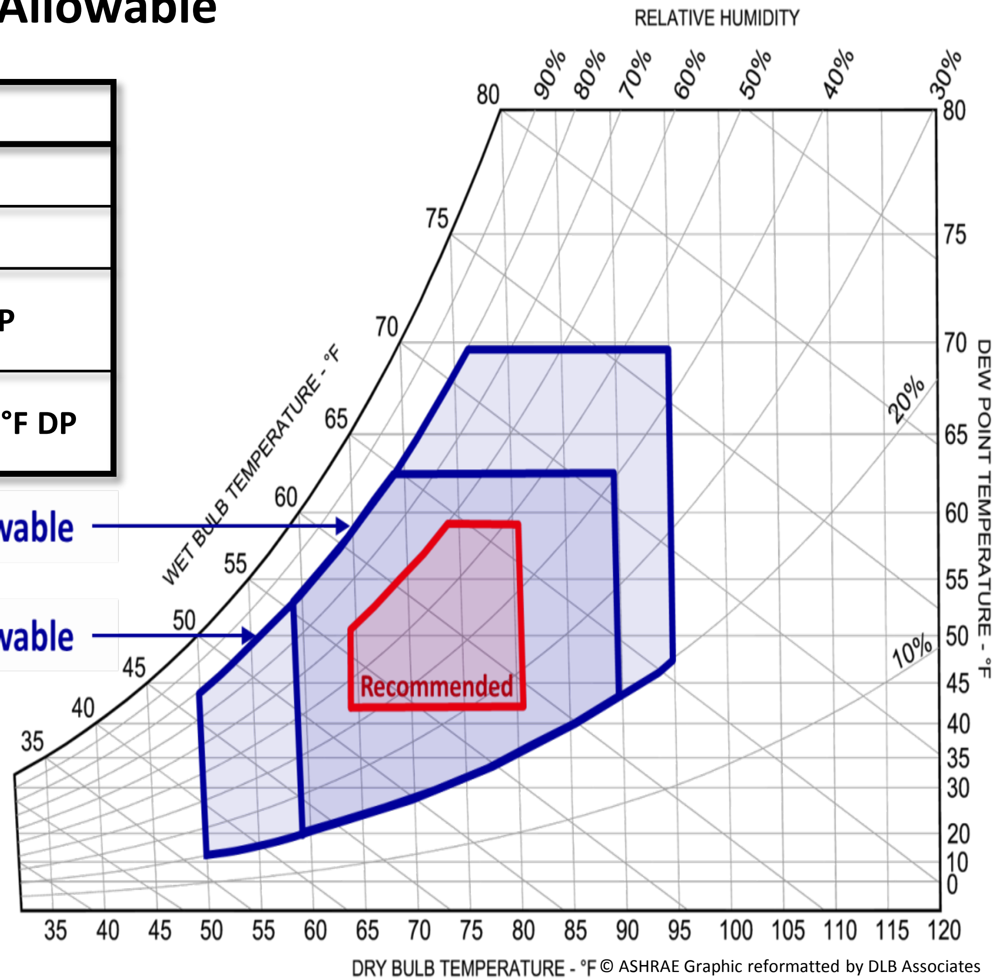
ITE Environment – ASHRAE Psychrometric Chart – 2004 / 2008 Recommended / Allowable

Criteria	2004	2008
Low End Temp.	68°F	64.4°F
High End Temp.	77°F	80.6°F
Low End Moisture	40% RH	41.9°F DP
High End Moisture	55% RH	60% RH & 59°F DP

ASHRAE 2004/2008 – Class 1 Allowable

ASHRAE 2004/2008 – Class 2 Allowable



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ITE Environment – 2011 Environment Specifications Table (Partial)

Class		Dry Bulb (°F)	Humidity Range	Max Dew Point (°F)	Max Elevation (ft)	Max Rate of Change (°F / hr)
Previous	Current					
Recommended						
1 & 2	**A1 to A4**	**64.4 to 80.6**	**41.9°F DP to 60% RH & 59°F DP**	N/A		
Allowable						
1	A1	59 to 89.6	20% to 80% RH	62.6	10,000	9 / 36
2	A2	50 to 95	20% to 80% RH	69.8	10,000	9 / 36
N/A	A3	41 to 104	10.4°F DP & 8% RH to 85% RH	75.2	10,000	9 / 36
N/A	A4	41 to 113	10.4°F DP & 8% RH to 90% RH	75.2	10,000	9 / 36

* More stringent rate of change for tape drives

ITE Environment – New Data Center Classes

OPTIONAL READING /
SKIPPED DURING PRESENTATION

Previously there were four data center classes (Class 1 through 4). Two of the four classes applied to ITE used in data center applications (Class 1 & 2).

The new environmental guidelines have more data center classes to accommodate different applications and priorities of ITE operation.

This is critical because a single data center class forces a single optimization whereas each data center needs to be optimized based on the operator's own criteria
(e.g. fulltime economizer use vs. maximum reliability).

The naming conventions have now been updated to better delineate the types of IT equipment. The old and new classes are now specified differently with the previous Classes 1, 2, 3 and 4 directly mapped to **A1, A2, B** and **C**.

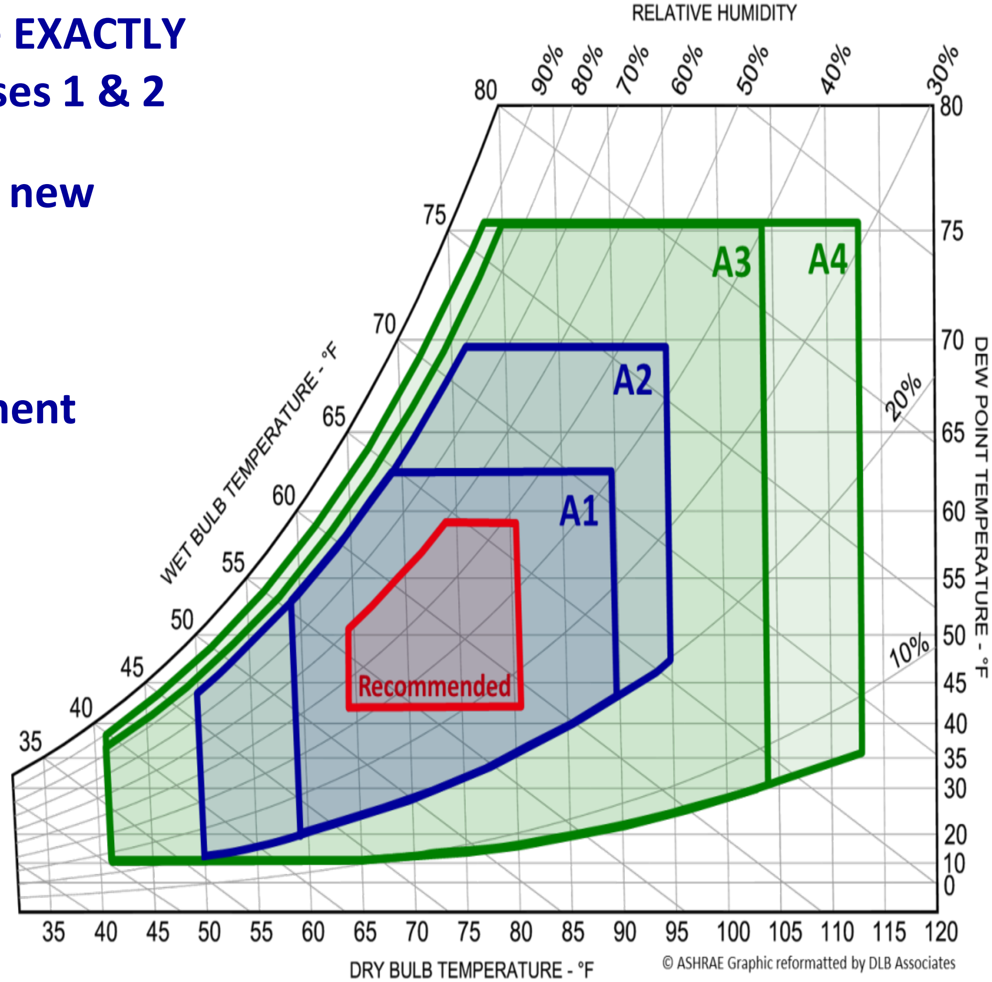
Two new data center classes have been introduced: **A3 and A4**.

ITE Environment – ASHRAE Psychrometric Chart – 2011

New Classes A1 and A2 are EXACTLY the SAME as previous Classes 1 & 2

Classes A1 and A2 apply to new and legacy equipment

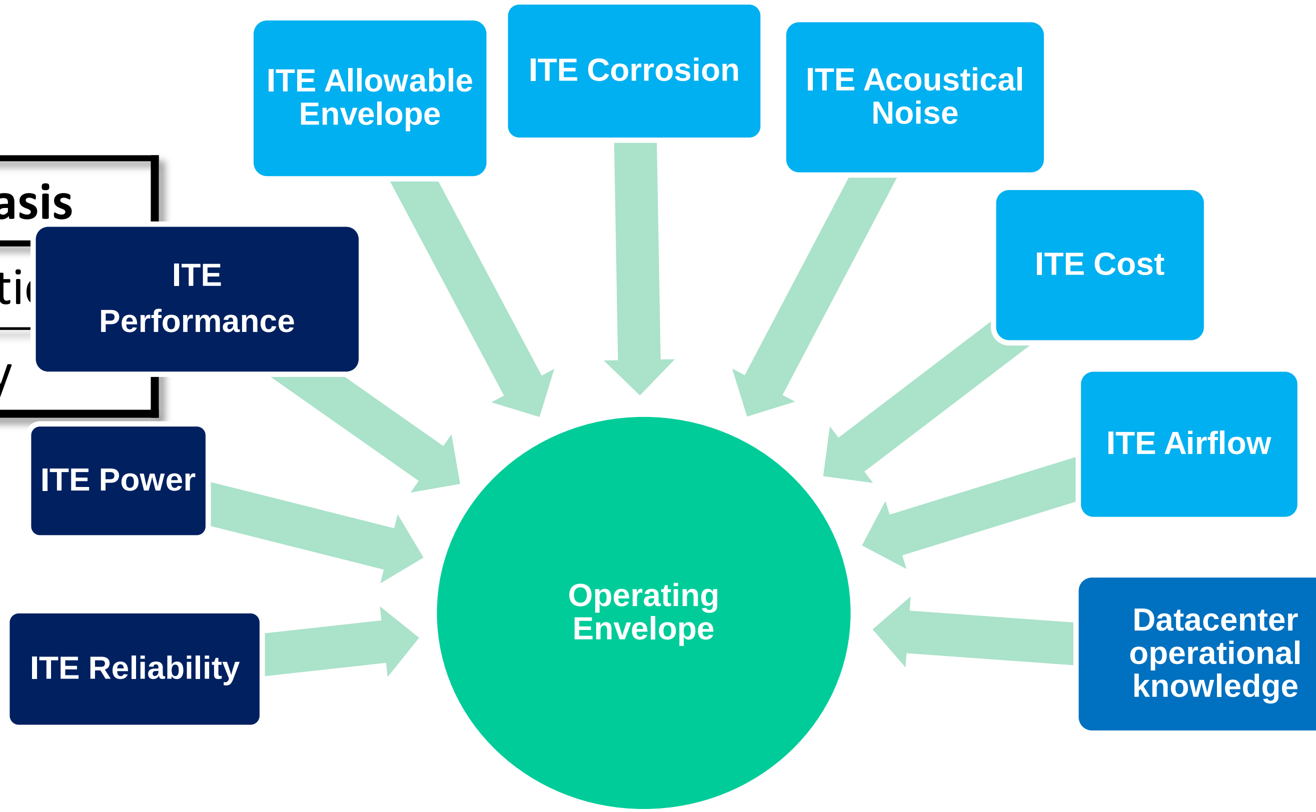
New Classes A3 and A4 do NOT include legacy equipment



2011 Thermal Guidelines – Operating Envelope

The data center optimization is a complex multi-variable problem and requires a detailed engineering evaluation to be successful.

Timeframe	**Emphasis**
Previously	Acousti
Current	Energy



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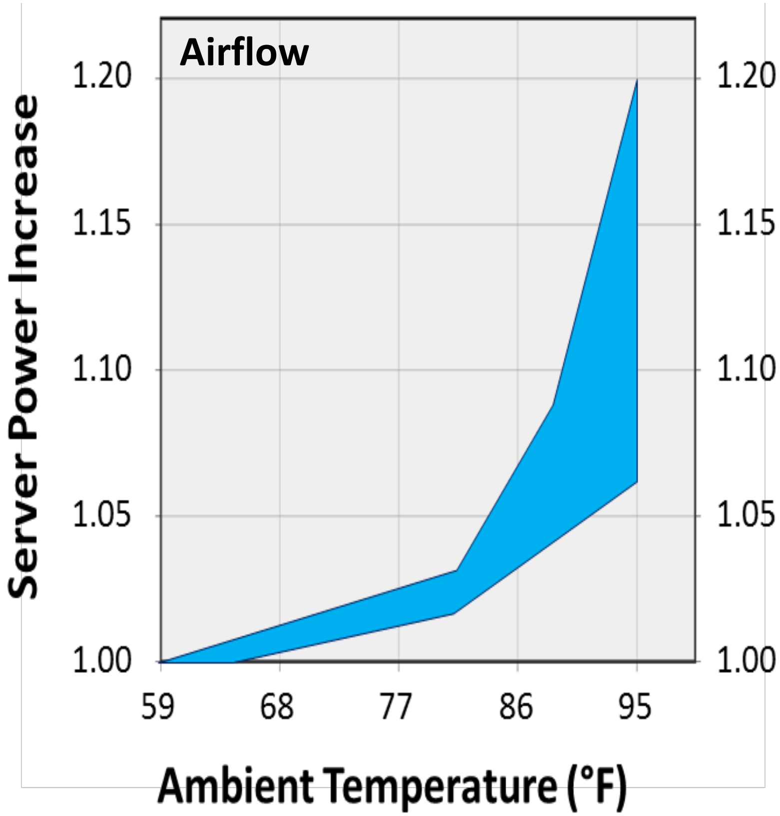
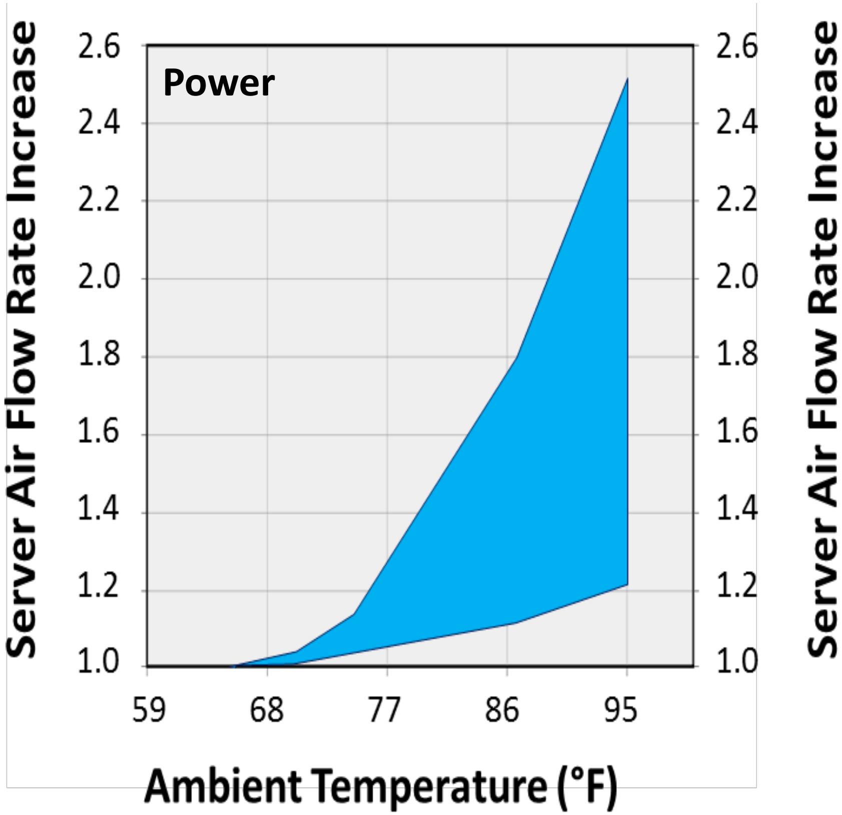
Server Manufacturer's Typical Power vs. Ambient Temperature (multiple manufacturers)





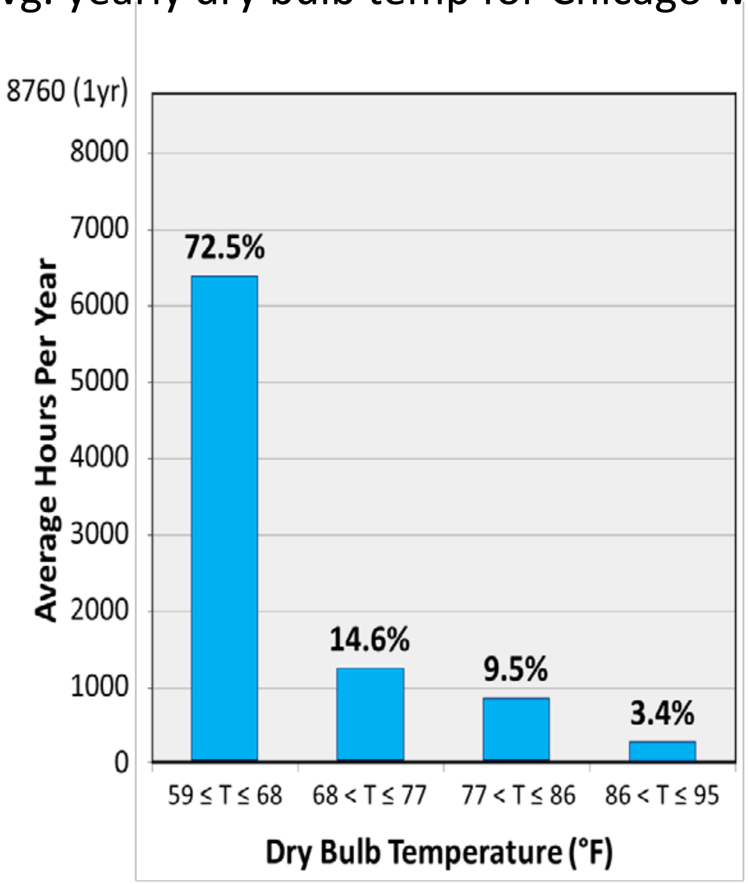
Server Manufacturer's Typical Power vs. Ambient Temperature (multiple manufacturers)

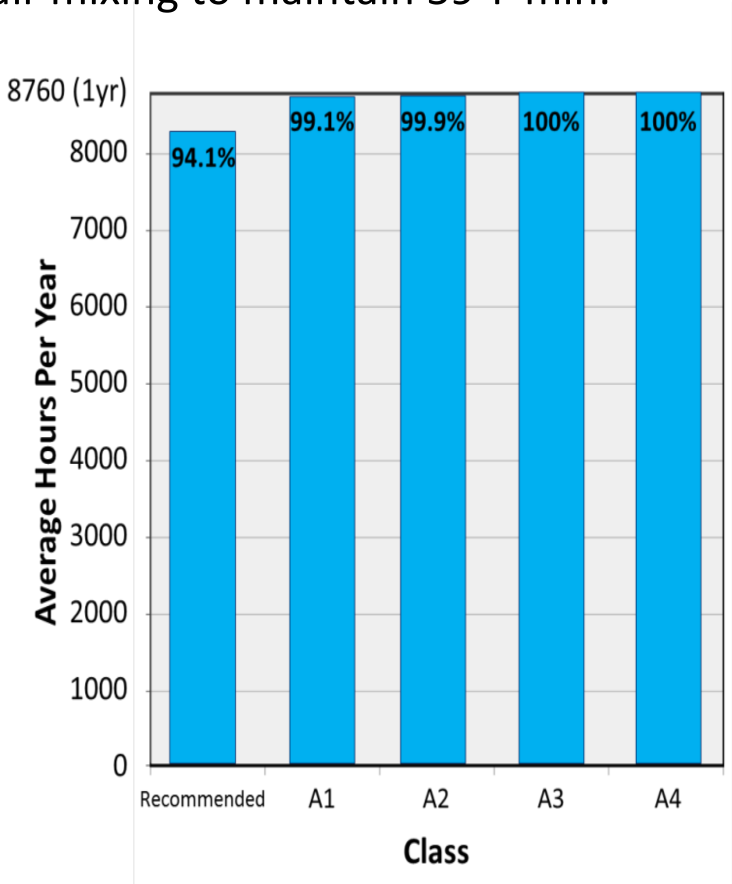
Power Increase Extrapolation From Graph					
Power	Power Increase Due to Temperature				
	68°F	77°F	80.6°F	89.6°F	95°F
Lowest	1.00	1.05	1.10	1.15	1.21
Highest	1.02	1.27	1.50	2.10	2.50

- Airflow and total power increase with temperature.
- Fan power required increases to the cube of fan speed (rpm)
- Total power increase includes both fan and component power

Server Reliability Trend vs. Ambient Temperature (cont.)

Avg. yearly dry bulb temp for Chicago with air mixing to maintain 59 F min.





Weather Data From ASHRAE Weather Data Viewer

Volume Server Failure Rate versus Ambient Temperature

Volume Server Failure Rate Versus Temperature				
Dry Bulb Temp (°F)	Avg. Failure Rate	Annual Server Failure Rate		Comments
		Typical	Adjusted Due To Temp.	
A	B	C	D = B x C	
59	0.72	4%	3%	Less Failures
68	1.00	4%	4%	Baseline
104	1.66	4%	7%	More Failures

- Assumes continuous (7 x 24 x 365) operation with Dry Bulb Temp. at ITE inlet.
- Based on years of Server Manufacturers' actual failures, Component Manufacturer's failure data, and modeling (published by ASHRAE TC 9.9).

CONCLUSION:

Temperature has minimal impact on Server Failure

Volume Server Failure Rate versus Ambient Temperature

Server Reliability Trend vs. Ambient Temperature – Relative Failure Rates			
Dry Bulb Temp. (°F)	Hardware Failure Rate for Volume Servers (X-Factor)		
	Average	Lower Bound	Upper Bound
59	0.72	0.72	0.72
63.5	0.87	0.80	0.95
68	1.00 (Baseline)	0.88	1.14
72.5	1.13	0.96	1.31
77	1.24	1.04	1.43
81.5	1.34	1.12	1.54
86	1.42	1.19	1.63
95	1.55	1.35	1.74
104	1.66	1.51	1.81
113	1.76	1.67	1.84

Lower bound, average, and upper bound are included since there is variation in server configuration and utilization

Achieving energy-efficient data centers with new ASHRAE thermal guidelines

FEMP Federal Energy Management Program

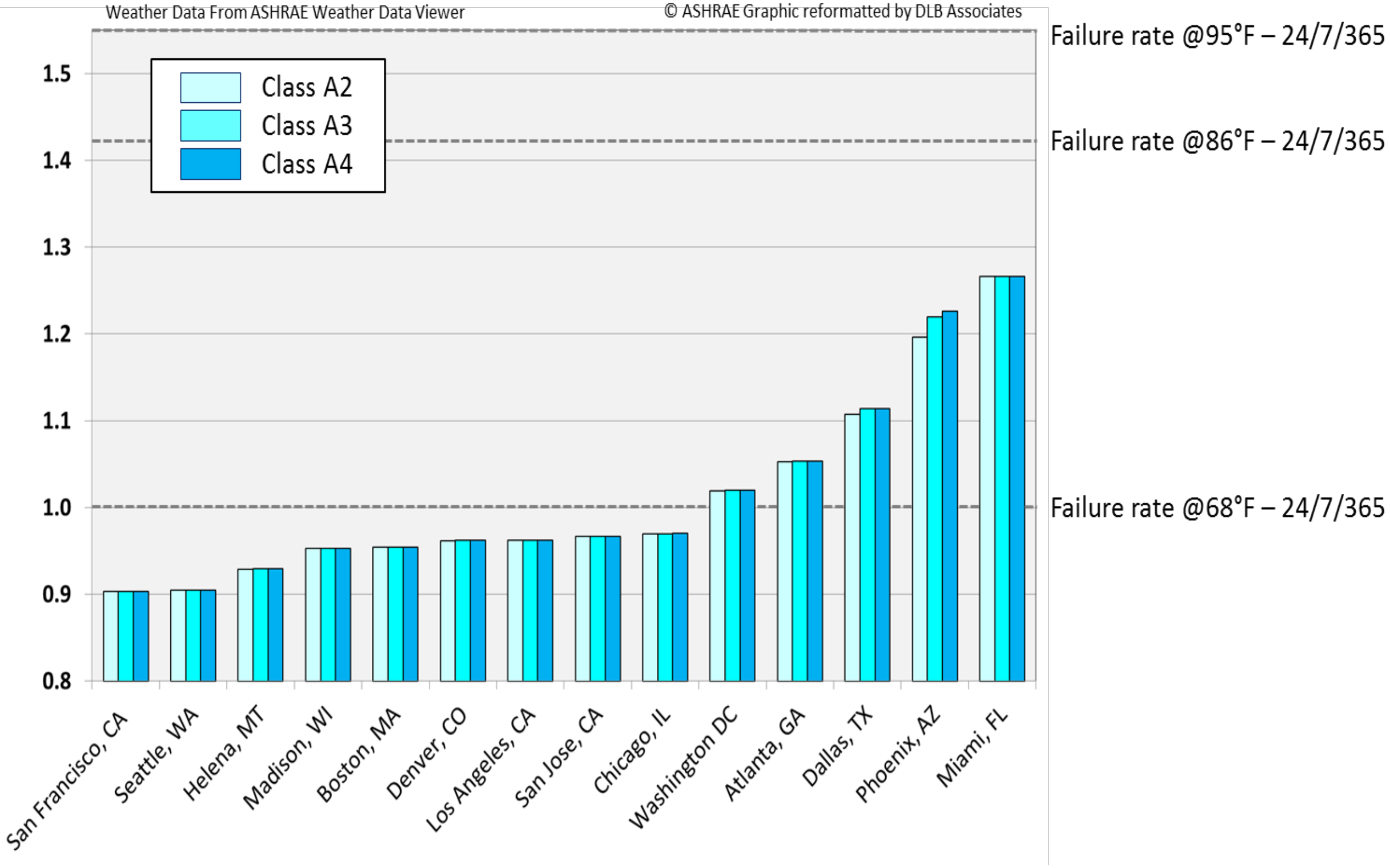
Chicago Net X-Factor Across The Whole Year

Time-at-Temperature Weighted Failure Rate Calculation for ITE in Chicago					
Location	**59 ≤ T ≤ 68°F**	**68 < T ≤ 77°F**	**77 < T ≤ 86°F**	**86 < T ≤ 95°F**	**Annual Failure Rate** (Net x-factor Total)
Chicago % Hours (R1)	72.5	14.6	9.5	3.4	-
X-factor (R2)	0.865	1.130	1.335	1.482	-
Failure Rate (R3 = R1 x R2)	0.627	0.165	0.127	0.051	**0.970**

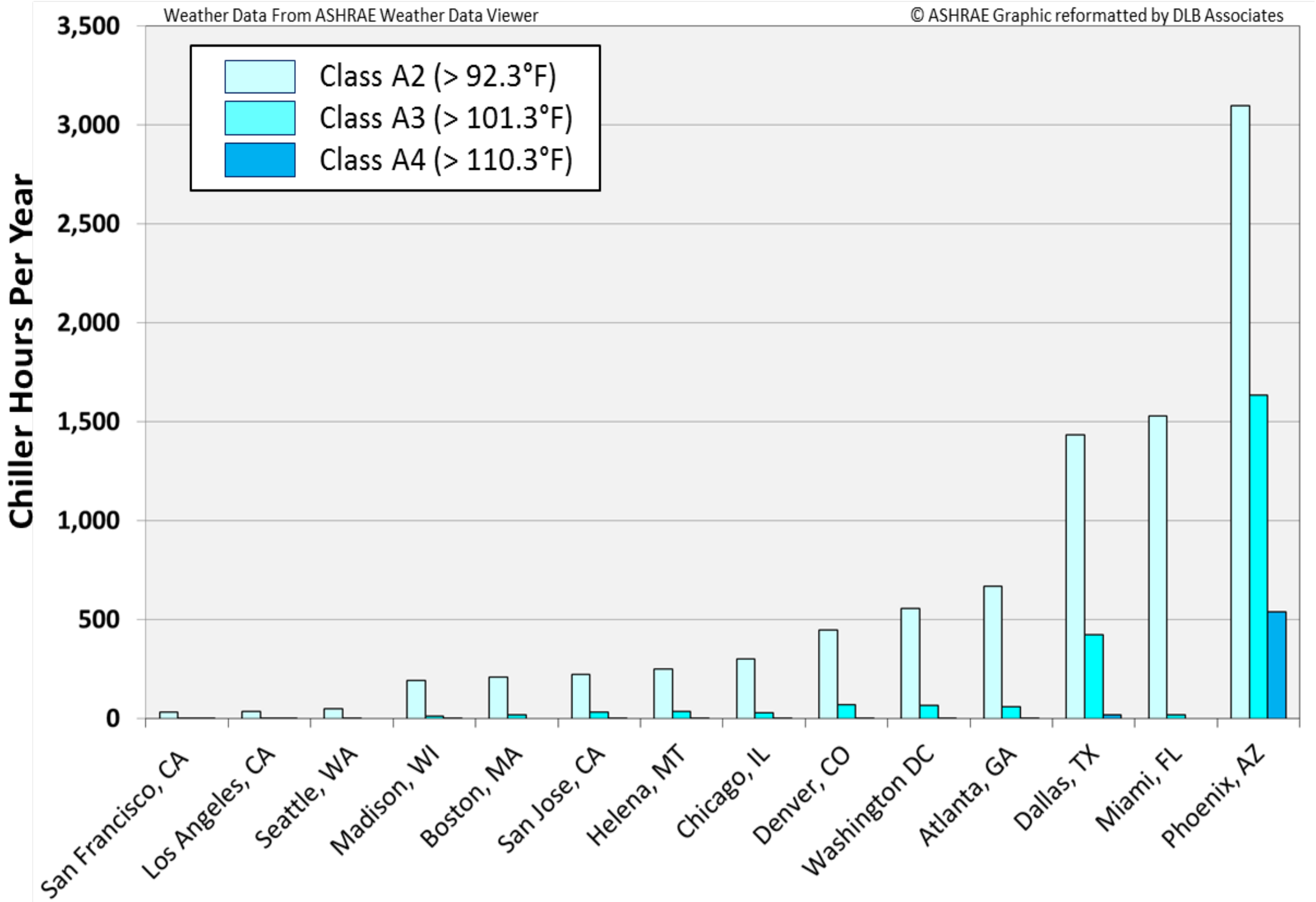
Weather Data From ASHRAE Weather Data Viewer

IT hardware failure in Chicago with a variable data center temperature is actually LOWER than if the data center was operating at a tightly controlled temperature of 68 F.

Average Net Failure Rate Projections for Air-side Economization (US Cities)



Chiller Hours Per Year for Air-side Economization (US Cities)



* Assumes 2.7 F approach between outdoor air dry bulb and supply air due to fan friction

Use & Application Guidance for New ASHRAE Data Center Classes

Server Reliability vs. Contamination

Particulate and gaseous contamination becomes a more important consideration when there is an increased use of economizer systems.

The air quality and building materials should be checked carefully for sources of pollution & particulates and additional filtration should be added to remove gaseous pollution and particulates, if needed.

Products of Combustion **Pollen** **Dirt** **Smoke**

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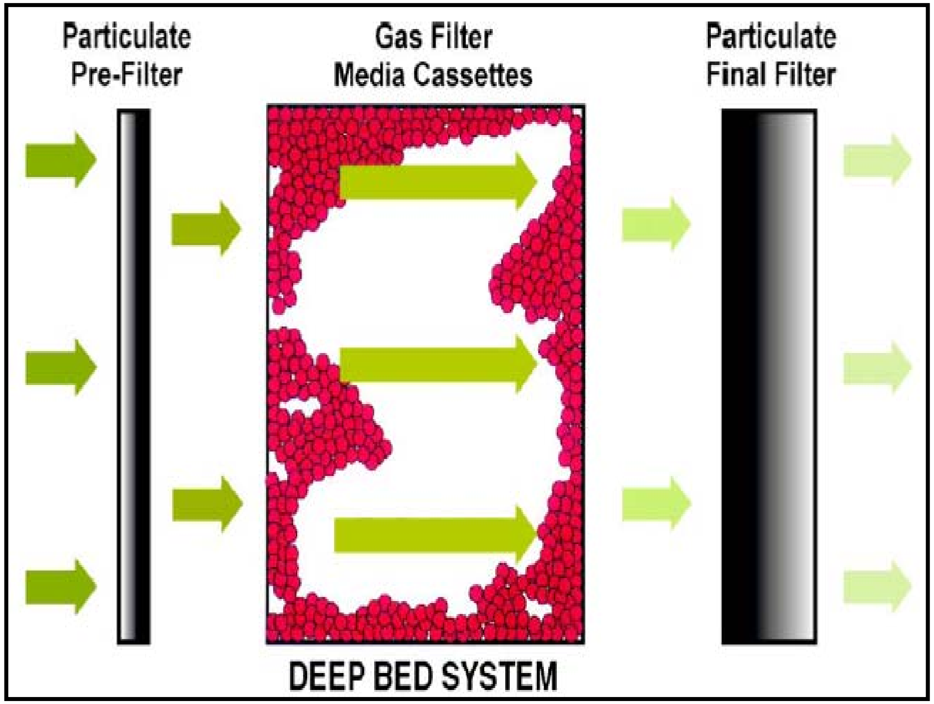
IT Equipment Environment – Contamination Filtration

Gas Filtration: scrub the problem gases out of the air stream



Economizer Cycles – Particulates & Gaseous Contamination

Particulates should be filtered as outlined here:

1) The room air may be continuously filtered with MERV 8 filters as recommended by ANSI / ASHRAE Standard 127-2007, "*Method of Testing for Rating Computer and Data Processing Room Unitary Air Conditioners*"
2) Air entering a data center may be filtered with MERV 11 or MERV 13 filters as recommended by ASHRAE book titled, "*Particulate and Gaseous Contamination in Datacom Environments*"

Economizer Cycles – Particulates & Gaseous Contamination

Gaseous contamination should be within the modified ANSI / ISA – 71.04-1985 severity level G1 that meets:

1) A copper reactivity rate of less than 300Å / month, and
2) A silver reactivity rate of less than 300Å / month

For data centers with higher gaseous contamination levels, gas-phase filtration of the inlet air and the air in the data center is highly recommended.

See the TC 9.9 Whitepaper "*Gaseous and Particulate Guidelines for Data Centers*"

Liquid Cooling

With server heat loads steadily climbing, the ability for data centers to deliver adequate airflow rates or sufficient chilled air is now being stretched to the limit.

Water and other liquids (dielectrics, glycols and refrigerants) may be used for Datacom Equipment heat removal instead of air.

1) Heat rejection with liquids typically uses LESS transport energy

2) Liquid-to-liquid heat exchangers have closer approach temperatures than Liquid-to-air (coils), yielding increased economizer hours.

Liquid Cooling

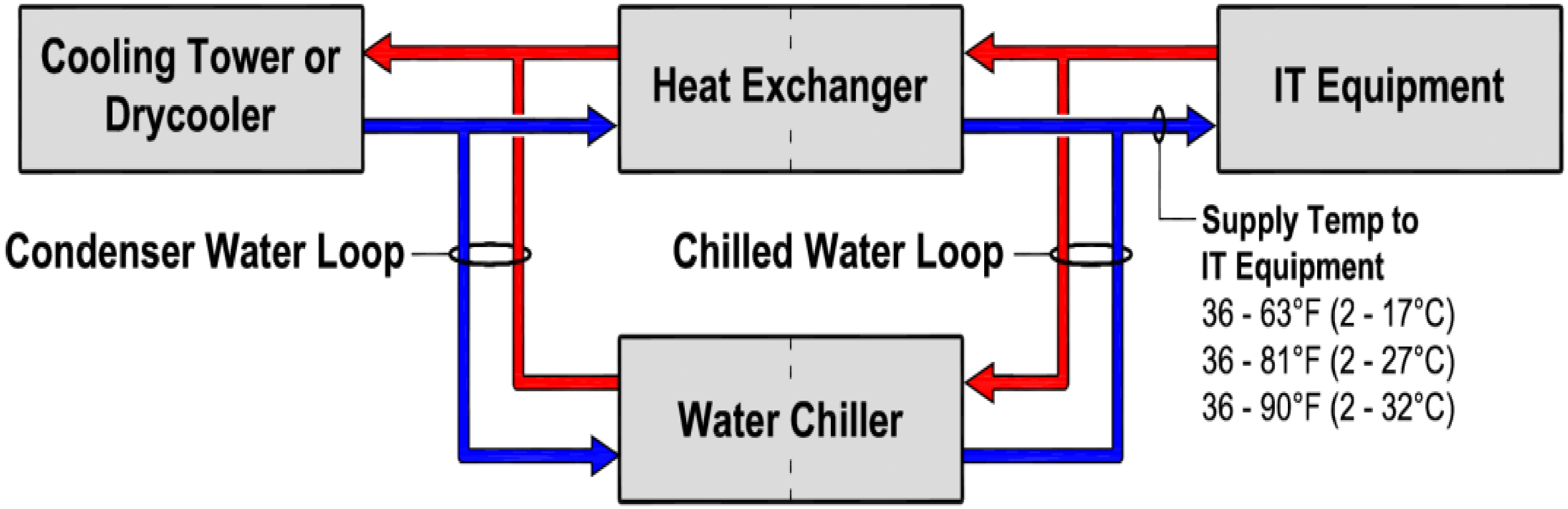
In 2006, ASHRAE published Liquid Cooling Guidelines for Datacom Equipment Centers which established basic guidelines for implementing liquid cooling solutions.

A 2011 whitepaper of the same name further defined classes and envelopes for implementing liquid cooling.

Liquid Cooling – ASHRAE 2011 Guidelines

Liquid Cooling Classes	Typical Infrastructure Design		Facility Supply Water Temp.
	Main Cooling Equipment	Supplemental Cooling Equipment	
W1	Chiller / Cooling Tower	Water-side Economizer (cooling tower or drycooler)	36 – 63 F (2 – 17 C)
W2			36 – 81 F (2 – 27 C)
W3	Cooling Tower	Chiller	36 – 90 F (2 – 32 C)
W4	Water-side Economizer (cooling tower or drycooler)	N/A	36 – 113 F (2 – 45 C)
W5	Building Heating System	Cooling Tower	> 113 F (> 45 C)

Liquid Cooling – Typical Infrastructures for Data Centers



Class W1, W2, W3

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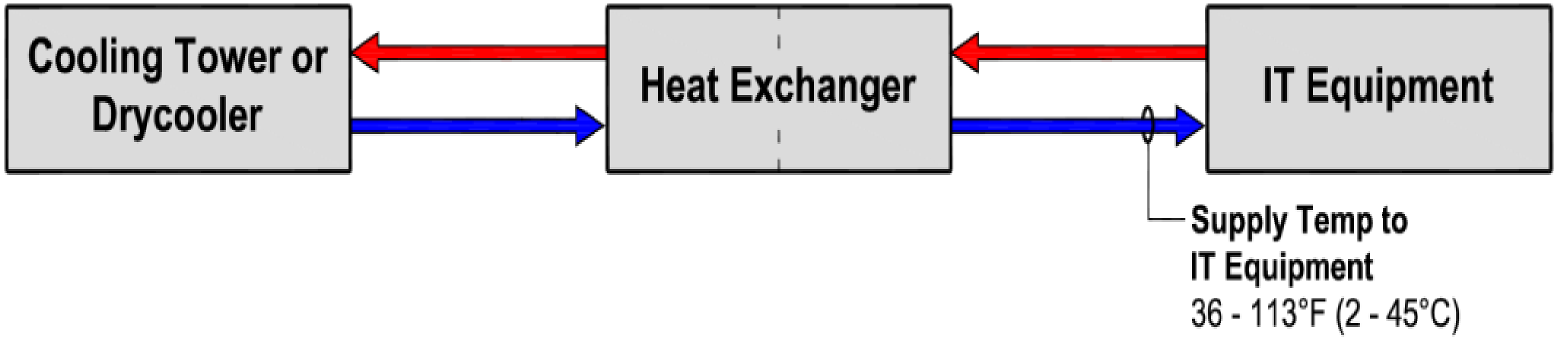
Liquid Cooling – Typical Infrastructures for Data Centers



Class W4

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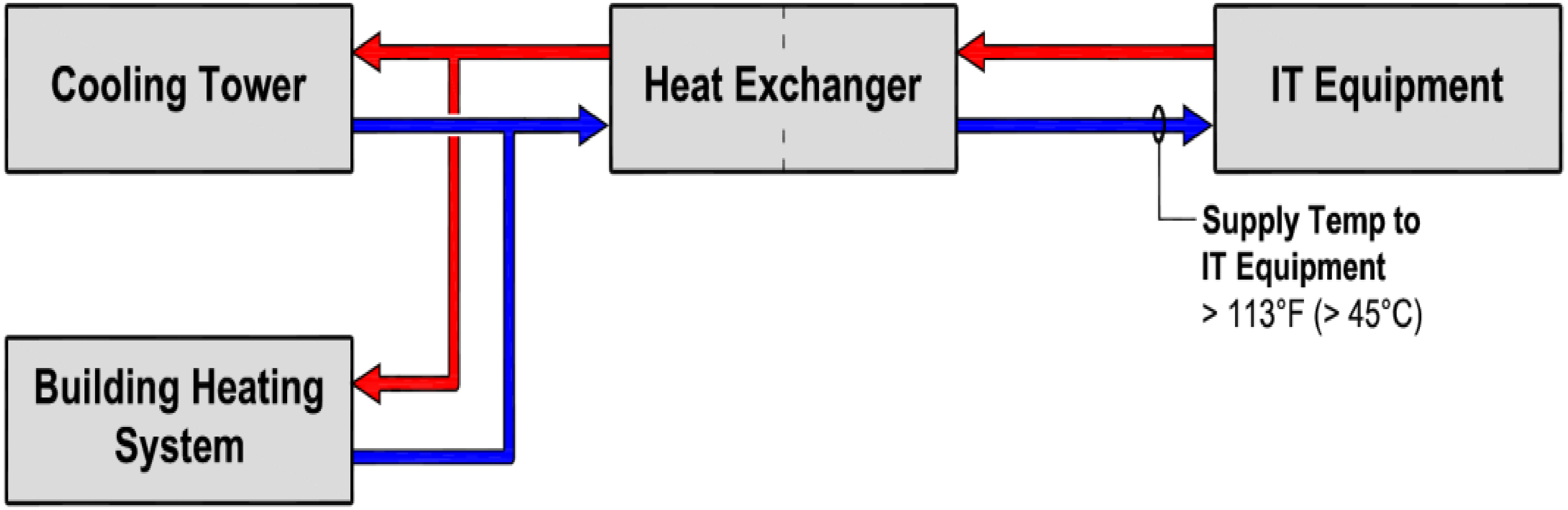
Liquid Cooling – Typical Infrastructures for Data Centers



Class W5

Closing Comments

There is a big difference between an Internet Data Center (IDC) and a Financial Services Data Center.

ASHRAE has created the opportunity to optimize on an individual basis to best meet the needs of the user and achieve the best TCO.

To accomplish this requires considering more variables and using an in depth engineering approach.

Closing Comments (cont.)

The payback for using an in DEPTH engineering approach can save NOT only operation expenses but save HUGE capital costs as well.

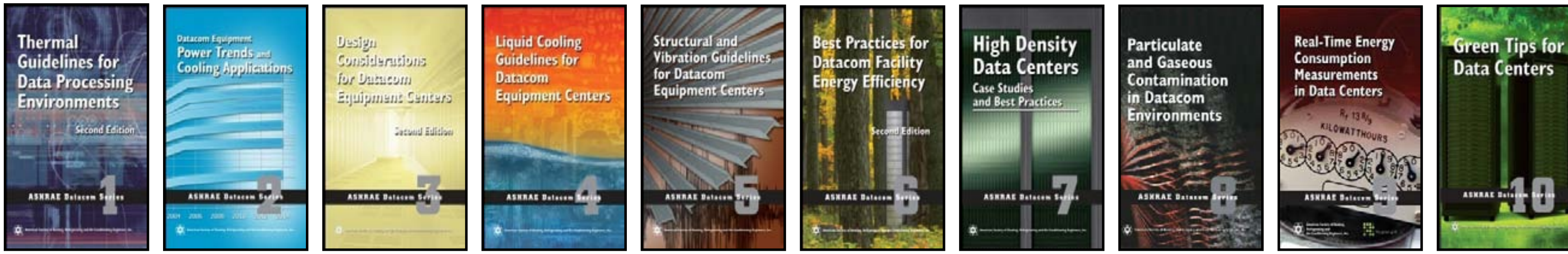
Holistic cooling design – IT hardware internal cooling and facility cooling infrastructure.

Multi-variable design approach – silicon to the outdoors and the associated tradeoffs.

Multi-discipline designers – Designers need understand IT & facility cooling.

EXPERTS WITH IN DEPTH ASHRAE EXPERIENCE COULD SAVE YOU PLENTY.

TC 9.9 Datacom Book Series



1. **Thermal Guidelines for Data Processing Environments 3rd Edition (coming soon)**
2. Datacom Equipment Power Trends & Cooling Applications 2nd Edition (coming soon)
3. Design Considerations for Datacom Equipment Centers (2006)
4. Liquid Cooling Guidelines for Datacom Equipment Centers (2006)
5. Structural & Vibration Guidelines for Datacom Equipment Centers (2008)
6. Best Practices for Datacom Facility Energy Efficiency (2008)
7. High Density Data Centers – Case Studies & Best Practices (2008)
8. Particulate & Gaseous Contamination in Datacom Environments (2009)
9. Real-Time Energy Consumption Measurements in Data Centers (2009)
10. Green Tips for Data Centers (2011)

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TC9.9 Whitepapers – available for free download at www.tc99.ashraetcs.org

ASHRAE TC 9.9

2011 Thermal Guidelines for Data Processing Environments – Expanded Data Center Classes and Usage Guidance

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

 1

2011 Gaseous and Particulate Contamination Guidelines For Data Centers[1]

EXECUTIVE SUMMARY

Most data centers are well designed and are in areas with relatively clean environments, and most contamination is benign. Therefore, most data centers do not experience particulate or gaseous contamination-related information technology (IT) equipment failures. A small number of data centers, however, do. According to the major IT equipment manufacturers, the number of data centers with contamination-related failures is on the rise, though their numbers remain quite small.

In 2009, the IT manufacturer members of ASHRAE TC 9.9 authored a white paper (ASHRAE 2009a), titled "Particulate and Gaseous Contamination Guidelines for Data Centers," primarily targeted toward a minority of data centers that may have harmful environments resulting from the ingress of outdoor particulate and/or gaseous contamination. The document stated that for a small number of data centers, located mostly in the emerging markets, contamination can be a serious risk, and it provided insight into how to manage the contamination risk.

This white paper is an update to the original 2009 ASHRAE paper. The update is based on an ASHRAE survey of the air quality in data centers and on lessons learned in cleaning the air in contaminated data centers.

The reasons for the increasing number of data centers experiencing corrosion-related hardware failures are as follows:

- Change from lead-containing solder to lead-free solder, such as copper-tin-silver solder
- Changes in data center temperature and humidity operating conditions

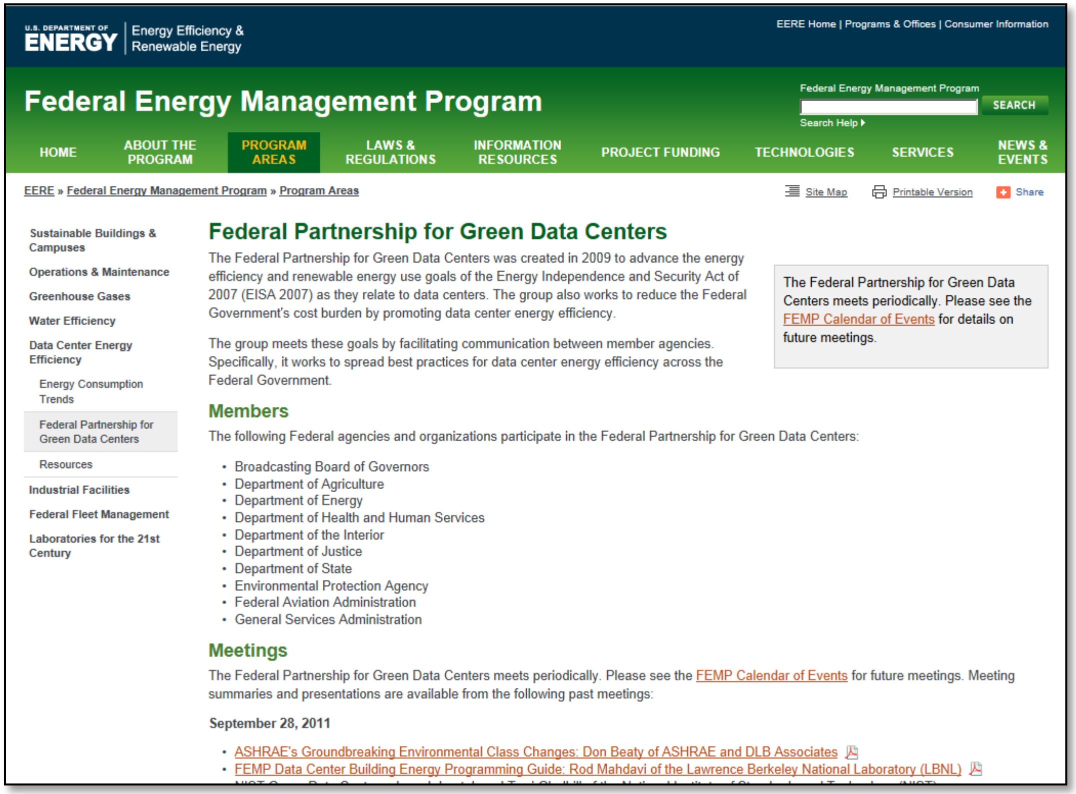
1. This white paper on data center airborne contamination was prepared by ASHRAE TC 9.9, Mission Critical Facilities, Technology Spaces, and Electronic Equipment. The committee's members represent the following IT equipment manufacturers: AMD, Cisco, Cray, Dell, EMC, Hitachi, HP, IBM, Intel, Oracle, Seagate, and SGI. Helpful information for technical and nontechnical readers can be found in *Particulate and Gaseous Contaminants in Datacom Environments* (ASHRAE 2009b).

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

FEMP Energy Efficient Data Center Resources

http://www1.eere.energy.gov/femp/program/data_center.html

Federal Partnership for Green Data Centers

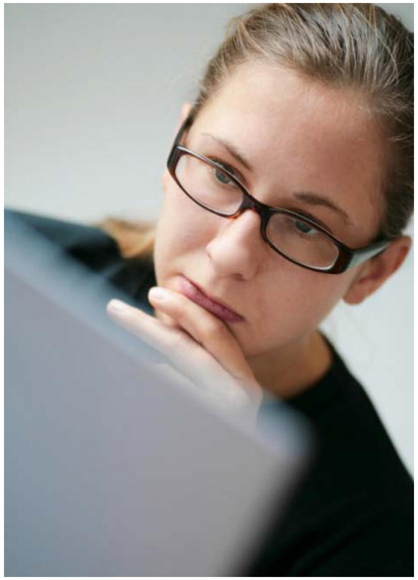


http://www1.eere.energy.gov/femp/program/fpgdc.html

Energy Efficient Data Center Training

Data Center Profiler (DC Pro) Tool Training **Webinar**

March 29, 2012



First Thursday Seminar

Labs, Data Centers and High Tech Facilities **– on demand**

http://apps1.eere.energy.gov/femp/training/index.cfm#results

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ASHRAE TC 9.9 Website

www.tc99.ashraetcs.org