

Welcome to the ASHRAE TC 9.9 Virtual Meeting!

No need to say hello, we will begin promptly at 4:00 pm MST

Agenda

- Introduction
- Programs
- Research
- Publications

A simple line-art icon of a lit lightbulb, symbolizing an idea or a key point.

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



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

ASHRAE Summer Conference 2025
Programs, Research, & Publication
Hybrid In-Person / Virtual

- Do not share your video due to the high number of virtual participants.
- Prior to speaking individuals should state their name so that others know who is speaking.
- Virtual participants should keep yourself muted unless giving permission to speak by the Host via chat.
- Please do not attempt to share your screen without being asked to do so by the Host or Co-Host.
- In-person participants are discouraged from joining the virtual meeting due to wireless bandwidth constraints.



ASHRAE TC 9.9 Attendance Record

B I U

ASHRAE Technical Committee 9.9 - Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment
2025 Summer Meeting

Programs, Research, & Publications

Hybrid Event Timing: Sunday, June 22, 2025; 4:00 - 6:00 pm MST
Event Address: <https://www.microsoft.com/microsoft-teams/join-a-meeting>
Meeting ID: 294 073 962 708
Passcode: cr7ze3Ce
Location: Phoenix Convention Center North Building, 230 (Level 2)

Main Meeting

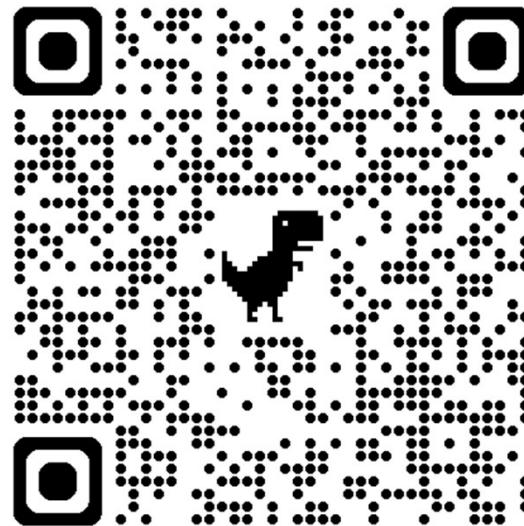
Hybrid Event Timing: Monday, June 23, 2025; 1:30 - 6:00 pm MST
Event Address: <https://www.microsoft.com/microsoft-teams/join-a-meeting>
Meeting ID: 260 212 501 636
Passcode: PL9AP9FD
Location: Phoenix Convention Center North Building, 232ABC (Level 2)

Contact us at tc99chair@gmail.com
Technical Committee Website: <http://tc0909.ashraetcs.org>

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

<https://forms.gle/A66jXpHBeyn3HRnb6>

Or use the QR Code below:



Virtual Host: Vice Chair - Mark Steinke

- Monitor the chat thread for questions and comments.
- Mute and Unmute Virtual Participants and Guests.
- Manage discussions and voting.
- Manage screen-sharing and in-person presentation

Virtual Co-Host: Secretary - John Gross

- Produce meeting minutes.
- Monitor time and keep the meeting on schedule.
- Record the event.
- Will repeat the attendance link multiple times during the meeting and upon chat request.
- Respond to audio problems.

- Video projector that displays the presentation being shared virtually.
- Be aware that chat comments sent to the Host may be seen by those in-person in addition to general chat comments.
- There are audio speakers in the room but unmuted virtual commentators may not be immediately connected. Please be patient.

Topic		Time	Presenter	In-Person or Virtual
Introduction	Welcome and Introductions	10	Matt Koukl	IP
Programs	2025 Summer (Phoenix) & 2026 Winter (Las Vegas)	20	Eric Yang	IP
Handbook	Handbook Update	15	Robert McFarlane/ Jonell Watson	IP
Research	Research Committee Update	30	Brad Cochran	IP
	Research Workshop - Topics Working Session	5	Brad Cochran	IP
Publications	Encyclopedia	15	Dustin Demetriou	IP
Voting Session	Closed Voting Member only Session	30		IP
	Total Time:	125	Minutes	



Programs Update

**ASHRAE 2025 Summer Meeting
June 21 - 25, 2025**

Eric Yang, Program Chair

ASHRAE Annual Conference-Phoenix

Conference Co-Sponsored by TC 9.9:

Seminar 5 LIVESTREAM: Thermal Energy Storage Requirements for Liquid-Cooled Data Centers, Sunday, June 22, 2025, 8:00 AM – 9:00 AM MST

Phoenix Convention Center North Building , Level 2, 224B

Panel 2: Hot! Hot! Hot! Best Practice and Challenges of Heat Recovery from Data Centers

Sunday, June 22, 2025, 1:30 PM – 3:00 PM MST

Phoenix Convention Center North Building , Level 2, 229A

Seminar 50: ARPA-E COOLERCHIPS Technology for a Future of Energy Efficient High Power Density/AI Data Centers

Tuesday, June 24, 2025, 11:00 AM – 12:30 PM MST

Phoenix Convention Center North Building , Level 2, 226BC

Panel 7: ASHRAE TC9.9 Panel Liquid Cooling Water Quality and Filtration Requirements (TCS Loop)

Wednesday, June 25, 2025, 8:00 AM – 9:30 AM MST

Phoenix Convention Center North Building , 229A

Seminar 62: ARPA-E COOLERCHIPS Technology for a Future of Energy Efficient High-Power Density/AI Data Centers (Part 2)

Wednesday, June 25, 2025, 9:45 AM – 10:45 AM MST

Phoenix Convention Center North Building , Level 2, 228AB

Conference Co-Sponsored by TC 9.9 (Sponsored by TC 4.10 Indoor Environmental Modeling)

Panel 5: Digital Twins for Data Centers and Other Built Environments

Tuesday, June 24, 2025, 8:00 AM – 9:30 AM MST

Phoenix Convention Center North Building , Level 2, 229A

Program submitted by TC 9.9, but not accepted.

- 1. Best Practices to Reduce Carbon Footprint in Liquid Cooled Data Centers (Kushal Pandit)**

Overview of Conference Tracks:

• Tracks

- **Fundamentals and Applications**
- **HVAC&R Systems and Equipment**
- **Research Summit**
- **Energy Storage and Grid Resiliency**
- **Pathways to building decarbonization**
- **Artificial Intelligence**
- **Indoor Environment Quality for Healthy Buildings**
- **Future-Proofing the Built Environment**

- **Fundamentals and Applications**
 - A2L refrigerant (Mukul)
- **HVAC&R Systems and Equipment**
 - Modular Electrical Room Design in Data Centers (seek speakers)
 - Single-phase and Two-phase Immersion Design for Ultra High-density Deployment (seek speakers)
 - TCS/FWS chilled water loop velocity requirement (John Gross)
 - Debate (90.1 scope requirement on TCS Loop: whether this should be exempted –(John Gross)
 - Lesson & learned on liquid cooling CDU (Pardeep)
 - TCO analysis of Liquid cooling- best practice & case studies
 - Panel -Liquid cooling - risk review and management (concurrency maintenance, thermal runaway)
 - Hot aisle containment best practice
 - PG25: users be aware on the difference between each vendor
 - Actional data/dashboard for data center operation (Nick Norman)

- **Research Summit**
 - 15 proposed conference paper from TC9.9 – Dedicated Conference Paper session sponsored by TC 9.9
 - OCP & TC 9.9 Collaboration - Status, Workstreams, & Path Forward (panel, already submitted)
- **Energy Storage and Grid Resiliency**
- **Pathways to building decarbonization**
 - Best Practices to Reduce Carbon Footprint in Liquid Cooled Data Centers (Kushal Pandit)
- **Artificial Intelligence**

Important Dates

Friday, August 1, 2025 | Debate, Panel, Seminar, Forum, Workshop, and Debate Proposals Due

Wednesday, September 3, 2025 | Conference Papers and Extended Abstracts Due

Next Step

- **Contact me at ericyangcem@gmail.com**
 - **If you need to co-sponsor the proposed session from other TCs**
 - **If you need suggestions of a speaker or need a speaker submission template or understand the process of submitting a session**

- **Technical Papers**
- **Conference Papers**
 - Not required to be approved by TC's
 - Organized by either CEC or TC into Sessions
- **Extended Abstracts**
 - Available at Annual Conferences
- **Seminars, Workshops**
 - Organized by TCs
 - Require Learning Objectives
- **Panels, Debates, Forums**
 - Organized by TCs
 - Do not require Learning Objectives

Panel Discussion

- Feature a broad range of subjects and explore different perspectives on industry related topics.
- This session format includes a panel of 3-6 speakers each addressing a facet of the session topic, followed by an interactive discussion lead by the session chair.

Debates

- Highlight hot-button issues commonly faced by ASHRAE members. Industry experts, either on teams or as individuals, argue opposing sides of an issue, concluding with position summaries and audience feedback.

Forums (no recordings)

- “Off-the-record” discussed held to promote a free exchange of ideas.
- Allow individuals to speak confidently without concern of criticism.
- There are no papers attached to forums.

- These sessions present papers on current applications or procedures, as well as papers reporting on research in process.
- Less rigorous than Technical Papers
- Can highlight case studies or ongoing research
- Maximum eight pages in length, single spaced. Published in *ASHRAE Transactions*.
- Single blind review process; subject to commercialism review
- Shorter timeline for the Conference
 - Abstracts due about 6-7 months prior to meeting
 - If accepted, papers due about 5 months prior to meeting

<https://www.ashrae.org/technical-resources/authoring-tools/citation-and-abstract-indexes#transactions>

- Present papers on current applications or procedures, as well as papers resulting from research on fundamental concepts and basic theory
- More involved papers usually detailing research or similar activities
- Maximum of 30 pages in length
- Rigorous double-blind review process; subject to commercialism review
- Longer timeline for development and approval
- Final papers required about 9 months prior to a Conference to go through the review process
- Published in ASHRAE Transactions

- Present extended abstracts on research in progress, applications, case studies, and other topics in HVAC&R technical areas. They are intended to be preliminary research results that will eventually be expanded into full papers.
- Extended abstracts may be presented in Conference Paper Sessions with papers on a similar topic.
- Available as part of the Annual Conference Research Summit
- Limited to Three Pages
- Included in ASHRAE Transactions

Seminar & Workshop Chair Responsibility

- Develop a detailed program abstract and identify speakers (contact Track Chair with questions)
- Upload the required information on the session and speakers to the Conference website
- Preview speaker presentations to check that they meet the ASHRAE Conference Presentation Policy (found at https://www.ashrae.org/file%20library/conferences/speaker%20resources/conference-presentation-policy_final_2019.07.10.pdf)
- Make sure speaker presentations are uploaded prior to the Conference
- Coordinate presentations to minimize overlap and make sure the timing is correct
- Introduce and monitor session at the Conference
- Assist authors in identifying learning objectives & completing Q&A

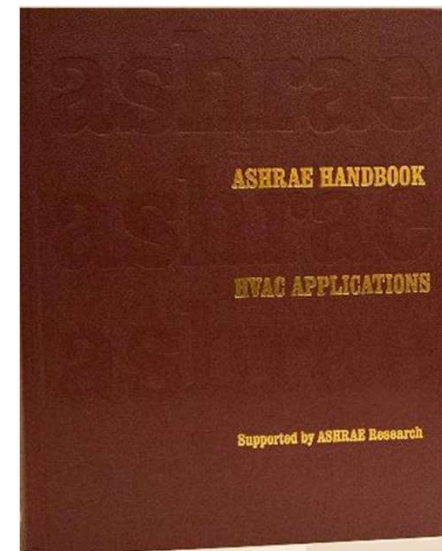
- Introduce and Moderate the session at the Conference
- Upload the required information to the Conference website
- Make sure are working to the required deadlines

- <https://www.ashrae.org/conferences/speaker-resources>
- Learning Objectives
- Presentation Template
- Commercialism policy & checklist

ASHRAE HANDBOOK “Applications”

Chapter 20

“Data Centers & Telecommunication Facilities”



- Background
- Purpose of “Applications”, Chapter 20
- Current Status
- Today’s Priorities
- Next Steps
- Questions

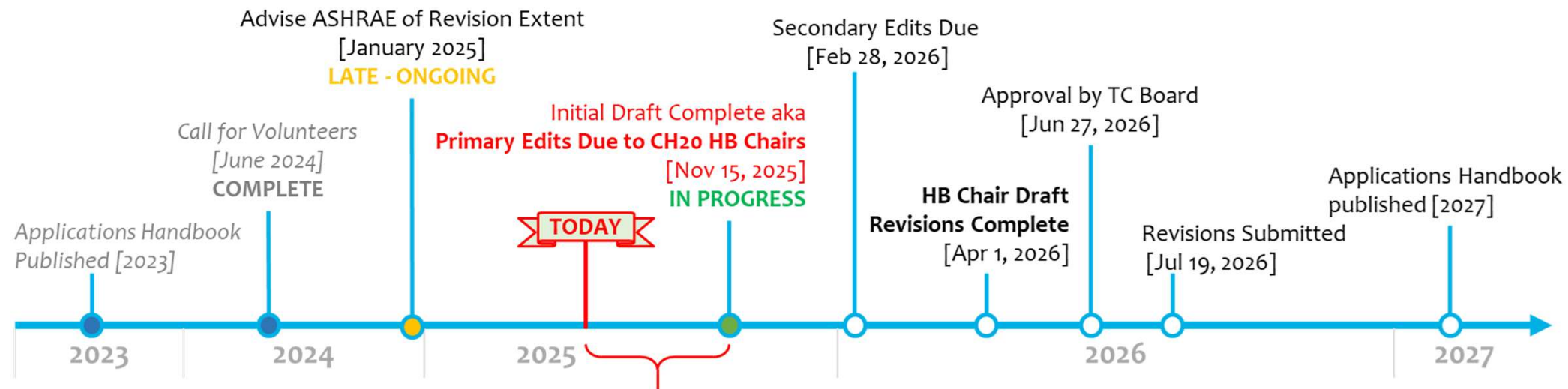
- ASHRAE's Handbooks - Four Publications
 - ✓ *Fundamentals*
 - ✓ *Refrigeration*
 - ✓ ***Applications***
 - ✓ *HVAC Systems and Equipment*
- Published on Four-year Cycle
- TC9.9's Responsibility: Chapter 20 of "Applications"
 - *"Data Centers and Communications Facilities"*
- All Revisions by Volunteers through TC9.9

- Tutorial for New Engineers
- Reference for Experienced Engineers
- Design Guideline for Those New to Data Centers
- To Alert to “What You Don’t Know”
 - And Then Encourage Retaining Subject Matter Experts?
- To Push Manufacturers to Standardization

We are currently in the middle of a revision cycle for the Applications Handbook!

Chapter 20 Has 120 Topics:

- 37 Initial Reviewers Assigned. 29 Responded ***THANK YOU!!***
 - 19 Require Major Revision or Rewrite
 - 31 Require Minimal Revision
 - 21 Are Fine “As Is”
 - **46 Still Not Reviewed**
 - **30 Of Those Were Assigned, But Not Reviewed => Will be Reassigned**
- 3 New Topics Suggested for Addition
 - Heat Pipe Technology
 - Above Hot Aisle Air Delivery
 - Controls



Between now and Nov 15...

1. <TODAY> Get volunteers for unassigned topics
2. Consolidate topics requiring significant edits to and assign Primary Reviewers
3. Receive acknowledgement and acceptance by assigned PR's
4. Provision access for PRs to ASHRAE Authoring Portal
5. Primary Reviewers to make their edits in Authoring Portal (SharePoint backend)
6. Handbook chairs to do final once-over

- Get Reviewers for Topics Not Covered to understand Extent of revisions: None / Minimal / Extensive / Rewrite
 - If You Volunteered, But Have Not Heard From Us:
 - You Didn't Respond to our Multiple Emails
 - You Didn't Add Bob & Jonell to your "Safe Senders" List
 - If You Still Want to Help:
 - Be Proactive - **Email Us!!**
 - Tell Us What Topic Numbers You Can Cover
 - List of Open Topics on TC 9.9 Website
 - **But Be Sure You Can Commit to Doing the Work**

Please advise Bob McFarlane and Jonell Watson
rmcfarlane@smwllc.com | Jonell.Watson@gmail.com

Unassigned Topics

ID	Section	Topic
10 / 113	2.3 DATACOM EQUIPMENT (HARDWARE)	Datacom Equipment Airflow (#113 - Fig. 4)
11 / 114	2.3 DATACOM EQUIPMENT (HARDWARE)	Liquid-Cooled Datacom Equipment (#114 - Fig. 5)
12	2.3 DATACOM EQUIPMENT (HARDWARE)	Contamination
13 / 135	2.3 DATACOM EQUIPMENT (HARDWARE)	Environmental Guidelines for Air-Cooled Equipment (#135 - Table 1)
14 / 136	2.3 DATACOM EQUIPMENT (HARDWARE)	Environmental Guidelines for Liquid-Cooled Equipment (#136 - Table 2)
17 / 116 / 117 / 137	2.3 DATACOM EQUIPMENT (HARDWARE)	Power Trends (#116 - Fig 7, #117 - Fig 8, & #137 - Table 3)
37	3.1 General Considerations	Lighting
86	4. RESOURCES => ASHRAE DATACOM SERIES	8. Particulate & Gaseous Contamination (2014a)
87	4. RESOURCES => ASHRAE DATACOM SERIES	9. Real-Time Energy Consumption (2010)
90	4. Resources => ASHRAE Datacom Series	12. Server Efficiency Metrics (2015b)
92	4. Resources => ASHRAE Datacom Series	14. Advancing DCIM w/ IT Equipment Integration (2019a)
96	4. RESOURCES => ASHRAE DATACOM SERIES	Data Center Handbook, 2nd ed (2021)
97	4. Resources => ASHRAE Datacom Series	ANSI/TIA Std. 942-B-2017
98	4. Resources => ASHRAE Datacom Series	ANSI/BICSI Std. 002-2019

Unassigned Topics

ID	Section	Topic
99	4. Resources => ASHRAE Datacom Series	ANSI/ASHRAE Std. 202-2018
100	4. Resources => ASHRAE Datacom Series	ASHRAE Guideline 0-2019
101	4. Resources => ASHRAE Datacom Series	BICSI 009-2019
102	4. Resources => ASHRAE Datacom Series	The Green Grid White Paper #79
103	4. Resources => ASHRAE Datacom Series	The Green Grid White Paper #68
104	4. Resources => ASHRAE Datacom Series	DIN EN 50600
105	4. Resources => ASHRAE Datacom Series	ISO/IEC 22237 Series
106	4. Resources => ASHRAE Datacom Series	European Commission - The European Code of Conduct for Energy Efficiency in DCs
115	FIGURES	Fig. 6 - Environmental Classes for Datacom Equipment Classes...
135	TABLES	Table 1 - 2021 Thermal Guidelines: Equip. Environmental Specs for Air Cooling
137	TABLES	Table 3 - Workload Types

Please advise Bob McFarlane and Jonell Watson
rmcfarlane@smwllc.com | Jonell.Watson@gmail.com

- Assigning Primary Editors for Content Requiring Change
 - Based on Initial Feedback
 - May Not Be Same People. (Topics Being Consolidated)
 - **Require Confirmation of Assignments !!!**
 - **Response Within 2 Weeks or Topics Re-Assigned**
- **Secondary Reviewers Will Be Assigned Next Year**

- Assign Revisions to Selected Reviewers
 - Topics Will Be Grouped to Reduce Number of Revisors
 - Not Everyone who Responded Will Do Actual 1st Edits.
 - You May Become Reviewers
- Provide Access to Authoring Portal
 - You Will Receive Email From:
 - *Kennedy, Heather is inviting you to collaborate on ASHRAE Authoring Portal*

- ASHRAE “Authoring Portal”
 - Used for All Review and Revisions
 - Now Works on ALL Browser Platforms Including MAC
 - Can Work Simultaneously on the Same File
 - Most Recent “Save” Will Be Seen by Others
 - All Work Must Use “Track Changes”
- New or Revised Illustrations
 - **Require Written Permissions!!**
 - Preference is “In Perpetuity”

QUESTIONS?



Please advise Bob McFarlane or Jonell Watson
rmcfarlane@smwllc.com | Jonell.watson@gmail.com

TC 9.9 Research Projects Planned and Proposed

- Only 1 RTAR submitted to RAC for Review in Spring.
 - No RTARs being reviewed at this meeting
 - So now is a good opportunity to submit RTARs, funding is available.
-

TRP-1913 - *Study of the Corrosion Impact on Information Technology Equipment in Data Centers Located in Coastal Regions with High Sea Salt Concentration*

TRP-1972 - *Data Center Direct-to-Chip Liquid Cooling Resiliency – Failure Modes and IT Throttling Impacts*

WS-1956 - *Compact CFD Modeling Guidance for Thin Flow Resistances*

- TC4.10 is the cognizant TC, TC9.9 is a Co-Sponsor

New RTAR – *Study of Height Limitations in U101.DVN.8.1*

RTAR in Development – *Guidelines for Data Center External Dispersion Modeling*

RTAR in Development – *Flow Velocity Limits for Erosion Control*

Proposed RTAR - *Digital twin for data center environments for liquid cooling and how that might be able to be developed*

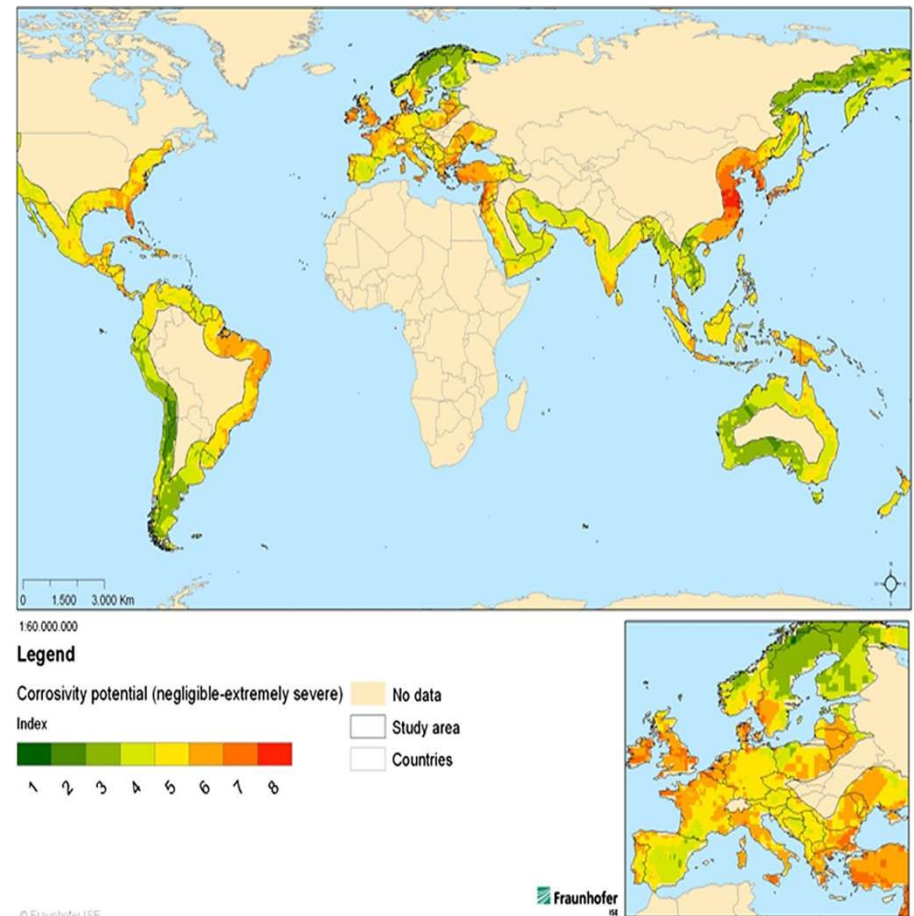
1913 - Study of the Corrosion Impact on Information Technology Equipment in Data Centers Located in Coastal Regions with High Sea Salt Concentration

- **Chris Muller**, Chair – AAF International, member of TC2.4
- **Rui Zhang** (Oakridge National Lab) – member of TC9.9
- **Kyung-Ju Choi**, PhD, LMS Technologies, ASHRAE TC2.3 Program subcommittee chair
- **Vali Sorell** – Oracle – member of TC9.9
- **Michael Corbat**, Rensa Filtration, TC2.3 voting member

1913 - Study of the Corrosion Impact on Information Technology Equipment in Data Centers Located in Coastal Regions with High Sea Salt Concentration

- TRP-1913 went out for bid last fall
- Four bids were received
- PES bid scores sent to MORTS

- Study of the Corrosion Impact on Information Technology Equipment in Data Centers Located in Coastal Regions with High Sea Salt Concentration
- Motivation
 - Electronic failures in marine environments occur – is sea salt important?
 - Can the data center environmental envelopes be expanded if we know?



1913-WS Objectives

- Conduct a literature survey to understand the importance of field variables. Variables include temperature, moisture content, wet/dry cycles, and salt concentration (fine particulates and airborne water droplets) and SO₂. Identify their impact on corrosion to design a set of experiments.
- Develop a draft test methodology and establish minimum specifications for the test facility and instrumentation.
- Based on literature survey and coastal environmental measurements, create a design of experiments that includes the key parameters and the parameter ranges to be tested.
- Develop a test facility (bearing in mind previous ITE contamination research) capable of monitoring and controlling the test parameters determined from the literature survey. The time it takes to cause corrosion of the IT equipment in marine environments is a key element of the testing.
- Document the results of the effect on corrosion of electronic equipment from the sea salts. Identify the tool/s for measuring corrosion of IT equipment in marine environments including recommendations on where the measurements should be.
- Develop new guidelines for operating data centers and other electronics in marine environments.

1913-WS Tasks & Deliverables

- Task 1. Perform and document a detailed literature review.
Deliverable: A report that summarizes the literature review.
- Task 2. Develop a test facility capable of monitoring and controlling dry bulb temperature, dew point, air flow velocity, sea salt concentration, and time of exposure that mimics the environmental conditions of data centers in marine environments.
Deliverable: A report that summarizes the test facility design and method to vary the various test parameters over the range of environmental parameters exhibited by data centers in coastal regions.
- Task 3. Experimentally characterize copper and silver corrosion of the test coupon samples using conditions appropriate to cover the ASHRAE thermal guidelines.
Deliverable: A report that summarizes corrosion test results over the range of environmental parameters experienced in coastal data centers. Highlight those parameters or group of parameters having the most destructive effect on IT equipment reliability. Include the effect of makeup air in your comments regarding the test results.
- Task 4. Understand and perform experiments to elucidate the relationship between the rate the change of humidity on the corrosion rates of copper and silver. For a direct air side economizer these changes can occur in minutes or hours depending on the weather patterns of the data center location and would impact the IT equipment housed within the data center.
Deliverable: A report of the effect that rate of change of humidity (wet/dry cycles) has on the corrosion of the IT materials.
- Task 5. Develop an updated set of thermal guidelines for coastal locations of data centers and specific guidelines that may focus on those data centers where resiliency may be the primary operational goal and not energy efficiency.
Deliverable: A report of the thermal guidelines for coastal data centers with those environmental conditions providing the highest reliability for IT equipment. In addition, a set of guidelines for coastal data center where resiliency is the primary operational goal should also be reported.
- Task 6. Provide guidance on what tool/s to use for quantifying corrosion in coastal data centers. In addition, provide recommendations on where those measurements should be made.
Deliverable: A report summarizing the tool/s for measuring corrosion in data centers and the optimum location for those measurements.

1972-WS Data Center Direct-to-Chip Liquid Cooling Resiliency – Failure Modes and IT Throttling Impacts

- David Quirk, **DLB**, Chair
- Jim VanGilder, **Schneider Electric**
- Eric Yang, **Vantage Data Centers**
- Tom Davidson, **DLB**
- Matthew Käufeler, **Cadence Design Systems**

1972 - Data Center Direct-to-Chip Liquid Cooling Resiliency – Failure Modes and IT Throttling Impacts

- December: WS resubmitted to MORTS Changes include:
 - Increased cost estimate from \$300K to \$350K
 - Total estimated corporate support (cash + in-kind) \$51K
 - Up to three more potential sponsors
 - Added Letters of Support from:
 - IBM
 - J.M. Gross
 - Vantage Data Centers
 - DLB Associates
 - Strategic Thermal Labs
- Spring 2025: WS Accepted for Bid by MORTS w/ comments
 - PES may wish to: provide letters of intent from additional co-sponsors
- Expect DRAFT RFP to be ready for review after Summer Meeting
- RFP to go out for Bids in the Fall

1972-WS Objectives

- Research failure system design for air/liquid hybrid and liquid cooled equipment using computer models and empirical data
- Examine ITE power and thermal capacitance impact on rate-of-rise and IT Throttling Time
- Look at impact of liquid cooling S-classes on IT throttling time
- Look at impact of secondary loop delta t on IT throttling time
- Look at impact of liquid cooling percentage on IT throttling time
- Look at impact of percentage of secondary loop failure on IT throttling time
- Conduct a comprehensive analysis (modeling + testing) of 30+ combinations
- Look at energy impact of specific liquid cooling systems and S-classes vs. air cooled baseline (metrics to include: MLC, ELC, PUE, and TUE)



Corporate co-sponsorship

Estimate cost of this research is \$350,000 (large by ASHRAE Standards, average is \$131,353 for 49 active projects). Corporate co-sponsorship greatly increases likelihood of project funding. (Just a pledge now, donations not accepted until project funded).

- In-kind or cash co-sponsorship available
- Corporate co-sponsors will be recognized in Work Statement and Final Report
- In-kind support may be of equipment (servers, CDU's, data acquisition, etc.)
- Field data support will aid in providing confidential failure and energy use data
- Cash donations directly to this research project must be at least \$1,000 per ASHRAE rules



If interested, contact Tom Davidson (tdavidson@dlbassociates.com), Mark Seymour (mseymour@cadence.com), or TC9.9 Chair Matt Koukl (mkoukl@aeieng.com)

1956-WS Compact CFD Modeling Guidance for Thin Flow Resistances

- Jim VanGilder
- Mark Seymour
- Duncan Phyfe
- Duncan Phillips
- One more representative from TC 9.9?

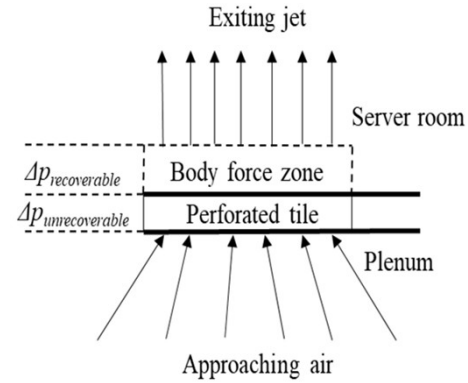
1956-WS Compact CFD Modeling Guidance for Thin Flow Resistances (TC4.10 is Cognizant TC)

- WS returned to PES with comments

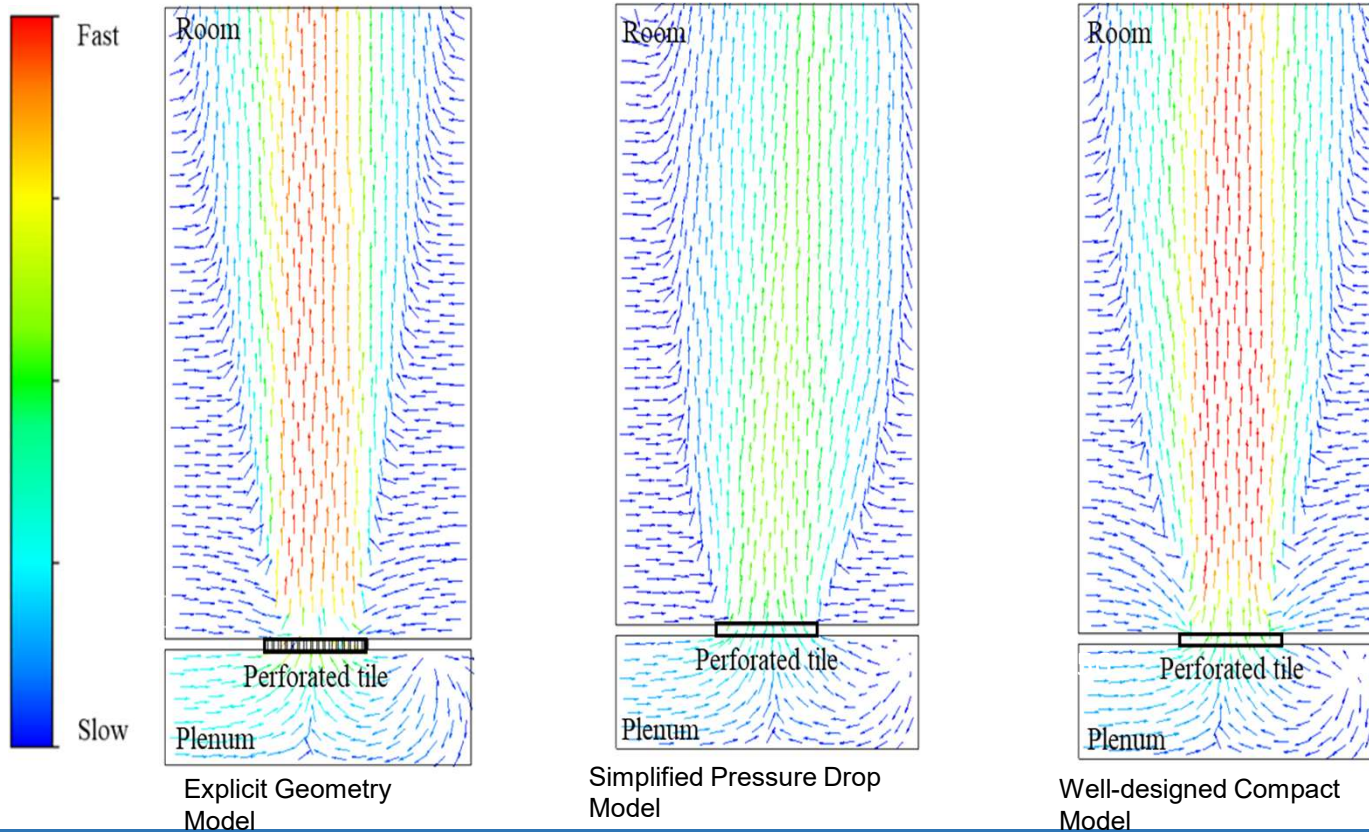
PES is concerned that RAC didn't understand the purpose of the work. Too precise, they may have been expecting larger, bigger expansive, expensive project.

- This should be worked out between TC4.10 and the Section 4 Research Liaison.

- Resistances are common
 - Tiles, perf doors, louvres...
 - Previous research incomplete
 - Implementation varied



Courtesy Hu, B
RP-1675



Determine thickness and strength distribution of the momentum source for a thin- resistance compact model to produce best agreement with reality (as benchmarked by detailed CFD and experimental validation).

Considerations:

1. CFD issues like grid size and grid scheme (staggered vs. co-located) are to be investigated.
2. Simple thin resistances (e.g., porous plates with uniform hole distributions) with varying percentage open-areas should be considered.
3. At least one commercial HVAC-style grille and one data center perforated floor tile should be considered.
4. Multiple flow rates (supply velocities) should be considered, at least, for the simple thin resistance.

Study of Height Limitations in U101.DVN.8.1

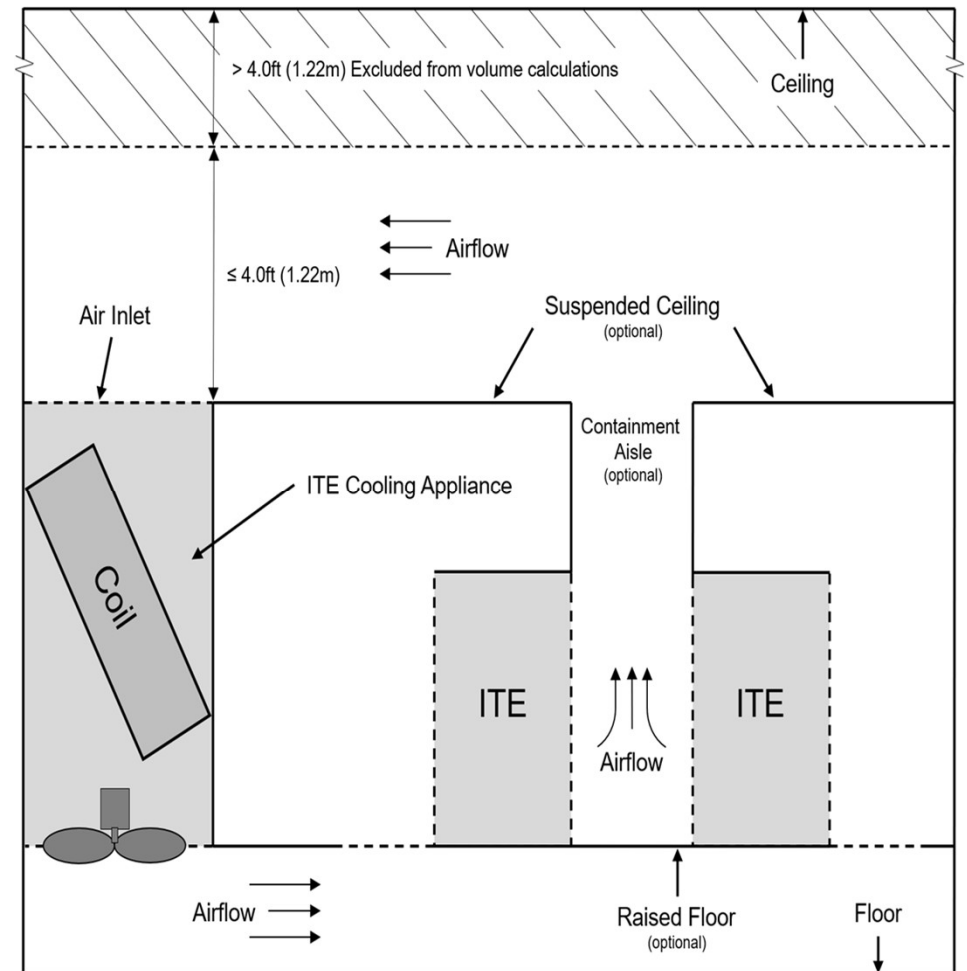
Study of Height Limitations in U101.CVN.8.1

- RTAR has been reviewed by Research Chair (Mark)
- Distributed to TC9.9 Voting Members for Review
- Vote to accept RTAR was delayed pending feedback from SSPC 15.
- SSPC 15 has agreed to review (meeting is on Saturday)

- Richard Pavlak
- Ben Dolcich, Vertiv (ret)
- Bill Kinas

Study of Height Limitations in U101.DVN.8.1

- Existing standards - Standard 15-2022 and UL/CSA are not designed for data centers
- Studies on 2L refrigerants are based on comfort cooling with low airflow rates
- There are inconsistent practices with regard to airflow volume – Only 4ft in height above drop/false ceiling is included in UL/CSA 60335-2-40 4th edition further limits refrigerant capacity



- Build a CFD geometric model based on the parameters in U101.DVN.8.1.
- Evaluate the effectiveness of the dilution of the refrigerant charge specified in ASHRAE Standard 15-2022, the air flow pattern into the return air, comparing these results to the safety metrics established in Standard 15-2022.
- If the base model identifies the effective volume is well mixed at the prescribed 4-foot limit, raise the height. (The authors believe the 4' limit is too low).

Objectives

- If the base model shows a dead air space below 4-foot limit lower the height to determine and verify whether there is a height with all acceptable circulation.
- The expectation is that the 4' limit is too low and that increasing the limit height above the return air opening is viable. Thus, the objective is to run successive models increasing the height limit until the total volume does not mix and a boundary layer of room air appears in the CFD model.

Guidelines for Data Center External Airflow Modeling

Guidelines for Data Center External Airflow Modeling

- Evaluate the accuracy of various plume dispersion models (analytical, CFD, physical modeling) to predict the increase in intake temperatures due to hot emission sources. (Results to be compared to measured data at an operating data center).
- Provide guidance on how to improve the accuracy of each model.
- Evaluate how well different modeling techniques (Number of WS and WD, for example) are at predicting design worst-case intake temperatures.
- Provide owner/engineer with guidance on the best approach to meet the acceptable margin of error of the worst-case intake temperature for a specific project.
- Looking for volunteers to help Brad Cochran and Mark Seymour put the final touches on the RTAR
- Interest from Data Center owners to privately support research

The Concern

- Data Center installations are complex and often built near existing facilities or within tight confines.
- Thermally sensitive intakes are surrounded by significant sources of heat rejection (cooling towers, chillers, DGs, hot aisle exhaust etc.)
- With server loads increasing significantly, understanding the level of re-entrainment of the hot exhaust is critical for defining cooling capacity.
- A plume dispersion study is important to help ensure that the necessary resilience is available to avoid insufficient cooling capacity.



Images and data courtesy Kao Data



ANALYTICAL

- ASHRAE Dilution Equations

Pro's

- Calculations can be performed in a simple spreadsheet
- Can quickly evaluate a full range of wind speeds

Con's

- Designed for evaluating a single emission source at multiple receptor locations
 - Assumes wind is always from emission source to receptor. Doesn't calculate off-axis concentrations. So, cannot combined exhausts.
- Assumes fully developed flow at the exhaust exit (may not be valid for cooling towers, chillers)
- Doesn't directly address building wake effects/increased turbulence

ANALYTICAL

- EPA's AERMOD Dispersion Program (Used primarily for air permitting applications)

Pro's

- Free software from EPA (GUI interface available from private vendor)
- Dispersion calculations can be conducted on an hourly basis using validated meteorological databases. (Doesn't assume design ambient temperature occurs for all hours)
- Can combine impacts from multiple emission sources.

Con's

- Dispersion model "tuned" to obtain fence line concentrations
- Does not calculate on-building concentrations
- Building wake model can create spurious results, particularly for a data center campus.

NUMERICAL MODELING

- Computational Fluid Dynamics

Pro's

- Can evaluate the entire campus in a single simulation with combined impacts from multiple sources
- Graphics can show the thermal distributions across the campus
- Commercial software programs available

Con's

- Steady-State “RANS” simulations do not resolve the full spectra of turbulence, the driving factor in plume dispersion, so accuracy of results can be a concern
- Unsteady “LES” simulations resolve the larger turbulent eddies, and thus can be more accurate, but are significantly more expensive to conduct
- Each combination of wind speed, wind direction, and ambient temperature is a separate simulation. So, the number of simulations is typically limited.
- No guidance documentation available for how to properly conduct a CFD dispersion modeling assessment. (ASHRAE recommends against using CFD for plume dispersion.)

PHYSICAL MODELING

- Atmospheric Boundary Layer Wind Tunnels

Pro's

- Properly designed ABL wind tunnel can provide the most accurate dispersion modeling results.
- A full range of wind speeds and wind directions can be readily evaluated.
- Probability distributions of intake temperatures can be obtained for each intake.

Con's

- Requires the construction of a physical model
- Limited number of ABL wind tunnels available for commercial work
- The most expensive option (if not taking into account the number of wind speeds and wind directions simulated).
- Most time consuming (again, if not taking into account the number of wind speeds and wind directions simulated)

- Any dispersion model will have uncertainties (margin of errors) associated with their ability to predict intake concentrations/temperatures.
- The objective of this proposed research is to:
 - Evaluate the ability of each type of dispersion model to accurately predict intake concentrations by comparing results to on-site measured data
 - Define techniques that can improve the accuracy or at least provide conservative results.
 - Evaluate the potential uncertainty (margin of error) in predicting maximum intake temperatures over the lifetime (or basis of design period) of the data center.
 - Variables may include:
 1. How many wind speeds (and what wind speeds) are modeled
 2. How many wind directions (and what wind directions) are modeled
 3. How many grid points should be used and what type of mesh (CFD simulations)
 4. Do you apply the same design ambient temperature for all wind speeds and wind directions.
- Results will include guidance for the owner/engineer on not only which dispersion model, but how that modeling effort should be conducted to provide estimated design temperatures that are within an acceptable margin of error for that project.

Flow Velocity Limits for Erosion Control

Flow Velocity Limits for Erosion Control

Develop a guideline that will replace the online reference regarding water velocities in liquid cooling applications.

Author - Mark Steinke

Looking for volunteers to help Mark assemble the RTAR

- ASHRAE Handbook
 - Does call out a 1.5 m/s as a velocity limit to keep pumping power minimized.
 - Does call out a 3.0 m/s limit on erosion with normal operation of 6,000 hr/yr. This is originally sourced from a Carrier study in 1960.
- ASHRAE TC9.9 Liquid Cooling guidelines – 3rd Edition
 - FWS section does have the callout for 1.5 m/s for energy consideration but states 3.0 m/s for >6,000 hr/yr (back to ASHRAE Handbook reference)
 - TCS section does call out a 1.5 m/s for any flexible hose and the table appears to confirm that, but this is more pointing towards pumping power. However, it does not clearly state that.
- ASHRAE TC9.9 Liquid Cooling guidelines – Online encyclopedia
 - FWS section does have the callout for 1.2 m/s for energy consideration but states 3.0 m/s for >6,000 hr/yr (back to ASHRAE Handbook reference).
 - TCS section has this guidance removed.
- Therefore...
 - There is not a current guideline for flow velocity limits to prevent corrosion
 - Some industry hose suppliers have references that call out 6.1 m/s
 - Should we consider an RTAR to provide a recommendation?

Table 23 Maximum Water Velocity to Minimize Erosion

Normal Operation, h/yr	Water Velocity, fps
1500	15
2000	14
3000	13
4000	12
6000	10

Source: Carrier (1960).

5.1.2.3. Velocity Considerations. The velocity of the water in the FWS loop piping must be controlled to ensure mechanical integrity is maintained over the life of the system. Excessive water velocity can lead to erosion, sound/vibration, water hammer, and air entrainment. Particulate-free water will impart less damage to the tubes and associated hardware. Table 5.2 provides guidance on maximum velocities in piping systems that operate over 8,000 hours per year. Flexible tubing velocities should be maintained below 1.5 m/s (5 ft/s). Excessive water velocity in piping systems also increases the pressure drop and energy usage of the system.

5.1.2.4. Liquid Quality/Composition. Table 5.3 identifies the water quality requirements that are necessary to operate the liquid-cooled system. The reader is encouraged to refer to Chapter 49 of the 2011 *ASHRAE Handbook—HVAC Applications*. This chapter, titled “Water Treatment,” provides a more in-depth discussion about the mechanisms and chemistries involved.

Table 5.2 Maximum Velocity Requirements

Pipe Size	Maximum Velocity (fps)	Maximum Velocity (m/s)
>3 in. (7.6 cm)	7	2.1
1.5 to 3 in. (3.8 cm to 7.6 cm)	6	1.8
<1 in. (<2.5 cm)	5	1.5
All flexible tubing	5	1.5

Digital twin for data center environments for liquid cooling and how that might be able to be developed

Digital twin for data center environments for liquid cooling and how that might be able to be developed

Author – Ali Heydari, Nvidia

Looking for volunteers to help Ali assemble the RTAR

Other Ideas for Research?

-
-
-

Brief overview of the beta version of the Datacom Encyclopedia V2

1. V2 is the wiki style format
2. Call for Volunteers

ASHRAE TC 9.9
Publications Update
Datacom Encyclopedia
June 22, 2025

Vision for the Encyclopedia

- TC 9.9 Datacom Encyclopedia, TC 9.9 has developed a central hub for providing on-demand access to frequently updated datacom-related content anytime, on any device, anywhere.
- In time, this site will evolve to incorporate the pertinent information from all of the existing TC 9.9 Datacom Series books, white papers, and technical bulletins, and the books will go out of print.

Timeline¹:

- This timeline is being provided for informational purposes only. The dates and content are subject to change.

March 2024	TC 9.9 Datacom Encyclopedia is launched with updates to Design Considerations for Datacom Equipment Centers & Liquid Cooling Guidelines for Datacom Equipment Centers.
Summer 2024	Process is introduced and approved by TC 9.9 for providing content updates and version tracking.
Winter 2025	TC 9.9 Datacom Encyclopedia begins to incorporate existing material from other Datacom Series book, white papers, and technology briefs.
Summer 2025	TC 9.9 Datacom Encyclopedia is transitioned to an encyclopedia format that incorporates Thermal Guidelines for Datacom Equipment Centers, Design Considerations for Datacom Equipment Centers
2026	Transition of Datacom Series books complete.
On-going	Quarterly updates, approved by TC 9.9, begin.

- Since the Winter meeting, a subgroup has worked on converting the content to a “Wikipedia” format
- The beta version of the new experience will go live **Monday prior to the Main Meeting**
- It is important that we receive feedback from the committee on this new format

Workshop # 1: Feedback on Encyclopedia

- Seeking volunteers to use the beta format and provide feedback.
 - Must have a datacom Encyclopedia subscription
- Spend ~30 minutes reading the content and navigating the site during the Monday meeting
- Send an email to: datacom@ashrae.net with your feedback

Requested Feedback:

- Ease of navigating the site
- Topics that could be subdivided
- Useability on desktop, mobile tablet
- Navigation that doesn't work or doesn't go where you expected
- “Wiki” style vs. books

Feedback Not Requested:

- Missing content
 - Remember, this is a beta, more content will come
- Changes to the technical content
 - Content has all been approved by TC

Datacom Encyclopedia Status

Facility Design Considerations	
Design Criteria	Red
HVAC Loads	Red
Humidification	Green
Dehumidification	Green
Ventilation	Green
Availability and Reliability	Red
Electrical Systems and Equipment	Red
Ancillary spaces	Red
Transition to Liquid Cooling	Red
Structural and Seismic	Red
Fire Protection & Suppression	Red

ITE Design Considerations	
ITE Heat & Airflow Reporting	Green
ITE Components	Green
<i>Thermal Resistance</i>	Green
ITE Power Trends	Red
ITE Reliability	Yellow
ITE Air-cooling	Red
ITE Liquid-cooling	Green
<i>ITE Liquid-cooling Adoption</i>	Green
<i>Trends of TCS Classifications for ITE</i>	Green
ITE Conductive Cooling	Green
Cold Plates	Green
ITE Hoses	Green
Quick Disconnect Couplings	Green
ITE Immersion Cooling	Green

Energy Efficiency	
Standards	Red
Best Practices	Red
Sustainability & Decarbonization	Red
Modeling	Red
Energy modeling	Red
CFD modeling	Red
Metrics (PUE, WUE)	Red

Environmental Guidelines	
Thermal Guidelines (temperature & humidity)	Green
Air-cooling Thermal Guidelines (Recommended & Allowable)	Green
<i>5th Edition Tables in I-P Units</i>	Green
<i>5th Edition Psychrometrics Charts</i>	Green
History of Expanding the Recommended Envelope	Green
Technology Cooling System Supply Temperature Classes (S-Classes)	Green
Facility Water System Supply Temperature Classes (W-Classes)	Green
Relationship Between TCS and FWS Classes	Green
Fluid quality considerations	Green
<i>Characteristics of Immersion-cooling Liquids</i>	Green
Liquid filtration	Green
Wetted materials	Green
Particulate & gaseous contamination (air)	Green
Air filtration	Green
Acoustics	Green
Personnel Thermal Safety	Green
Electrostatic Discharge (ESD)	Green

Cooling Technologies	
Air-cooling	Green
Air distribution	Green
Aisle Containment	Green
Liquid-cooling	Green
Liquid distribution	Green
<i>Piping Arrangements for the Cooling Plant</i>	Green
<i>External CDU Piping Considerations</i>	Green
Cooling Equipment	Green
<i>Approach Temperature</i>	Green
Coolant Distribution Unit	Yellow
Close-Coupled Cooling	Green
Economizers & Free Cooling	Green

Everything Else	
Controls	Yellow
Commissioning	Orange

- Topics is **Red** need owners

Workshop #2: Editing Remaining Encyclopedia

- Seeking volunteers to help edit the remaining content to convert it into a Wikipedia style format
- **Completing this task at the Monday meeting** is the only way to get this fully published by the end of the year
- The content from three books (Thermal Guidelines, Best Practices, Liquid Cooling) has been consolidated into topic; however, it has not been edited
- You **do not need to be a SME** to help edit a topic
 - You will not be adding or changing any of the content.
 - We need to edit the content so that it reads as a cohesive topic
- Expected commitment is 30 minutes – 2 hours depending on the topic

Workshop #2

- **Task #1:** Read the existing content and rearrange into a readable format
- **Task #2:** Determine if the topic should be further broken up into additional topics. Topics should be substantial. **Share these topics with Dustin prior to editing.**
- **Task #3:** Edit the content following the guidance on the following charts
- **Task #4:** Provide the edited document(s) to Dustin

If you'd like to volunteer, scan the QR code and complete the form.

Complete instructions will be provided during the workshop on Monday



Other Discussions

- Monday June 23, 2025 9:00 am – 11:30 am MST
- Location: Sheraton Phoenix Downtown, Maryvale A (Level 2)

MS Teams: [Join the meeting now](#)

Meeting ID: 280 351 670 555 7

Passcode: hd7we98g

Topic	Presenter	Duration (min)
Announcements	Dustin Demetriou	5
Datacom encyclopedia updates <ul style="list-style-type: none"> • CDU technical alert • S-class update • Beta of Encyclopedia V2 	Dustin Demetriou	5
Research <ul style="list-style-type: none"> • Sea salt corrosion • Liquid cooling resiliency 	Roger Schmidt Tom Davidson	10
DZR Brass compatibility with PG25	Sankar Padhmanabhan	10
OCP presentation on fluid guidelines	TBD	15
Discussion <ul style="list-style-type: none"> • Filtration requirements on the TCS 	All	10
Discussion <ul style="list-style-type: none"> • FWS water quality 	All	10
Working Session(s) <ul style="list-style-type: none"> • S-Class case studies • Fluid velocity erosion 	All	30

Monday, June 23, 2025

TC 9.9 Main Meeting, IT & Publications Workshops

1:30 PM – 6:00 PM MST

Location: Phoenix Convention Center North Building,
232ABC (Level 2)

Thank You

TC 9.9 Website:
tc0909.ashraetcs.org

- Meeting Minutes
- Dave Quirk TCS Presentation
- Proposal from SSPC 90.4 for adding a 90.4 User Manual to to the data center Encyclopedia

- Summer 2024
- Winter 2025

Produce a more comprehensive guide to design, construction, fill/flush, commissioning, & operation of TCS systems for the 9.9 committee review and publication as a technical bulletin / whitepaper. The consortium contributors included: NVIDIA, Nalco, Legence, Southland, and DLB Associates (we'll confirm as part of publication).

The fourth version of ANSI/ASHRAE Standard 90.4 “*Energy Standard for Data Centers*” will be published this year. It can now be considered a mature Standard, not only referenced in ANSI/ASHRAE 90.1, but being adopted as Code by States as well as Internationally.

There has been discussion about developing a User Manual for this Standard, but the Committee thinks a better way would be to make an addition to the TC 9.9 *Data Center Encyclopedia* covering its use and application. This would lead users to the entirety of TC 9.9 publications at the same time as it provides the information now being requested by users.

As such, SSPC 90.4 is proposing that a chapter be written for the *Data Center Encyclopedia* fulfilling this requirement. We envision that it would be similar in purpose and content to an existing book in the Telecom series; “*PUE™ – An Comprehensive Examination of the Metric*”.

Development of the text for this undertaking will be entirely by members of SSPC 90.4. The following members have already volunteered to participate in the writing:

Robert E. McFarlane

Chris Larry

Terry Rogers

Rick Zbin

Mukul Anand