Welcome!

Welcome to the ASHRAE TC 9.9 Virtual Meeting!

No need to say hello, we will begin promptly at 10:00 am EDT

Agenda

- Introduction and TC 9.9 Overview
- Program
- Webmaster
- Liaison Reports
- External Engagement
- Break
- International
- Publications
- IT Subcommittee

Housekeeping

Audio

- Attendees are muted upon entry
- Do not un-mute your line
- If you are joining via computer and phone line, ensure both are muted

Video

- We encourage you to keep your video off
- If you do enable your video, be mindful that you are on display! Turn off your video when needed.

Q&A

- Use the chat function to ask questions
- Our moderator will share questions throughout the presentation with the speaker to answer.
- If you need to speak, please use the Raise Hand button and the moderator will enable your microphone.

Attendance

- Please complete the attendance form found at the URL at the bottom of this slide

Attendance: http://bit.ly/tc99-summer

Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment

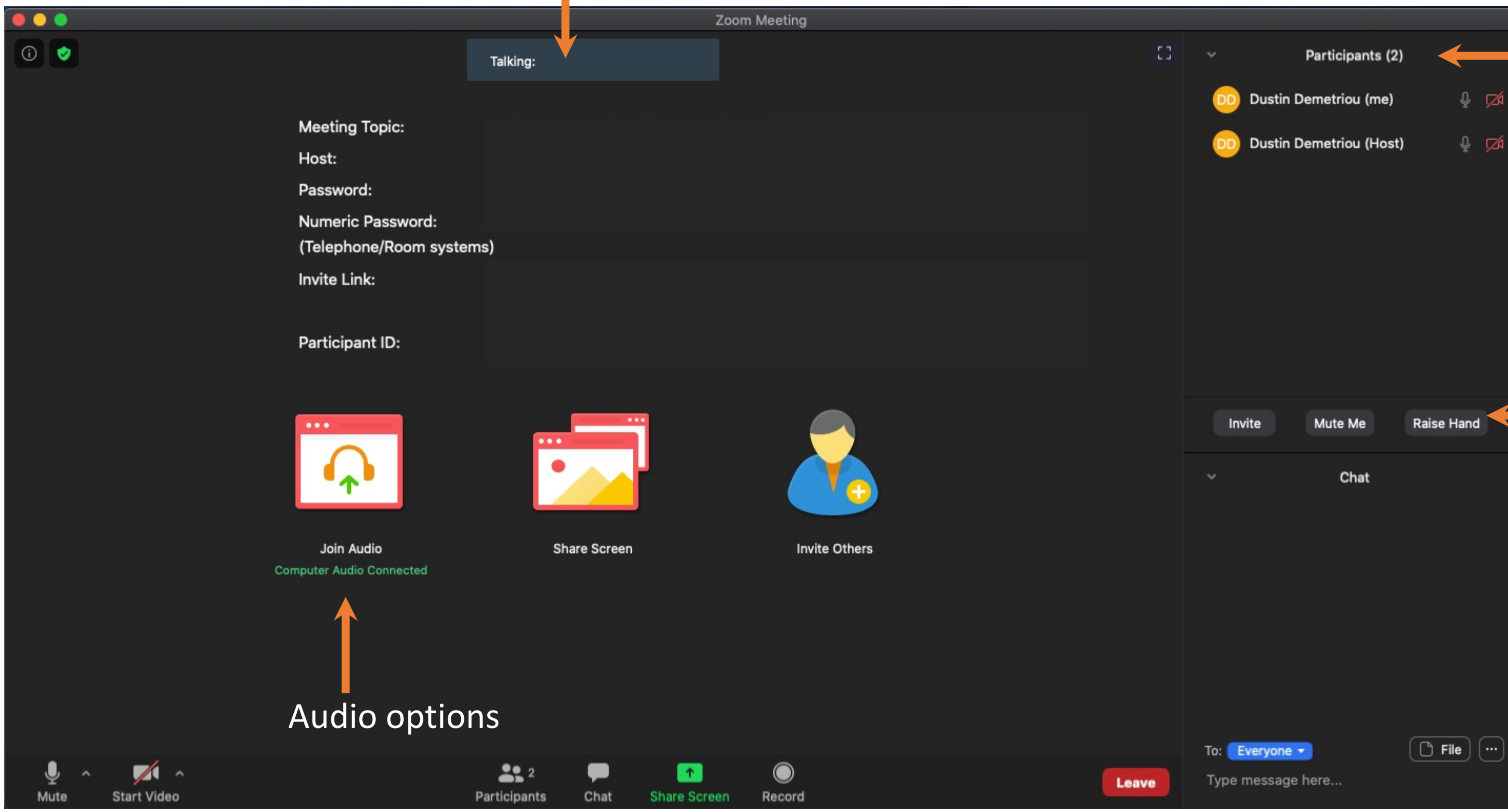
ASHRAE Annual Conference 2021

Virtual

Zoom Controls

Full Zoom Window

Speaker



Participant panel

Raise hand

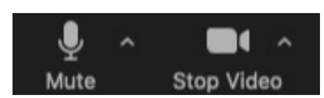
Chat panel

Audio options

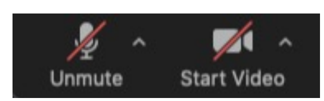
Toggle chat panel on/off

Turn video on / off

Mute / unmute audio



Audio and Video ON



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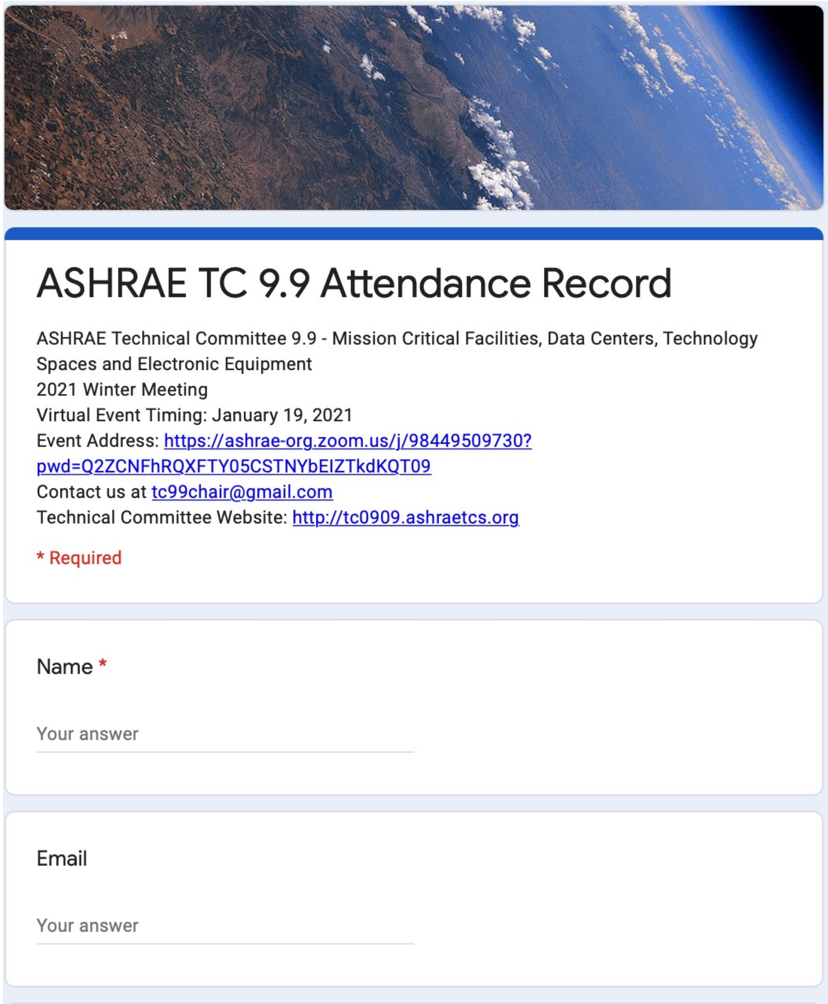
Attendance: http://bit.ly/tc99-summer

Attendance



ASHRAE TC 9.9 Attendance Record

ASHRAE Technical Committee 9.9 - Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment
2021 Winter Meeting
Virtual Event Timing: January 19, 2021
Event Address: https://ashrae-org.zoom.us/j/98449509730?pwd=Q2ZCNFhRQXFTY05CSTNYbEIZTkdKQT09
Contact us at tc99chair@gmail.com
Technical Committee Website: http://tc0909.ashraetcs.org

* Required

Name *

Your answer

Email

Your answer

Attendance is being recorded using a Google Form. Please make sure you complete the form at:

http://bit.ly/tc99-summer

ASHRAE Code of Ethics

As members of ASHRAE or participants in ASHRAE committees, we pledge to act with honesty, fairness, courtesy, competence, integrity and respect for others in our conduct.

A. Efforts of the Society, its members, and its bodies shall be directed at all times to enhancing the public health, safety and welfare.
B. Members and organized bodies of the Society shall be good stewards of the world's resources including energy, natural, human and financial resources.
C. Our products and services shall be offered only in areas where our competence and expertise can satisfy the public need.
D. We shall act with care and competence in all activities, using and developing up-to-date knowledge and skills.
E. We shall avoid real or perceived conflicts of interest whenever possible and disclose them to affected parties when they do exist.
F. The confidentiality of business affairs, proprietary information, intellectual property, procedures, and restricted Society discussions and materials shall be respected.
G. Each member is expected and encouraged to be committed to the code of ethics of his or her own professional or trade association in their nation and area of work.
H. Activities crossing national and cultural boundaries shall respect the ethical codes of the seat of the principal activity.

Agenda

Tuesday, June 15, 2021
TC 9.9 Main Meeting
10:00 AM – 3:00 PM EDT
Location: Virtual

Topic		Time	Presenter
Introduction	Welcome and Introductions	5	
	What is TC 9.9 Presentation	15	Dustin Demetriou
	TC 9.9 Officers and Membership	10	
Program		10	Nick Gangemi
Webmaster		5	Ecton English
Liaison Reports	Standard 90.1	10	Rick Pavlak
	Standard 90.4	10	Rick Pavlak
	SPC-127	10	John Bean
	AHRI 1360	10	David McGlocklin
	SSPC 300, Guideline 1.6	10	Terry Rodgers
	MTG.CYB	10	Ecton English
External Engagement	Datacenter Dynamics	5	Dustin Demetriou
	Open Compute Project	15	Nigel Gore
	UL 60335-2 A2L Refrigerants	15	B. Dolcich, B. Kinas, J. Rede
	Data Center Cooling Resiliency	10	Mark Mannex
Break		15	
International	International Update	10	Don Beaty
Publications	Publication Statistics	10	Ecton English
	Thermal Guidelines 5th Edition	15	Roger Schmidt
	Design Considerations 3rd Edition	10	John Gross
	Emergence & Expansion of Liquid Cooling	10	Dave Moss
IT Subcommittee	Liquid Cooling Datacom Book	15	Roger Schmidt
	Liquid Cooling Pressure Testing	10	Roger Schmidt
	IEC Connector Harmonization	10	Roger Schmidt

Total Time 4 hours 15 minutes

Title

- Mission Critical Facilities, Data Centers, Technology Spaces, and Electronic Equipment

Purpose

- To be recognized by ALL areas of the datacom industry as the UNBIASED engineering leader in HVAC and an effective provider of technical datacom information.

Scope

- All things datacom facilities: datacom refers to data processing and communication facilities. It includes rooms or closets used for communication, computers, or electronic equipment

ASHRAE TC 9.9 Membership

Participants

- TC 9.9 is the largest and most active TC with over 400 members

Representatives

- Producers of Datacom Equipment: computing hardware, software, and services
- Producers of Facility Equipment: HVAC, software, DCIM, rack solutions
- Users of Datacom Equipment: facility owners, operators, managers
- General Interest: government agencies, utilities, consultants, academia, testing laboratories

ASHRAE TC 9.9 Contributions

Industry Volunteers Provide the Expertise

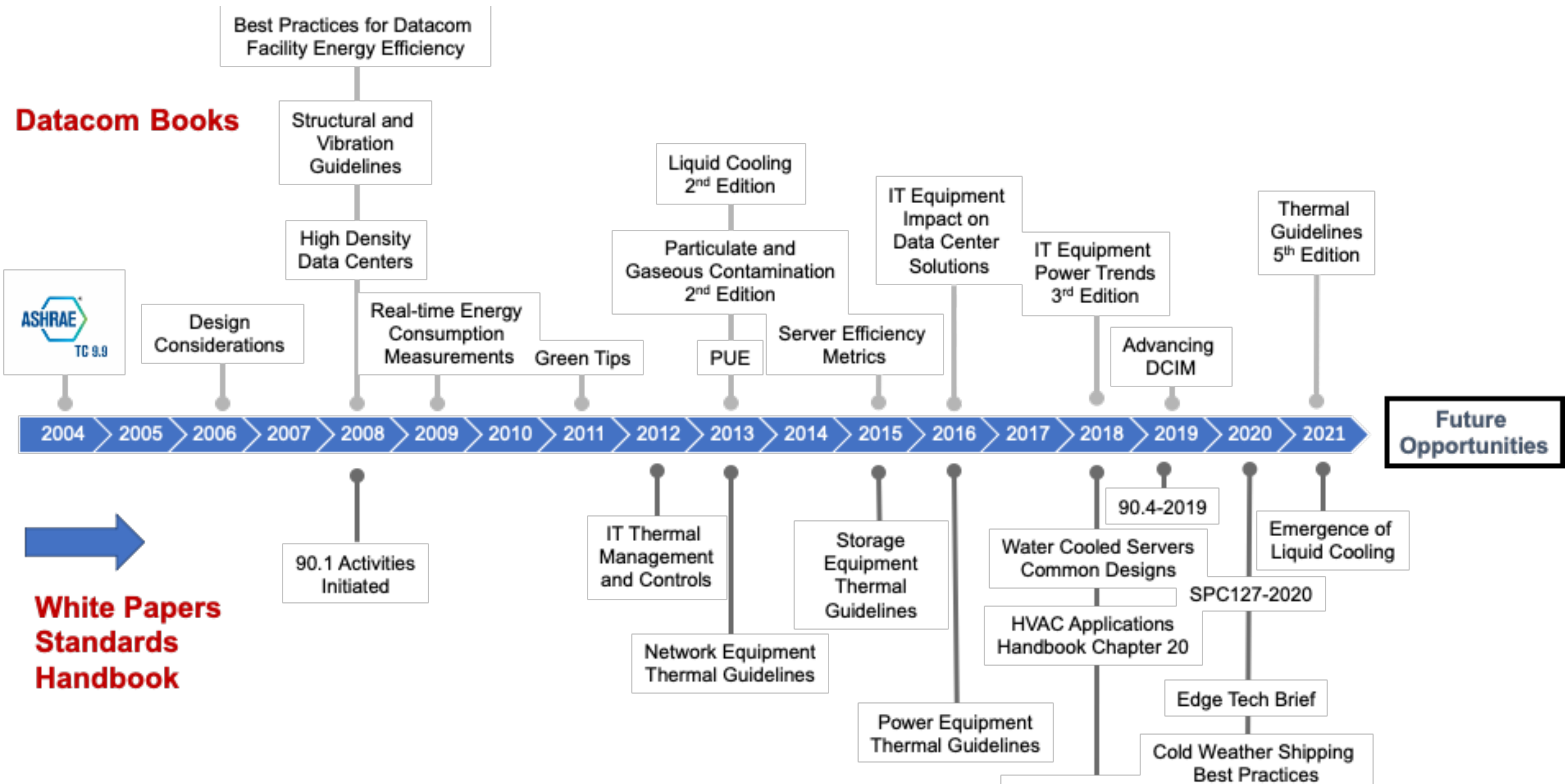
- Manufacturers, consultants, researchers, universities, utilities, regulators, contractors, and government

Areas of Influence

- Standards
- Research
- Handbook
- Programs (including paper reviews)
- Technical Activities: Books, White Papers, Education

Attendance: http://bit.ly/tc99-summer

Timeline of ASHRAE TC 9.9 Published Results



* Only most recent versions shown for clarity

Attendance: http://bit.ly/tc99-summer

TC 9.9 Datacom Book Series

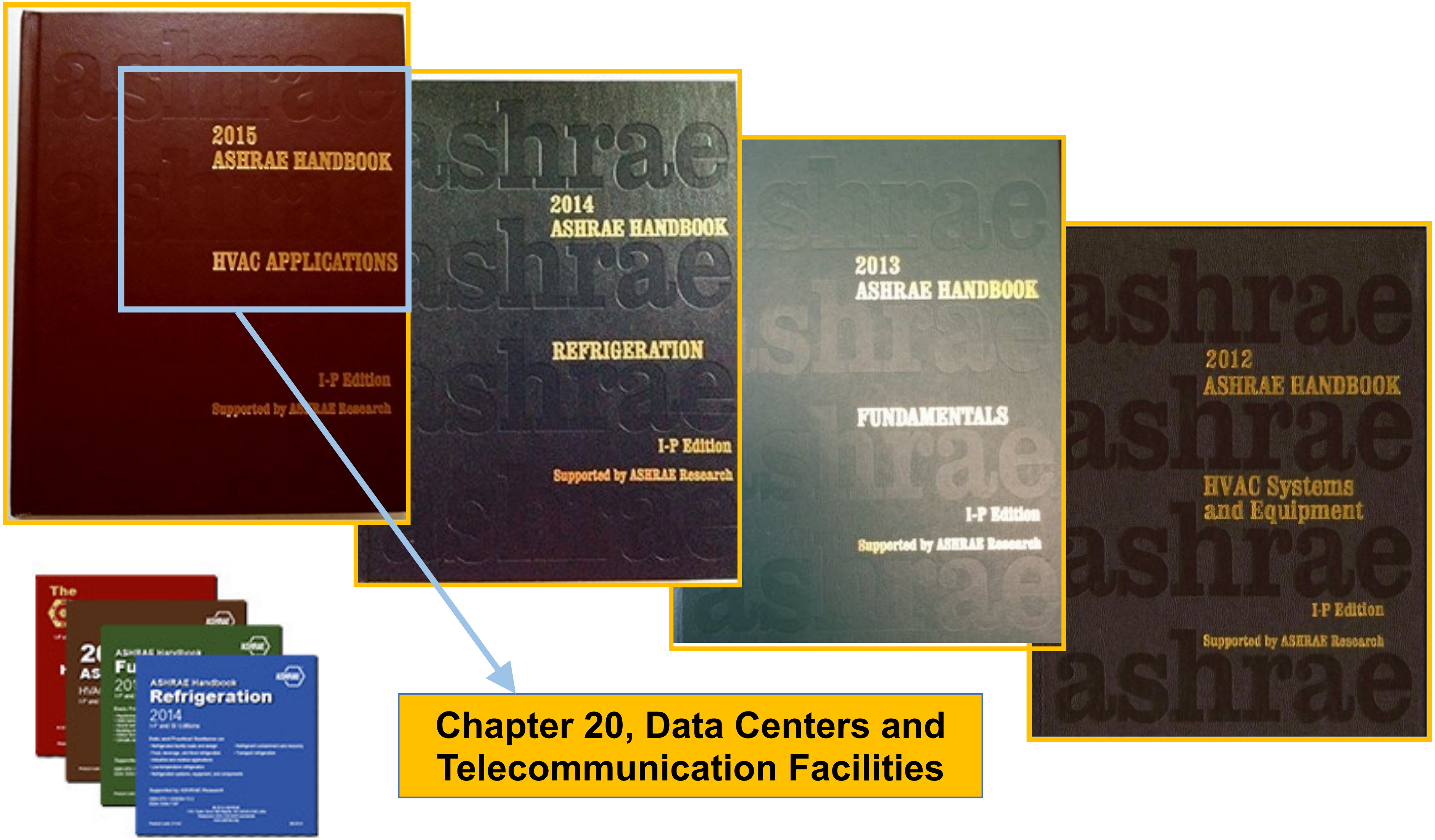
Essentials of Data Center Design

- Establish a Baseline
- Target Forecasts and Trends
- Engage in Best Practices
- Prepare for Special Cases
- Measure Key Metrics

Attendance: http://bit.ly/tc99-summer

ASHRAE Handbook

ASHRAE Handbook Series is the backbone resource of the HVAC Industry



Chapter 20, Data Centers and Telecommunication Facilities

Attendance: http://bit.ly/tc99-summer

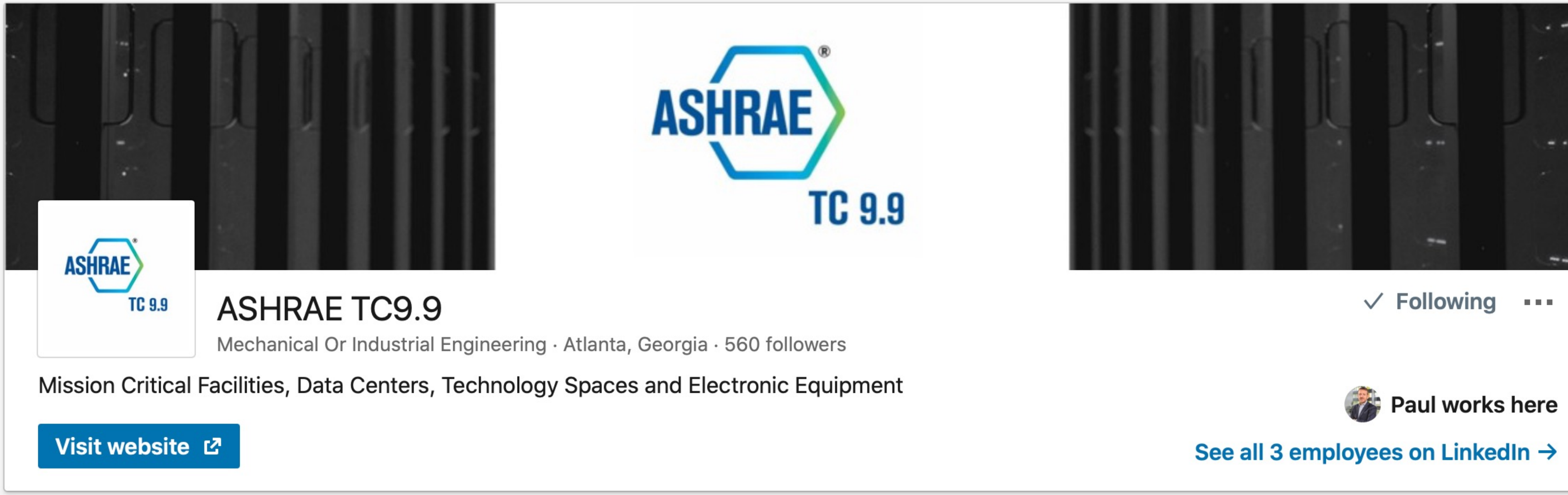
Current TC 9.9 Work Activities

Latest TC Activities

If you would like to get involved in this TC's activities you can contact the appropriate Point of Contact in the TC 9.9 Work Items listing, attend the biannual meetings, or contact our committee chair at tc0909@ashrae.net.

- Datacom Series Books
  - Design Considerations for Datacom Equipment Centers, 2nd Edition
  - Liquid Cooling Guidelines for Datacom Equipment Centers, 3rd Edition
- Research
  - 1675-RP, Guidance for CFD Modeling of Data Centers
  - RTAR, Wetted Materials
- White Papers / Technical Briefs
  - Impact of Human Health for Hot Aisle Containment Solutions

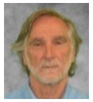
TC 9.9 LinkedIn Page



https://www.linkedin.com/company/18665978

ASHRAE TC 9.9 Officers & Membership
July 1, 2021 – June 30, 2022

TC 9.9 Officers

Chair		John Groenewold, *Vantage Data Centers*
Vice Chair		Matt Koukl, *Affiliated Engineers*
Secretary		Mark Steinke, *AMD*
Research Subcommittee Chair		Mark Seymour, Future Facilities
ITE Subcommittee Chair		Dr. Roger Schmidt, *IBM Fellow Emeritus Syracuse University*
Standards Subcommittee Chair		Rick Pavlak, *Heapy Engineering*
Program Subcommittee Chair		Nick Gangemi, *Northern Air Systems*
Handbook Subcommittee Chair		Robert McFarlane, *Shen Milsom & Wilke, LLC*
Membership Subcommittee Chair		Jack Glass, *Citigroup retired*
Webmaster		Ecton English, *Department of Defense*
Marketing Subcommittee Chair		Paul Finch, *KAO Data*

Attendance: http://bit.ly/tc99-summer

TC 9.9 Liaisons

- Standard 90.1: Rick Pavlak
- Standard 90.4: Dave Kelley
- Standard 127: John Bean
- Standard 300, Guideline 1.6: Terry Rodgers
- International: Don Beaty
- MTG.CYB: Ecton English

Voting Members

1. Gerardo Alfonso, Ingeal
2. John Bean, Green Revolutions Cooling
3. Don Beaty, DLB
4. Lex Coors, Interxion Headquarters
5. Dave Kelley, Vertiv
6. Ecton English, DoD
7. John Groenwald, Vantage Data Centers
8. John Gross, J.M. Gross Engineering
9. Matt Koukl, Affiliated Engineers
10. Dave Meadows, Stultz America
11. Dave Moss, Dell
12. Joseph Prisco, IBM
13. Terry Rogers, JLL
14. Roger Schmidt, Syracuse University
15. Vali Sorell, Microsoft

2021 Votes

Vote	Date	Approved
Emergence of Liquid Cooling White Paper	March	Yes
Winter Virtual Meeting Minutes	May	Yes

Membership Information

Provisional Corresponding Members (89 as of 6/2021)

- Newly registered
- Implies participation in committee activities through correspondence or in-person involvement to become corresponding member
- Provisional corresponding members serves up to two, one-year terms
- Chair updates roster to move from provisional to corresponding
  - Roster update always due Tuesday following main meeting during Winter Conference
  - If the chair takes no action on a provisional member, they are dropped from the roster in two years
- Can not be voting members, but after provisional term, may be considered for future voting membership.’
- For purposes of committee assignments and other work “Provisional” status does not limit an individual’s active involvement in the work of the committee

Corresponding Members (348 as of 6/2021)

- Full members
- Can be voting members
- Can be nominated/elected as an officer

Keep Your ASHRAE Profile Updated!

Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment

ASHRAE Technical Committee 9.9

Home | Membership | Meetings | Documents | Functions | More

Member Roster

Current as of 6/04/2020

Join TC 9.9

If you want to become a provisional corresponding member of this TC, click on the "Join TC" button above. You will be automatically added to the roster and will receive all TC communications.

Committee members can download a copy of the complete roster in any of three formats by logging in to their ASHRAE member account, clicking on my account and selecting Committees.

http://tc0909.ashraetcs.org/membership.php

2021-2022 Hightower Award Nominations by Wednesday, September 1st

TAC wishes to encourage TCs to make nominations for the 2020-2021 *George B. Hightower Technical Achievement Award.* Nominations are due to Section Heads by September 1, 2021 or sooner.

The award recognizes outstanding technical leadership and contributions on a TC/TG/TRG during the past four years, excluding research and standards activities. Please go to the Technical Committee page of the ASHRAE website at the following link under the “Procedures, Forms…” heading: www.ashrae.org/tcs.

https://www.ashrae.org/membership/honors-and-awards

CEC’s Standing Request for Future Society Meeting Program Track Suggestions

The Conferences and Expositions Committee (CEC) oversees ASHRAE’s annual and winter conferences and other specialty conferences and expositions globally. The CEC continually works to improve the conference experience for all attendees. To help keep a “pulse” on the technical issues facing professionals in the HVAC&R marketplace, and to create meetings that reach all of ASHRAE’s constituencies, the CEC seeks ideas for tracks for the Chicago 2021 Winter meeting and annual and winter conferences beyond as well as topics for specialty conferences from TC members.

The Professional Development Committee (PDC) is seeking ideas for new ASHRAE Learning Institute (ALI) courses.

The Professional Development Committee (PDC) is actively seeking ideas for new ASHRAE Learning Institute (ALI) courses. We need practical courses of broad interest to be presented as face-to-face seminars or short courses, instructor-led online courses and self-paced courses. Examples include courses with a focus on new technologies that need to be shared, fundamentals for engineers new to the discipline, standard applications that need explanation, and courses based on new design guides. Does your TC have a potential course idea?

Decarbonization Task Force

The ASHRAE Task Force for Building Decarbonization (TFBD) has been established to develop technical resources and provide leadership and guidance in mitigating the negative carbon impact of buildings on the environment and the inhabitants of our planet.

"In a similar vein to how ASHRAE took the lead in responding to the energy crisis of the 1970s era and defined the energy efficiency journey, ASHRAE has much to offer with respect to paths for responsible decarbonization strategies," said 2020-21 ASHRAE President Charles E. Gulledge III, P.E., HBDP. "The challenges of decarbonization are complex. but this task force is positioned to offer actionable technical guidance to improve how building are built and operated."

The specific responsibilities of the task force include:

- Providing recommendations and practices for industry stakeholders in decarbonization of the built environment.
- Defining the objectives of this holistic initiative; including, but not limited to:
  - Developing a framework for characterizing the issues related to decarbonization.
  - Identifying existing portfolio of ASHRAE technical resources on issues relating to decarbonization, and package them in a way useful to policy makers and stakeholders.
  - Identifying and quantifying knowledge gaps for policy makers and stakeholders who are tackling building decarbonization and develop resources to address these gaps.
- Formulating a value proposition statement as to why ASHRAE is embarking on this journey.
- Identifying the global audience related to this initiative.
- Establishing guiding principles that frame this journey.
- Objectively framing the issues associated with this initiative.

Decarbonization PPIB approved –see here

2019 – 2025 ASHRAE Strategic Plan

- Strategic Plan extended for 1 more year, through 2025
- Mission
  - To serve humanity by advancing the arts and sciences of heating, ventilation, air conditioning, refrigeration and their allied fields.
- Vision
  - A healthy and sustainable built environment for all.
- Values
  - Excellence, Commitment, Integrity, Collaboration, Volunteerism, Diversity

Handbook Sign Up

TC 9.9 Handbook Sign Up

This signup sheet is meant to solicit interest in providing reviews and content for the 2022 Edition of the ASHRAE Applications Handbook, Chapter 20, "Data Centers & Telecommunications Facilities.

* Required

Name *

Your answer

Email *

Your answer

Subject Matter Expertise *

Please select areas you wish to contribute to

- [ ] CRAC's & CRAHs
- [ ] PUE
- [ ] Economizers
- [ ] BICSI
- [ ] TGG
- [ ] CFD
- [ ] Datacom Books
- [ ] Gaseous Contamination
- [ ] Liquid Cooling
- [ ] Other:

Submit

TC 9.9 is asking for volunteers to support the 2022 Handbook. If interested, please complete the following sign up sheet:

http://bit.ly/tc99-handbook

Attendance: http://bit.ly/tc99-summer

Thank You

TC 9.9 Website

tc0909.ashraetcs.org

Programs Update

ASHRAE Virtual Winter Meeting

Nick Gangemi, Program Chair

ASHRAE VIRTUAL ANNUAL CONFERENCE
June 28-30, 2021

2021 ASHRAE Virtual Conference
Jun 28–30, 2021

Tuesday, June 29, 7:00 AM – 8:30 AM

Seminar 8 (Intermediate)

Energy Management Best Practices, Case Studies and Lessons Learned from Real-World Data Center

Track: Design, Control, and Operation of Critical Environments
Sponsor: 9.9 Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment, 7.6 Building Energy Performance, TC 7.3, TC 7.5
Chair: Eric Yang, P.E., Member, Energy Systems Group, Washington, D.C.

This session includes energy management best practices, case studies and lessons learned from real-world data center operation. Presentations address how controls systems, smart building technologies and data analytics are helping data centers operate more efficiently and reliably via real world examples and case studies. Common pitfalls in the data center operation are also discussed.

1. Harnessing the Power of Data Analytics for Reliable and Efficient Data Center Operations at LBNL's High Performance Computing Center, Jingjing Liu, P.E., BEAP, Lawrence Berkeley National Laboratory, Berkeley, CA
2. Is Your Legacy Data Center Ready to Improve Energy Efficiency through the Use of Data Analytics, AI/ML and Intelligent Controls Optimization?, John Dumler, P.E., Member, Digital Realty, Atlanta, GA
3. Classic Pitfalls to Avoid in Data Center Operation Mark Seymour, P.E., Member, Future Facilities, London, United Kingdom

Wednesday, June 30, 3:00 PM – 4:00 PM

Conference Papers Session 3 (Intermediate)

Air Quality and Handling in Mission Critical Facilities

Track: Design, Control, and Operation of Critical Environments
Chair: Eric Yang, P.E., Member, Energy Systems Group, Washington, D.C.

Air quality and flow control are a key consideration in mission critical environments. such as data centers, healthcare facilities and clean rooms. This session begins with an introduction of latest air-mover technologies and the requirements for improved fan performance continue to grow with demand for higher HVACR energy efficiencies. This is followed by a discussion of temperature controlled air-flow in healthcare facilities, and the impact of exhaust grilles on the air quality and flow patterns. The last paper focuses on the development of digital twin of a data center to improve its design, control and operation.

1. Air Considerations in Imaging (X-Ray) Rooms (VC-21A-C014) Travis English, P.E., Member, Kaiser Permanente, Anaheim, CA
2. Development of Detailed Server Digital Twin Models for Enabling a Data Center Digital Twin for Design, Control and Operation (VC-21A-C015) Dustin Demetriou, Ph.D., Member, Yuanchen Hu, Ph.D. and John Madalengoitia, IBM, Poughkeepsie, NY
3. EC Fan Array Implementation – How to Capture the Energy Savings without Sacrificing Power Quality (VC-21AC016) Anthony Hoevenaars, P.Eng., Member and Joseph Landrette,
4. Effect of Exhaust Grille Position on Air Quality and Flow Patterns in Clean Rooms (VC-21A-C017) Essam Khalil, Ph.D., P.E., Fellow ASHRAE, Taher AbouDief, Dr.Eng, Ahmed Abou Zeid, Dr.Eng and Hesham Metwally, P.Eng., Cairo University, Cairo, Egypt
5. The Efficacy of Temperature-Controlled Air Flow in Maintaining Ultraclean Conditions throughout the Operating Room (VC-21A-C018) Clemens Bulitta, M.D.1, Kathy Warye, Associate Member2 and Peter Hojerback3, (1)Technical University of Applied Sciences Amberg-Weiden, Amberg-Weiden, Germany, (2)Infection Prevention Partners, Sonoma, CA, (3)A vidicare, Lund, Sweden

On Demand

Seminar 39 (Basic) Demand for Variable Speed Equipment in Data Center Applications

Track: HVAC&R Systems and Equipment
Sponsor: 1.11 Electric Motors and Motor Control, 5.1 Fans
Chair: Nicolas S. Rosner, P.E., Member, Eaton, City of Industry, CA

Data center is a fast-growing niche in the HVAC&R industry and Data Center mechanical equipment design requires both redundancy and energy efficiency. The purpose of this presentation is to identify the needs of a Data Center end-user, including critical equipment. ECM and VFD fan arrays will be presented. Speakers will also discuss Custom Air Handler system design with an emphasis on variable speed technology. Top industry experts will explain equipment considerations. Participants will understand equipment solutions in this critical segment of the industry.

1. Fan Array Technology: Efficiency, Basics, Inductions Motors with VFDs and ECMs Tom A. Bise, Associate Member, Johnson Controls, York, PA
2. Custom Air Handlers George Paich, Associate Member, Alliance Air Products, San Diego, CA
3. Data Center Mechanical Equipment Design, Redundancy and Variable Speed Applications Tim Chadwick, P.E., Member, AlfaTech, San Jose, CA

On Demand

Seminar 65 (Intermediate) Sound and Vibration Issues with Mission Critical Facilities

Track: Design, Control, and Operation of Critical Environments
Sponsor: 2.6 Sound and Vibration
Chair: Patrick Marks, P.E., Fellow ASHRAE, Johnson Controls, New Freedom, PA

Whether it is a hospital, a data center or another mission critical facility, these projects present their own unique sound and vibration control challenges. This seminar will highlight specific noise and vibration concerns unique to data centers and health care facilities and will review successful case studies of applications.

1. Data Center Sound and Vibration Control Issues Paul Bauch, Member1 and Patrick Marks, P.E., Fellow ASHRAE2 , (1) Johnson Controls, York, PA, (2)Johnson Controls, New Freedom, PA
2. Generator Noise Control Dan LaForgia, Member, Vibro-Acoustics, Huntington, NY
3. Noise Control That Focuses on Care and Safety in Healthcare Erik Miller-Klein, P.E., Member, Tenor Engineering Group LLC, Seattle, WA

On Demand

Seminar 71 (Intermediate) The Continuing Evolution of the ASHRAE Data Center Environmental Guidelines

Track: Design, Control, and Operation of Critical Environments
Sponsor: 9.9 Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment
Chair: Joseph Gangemi, Life Member, Data Aire, Orange, CA

To address the growing emphasis on energy efficiency of data centers, TC 9.9 has been evolving the Thermal Guidelines on a regular basis as data becomes available. A historical perspective is given including the latest change to the recommended envelope based on research of high humidity and gaseous pollutants as it affects the reliability of IT equipment. Another environmental envelope has been added to the existing 4 air-cooling classes to accommodate high density racks. With increasing high density racks the IT industry will be deploying more liquid cooling products. With these trends the water-cooling classes have been expanded and renamed.

1. History of the ASHRAE Thermal Guidelines and IT Equipment Power Trends Dustin Demetriou, Ph.D., Member, IBM, Poughkeepsie, NY
2. Research on High RH and Gaseous Pollutants Impact on IT Equipment Reliability Roger Schmidt, Ph.D., P.E., Member, IBM, Poughkeepsie, NY
3. Expanded Guidelines for Data Center and IT Air Cooling Paul Artman, Lenovo, Raleigh, NC
4. Liquid Cooling White Paper and Updates to the ASHRAE Water Cooling Classes Dave Moss, Dell Inc., Round Rock, TX

2022 ASHRAE Winter Conference
Las Vegas, NV
Jan. 29 – Feb. 3, 2022

Las Vegas Tracks

1. **HVAC&R Systems and Equipment:** HVAC&R systems and equipment are constantly evolving to address the changing requirements of the built environment. Papers and programs in this track focus on the development of new systems and equipment, improvements to existing systems and equipment and the proper application and operation of systems and equipment.

2. **Fundamentals and Applications:** Fundamentals are the foundation for understanding applications in engineering. Key components of ASHRAE fundamentals include thermodynamics, psychometrics, fluid and mass flow. This track provides opportunities for papers and presentations of varying levels across a large topic base. Concepts, design elements and shared experiences for theoretical and applied concepts of HVAC&R design are included.

3. **Refrigerants and Refrigeration:** Refrigeration systems generate and use cold for a range of processes, from food preparation and conservation, to vaccine preservation, to long-term protection of fragile ancient inks of historic documents and others. Differences in technologies and equipment, performances, refrigerants, etc., may hide synergies from which both industrial and commercial systems might benefit, also, but not only, from the points of view of reducing direct and indirect GHG emissions.

4. **Buildings at 360°:** Buildings use a large share of a country's final energy, in particular for heating, cooling and various services. Papers and presentations explaining methods, equipment, systems and solutions to satisfy occupants' needs, to guarantee buildings' performances and resilience, and to save resources (energy, water, etc.) will fit this track.

5. **Energy System Integration:** Energy is the omnipresent reality of our daily lives (e.g., electricity for appliances and equipment, heat and cold for industrial processes and commercial purposes). Once used, part of the input the energy is wasted as heat/cold or as exhaust byproducts, thus contributing to the pollution of soil, water and air. The integration of various energy sources/grids with buildings, processes and transportation allows to better exploit the available energy (renewables, in particular) while reducing the said waste through a circular approach to energy usage. Papers on renewables, fossil fuels, grid integration, aggregation, demand-side flexibility, smart devices, IoT, synthetic hydrogen and synthetic fuels, CCUS, electrification would fit this track.

Las Vegas Tracks

6. **Environmental Health and IEQ in the International Arena:** We spend a large part of our days indoors to live, work, practice gym, etc. Indoor environment is essential for our comfort, well-being, health, productivity, but is often treated and regulated differently in various parts of the world due to local conditions, circumstances, history, traditions. Presentations that explain local norms and trends are welcome to increase the knowledge on such an important topic, with an eye also on energy usage.

7. **HVAC for Industrial and Commercial Purposes - Challenges and Opportunities:** How to guarantee a set point within the required tolerances in a large industrial facility? How to increase the overall energy efficiency of a commercial facility through HVAC systems? What are the lessons that can be learnt from in terms of equipment, installation, commissioning, etc. and that can be transferred to other types of facilities; and vice versa? This is the track where such topics can find suitable space.

8. **Refrigerants, Safety, Performances:** Be it for cooling and refrigeration, be it for heating, refrigerants are at the heart of vapor compression cycles. Space cooling and refrigeration for food cold chains and medical purposes are forecast to grow in the coming decades; the same can be envisaged for residential-, commercial- and industrial-grade heat pumps. The choice of refrigerant plays an important role, along with control and safety features of the equipment, both to maximize performances, and to minimize direct and indirect GHG emissions (the former are usually associated to runtime leakages and end-of-life incomplete recovery of the refrigerant, whereas the latter are associated to the consumed energy). Presentations in this track present advancements and developments about flammability of refrigerants (e.g., HFOs, naturals, etc.), that can reduce the direct emissions, but that may have safety, regulatory and performance issues when deployed on the field.

Important Dates for Las Vegas

Monday, April 12, 2021: Conference Paper Abstracts, Technical Papers Due
Friday, April 30, 2021: Conference Paper Abstract Accept/Reject Notifications
Friday, June 18, 2021: Website Opens for Program Proposals
Monday, July 12, 2021: Conference Papers Due
Monday, August 2, 2021: Debate, Panel, Seminar, Forum, Workshop and Debate Proposals Due
Friday, August 6, 2021: Revised Conference Papers/Final Technical Papers Due
Monday, August 23, 2021: Conference Paper Accept/Revise/Reject Notifications

Nick Gangemi, Program Chair

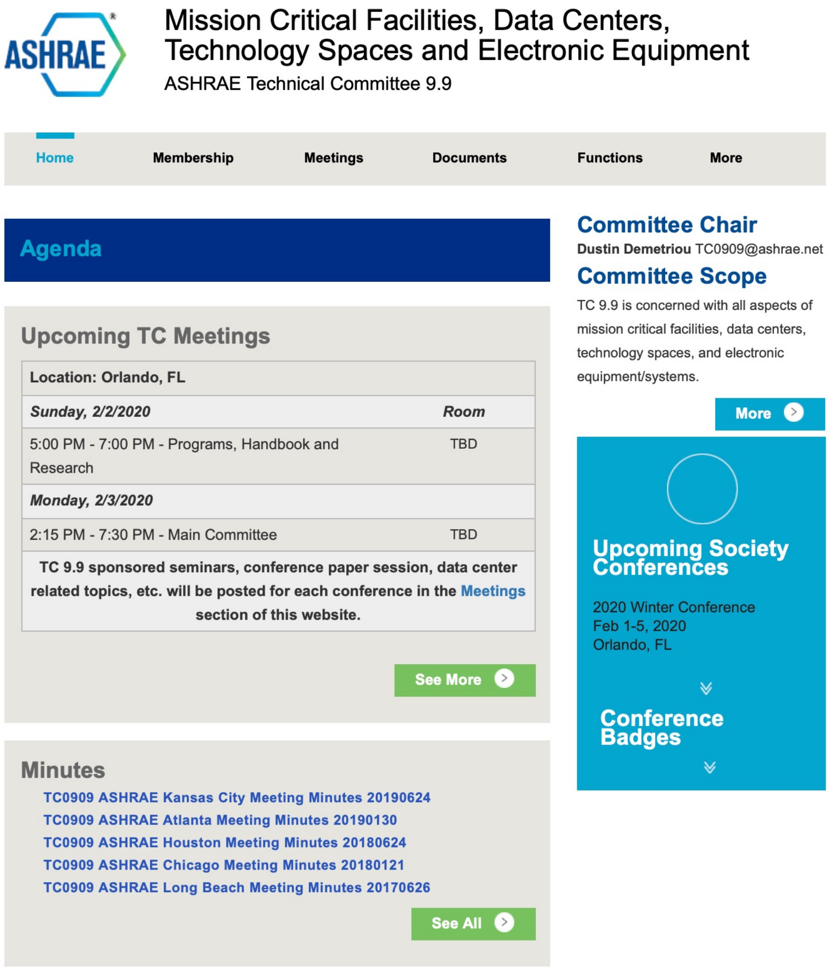
585-721-8795

Nick.GANGEMI@bureauveritas.com

Webmaster

Ecton English

TC 9.9 Webpage



Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment
ASHRAE Technical Committee 9.9

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Agenda

Upcoming TC Meetings

Location: Orlando, FL	
Sunday, 2/2/2020	***Room***
5:00 PM - 7:00 PM - Programs, Handbook and Research	TBD
Monday, 2/3/2020	
2:15 PM - 7:30 PM - Main Committee	TBD

TC 9.9 sponsored seminars, conference paper session, data center related topics, etc. will be posted for each conference in the Meetings section of this website.

See More

Minutes

- TC0909 ASHRAE Kansas City Meeting Minutes 20190624
- TC0909 ASHRAE Atlanta Meeting Minutes 20190130
- TC0909 ASHRAE Houston Meeting Minutes 20180624
- TC0909 ASHRAE Chicago Meeting Minutes 20180121
- TC0909 ASHRAE Long Beach Meeting Minutes 20170626

See All

Committee Chair
Dustin Demetriou TC0909@ashrae.net

Committee Scope
TC 9.9 is concerned with all aspects of mission critical facilities, data centers, technology spaces, and electronic equipment/systems.

More

Upcoming Society Conferences

2020 Winter Conference
Feb 1-5, 2020
Orlando, FL

Conference Badges

http://tc0909.ashraetcs.org

Attendance: http://bit.ly/tc99-summer

TC 9.9 Webpage

Analytics — TC Websites - Section 09
TC0909

Go to report

TC 9.9 Site Performance Overview

Jul 1, 2020 - Jun 1, 2021

Unique Visitors

4,359
% of Total: **100.00% (4,359)**

Pageviews

9,490
% of Total: **100.00% (9,490)**

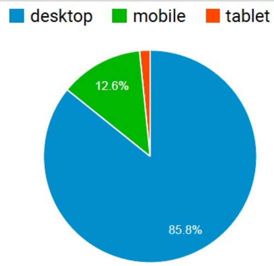
Avg. Visit Duration

00:01:02
Avg for View: **00:01:02 (0.00%)**

Pageviews and Unique Pageviews b...

Page	Pageviews	Unique Pageviews
/	5,970	4,768
/documents.php	1,513	1,296
/membership.php	626	396
/index.php	555	411
/meetings.php	369	275
/functions.php	261	221
/about.php	165	140
/listserv-instructions.php	25	23
/?from=groupmessage	2	2
/?fbclid=IwAR15rkHmmxbsrC4Gw1C9HALvkwSYOdDJI1ASs-fnlvOGTZPnyPDBFzDfxsw	1	1

Mobile



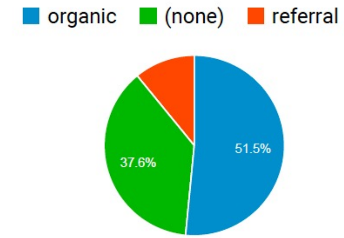
Sessions and Pages / Session by Mobile Device In...

Mobile Device Info	Sessions	Pages / Session
Apple iPhone	196	1.27
Huawei EML-AL00 P20	36	1.00
Microsoft Windows RT Tablet	36	2.69
Samsung SM-G950U Galaxy S8	17	2.00
Motorola moto E5 play	13	2.00
Motorola Moto E(4)	11	2.00
Apple iPad	10	1.30
LG LM-X210(G) Aristo 2	9	2.00
LG LGL52VL Treasure LTE	8	2.00
Alcatel 5059Z 1X Evolve	6	2.00

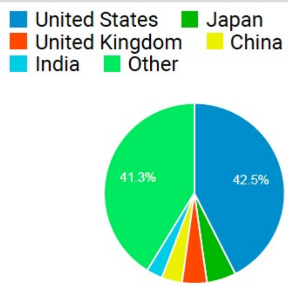
Visits

5,462
% of Total: **100.00% (5,462)**

Traffic Types



Unique Pageviews by Country



Attendance: http://bit.ly/tc99-summer

Analytics

TC Websites - Section 09

TC0909

Go to report

TC 9.9 Site Performance Overview

Apr 1, 2021 - May 31, 2021

Pageviews

2,036

% of Total: **100.00% (2,036)**

Avg. Visit Duration

00:00:48

Avg for View: **00:00:48 (0.00%)**

Pageviews and Unique Pageviews b...

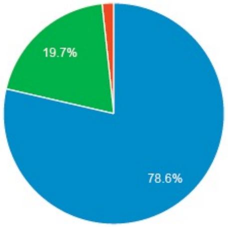
Page	Pageviews	Unique Pageviews
/	1,488	1,064
/documents.php	258	226
/index.php	88	70
/membership.php	81	64
/functions.php	48	41
/about.php	34	29
/meetings.php	34	32
/?fbclid=IwAR15rkHmmxbsrC4Gw1C9HALvkwSYOdDJI1ASs-fnlvOGTZPnyPDBFzDfxsw	1	1
/?fbclid=IwAR1NpfEQatlGg-YPEdsIre1ghhk0Bk9yGdEesNaRnbbfxLxbVFE79GlkISU	1	1
/?fbclid=IwAR10-CJVFlIOd5q0Mns20lBhXDeY7D4qjONZ3PUUcJGnMLTuwSpLqEpQn_k	1	1

Unique Visitors

1,033

% of Total: **100.00% (1,033)**

Mobile



Sessions and Pages / Session by Mobile Device In...

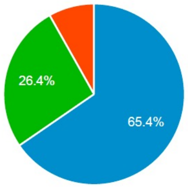
Mobile Device Info	Sessions	Pages / Session
Apple iPhone	26	1.31
Huawei EML-AL00 P20	11	1.00
Samsung SM-G950U Galaxy S8	10	2.00
Motorola moto E5 play	9	2.00
LG LGL52VL Treasure LTE	5	2.00
Alcatel 5059Z 1X Evolve	4	2.00
LG LM-X210(G) Aristo 2	4	2.00
Motorola Moto E(4)	4	2.00
Alcatel A502DL	3	2.00
Coolpad 3622A Catalyst	3	2.00

Visits

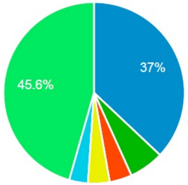
1,177

% of Total: **100.00% (1,177)**

Traffic Types



Unique Pageviews by Country



Attendance: http://bit.ly/tc99-summer

90.1 Liaison Report

Rick Pavlak

90.4 Liaison Report

Rick Pavlak

SSPC 127

John Bean

AHRI 1360 Liaison Report

Dave McGlocklin

SSPC 300, Guideline 1.6

Terry Rodgers

MTG.CYB

Ecton English

Datacenter Dynamics

Dustin Demetriou

Industry Impact

DATA CENTER KNOWLEDGE

Uptime Institute®

DCD

Mission CRITICAL

ICEOTOPE COOLING REDEFINED

ATTOM

TECHERATI We live technology.

Attendance: http://bit.ly/tc99-summer

Broadcasts

Past Upcoming

Core-challenges series

DCD>Building the Edge | Stream on-demand

DCD>Grid Scale | Stream on-demand

DCD>Building at Scale | Stream on-demand

DCD>Keeping IT Cool

DCD>Critical Power

Location based series

DCD>New York

DCD>México 2021

DCD>Asia-Pacific | Edge to Cloud

DCD>San Francisco

DCD>España 2021

DCD>Europe

DCD>Brasil 2021

DCD>Virginia

ASHRAE Coverage at DCD

2020

- DCD > Keeping IT Cool
  - Fireside chat: Cooling past, present and future (Don Beaty)
  - ASHRAE workload-defined power trends and implications for cooling (Dustin Demetriou)
- DCD > Virginia
  - Standardizing the pathway to the reliable edge (Jon Fitch)

2021

- DCD > Building the Edge
  - Standardizing the pathway to the reliable edge (Jon Fitch)
- DCD > Keeping IT Cool
  - ASHRAE TC 9.9 update – An overview of the 5th Edition of the Thermal Guidelines (Dustin Demetriou, Roger Schmidt)
  - Panel: The state of play in the world of cooling – where are we and where do we need to get to? (Dave Moss)

Open Compute Project Update

ASHRAE TC 9.9 Summer Conference

15 June 2021

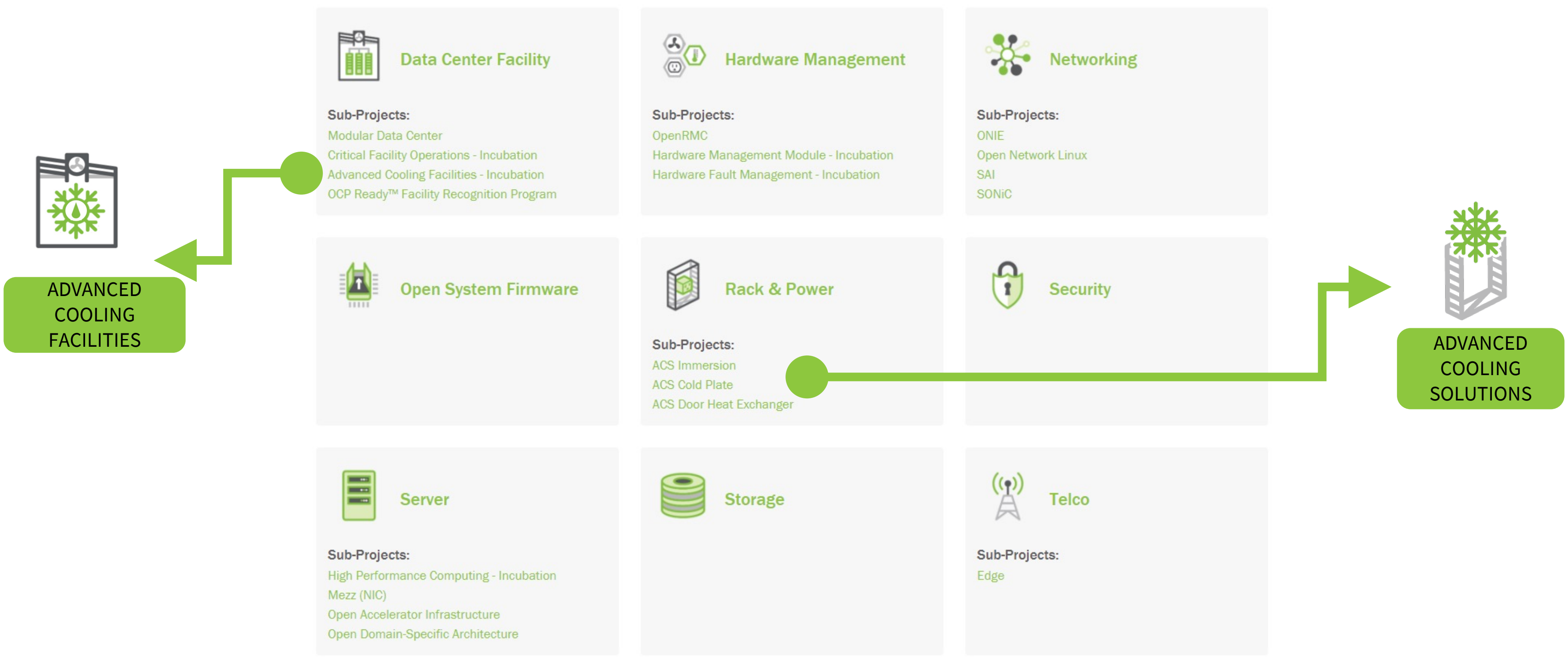
Nigel Gore- Vertiv

What is the Open Compute Project (OCP)?

- Industry non-profit focused on establishing an open source HW ecosystem for the Data Center market
- Founded in 2011 by Facebook, Rackspace, Intel - now 200+ members and growing
- Current board member companies are Facebook, Rackspace, Intel, Microsoft, Goldman Sachs
- Community of members contribute specifications, guidelines and products

https://www.opencompute.org/

Open Compute Project – Structure



https://www.opencompute.org/

Advanced Cooling Solutions charter

Enable global adoption of liquid cooling for data center equipment

ADVANCED COOLING SOLUTIONS

Project activities:

- Create specifications
- Create standards
- Create support documentation
- Create reference designs
- Harmonization of liquid cooling solutions

Project Focus

- Standardization and definition of critical interfaces
- Standardization of operational parameters
- Standardization of environmental conditions

https://www.opencompute.org/

Immersion Sub-Project Overview

Focus

- Community based program to facilitate the progression of immersion cooling
- Harmonisation effort across other ACS& ACF workstreams

Current Active projects:

- Material & Liquid compatibility: Whitepaper/database
- Immersion Requirements revision 2

Approved contributions:

- 2020: Open Cassette spec
- 2020: OCP whitepaper "Design Guidelines for Immersion Optimized IT Equipment"
- 2019: OCP "Immersion Requirements" spec
- 2019: FAN SIM spec

https://www.opencompute.org/

Door HX Sub-Project Overview

Focus

- Community based program to facilitate the progression of door cooling
- Managing high density GPU solutions with door cooling

In-scope activities

- Hybrid Air to liquid and liquid to liquid rear door solutions
- Operating conditions and Quality/Reliability
- Definition of different solutions (in Facility Water ready DC or in Air-ready DC)

https://www.opencompute.org/

Cold Plate Sub-Project Overview

Focus

- Generate an open specification and supporting documents focusing on standardization and definitions of cold plate liquid cooled solutions and interfaces.

Current projects:

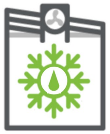
- Manifold design for OCP Rack
- Logistics and Integration White Paper

Approved contributions:

- 2020: Leak Detection and Mitigation: Whitepaper
- 2020: Manual Couplings and Hoses Best Practices whitepaper
- 2019: ACS Cold Plate Requirements

https://www.opencompute.org/

Advanced Cooling Facility



ADVANCED COOLING FACILITIES

Focus

- The Advanced Cooling – Facilities Sub-Project collaborates on integration of Advanced Cooling Solutions (ACS) into Data Center Facilities via liquid distribution.
- Participants develop solutions, guidance and reference designs that enable ACS deployment in both new and existing data centers

Current projects:

- Guidelines for connection of liquid cooled ITE to Data center Facility Systems
- Data Center Liquid Distribution Guidance and Reference Designs

https://www.opencompute.org/

Thank you!

https://www.opencompute.org/

OPEN Compute Project®

UL 60335-2 A2L Refrigerants

Jake Rede

New Low GWP Refrigerant Requirements Affecting CRAC Unit Design and Application Regulations Needing TC 9.9 Attention

ASHRAE TC 9.9 June 2021

Ben Dolcich

Bill Kinas

Jake Rede

Agenda – 15 minutes total

1. **Problem Statement and Action Needed**
2. **History of Refrigerant phase downs, Ozone Depleting and Global Warming Potential**
3. **HFO's - mildly flammable refrigerants**
4. **Recent regulations – California and Federal**
5. **Comfort Cooling Standard and ITEF (Information Technology Equipment Facilities)**
6. **What to do? Need is now. Give ITEF input to UL/CSA 60335-2-40**

Problem Statement and Action Needed

1. Q1 -2021 decisions by California (prescriptions) and similar prescriptive proposals to Federal EPA would prescriptively push (practically) computer room air conditioning units (CRACs) to use mildly flammable refrigerants (A2L) beginning in January 2025.

2. Current product safety standard UL/CSA 60335-2-40 and refrigerant safety standard ASHRAE 15 have not yet properly addressed A2L applications in Information Technology Equipment Facilities (ITEF.) Focus and knowledge has been on residential and commercial comfort cooling. They want ITEF input.

3. Immediate TC 9.9 input is needed to guide UL/CSA 60335-2-40 WG 14 subcommittee. Thursday, 17-June is first meeting.

Climate Change And Refrigerant GWP History

Montreal Protocol

- **1987:** Most successful environmental agreement in history. **Initially** focused on "**ozone depleting**" chemicals
- **Latterly** updated to **include CO_2 emission limitations**. E.g.: GWP limits on refrigerants

Kyoto Protocol

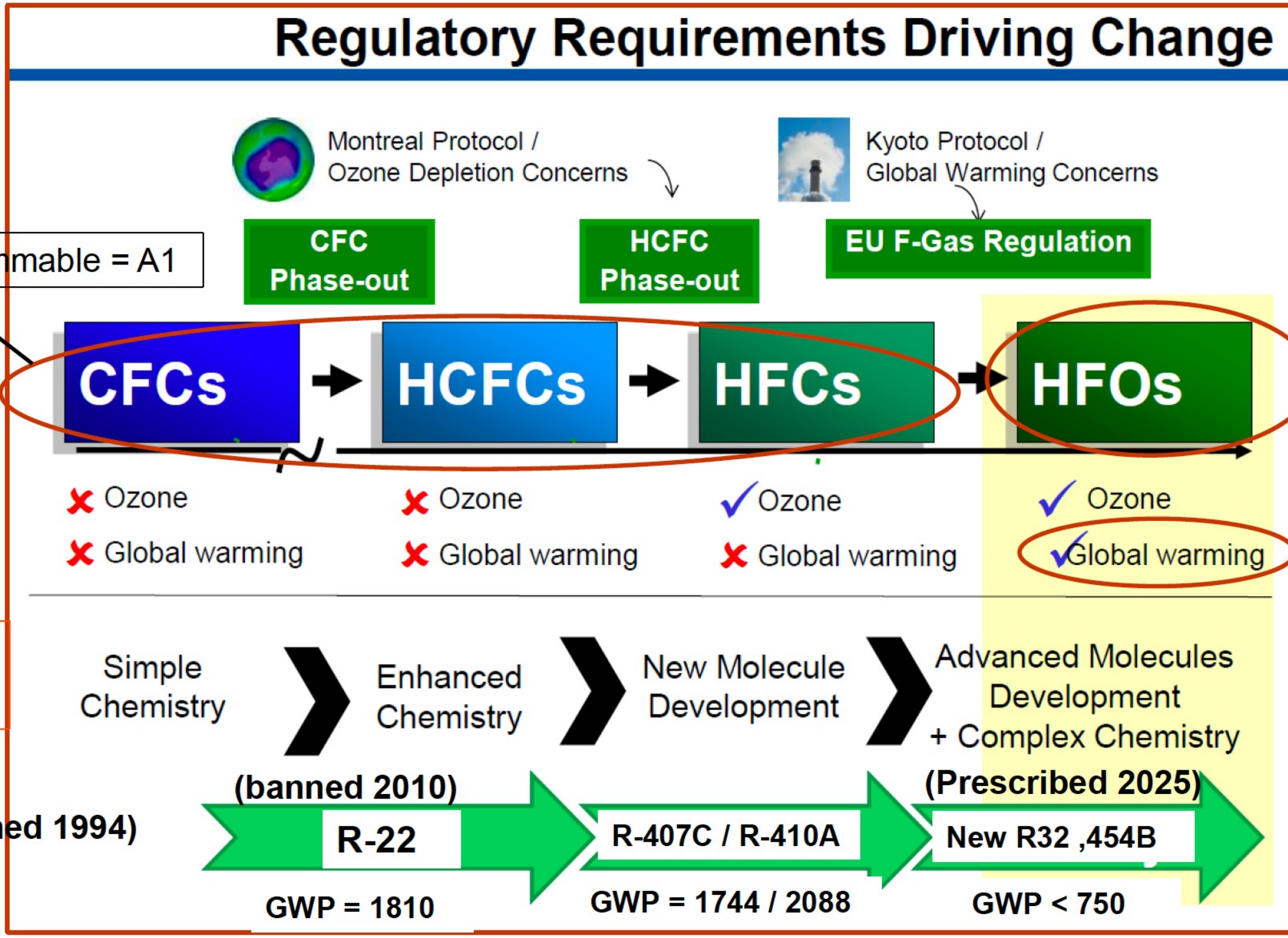
- **2005:** United Nations based treaty focused **mainly on reducing greenhouse gas emissions** (CO2, Methane, HFC's, etc)
- First commitment started in 2008. EU leading. Not ratified by the US.

Kigali Agreement

- **2016:** The major amendment to the Montreal protocol aimed at reducing global warming to 0.5°C or less by 2100. Latest studies suggest this is not achievable and a rise of **1.5 – 2.0°C is likely.**
- **Specific focus on HFC's (like R134a and R410A). Expected to freeze HFC consumption levels by 2024 and reduce HFC use by 85% by 2045.**

Not Flammable = A1

Many are Mildly Flammable = A2L

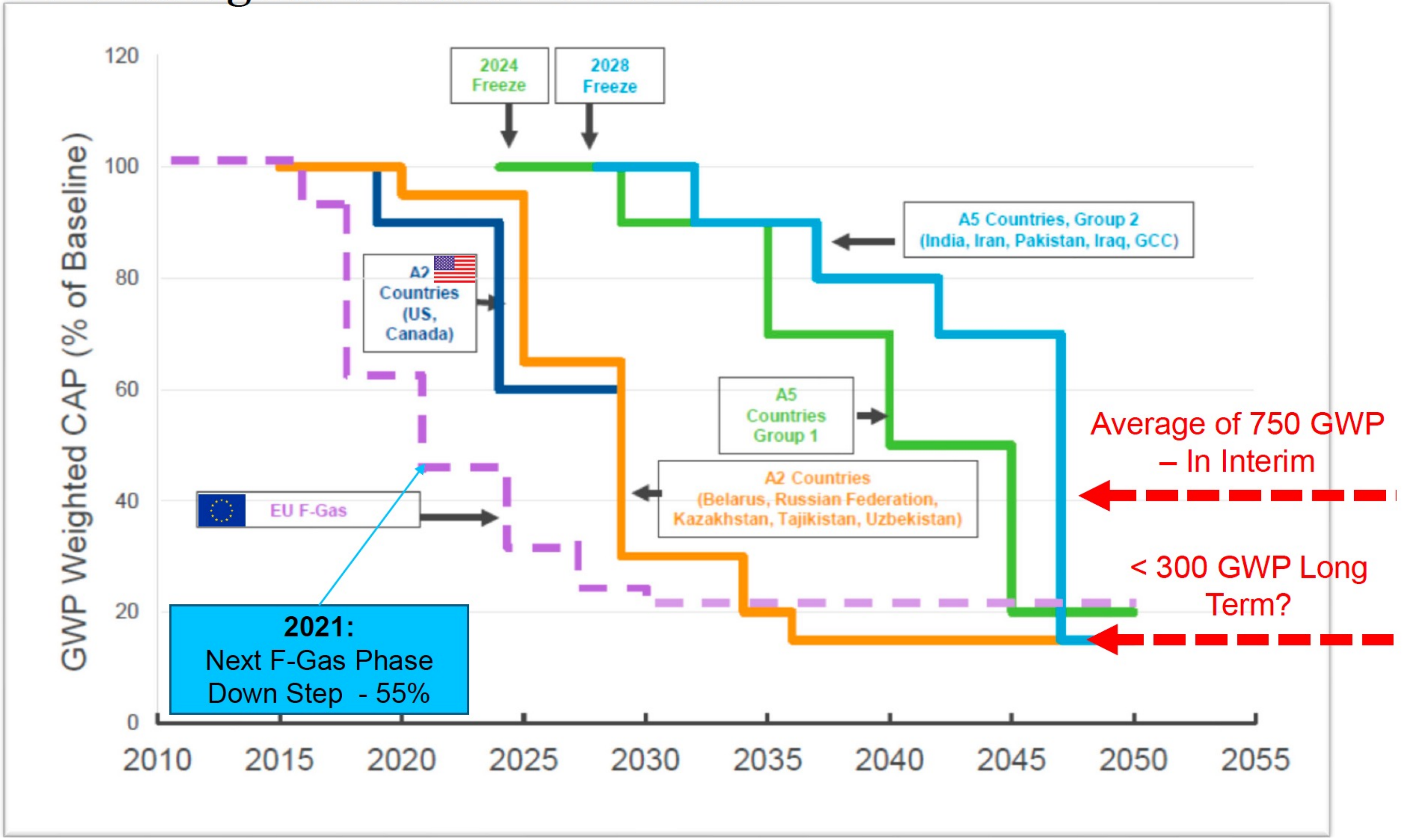


Montreal Protocol 1984

R-12 (banned 1994)

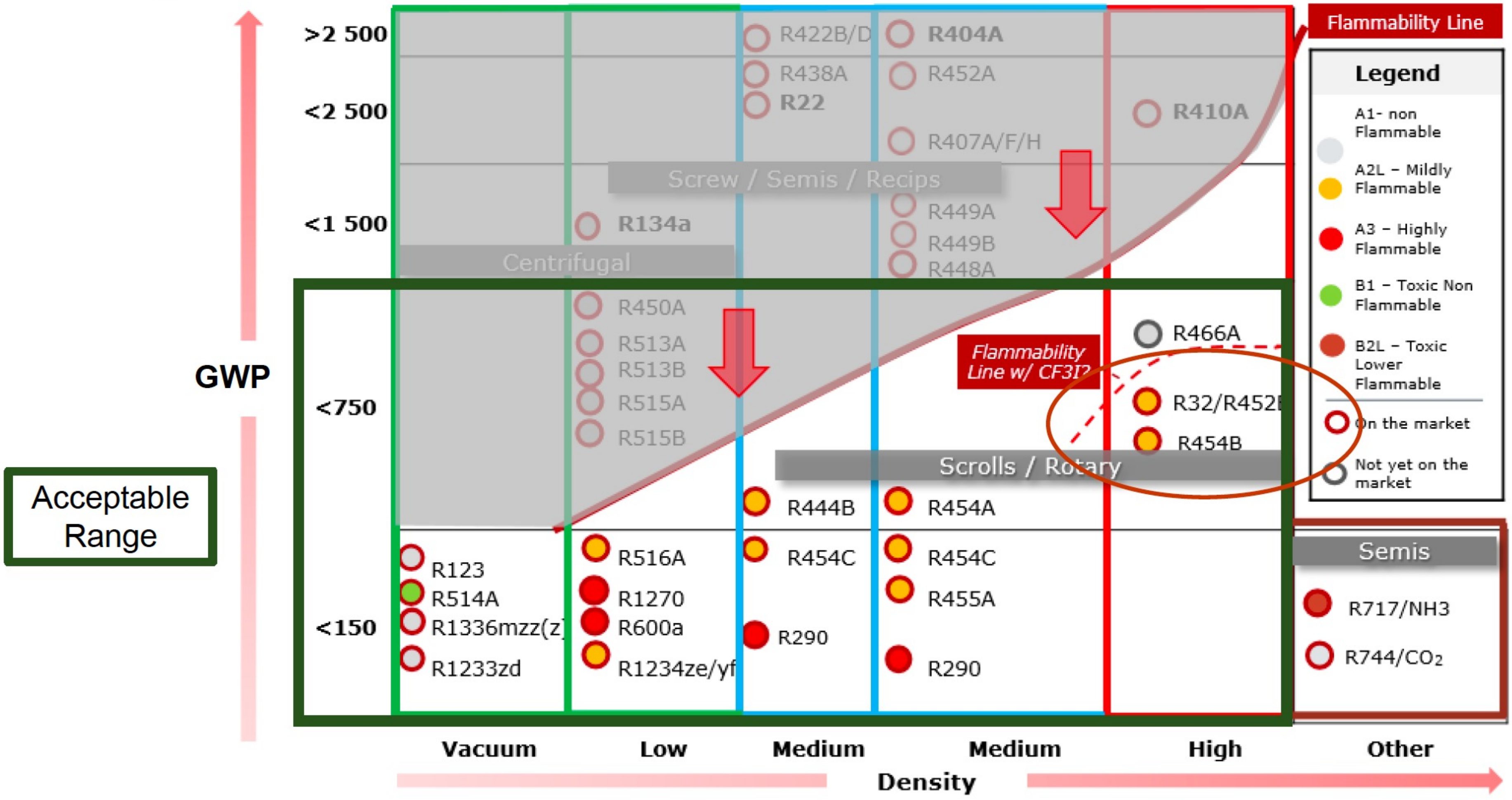
Attendance: http://bit.ly/tc99-summer

Global HFC Refrigerant Phase Down Plan



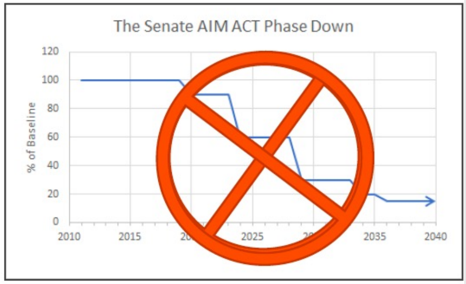
Attendance: http://bit.ly/tc99-summer

Refrigerant Landscape



Attendance: http://bit.ly/tc99-summer

Low GWP HFC Regulations – California Activity (CARB – California Air Resource Board)



February 2021 CARB Decision

Prescriptive Product Focused Requirement – Not phase down for some product types

Effective January 1, 2025 for all new equipment sold into California

California Fire Marshall has stated that Fire Code will not be updated in time for 2023

Applies to all 'Stationary Air-Cooling Equipment

Includes Computer Room Air Conditioners (CRAC) used in Information Technology Equipment Facitities (ITEF)

Practically this means all must use A2L refrigerants (mildly flammable)

Product Safety Standard UL/CSA 60335-2-40 and ASHRAE 15 not written recognizing ITEF

UL/CSA 60335-2-40 Working Group 15 sub-committee recently mobilized to address requirements for ITEF.

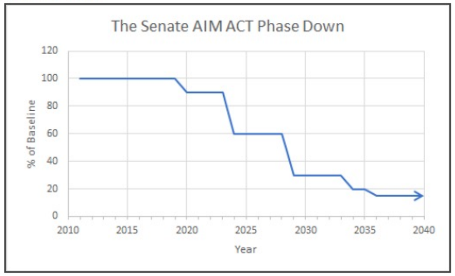
First detailed review meeting is 17-June

Attendance: http://bit.ly/tc99-summer

Low GWP – US Federal Level – Activity on HFC Phase Down

American Innovation and Manufacturing (AIM) Act:

- Passed December 27, 2020 inside of Consolidated Appropriation Act, COVID Relief Bill
- Follows the HFC Phase-down of the Kigali Amendment to the Montreal Protocol (US 2022-2036)
  - Not preemptive, but currently would have likely included all states except California
  - Similar to Europe's multilevel stepdown plan (2015-2030)



Recent Events: (March 2021)

- **Proposals to Federal EPA echoing California rules**, that all "Stationary Air-Cooling Equipment" follow the January 2025 A2L requirement.
  - Data Center CRACs are currently classified by Federal Government as "Stationary Air-Cooling Equipment"

Expected Activity / Next Steps:

- September 2021 - EPA to issue Final Rule(s) for allocation and phase down program on HFCs
  - May define sector-specific use restrictions (exemption hearings expected in October 2021)

Typical ITEF and CRAC design and applications

- **ITEF internally generated heat load is 5-10 times greater per square foot than comfort cooling**
- **ITEFs range in size from 100 sq ft to 100,000 sq ft or more. Often as one large room.**
- **ITEF's load grows overtime and may require new cooling equipment be added over 25 years.**
- **Majority of ITEFs are applied on raised floors (6 inches to 3 feet height) which is used direct conditioned air to server cold aisles. Raised floors are a type of duct.**
  - Raised floors (in addition to air distribution) also house utilities, server wiring, piping.
- **Concrete floor to truss height range from 10 - 20 feet depending on application**
- **ITEFs are secured locations with very low occupancy.**
- **Use of Outside air is typically not used to limit contamination and condensation and improve security (sabotage) and temperature stability. Customer Service Level Agreements (SLAs)**
  - Use of Outside air is limited to that needed for low occupancy.

- **CRAC is year-round cooling with continuous air flow and must deal with low OD air condensing temperatures**
  - CRAC fans and server fans are always running
  - Liquid receivers often applied with condenser controls
- **CRACs typically have compressors indoors within conditioned space**
  - Short suction lines – better performance and reliability (no vapor condensation, good oil return)
- **CRAC equipment is typically located within the conditioned space (security and efficiency)**
  - Often deep in building resulting in discharge and liquid line lengths of 300 feet.

Consideration	Notes	Current UL/CSA 60335-2-40	ITEF Applications (needs addressed)
Lower Flammability Limit (LFL)	Dictates Mass of refrigerant that could be released into a space.	Based on a floor area not volume assuming 2.2m (7.2 ft) height	Typically, taller height and resulting larger volume - reducing risk
A2Ls have low burning velocity	Near still air is needed to enable combustion	Focuses on comfort cooling with near still air	Continuous Air Flow restricts/eliminates combustion
Combustion Sources	Furnace flames and hot surface ignition can ignite A2L	Assumes such ignition sources may be present	No such ignition sources
Air Supply Method	Ducts, Free Air	Raised Floors not considered	Majority Raised Floor
Access Restrictions	Ease of unknowledgeable persons gaining access	No restrictions. Pushes compressors outside to reduce risk	Significant restrictions. Traditional application of compressors indoors
Outside Air Ventilation	Based on occupancy	LFL mitigation method	Very low occupancy. Not desired for reliability, security
Growth of Cooling Load	Generally, no growth for comfort cooling applications	Assumes A2L mitigation can be added with new/replacement equipment.	Load can grow with time. A challenge to update an existing facility to meet A2L requirements.

What to do ? The need is now. 17-June First Meeting

If interested in providing direction to UL/CSA 60335-2-40 ?

Some Basic Needs

- Create a new definition of allowable space volume to refrigerant system mass with appropriate safety factors
- Create specific requirements and allowances for compressors and safety isolation valves in ITEF refrigerant applications to prevent uncontrolled release that would result in a flammable volume
- Review/create new safety rules specific to A2L refrigerant release into DC underfloor air spaces
- Review mitigation measure actions and create applicable requirements for the removal of any released refrigerant vapor to the external environment

Contact Gregory Relue – Chair – UL/CSA 60335-2-40 Committee

Gregory.Relue@emerson.com

Q & A

Data Center Cooling Resiliency

Mark Mannex

ASHRAE - Technical Committee 9.9 - Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment

Meeting 14-15 June 2021

Data Center Cooling Resiliency

It is proposed that the overall scope of this TC includes maximizing datacom throughput uptime. A such, it is natural for the TC to concentrate on adequate design, installation, commissioning, and inspection, testing, and maintenance (ITM) issues which are oriented to maximize production uptime. But holistically, maximizing uptime includes minimizing downtime.

Unintended interruption to cooling to the equipment space has occurred in several data centers. The resultant information technology equipment (ITE) downtime can include not only the duration of the cooling outage, but also the time to repair or replace the ITE if it is damaged as a result of the cooling interruption, which can be much longer than the initial interruption.

Planning for such unintended cooling system interruptions can significantly reduce the overall downtime. It is important to have a contingency plan which educates the operators to the hazard and provides procedures implemented before, during, and after the interruption to cooling. For example, temperature trending and associated alarms can be implemented into the HVAC controls to alert operators to developing problems. Just becoming aware of how fast these situations can develops and the potential consequences can be helpful in operators to prepare for these issues.

For reference, such a plan is recommended in section 2.7.7.1 *Equipment Contingency Plan* in the FM Global Data Sheet 5-32 *Data Centers and Related Facilities*:

> 2.7.7.1 Equipment Contingency Plan
>
> When a data center utilities and/or support system equipment breakdown results in an unplanned outage to site processes and systems considered key to the continuity of operations, develop and maintain a documented, viable utilities and support system equipment contingency plan (ECP) per Data Sheet 9-0, Asset Integrity. See Appendix C of that data sheet for guidance on the process of developing and maintaining a viable equipment contingency plan. Also refer to sparing, rental, and redundant equipment mitigation strategy guidance in that data sheet
>
> Conduct a systematic, strategic assessment of data center utilities and support system equipment. Consider process bottlenecks, single points of failure, unique and long lead time equipment, evaluate equipment integrity, reliability and remaining useful life, fitness for service, and operating history/trends. Evaluate the type and scope of ECP needed to mitigate the equipment specific breakdown exposures
>
> The data center ECP includes recovery options and mitigation strategies to respond to and recover from the equipment breakdown exposures, focusing on electrical and cooling equipment. This can include repair, replacement, rental lead time options, used and/or surplus equipment, redundancy, and sparing to minimize the downtime
>
> 2.7.7.2 For loss of cooling to data center equipment due to a cooling support system equipment breakdown, the overall objective of the ECP for this scenario is to shut down data processing equipment in an orderly manner upon loss of cooling, or impending loss of cooling, before the temperature exceeds the facility's or the manufacturer's guidelines, including warranty restrictions (i.e., thermal runaway)
>
> For loss of cooling, the ECP should consider operations, sensors and alarms, and response capabilities of emergency and operating personnel. Include the criticality of the data processing functions and an understanding of the time available to become aware of developing overheating situations, make decisions, and take actions to prevent data processing equipment damage from overheating
>
> 2.7.7.3 In addition, evaluate the following elements in the contingency planning process specific to equipment breakdown resulting in loss of cooling to data center processing equipment:
>
> A. Data from the original equipment manufacturer's (OEM) literature for all critical data processing equipment components. Include warranty thresholds, recommended maximum short-term operating temperatures, and automatic equipment shutdown interlocks provided by the OEM due to excess temperatures in all data processing equipment (power supplies, servers, data storage equipment, etc.)
>
> B. Calculations by qualified design professionals involving the nature of the cooling equipment, the room and surroundings, and data processing equipment, to determine the expected room temperature rate of rise on loss of cooling, assuming continued operation of the data processing equipment
>
> C. The probable time to data processing equipment damage due to temperatures exceeding critical thresholds. Include at least the following input: data processing equipment individual heating characteristics, electrical power input to the data processing equipment room, data processing equipment space volume and height, normal data processing equipment space operating temperature, any partial cooling from the cooling equipment connected to standby power
>
> D. Using the information in A through C, develop the following scenarios, at a minimum, in the ECP at several levels of temperature threshold alarms, with the mitigation actions to be taken at each level: 1. Short-term (1 sec), medium-term (1 min), and long-term (1 hr) interruptions of utility power to the entire facility (See 2.7.8 for Service Interruption Planning)
>
> 2. Breakdown of a single critical cooling system component, such as chillers, chilled water pumps, condenser water pumps, cooling tower fans, air handler fans (e.g., bearing seize), cooling media control valves (e.g., failing closed), cooling system local and centralized controls, variable speed drives, and electric power (e.g., circuit breakers) for any of the above equipment
>
> 3. Additional breakdown scenarios as needed based on a review of the facility's unique design, arrangement, and operation
>
> E. The time necessary to provide sufficient cooling to the data processing equipment space following short-term power loss to the facility, followed by power restoration, to avoid data processing equipment overheating damage. Include at least the following input: time to start standby power generators, cooling equipment connected to the standby power and time to start cooling equipment (e.g., controls, chillers, pumps, cooling towers, CRAH, etc.)
>
> F. Guidance if initial mediation efforts are not successful and the data processing equipment space temperature continues to rise, including interrupting power to the data processing equipment (e.g., main power, emergency power, facility UPS, and equipment based UPS) in accordance with the data processing equipment power isolation plan

2.7.7.4 Implement the loss-of-cooling ECP using the following elements:

A. Training: Provide plan training to facility operations personnel and data processing equipment operations personnel

B. Authority: Designate at least one person per shift to have the authority to implement the ECP including the data processing equipment power isolation plan (Section 2.7.2), if data processing equipment shutdown is needed to prevent damage

C. Operation: Designate personnel on each shift to perform the steps in the loss of cooling equipment contingency plan

D. Practice: 1. Review, test, and validate the loss-of-cooling equipment contingency plan at least annually to confirm efficacy

2. Practice recovering cooling to the data processing equipment, including starting emergency generators, shifting critical equipment operation to backup (N+1) components, restarting HVAC equipment (CRAH, chillers, pumps, cooling towers, controls, etc.)

3. Practice the real-time decision path in identifying situations in which cooling cannot be restored before the data processing equipment incurs critically high temperatures, resulting in the decision to shut down the data processing equipment

4. Practice the actions required to interrupting power to the data processing equipment in accordance with the power isolation plan to ensure the required timeframe is met

2.7.7.5 Review and validate the ECP annually and when there are significant changes on site to manage change and confirm efficacy of the plan.

In concert with these goals, controls should be configured to identify impending overheating events as soon as possible:

2.8.5.1 Controlling HVAC Systems

A. Provide HVAC control systems using a proportional-integral-derivative (PID) algorithm. Program the

controls to provide an alarm if the setpoint error and the historical rate of room temperature change indicate an impending overheating event.

B. Provide alarms to initiate mitigation actions based on several levels of temperature thresholds.

1. High temperature: No more than 2°F or 2°C above the normal setpoint operating temperature of the lower of either (a) the high data processing equipment temperature (as recommended by the OEM) measured at the equipment, or (b) the high space air temperature setpoint per the facility HVAC design.

2. Rate of temperature change: As a result of the study recommended in the loss-of-cooling equipment contingency plan (see 2.7.7.1).

C. Provide audible and visual alarms in the vicinity of the equipment and at a constantly attended location.

D. Provide emergency power to HVAC systems (e.g., fans, CRAHs, chillers, cooling towers) for data processing equipment spaces.

E. Provide battery or an alternative power backup such as capacitors for HVAC controls.

Welcome!

Welcome to the ASHRAE TC 9.9 Virtual Meeting!

We are on a break and will resume at 12:20 pm EDT

Agenda

- Break
- Publications
- IT Subcommittee

Housekeeping

Audio

- Attendees are muted upon entry
- Do not un-mute your line
- If you are joining via computer and phone line, ensure both are muted

Video

- We encourage you to keep your video off
- If you do enable your video, be mindful that you are on display! Turn off your video when needed.

Q&A

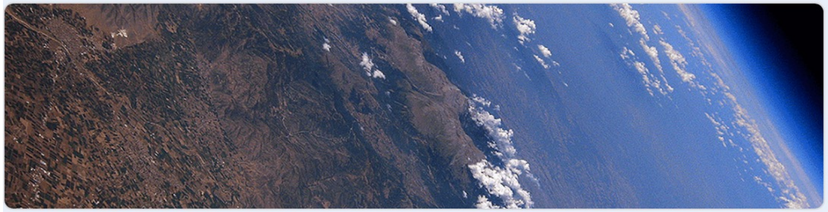
- Use the chat function to ask questions
- Our moderator will share questions throughout the presentation with the speaker to answer.
- If you need to speak, please use the Raise Hand button and the moderator will enable your microphone.

Attendance

- Please complete the attendance form found at the URL at the bottom of this slide

Attendance: http://bit.ly/tc99-summer

Attendance



ASHRAE TC 9.9 Attendance Record

ASHRAE Technical Committee 9.9 - Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment
2021 Winter Meeting
Virtual Event Timing: January 19, 2021
Event Address: https://ashrae-org.zoom.us/j/98449509730?pwd=Q2ZCNFhRQXFTY05CSTNYbEIZTkdKQT09
Contact us at tc99chair@gmail.com
Technical Committee Website: http://tc0909.ashraetcs.org

* Required

Name *

Your answer

Email

Your answer

Attendance is being recorded using a Google Form. Please make sure you complete the form at:

http://bit.ly/tc99-summer

International

Don Beaty

Publication Statistics

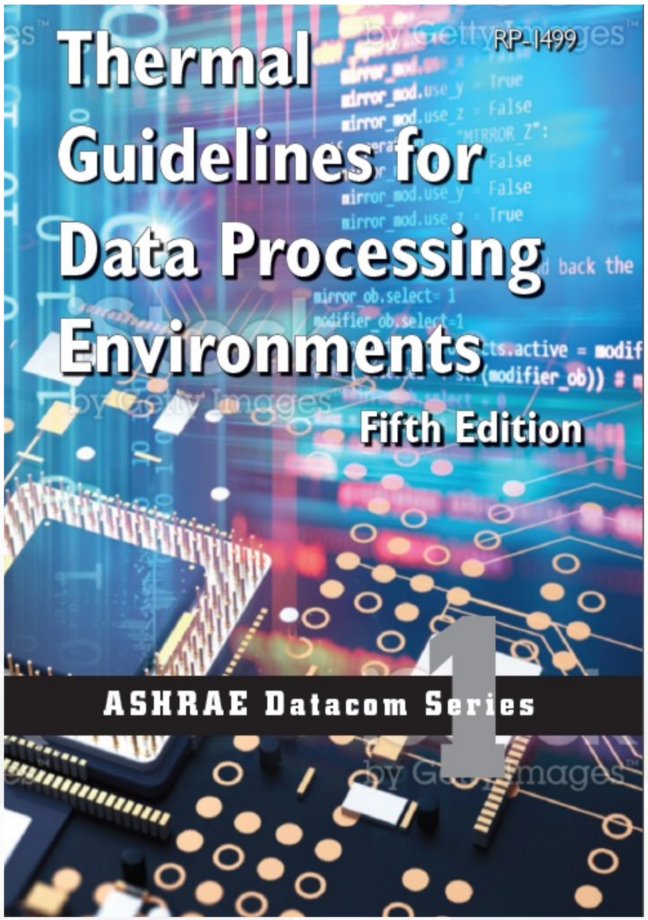
Ecton English

Thermal Guidelines 5th Edition

Roger Schmidt

ASHRAE VIRTUAL ANNUAL CONFERENCE

June 28-30, 2021



Thermal Guidelines – 5th Edition

Published by ASHRAE in April, 2021

Roger Schmidt
c28rrs@us.ibm.com

Major Changes incorporated in the 5th Edition

- Change to the recommended envelope as a result of research of the effect of RH and gaseous pollutants
- Addition of new high density air-cooled environmental envelope
- Change in nomenclature of liquid cooling classes

❑Change to the recommended envelope as a result of research of the effect of RH and gaseous pollutants

ASHRAE 1755-RP
Effects of Gaseous Pollutant and Thermal Conditions on the Corrosion Rates of Copper and Silver in Data Center Environments

Research performed at Syracuse University
Rui Zhang obtained her PhD based on this project/Prof. Jensen Zhang was the PI

ASHRAE TC 9.9

Background

- In 2009 ASHRAE published results of a survey made of data centers around the world on the impact of corrosion on IT equipment reliability.
- The results were from placing copper and silver coupons in data centers for 30 days.
- Those results showed that if the 30-day corrosion thickness is below 300A and 200A for copper and silver, respectively, datacom equipment would not have premature failure within its service life.

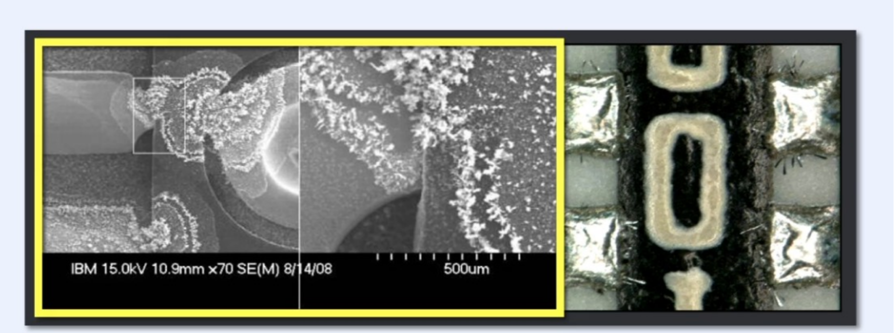
ASHRAE, 2009. *Particulate and Gaseous Contamination in Datacom Environments*, Second Edition, Atlanta, ASHRAE.

Background

- However, no information was available on the actual pollutants or levels of pollutants or the T & RH that affected the IT reliability.

Two common modes of failures corrosion fails in IT equipment

Copper creep corrosion on circuit boards



Corrosion of silver metallization on surface – mounted components

Motivation

- The severity of copper and silver corrosion in a data center environment is determined by the air pollution level and composition as well as the temperature and relative humidity.
- Can the data center environmental envelopes be expanded for the purpose of reducing cooling energy consumption if the air pollution conditions are better understood and controlled?
- The objective of the present study was to experimentally investigate how increasing the relative humidity and temperature from the recommended reference range would affect the corrosion rate of copper and silver coupons exposed to gaseous pollutants.

Research Approach and Methods

- A comprehensive literature review and analysis was first conducted to determine the typical pollutants found in data center environments and their concentration levels.
- Results showed that O_3, NO_2 and SO_2 are the most pervasive pollutants in atmospheric pollution
- And Cl_2 and H_2S were also evident but limited to those locations near landfills or nearby manufacturing

Research Approach and Method

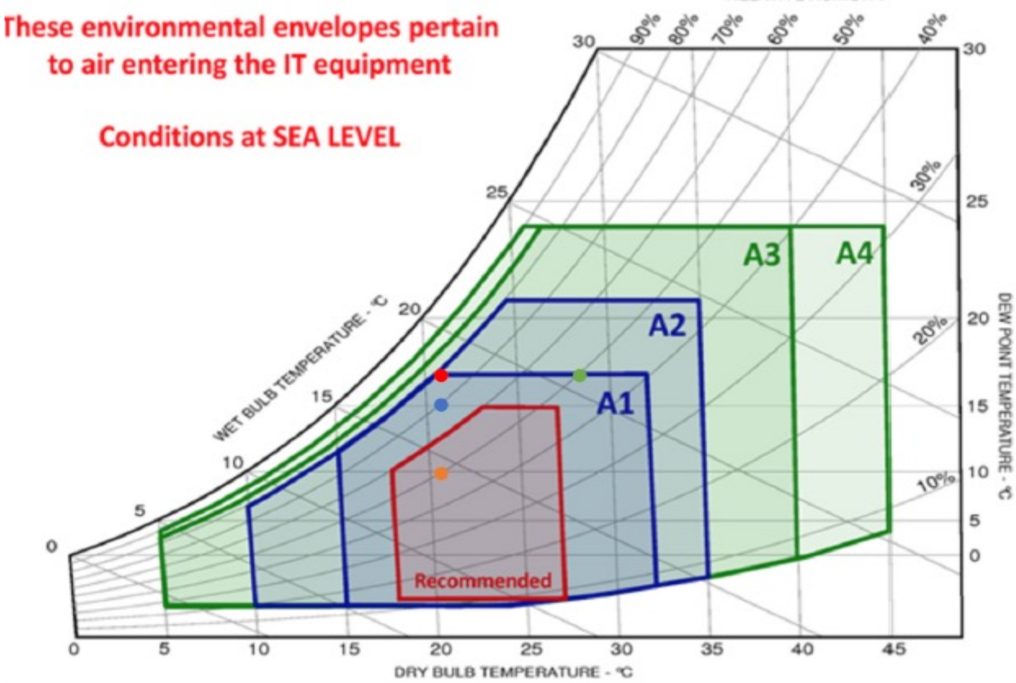
Realistic Worst Case Concentration Levels for Mixed Flowing Gas Tests

Gas	H_2S	NO_2	SO_2	Cl_2	O_3
Concentration (ppb)	10	80	40	2	60

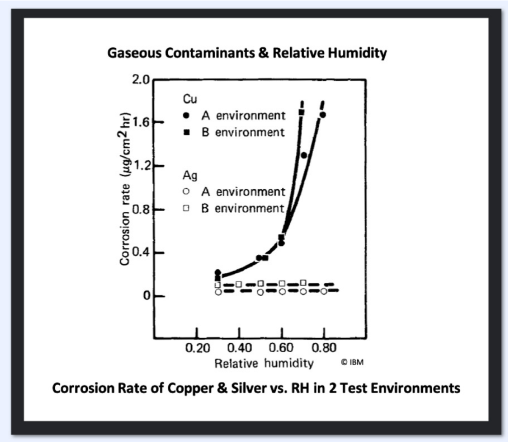
- As a result of the literature research the experiments were designed around two groups of mixed flowing gas mixtures
  - one consisting of the planet's most pervasive pollutants of O_3, NO_2 and SO_2 and their combinations
  - second includes the above pollutants plus catalyst pollutants of Cl_2 or H_2S or both

Research Approach and Method

2015 ASHRAE Environmental Envelopes
-Temperature and RH Test Conditions-

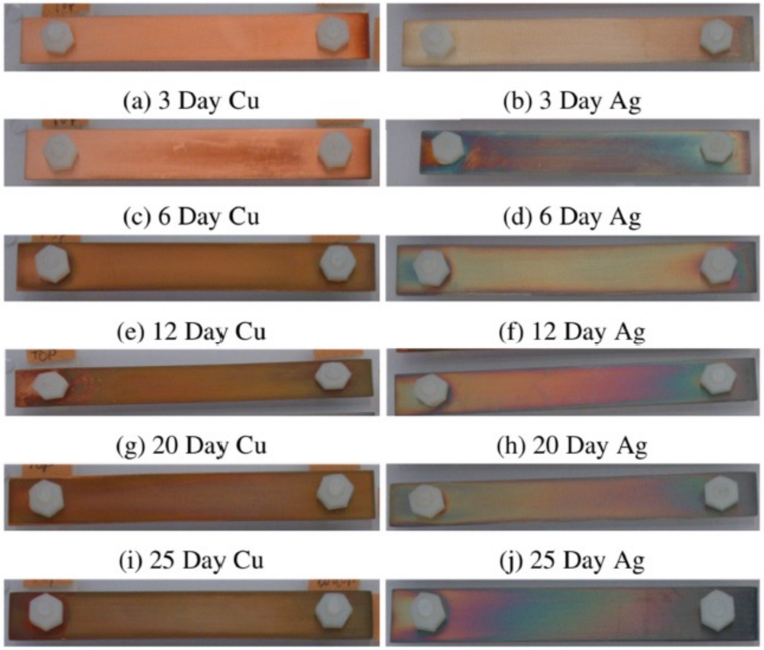


1960's publication



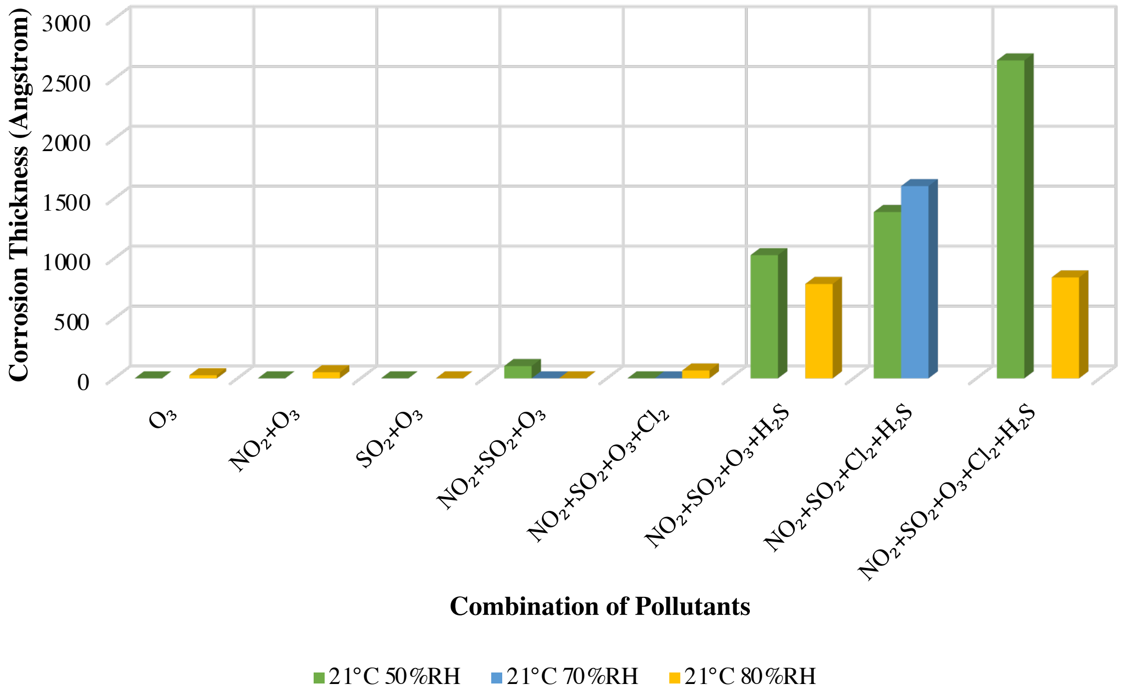
Corrosion Rate of Copper & Silver vs. RH in 2 Test Environments

Test Results after coupons exposed to pollutants

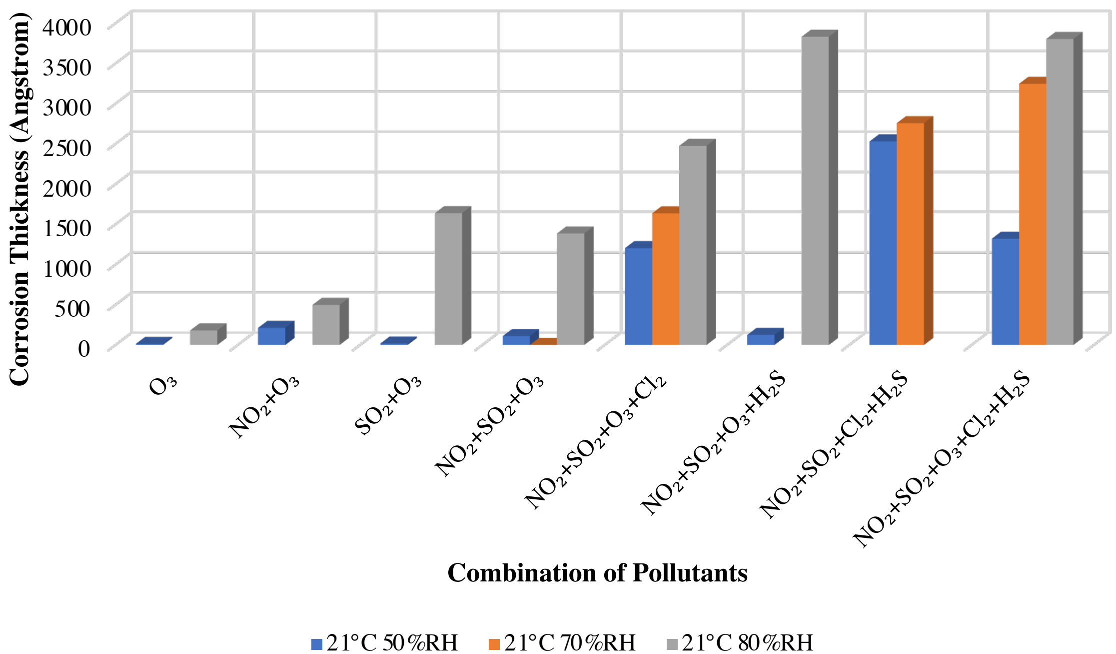


(a) 3 Day Cu (b) 3 Day Ag
(c) 6 Day Cu (d) 6 Day Ag
(e) 12 Day Cu (f) 12 Day Ag
(g) 20 Day Cu (h) 20 Day Ag
(i) 25 Day Cu (j) 25 Day Ag
(k) 30 Day Cu (l) 30 Day Ag

Test Results for Silver – 21 C and 50%, 70% and 80% RH



Test Results for Copper – 21 C and 50%, 70% and 80% RH

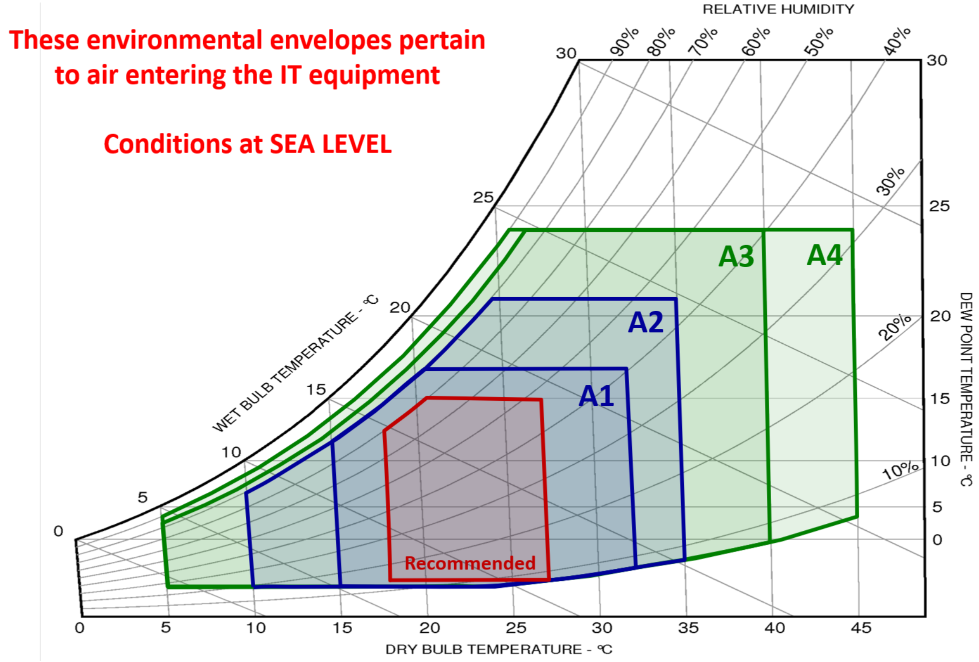


Conclusions and Recommendations

1. Data center operators should use silver and copper coupons inside their data centers at least twice a year(once in the winter and once in the summer) to detect the level of corrosion in the environment.

Conclusions and Recommendations

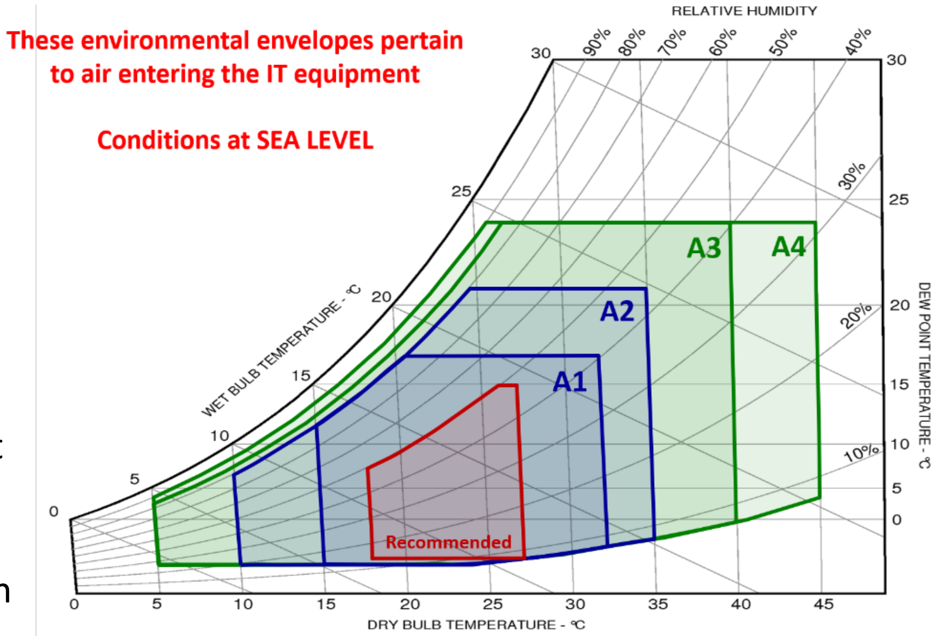
2. For data center environments tested with silver and copper coupons that are shown to have corrosion levels less than 300A/month for copper and 200A/month for silver, suggesting that only pervasive pollutants (SO_2, NO_2, and O_3) may be present, the recommended moisture limit has been raised from 60% to 70% RH.



Conclusions and Recommendations

3. For data center environments tested with silver and copper coupons that are shown to have levels of corrosion greater than 300A/month and 200A/month for silver, suggesting that Cl_2 and/or H_2S(or other corrosive *catalysts*) may be present, then the recommended moisture levels should be kept below 50% RH. Chemical filtration should be strongly considered in these situations.

4. If coupon measurements are not performed to aid in understanding the possible corrosion impact on ITE, the data center operator should consider maintaining a lower humidity level to protect the ITS, either below 60% as specified in the 4th edition of this book or below 50% as specified in the current edition.



Conclusions and Recommendations – other relevant results

1. Effects of temperature: For copper, increasing the temperature from 21C to 28C (69.8F to 82.4F) while keeping the relative humidity at the 50% dramatically reduced corrosion thickness for all mixture conditions tested. This confirms Information from IT manufacturers that corrosion at the rear of servers(where temperatures are greater) is much less than that noticed at the front .

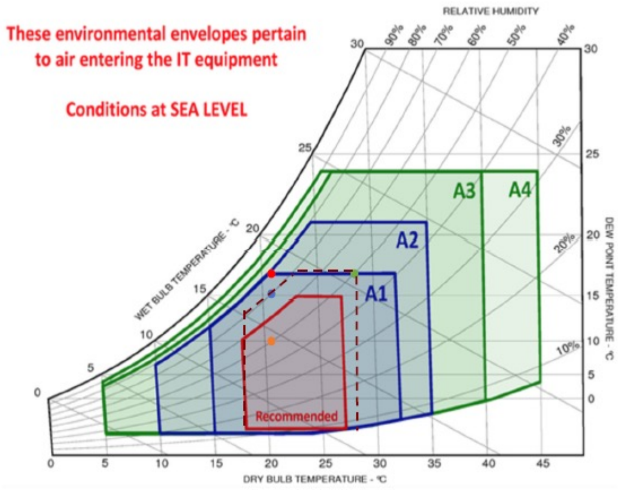
2. Effect of humidity fluctuations: Fluctuations of RH did not show significant difference in the corrosion compared to stable RH.

3. Effect of voltage bias: Voltage bias on PCB's reduced the corrosion, likely due to the heating of the PCB which is consistent with the temperature effect measured by the copper coupon tests.

Conclusions and Recommendations – other relevant results

4. The data showed that increasing the recommended temperature from 27C to 28C (80.6 F to 82.4F) would be acceptable from a reliability standpoint. However, because IT manufacturers typically start increasing airflow through servers around 25C (77F) to offset the higher ambient temperature, this increased air moving device power draw did not warrant changing the recommended upper temperature limit.

5. In addition, the data showed that increasing dew points from 15 to 17C (59F to 62.6F) would be acceptable from a reliability standpoint. However, this change would put the recommended upper moisture limit coincident with the upper moisture limit of the allowable envelope of Class A1. For those data centers that operate to the Class A1 environment, it was decided to maintain the buffer of 2C (3.6 F) and to maintain the recommended envelope the same for all air cooling classes.



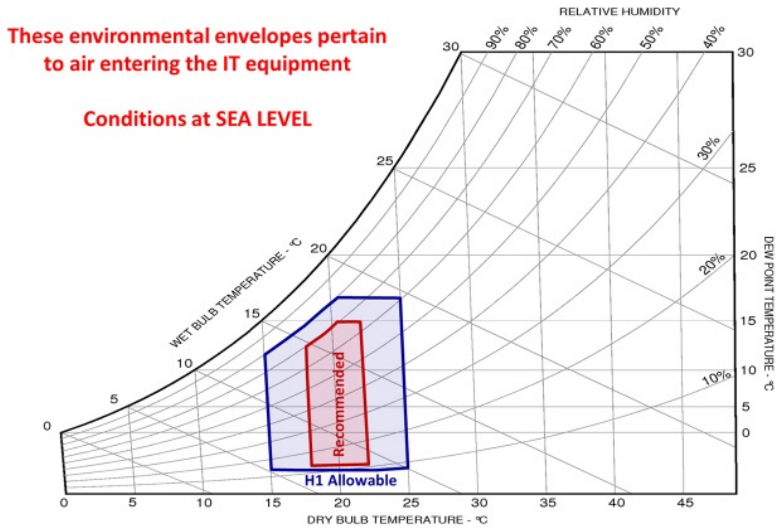
❑Addition of new high density air-cooled environmental envelope

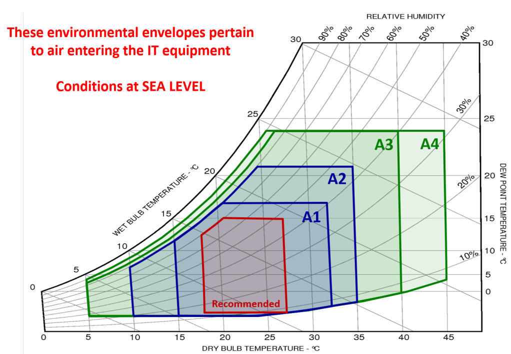
- High density products that employ high powered components such as CPU’s, GPU’s and memory requiring increased cooling that could be provided with an increase in heat sink volume/fan performance. However, allowable server volume does not permit these performance enhancements.

- In order to meet the component temperature limits, the ambient temperature needs to be lowered. To address these high powered IT equipment, a new air-cooling class specific to high density servers is being added.

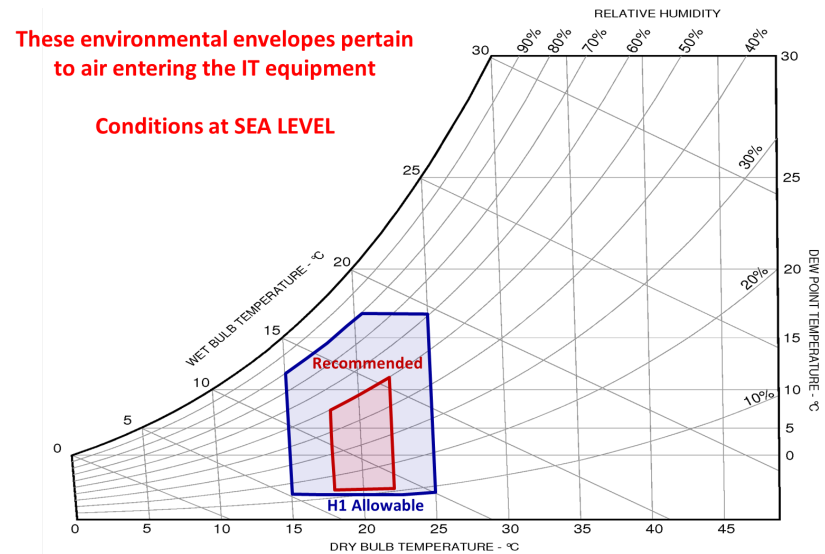
- All the current environmental classes will continue as described

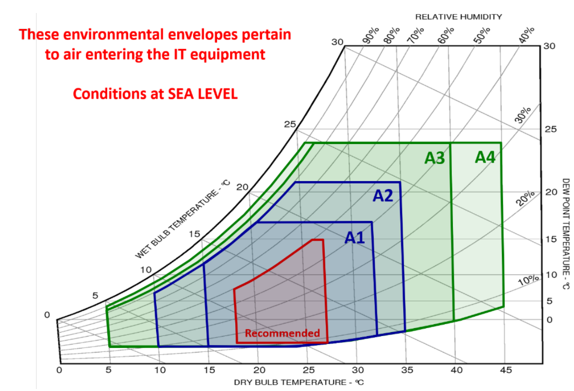
Recommended Envelope is for low level of pollutants





Recommended Envelope is for high level of pollutants





❑Change in nomenclature of liquid cooling classes

Table 3.1 2011 ASHRAE Liquid-Cooled Guidelines

Liquid Cooling Class	Equipment Environment Specifications for Liquid Cooling		
	Typical Infrastructure Design		Facility Water Supply Temperature, °C (°F)
	Primary Facilities Cooling Equipment	Secondary/ Supplemental Cooling Equipment	
W1	Chiller/cooling tower	Water-side economizer	2 to 17 (35.6 to 62.6)
W2			2 to 27 (35.6 to 80.6)
W3	Cooling tower	Chiller	2 to 32 (35.6 to 89.6)
W4	Water-side economizer (with dry-cooler or cooling tower)	N/A	2 to 45 (35.6 to 113)
W5	Building heating system	Cooling tower or dry-cooler	>45 (>113)

Table 3.1 2021 ASHRAE Liquid-Cooled Guidelines

Liquid Cooling Class	Equipment Environment Specifications for Liquid Cooling		
	Typical Infrastructure Design		Facility Water Supply Temperature, °C (°F)[a]
	Primary Facilities	Secondary/ Supplemental Facilities	
W17	Chiller/cooling tower	Water-side economizer (cooling tower)	17 (62.6)
W27			27 (80.6)
W32	Cooling tower	Chiller or district heating system	32 (89.6)
W40			40 (104)
W45	Cooling tower	District heating system	45 (113)
W+			>45 (>113)

a. Minimum water temperature for all classes is 2°C (35.6°F).

Acknowledgements

ASHRAE TC 9.9 would like to thank the following members of the IT subcommittee for their groundbreaking work and willingness to share in or-der to further the understanding of the entire data center industry and for their active participation, including conference calls, writing/editing, and reviews: **Dustin Demetriou(IBM), Dave Moss (Dell), Mark Steinke(hpe), Roger Schmidt (IBM-retired), and Robin Steinbrecher (Intel-retired).** Thanks also to Roger Schmidt for leading the effort on updating this fifth edition.

A special thanks to Syracuse University Mechanical and Aerospace Department and the leadership of Professor Jianshun Zhang and his team including PhD student Rui Zhang for carrying out the research to investigate the effect of high humidity and gaseous pollutants on the IT equipment. The result of this work was the primary reason for this fifth edition.

ASHRAE TC 9.9 also wishes to thank the following people for their constructive comments on the draft version of this edition **Jason Matteson (Isotope); Jon Fitch(Midas Green Technologies), John Gross (J. M. Gross Engineering, LLC); Dave Kelley (Vertiv-retired); Ecton English, Gerardo Alfonso(Ingeal) and Vali Sorell(sorellengineering).**

Finally, **special thanks to Neil Chauhan of DLB Associates for creating a consistent set of graphics in this updated edition**.

Roger Schmidt

rrschmid@syr.edu

Design Considerations 3rd Edition

John Gross

Emergence & Expansion of Liquid Cooling

Dave Moss

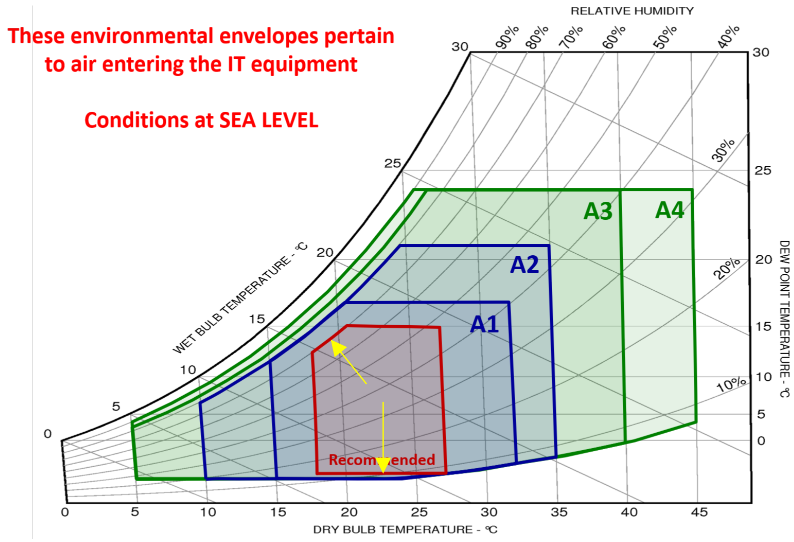
1. Describe change to the recommended envelope as a result of research of the effect of RH and gaseous pollutants
2. Changes in air cooling classes including a new class for high density
3. Describe high density trends of IT equipment and the need for water cooled products
4. Simplification in nomenclature for water cooling classes including an additional class
5. IT equipment power increasing substantially; impacts to the air-cooled data center
6. With IT power increasing, when does it make sense to adopt liquid cooling
7. Required chip maximum temperatures are decreasing, and at some point, it will affect data center operating temperatures for both air and liquid cooled equipment

Paul Artman - AMD
Tozer Bandorawalla - Intel
David Grant - ORNL
John Gross – J.M. Gross Engineering
Jason Matteson – Iceotope
David Moss (Co-lead) – Dell
Chris E. Peterson- Dell
Suresh Pichai – Equinix
Mani Prakash – Intel
Matt Shumway - Seagate
Mark Steinke (Co-lead) – AMD

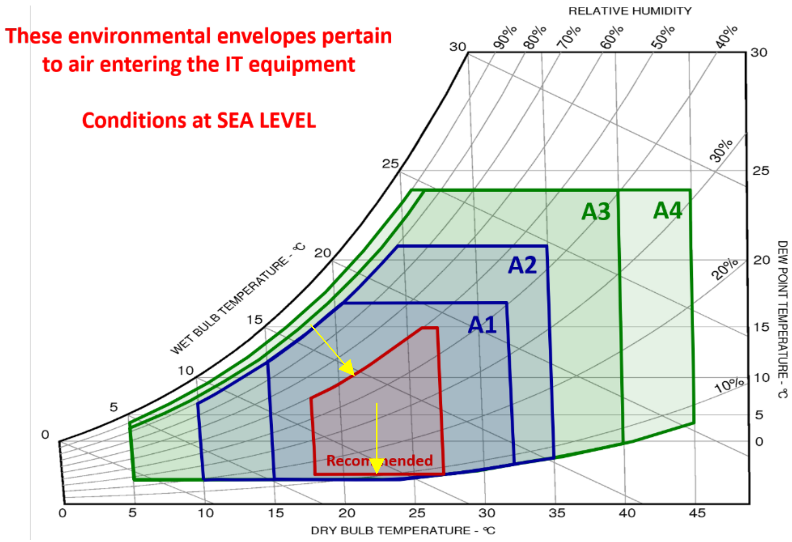
- Air-class changes
- W-class nomenclature changes
- Strengthening of server “compliance”
- Power increases; introducing the difficulty-to-cool metric
- Impacts to air-cooled data centers
- Liquid cooling transitions
- Reductions in data center operating temperatures

Changes to Existing Classes

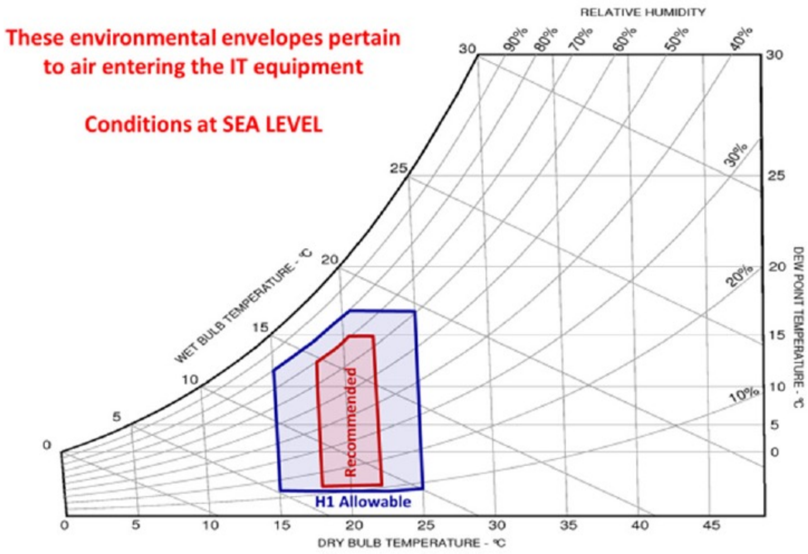
Data Centers with Low Level of Corrosion Potential



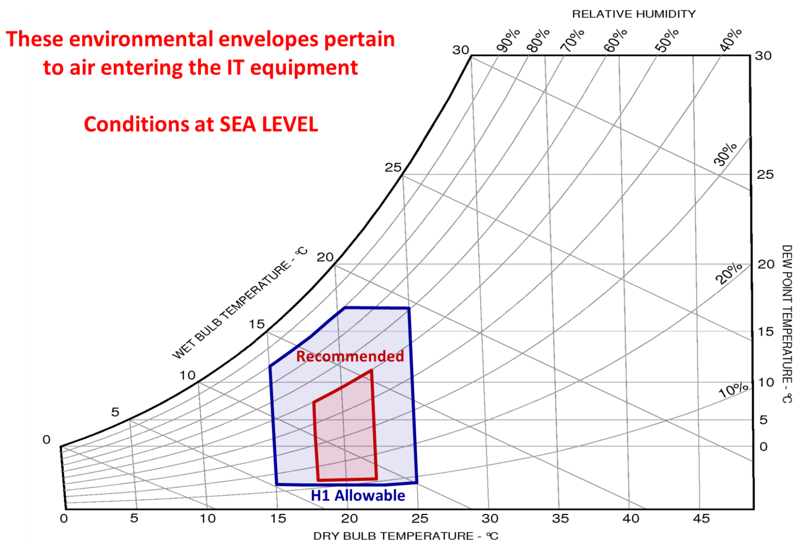
Data Centers with High Level of Corrosion Potential



Data Centers with Low Level of Corrosion Potential



Data Centers with High Level of Corrosion Potential



New Class H1

Equipment Environment Specifications for High-Density Air Cooling							
	Product Operation[b,c]					Product Power Off[c,d]	
Class[a]	Dry-Bulb Temp.[e,g], °C	Humidity Range, Noncond.[h,i,k,l,n]	Max. Dew Point, °C	Max. Elev.[e,j,m], m	Max. Rate of Change[f], °C/h	Dry-Bulb Temp., °C	RH, %
Recommended							
H1	18 to 22	–9°C DP to 15°C DP and 70% rh[n] or 50% rh[n]					
Allowable							
H1	5 to 25	–12°C DP and 8% rh to 17°C DP and 80% rh[k]	17	3050	5/20	5 to 45	8 to 80[k]

n. If testing with silver or copper coupons results in values less than 200 and 300 Å/month, respectively, then operating up to 70% rh is acceptable. If testing shows corrosion levels exceed these limits, then catalyst-type pollutants are probably present and RH should be driven to 50% or lower. See note 3 of Section 2.2 for more details.

Previous

Class	Typical Infrastructure Design: Main Cooling Equipment	Typical Infrastructure Design: Supplemental Cooling Equipment	Facility Supply Water Temperature, °C (°F)
Equipment Environment Specifications for Liquid Cooling			
W1	Chiller/cooling tower	Water-side economizer	2 to 17 (35.6 to 62.6)
W2			2 to 27 (35.6 to 80.6)
W3	Cooling tower	Chiller	2 to 32 (35.6 to 89.6)
W4	Water-side economizer (with dry-cooler or cooling tower)	N/A	2 to 45 (35.6 to 113)
W5	Building heating system	Cooling tower	>45 (>113)

2021

Liquid Cooling Class	Typical Infrastructure Design: Primary Facilities	Typical Infrastructure Design: Secondary/ Supplemental Facilities	Facility Water Supply Temperature, °C (°F)[a]
Equipment Environment Specifications for Liquid Cooling			
W17	Chiller/cooling tower	Water-side economizer (cooling tower)	17 (62.6)
W27			27 (80.6)
W32	Cooling tower	Chiller or district heating system	32 (89.6)
W40			40 (104)
W45	Cooling tower	District heating system	45 (113)
W+			>45 (>113)

a. Minimum water temperature for all classes is 2°C (35.6°F)

Server "Compliance" Strengthened

- Compliance is a strong word to be tied to a guideline
- Previously, the verbiage describing IT equipment operation relative to a particular class was "requires full *operation* of the equipment within the class specified"
  - This didn't mean necessarily mean full performance, it just had to operate
  - Operating within the class did not require the IT equipment to even operate to the upper extent of the class
- New verbiage: "Operating within a particular environmental class requires full performance of the equipment over the entire environmental range of the specified class, based on nonfailure conditions."

Emergence and Expansion of Liquid Cooling in Mainstream Data Centers

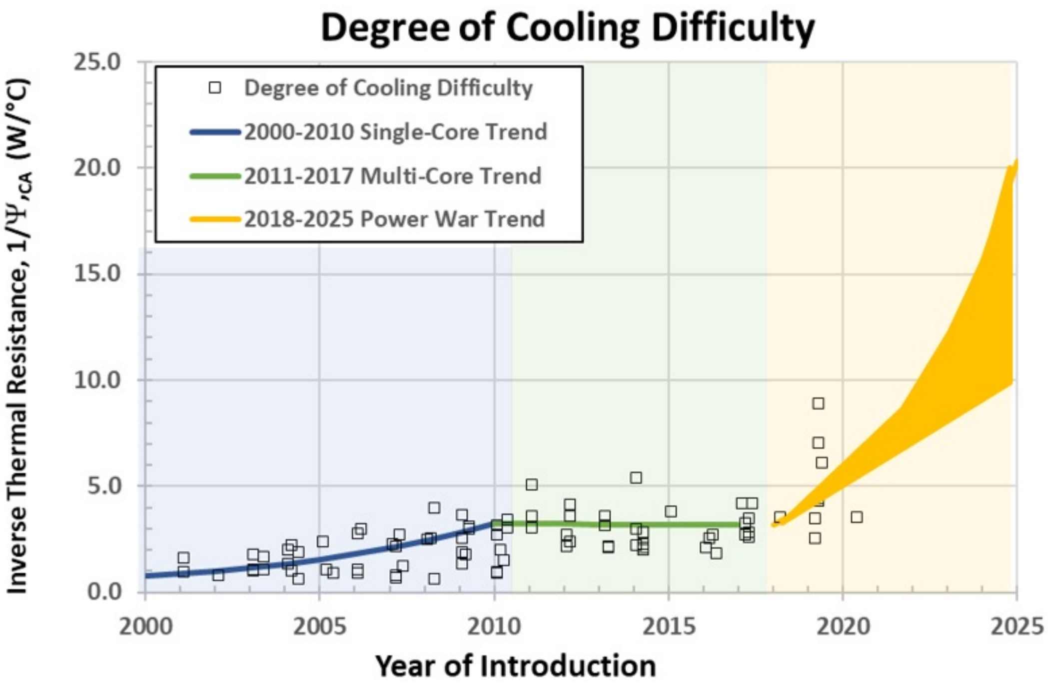
White Paper Developed by
ASHRAE Technical Committee 9.9, Mission Critical Facilities,
Data Centers, Technology Spaces, and Electronic Equipment

ASHRAE
Peachtree Corners

IT Equipment Power is on the Rise

- As will be seen in the following slide, the industry has benefitted from a near decade long period of minor IT equipment power increases while simultaneously still enjoying performance increases
- That period ended around 2018, and the desire for higher performance is once again accompanied by system power increases
- CPU, GPU, memory, and storage power are all on the rise
- A corollary to the power increase at the chip is the fact that required case temperatures are decreasing
  - Difficult to cool higher power chips
  - Difficult to cool them to a lower temperature

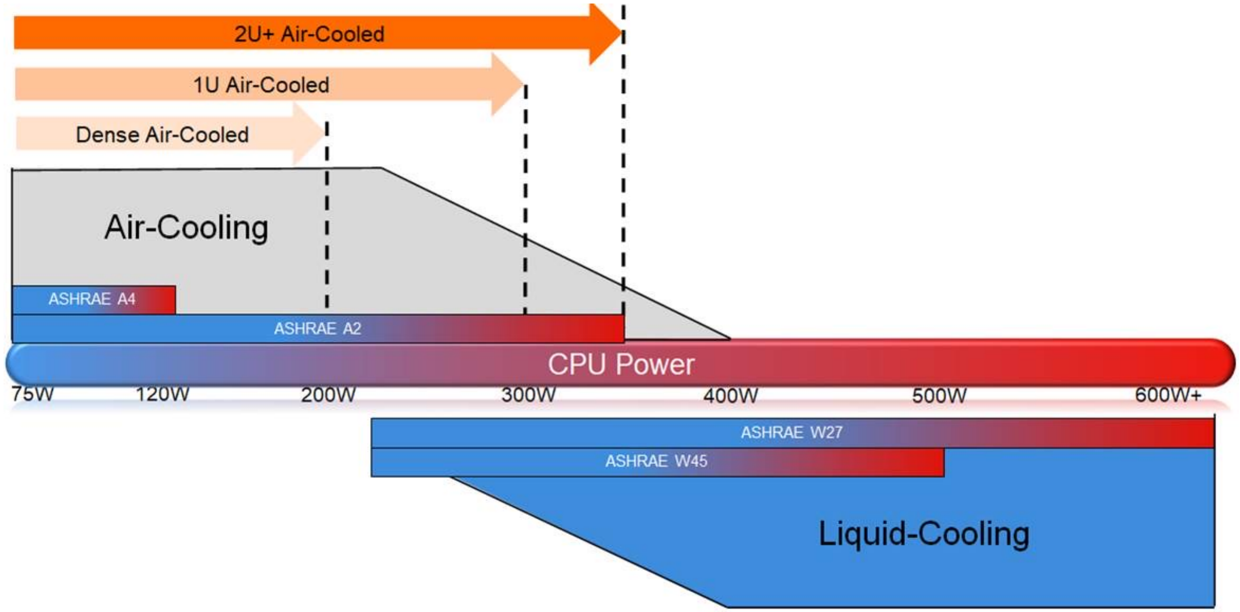
Difficulty-to-Cool Metric



Impacts to Air-cooled Data Centers

- More power generally means increased airflow requirements
- During the multi-core period, fan power as a percent of IT equipment power was often as low as 2%; expect that to rise
- Consider an increase in airflow requirements of 25% or more; does the data center need to increase air handler capability, or will it deploy fewer servers per rack?
- Acoustics have been an issue for some time now, especially with hard disk drives; increased airflow will exacerbate that issue

Approximate Transitions to Liquid Cooling



Regression (Decreases) in Air and Water Inlet Temperatures

- Fueled, in part by chip power increases, but primarily by case temperature decreases, there will be fewer products capable of the upper air and water class temperatures
  - Case temperatures that were as high as 90C capable will soon be down into the 70s
- W45 operation will slip to W40 and eventually down to W32 and beyond
- Economizing hours will come down
- Chiller-less facilities will face the fact that they might need to add chilling capability
- Businesses will come to decisions of performance need versus operating costs or performance versus heat reuse effectiveness

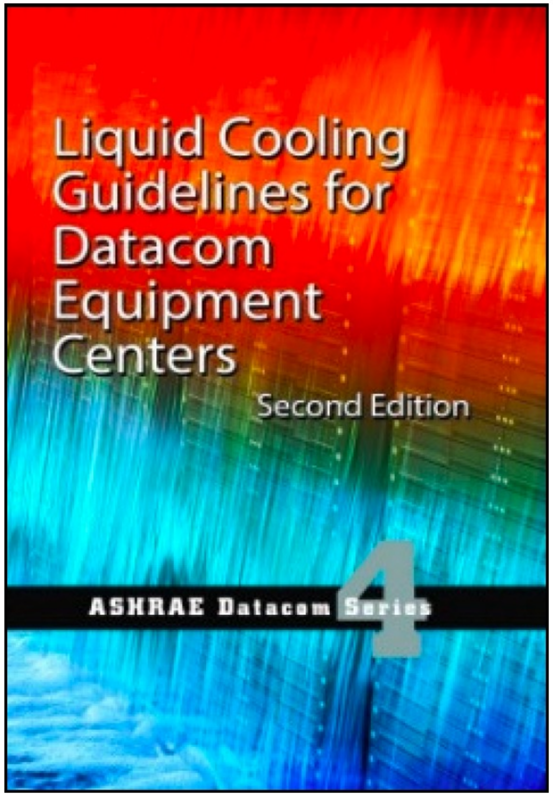
David Moss

David_moss@dell.com

IT Subcommittee

Roger Schmidt

Plans to update 2^{nd} Edition of the Liquid Cooling Guidelines



Chapter 1 – Introduction

Chapter 2 – Facility Cooling Systems

Chapter 3 – Facility Piping Design

Chapter 4 – Liquid Cooling Implementation for Datacom Equipment

Chapter 5 – Liquid Cooling Infrastructure Requirements for Chilled-Water Systems

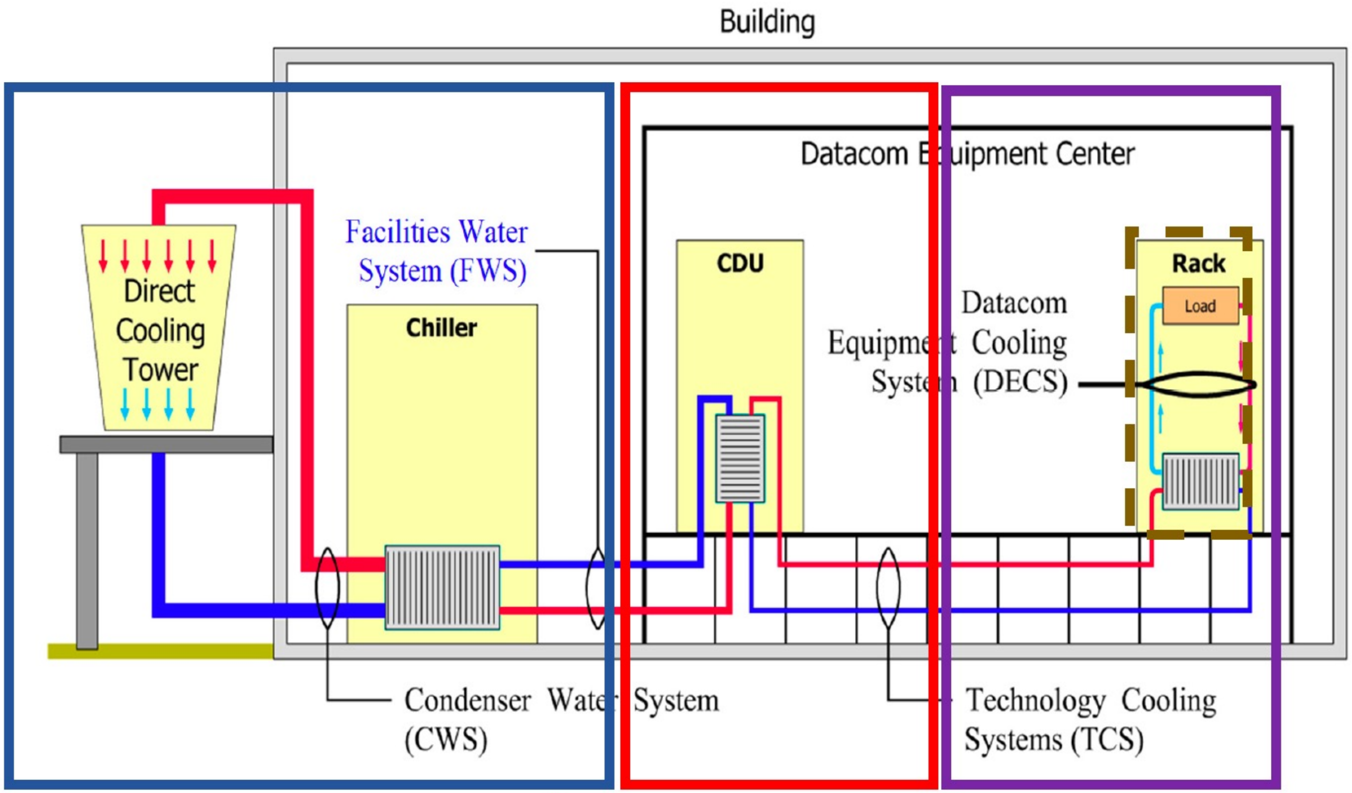
Chapter 6 – Liquid Cooling Infrastructure Requirements for Technology Cooling Systems

Appendix

Roger Schmidt
c28rrs@us.ibm.com

Six ASHRAE publications on Liquid Cooling to consider integrating into new book

- ❑ Liquid Cooling Guidelines – 2nd edition, 2014, 92 pgs.
- ❑ IT Equipment Design Impact on Data Center Solutions, 10 pgs., Chapter 3
- ❑ Thermal Guidelines for Data Processing Environments – 4th edition,15 pgs.,Chapter 3
- ❑ Emergence and Expansion of Liquid Cooling, 2021, 22 pgs.
- ❑ Water Cooled Servers: Common Designs, Components and Processes, 2019, 43 pgs.
- ❑ Liquid Cooling Whitepaper Brief, 2019 , 3 pgs.



Part 1:Technology Trends

5 pgs.-Liquid Cooling Bk – 2nd
5 pgs.-Components WP
20 pgs.-Technology Emergence
3 pgs.-Liquid Cooling Brief

65 pgs.-Liquid Cooling Bk – 2nd
12 Pgs – Thermal Guidelines – 4th

Part 2: Facilities

5 pgs.-Liquid Cooling Bk-2nd
20 pgs.-Components

20 pgs.-Liquid Cooling Bk-2nd
20 pgs.-Component Whitepaper
10 pgs.-IT Equipment Design Impact Bk
5 pgs.-Immersion Cooling

Part 3: Technology and Cooling Systems

Attendance: http://bit.ly/tc99-summer

Given the interest and amount of materials to incorporate we decided to form 3 groups as shown on the last slide :

- ❑ Part 1: Technology led by Dave Moss(David.Moss@dell.com)
- ❑ Part 2: Facilities led by Dustin Demetriou(dwdemetr@us.ibm.com)
- ❑ Part 3: Technology and Cooling Systems led by Mark Steinke(Mark.Steinke@amd.com)

If you have an interest please send a note of your interest to the team leader. To keep a balance of people it is best to sign up to just one part to help with the writing.

Pressure Testing Requirements for IT Liquid Components – the problem

- IEC 62368-1: 2014, (2nd edition) published on Feb 2014, : "… one sample of LFC is subjected to a hydrostatic pressure test for 2 min at room temperature and a pressure that is 5 X that maximum working pressure specified by the manufacturer at the maximum temperature measured during normal operating conditions."

- Noting that when the liquid cooling loop is driven by a CDU or a facility cooling system the required test pressure could be well over 100 psig and could cause problems for some of the heat transfer components.

- Of particular interest are the cold plates that would be attached to the silicon components. These are generally thin, rectangular components where the lid could deform at high pressures.

- TC 9.9 expressed concern of the IEC 62368-1 committee to pressure test liquid filled components(LFC) to 5X maximum working pressure.

- The ASME B31.n series, B31.3 [6] specifically for interconnecting piping requires a pressure test of 1.5 X the design pressure.

Roger Schmidt c28rrs@us.ibm.com

Pressure Testing Requirements for IT Liquid Components – the solution

- In 2018 the IEC committee responsible for IEC 62368-1 informed TC 9.9 that the 3rd edition had been modified such that the 5X value was changed to 3X .
- The 4th edition of IEC 62368-1 is the one where we will first see the adjusted testing requirements, developed with your help, that will apply to high end equipment that uses liquid cooling.
  - a) Section G.15.3, describes testing requirement for modular LFC, (high end equipment that connects to facilities). *One sample of the* ***LFC*** *or* ***LFC Assembly*** *is subjected to a hydrostatic pressure test for 2 min at room temperature at a pressure that is 1.5 times the maximum rated working pressure of the* ***LFC*** *or* ***LFC Assembly***

Pressure Testing Requirements for IT Liquid Components – clarifications

The discussions and review of this topic did make the TC aware that this topic is confusing and needing additional guidance for the end user. The following is intended to make this clearer.

- Pressure testing the IT equipment at the data center is not recommended; beyond checking for leaks when the final connection is made. The IT manufacturer is responsible for ensuring the equipment is sound when it is shipped. This equipment or assembly may be at the blade or server level up to the rack or rack/CDU combination. Shutting down or taking off-line operating IT equipment such that new assemblies could be pressure tested when added to a liquid loop in the field is exactly what should be avoided.

- The IT manufacturer is responsible for the pressure testing of the assembly they will ship. This is generally done to the IEC code.

- The end-user and/or their construction contractor is responsible for the pressure testing of the site designed and installed interconnect piping/hosing between the site-based systems and IT supplied hardware. This is generally done to the ASME B31.3 (or international equivalent) code. This is typically done prior to the installation of the IT kit.

- It is the responsibility of the end-user/owner to ensure that the IT equipment pressure rating exceeds that of the cooling loop that it will ultimately be attached to. Detailed discussions between the owner, IT supplier and CDU supplier (if different than the IT supplier) are strongly recommended.

Harmonization of cable/ connectors/ appliance coupler temperature standard w/ Server operation environments

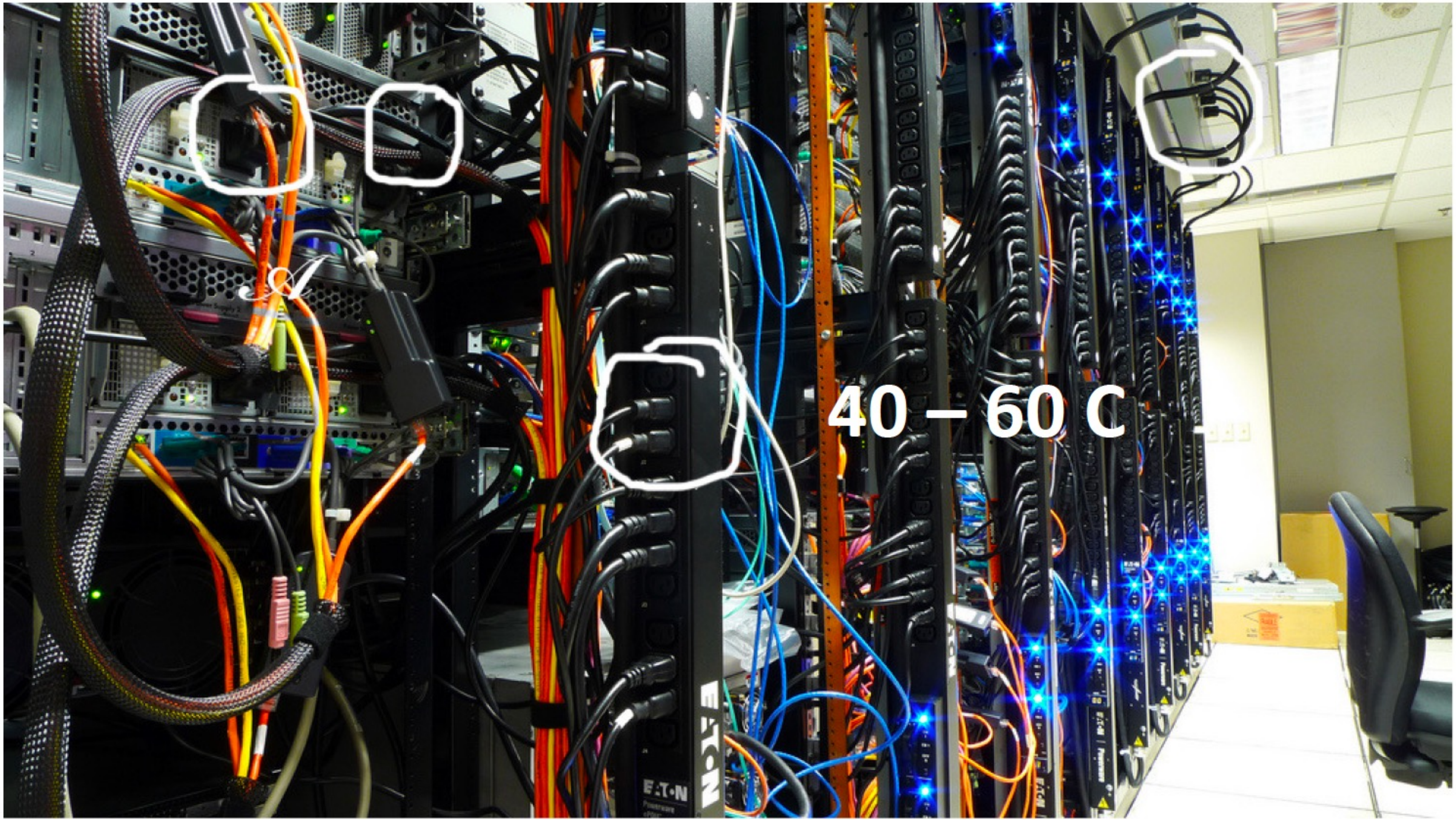
Dave Moss/Roger Schmidt

- The ASHRAE environmental envelopes appear to be in conflict with operating environments with more basic safety standards used to define cables, connectors, appliance couplers, receptacles, etc . This can be looked at from two perspectives
  - ✓ Building components : Components / devices installed with in a building (and potentially inspected by a municipality agency for a IT device to mate with.
  - ✓ Components within a server that is based on a building component and may used the same safety standards.

- IEC/UL/CSA/NEMA Standards for plugs, connectors, wiring, cabling need to be consistent with requirements of maximum environmental conditions of IT equipment deployed in Data Centers

- Request made for IT manufacturers to report on current and future requirements of environmentals for connectors, wiring and cabling at their March, 2020 Standards Working Group meeting in Florida.

Rear of a Server Rack - Hot Aisle Side



NEMA Standards Publication WD-10

High Ambient Temperature Test Procedure for Wiring Devices

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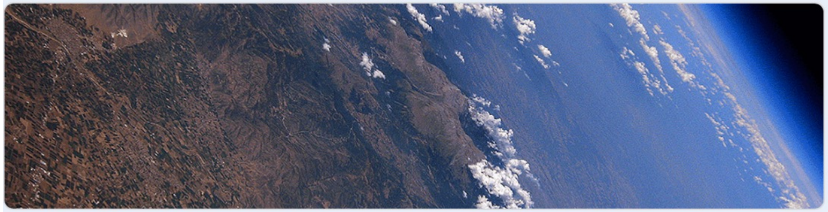
Attendance



ASHRAE TC 9.9 Attendance Record

ASHRAE Technical Committee 9.9 - Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment
2021 Winter Meeting
Virtual Event Timing: January 19, 2021
Event Address: https://ashrae-org.zoom.us/j/98449509730?pwd=Q2ZCNFhRQXFTY05CSTNYbEIZTkdKQT09
Contact us at tc99chair@gmail.com
Technical Committee Website: http://tc0909.ashraetcs.org

* Required

Name *

Your answer

Email

Your answer

Attendance is being recorded using a Google Form. Please make sure you complete the form at:

http://bit.ly/tc99-summer

Thank You

TC 9.9 Website:

tc0909.ashraetcs.org