

# Your Guide to the Annual Conference

June 22–26, 2013

Personal Program.....	2	Scheduled Events.....	22
Hotel Floor Plan.....	4	General Tours.....	24
Future ASHRAE Conferences .....	8	Technical Tours .....	25
Chapter and Society Officials .....	9	ASHRAE Learning Institute Courses.....	26
General Information .....	10	Standing Committee Chairs .....	28
Lost and Found.....	10	Types of Sessions.....	29
How to Find Your Meeting Room .....	12	Technical Program Schedule .....	30
16th Street Shuttle Schedule .....	13	Sunday.....	30
Spouse/Guest Guide .....	14	Monday.....	37
Past and Future Meetings .....	14	Tuesday .....	41
Welcome Party Information.....	15	Wednesday.....	47
President's Luncheon Information .....	15	Society Committee Meetings.....	53
Members' Night Out Information .....	15	What is a Technical Committee?.....	59
10 Things to Know About Denver .....	16	Technical Committee Meetings.....	60
Denver Rescue Mission Project.....	17	ASHRAE Staff .....	73
Nearby Restaurants .....	18	Speaker Listing.....	74
Awards Presentation.....	19		

## ASHRAE EVENTS APP

Find 2013 Annual Conference sessions by name, location, speaker or description; access education courses and social events with the touch of a button; have maps and floorplans in hand to find your way around; add sessions to your personal schedule and create a one-touch custom agenda of events; receive instant updates on time or location changes and more through ASHRAE Announcements, all on your smartphone or tablet. This app, available in the iTunes App Store and Google Play Store, serves as a digital version of Your Guide to the ASHRAE Annual Conference and functions as a one-stop shop for all of your program-related needs. The app is made possible through support from Premium Sponsor Taco and Gold Sponsors AHRI, Systemair and Munters.



Get the free mobile app at  
<http://gettag.mobi>

**PERSONAL PROGRAM—PLAN YOUR OWN MEETING SCHEDULE!**

FRIDAY, JUNE 21	SATURDAY, JUNE 22	SUNDAY, JUNE 23
8:00 am–12:00 noon	8:00 am–12:00 noon	8:00 am–9:00 am
1:00 pm–5:00 pm	8:00 am–3:00 pm	9:45 am–10:45 am
5:00 pm–10:00 pm	1:00 pm–3:00 pm	11:00 am–12:30 pm
	<b>3:15 pm–5:00 pm</b> <b>Plenary Session</b> Denver Sheraton Grand Ballroom	1:30 pm–3:00 pm
		3:15 pm–5:45 pm
	<b>6:30 pm–8:30 pm</b> <b>Welcome Party</b> Denver Art Museum	3:00 pm–5:00 pm <hr/> 5:00 pm–7:00 pm

**NOTES:**

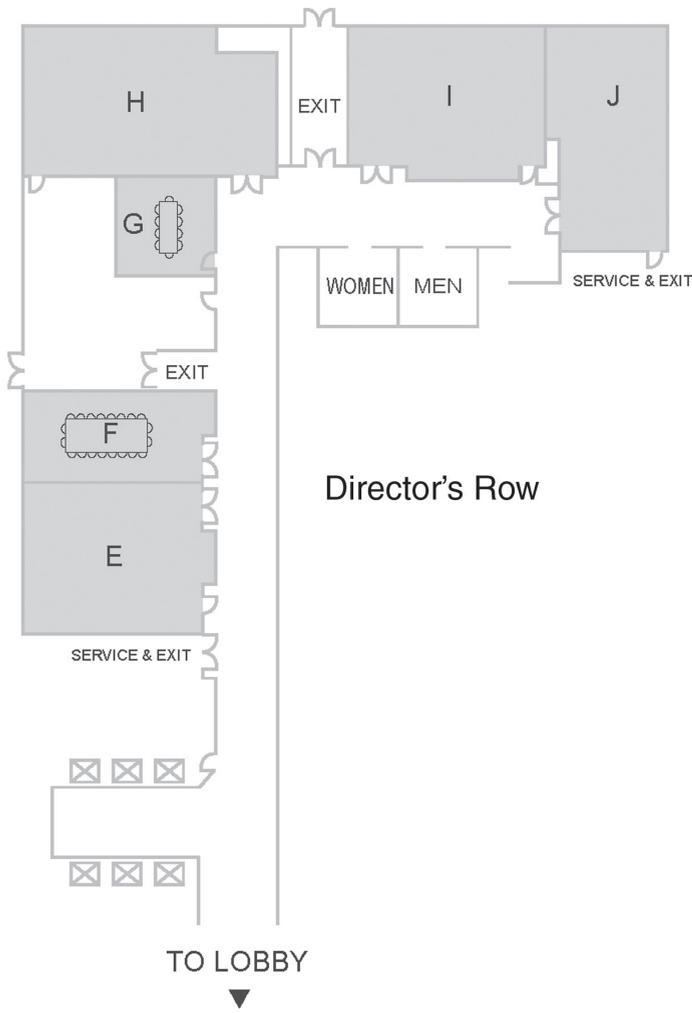
**PLAN YOUR OWN MEETING SCHEDULE!—PERSONAL PROGRAM**

<b>MONDAY, JUNE 24</b>	<b>TUESDAY, JUNE 25</b>	<b>WEDNESDAY, JUNE 26</b>
8:00 am–9:30 am	8:00 am–9:30 am	8:00 am–9:30 am
9:45 am–10:45 am	9:45 am–10:45 am	9:45 am–10:45 am
11:00 am–12:00 noon	11:00 pm–12:30 pm	11:00 am–12:30 pm
<b>12:15 pm–2:00 pm</b> <b>President’s Luncheon</b> Denver Sheraton Grand Ballroom	1:00 pm–3:30 pm	1:00 pm–5:00 pm
2:15 pm–4:15 pm	3:30 pm–6:00 pm	
4:15 pm–6:30 pm	<b>6:15 pm–10:30 pm</b> <b>Members’ Night Out</b> Denver Sheraton Grand Ballroom	

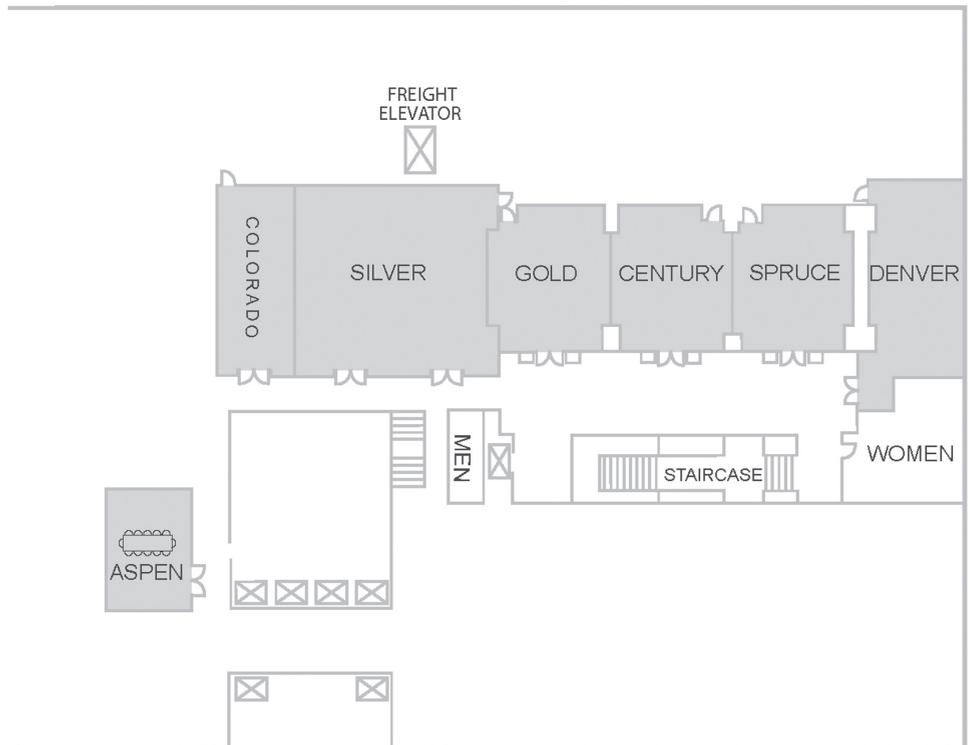
# SHERATON DENVER DOWNTOWN PLAZA BUILDING CONCOURSE LEVEL



# SHERATON DENVER DOWNTOWN PLAZA BUILDING LOBBY/STREET LEVEL

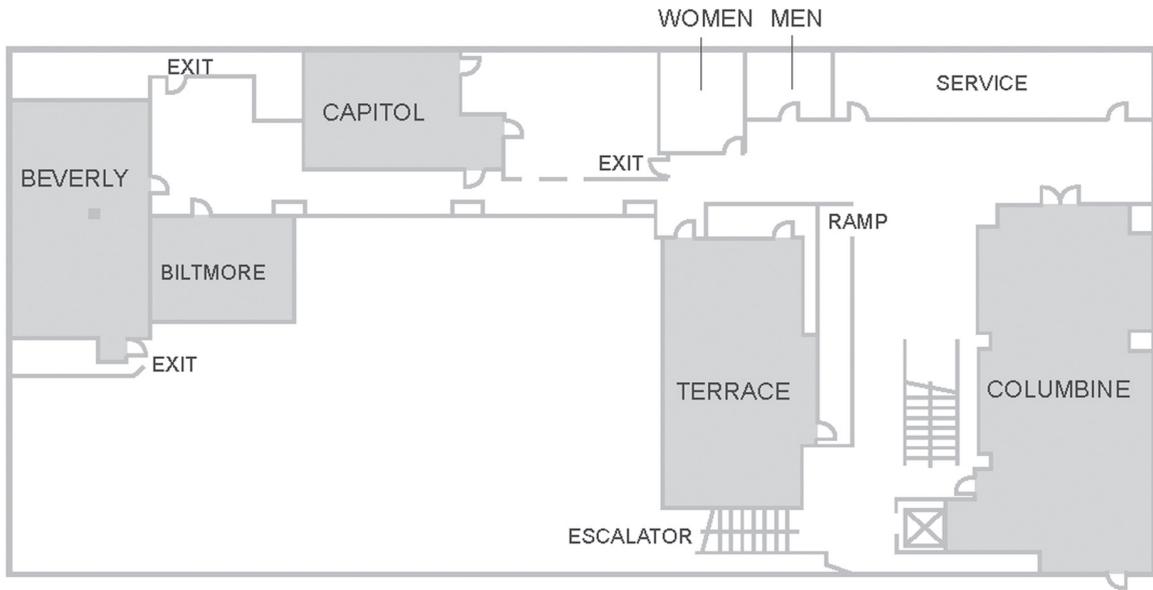


# TOWER BUILDING MEZZANINE LEVEL

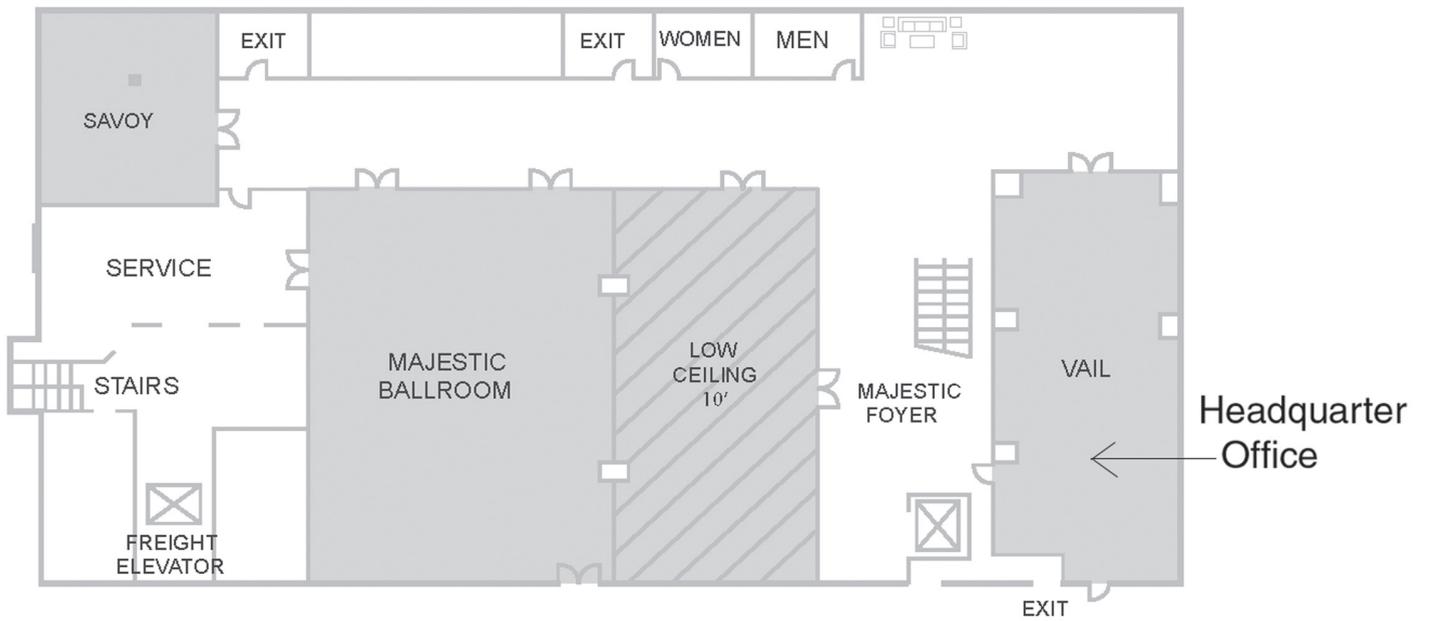




# SHERATON DENVER DOWNTOWN TOWER BUILDING TERRACE LEVEL



# TOWER BUILDING MAJESTIC LEVEL



## ASHRAE CONFERENCE SCHEDULE

ASHRAE's conference schedule for 2013-2014 stretches globally while also specializing with some specific regional focus. The topics range from high performance buildings to buildings that have combustion with low-grade fuels. ASHRAE conferences present the latest developments in the industry and fundamental, tried and true practices. Mark your calendars now so you don't miss out on these ASHRAE conferences that help to shape tomorrow's built environment today!

These conferences feature peer-reviewed papers, presentations with hands-on information presented in a non-commercial format, Professional Development Hours and networking opportunities.

**Oct. 15-18, 2013** – ASHRAE IAQ 2013: Environmental Health in Low Energy Buildings, Vancouver, British Columbia, Canada | [www.ashrae.org/iaq2013](http://www.ashrae.org/iaq2013)

IAQ 2013 reviews the state of knowledge of the balance of environmental health and energy efficiency in buildings and helps define future education, policy and research directions. The roles of building, HVAC and passive system design and operation for achieving good environmental health in low energy buildings (both new and retrofit) are the core theme of this conference.

**Co-organizer:** ISIAQ – [www.isiaq.org](http://www.isiaq.org)

**Jan. 18-22, 2014** – 2014 ASHRAE Winter Conference, New York, New York | [www.ahrexpo.com](http://www.ahrexpo.com) | [www.ashrae.org/newyork](http://www.ashrae.org/newyork)

What better city than New York for ASHRAE to host a Winter Conference with a Technical Program focused on buildings? The conference has a building-oriented theme with papers and presentations related to building information systems; environmental health; international design; HVAC&R applications and systems; and, of course, tall building performance. Make plans to join ASHRAE in New York as the Society strives to reach new heights in sustainability, professional development and built environment technology.

**Feb. 24-26, 2014** – First International Conference on Energy and Indoor Environment for Hot Climates, Doha, Qatar | [www.ashrae.org/hotclimates](http://www.ashrae.org/hotclimates)

This conference is the first to tackle energy and indoor environmental quality issues in humid and arid hot climates, providing a forum for discussion of the latest research and developments. Consulting engineers, building owners, industry manufacturers, environmental organizations, researchers, scientists and all interested professionals are invited to present and participate.

**Co-Sponsors:** AHRI – [www.ahrinet.org](http://www.ahrinet.org)  
IAPMO – [www.iapmo.org](http://www.iapmo.org)

**Organized by:** ASHRAE Qatar Chapter – [www.ashraeqatar.com](http://www.ashraeqatar.com)  
Qatar Environment and Energy – [www.qeeri.org.qa](http://www.qeeri.org.qa)

**Endorsed by:** CIBSE – [www.cibse.org](http://www.cibse.org)  
UNEP – [www.unep.org](http://www.unep.org)

**Feb. 26-28, 2014** – 49th AiCARR International Conference, Historical and Existing Buildings: Designing and Retrofit, Rome, Italy | [www.aicarr.org](http://www.aicarr.org)

The conference is devoted to providing a deep overview on the retrofit design of the historical and existing buildings. The theme is related to the energy performance, indoor air quality energy sustainability and to innovations in buildings and systems. The conference aims to address the systems and equipment applicable today in existing buildings and to improve energy performance, indoor environmental quality and sustainability.

**Endorsed by:** ASHRAE – [www.ashrae.org](http://www.ashrae.org)

**April 6-8, 2014** – High Performance Buildings Conference, San Francisco, Calif.

Building upon its 2012 High Performance Buildings Conference and 2009 Net Zero Conference, ASHRAE seeks to advance the industry's efforts to change the energy-use aspects of the built environment through its 2014 Conference. The tracks include building performance modeling, envelope strategies, lighting/daylighting strategies, indoor environmental quality strategies, building occupant behavior, market value, new building technologies and case studies and lessons learned.

**April 24-25, 2014** – Efficient, High Performance Buildings for Developing Economies, Manila, Philippines

The design, construction and operation of energy efficient, high performance buildings in developing economies have been identified by the building industry and policymakers as a key area where technology, standards and investments are needed. The conference will address a number of themes on this topic.

**Organized by:** ASHRAE – Philippines Chapter

**Co-Sponsor:** AHRI – [www.ahrinet.org](http://www.ahrinet.org)

**Endorsed by:** IAPMO – [www.iapmo.org](http://www.iapmo.org)

**June 28-July 2, 2014** – 2014 ASHRAE Annual Conference Seattle, Wash. | [www.ashrae.org/seattle](http://www.ashrae.org/seattle)

ASHRAE visits Seattle, known as a city that eats, breathes and acts green. The Conference addresses broad topics in the application of technology to practice, specific applications in ground source heat pumps, operations and maintenance and indoor environmental quality as well as new reports on research taking place worldwide.

Experience an  
**ASHRAE conference**  
first-hand!

[www.ashrae.org/events](http://www.ashrae.org/events)

## CONFERENCE SPONSORS

ASHRAE thanks the following sponsor for their support of the 2013 Annual Conference



## CHAPTER AND SOCIETY OFFICIALS

*A special thanks to all the members in the Rocky Mountain Chapter who helped make the conference a success!*

### ROCKY MOUNTAIN CHAPTER OFFICERS

Michelle Swanson, *President*  
Jon Rundquist, *President-Elect*  
Jessie Jones, *Vice President*  
Michael Harrington, *Secretary*

### DENVER HOST COMMITTEE

Dave Olson, *General Chairman*  
Sheila Hayter, *Vice Chairman*  
Kevin and Aimee Ainsworth, *Entertainment*  
David Rodenberg, *Sessions*  
Dave Baumann, *Hospitality*  
Rachael Romero, *Tours*  
Celeste Cizik, *Sustainability*  
Michael Brandemuehl, *Information/Publicity*

### ASHRAE OFFICERS

Thomas E. Watson, P.E., *President*  
William P. Bahnfleth, Ph.D., P.E., *President-Elect*  
Thomas H. Phoenix, P.E., *Treasurer*  
Constantinos A. Balaras, Ph.D., P.E., *Vice President*  
Daniel C. Pettway, *Vice President*  
Timothy G. Wentz, P.E., *Vice President*  
Thomas E. Werkema, *Vice President*  
Jeff H. Littleton, *Executive Vice President*

### CONFERENCES AND EXPOSITIONS COMMITTEE

Ben A. Leppard, *Chair*  
Monte G. Troutman, *Vice Chair*  
Pamela L. Androff  
Walid Chakroun  
David E. Claridge  
Douglas C. Cochrane  
Jon J. Cohen  
Wade H. Conlan  
K. William Dean  
Daniel E. Fisher  
Kevin B. Gallen  
Charles E. Henck  
Mohammad H. Hosni  
Yunho Hwang  
Thomas H. Kuehn  
Dunstan L. Macauley III  
Sarah E. Maston,  
*Denver Conference Program Chair*  
Michael J. McDermott  
Keith C. Newcomer  
Robert B. Risley  
Steven L. Rosen  
Jeffrey D. Spitler  
Samir R. Traboulsi  
T. David Underwood  
Brandt H. Williams  
A. Damon Gowan

## GENERAL INFORMATION

### BADGES MUST BE WORN FOR ADMISSION TO SESSIONS

Your ASHRAE Conference badge is required for admission to the technical program. Room monitors will be checking and scanning badges at the rooms. The scanning process will provide you with a summary of all sessions attended at the conclusion of the conference and will be sent directly to you by email. The room monitors will also distribute evaluation forms for each session. Please complete the form and return it to the monitor when you leave the session. Room monitors will also distribute and collect comment cards on which attendees are encouraged to submit written questions regarding papers presented in the technical paper sessions. Questions are given to the authors for reply and published in ASHRAE Transactions.

### HOTEL ADDRESS, TELEPHONE

**Denver Sheraton**  
1150 Court Place  
Denver, CO 80202  
303-893-3333

### INTERNET ACCESS

Internet access for e-mail is available in the Cyber Café located in the registration area during operating hours. Please be considerate to others and limit your usage to five minutes.

Internet is also available complimentary in your sleeping room in the Sheraton.

### MEMBERSHIP BALLOT

Eligible Members will have the opportunity to cast online ballots for Society officers in the meeting registration area (Denver Sheraton, Plaza Exhibit/Foyer, Plaza Building, Concourse Level). Polls will be open during registration hours on Friday, June 21 through Sunday, June 23 at 3:00 p.m. MDT (5:00 p.m. EDT). New Officers and Directors will be installed at the President's Luncheon on Monday, June 24.

### NOTICE

ASHRAE regards the materials presented at these sessions to be the unique work of ASHRAE and exercises control over the dissemination and/or use of such products in the future. Accordingly, videotaping and recording of this program are not allowed without ASHRAE's prior written consent.

### CELL PHONES/PAGERS

Please be considerate and turn off your phones and pagers in committee meetings and in technical program sessions.

### COMPANY-SPONSORED HOSPITALITY SUITE POLICY

Hospitality suite hours must not conflict with ASHRAE meetings or social functions. Product displays, literature handouts, posting of signs in hotel lobbies or hallways, and commercial advertising or recruiting are not allowed in the Denver Sheraton, ASHRAE's headquarters hotel.

### SALE OF MERCHANDISE

Sale of merchandise, or the solicitation to sell merchandise, of any type at the Annual and Winter Conferences will only be permitted by prior approval of the Conferences and Expositions Committee and any surplus will go to the Society.

### SIGNS/DISPLAY OF AFFILIATE MEETING INFORMATION

Signs and information concerning affiliate or related organizations must be approved by the Society prior to display. No signs are to be attached to walls, and all signs must be professionally printed.

### PHOTO RELEASE

Photographs will be taken at the ASHRAE Annual Conference. By registering for this conference, you agree to allow ASHRAE to use your photo in any ASHRAE-related publications or Web site.

### WHAT TO WEAR

Business casual attire is appropriate for meetings and social events. For Members' Night Out, sport coat and sport shirt. The Welcome Party is casual.

### WEATHER

Average June temperatures  
Average June high: 66.9° F (19.4° C)  
Average June low: 58.6° F (14.8° C)

### LOST AND FOUND

Items found during the conference should be turned into the staff in the ASHRAE headquarters room, Vail (Tower Building, Terrace Level) or ASHRAE registration in the Plaza Exhibit/Foyer. If you have misplaced something during the conference please check these two locations as well as security with the hotel and convention center.

### TECHNICAL PROGRAM PDHs

All of the sessions presented in the technical program are approved for professional development hours (PDHs). All sessions qualify for State of Florida PDHs. In order to report your attendance at the session, please sign the PDH sign-in sheets that are in each room and include your license number for Florida. In addition, most sessions are approved for State of New York PDHs, AIA Learning Units and GBCI LEED AP credits. See program listing for specific information. Sessions are approved for 1, 1.5 or 2 PDHs depending on the length of the session. Certain sessions may be acceptable for ASHRAE certification renewal. Send questions to [certification@ashrae.org](mailto:certification@ashrae.org).

Badges are required for attendance at any of the technical sessions. Scanners will be used to capture the information located on your badge. Upon conclusion of the conference you will be able to get a complete record of all the sessions you attended.

## MEETING PAPERS

Abstracts of all sessions are included in this program. During the conference, papers presented at the technical paper and conference paper sessions can be purchased in the ASHRAE Bookstore. After the conference, papers will be posted in the online ASHRAE Bookstore. Papers are not available for seminars or forums. Technical paper session papers will be published with discussion in ASHRAE Transactions. Prior meeting papers can be purchased in the online Bookstore at [www.ASHRAE.org](http://www.ASHRAE.org) or searched online in Abstract Center. The Abstract Center is a searchable database of abstracts on everything ASHRAE has published since 1980. This service is free to ASHRAE members, but a subscription fee will be charged to nonmembers. For ordering information, contact ASHRAE Customer Service at 1-800-527-4723.

## VIRTUAL CONFERENCE

### *Free for Paid Conference Registrants*

ASHRAE is offering a virtual conference option so you won't miss the state-of-the-art concepts and latest design techniques presented in the Society's technical program. The Denver Virtual Conference allows you to view presentations and to interact with an online audience through a discussion board. All conference attendees paying the full registration fee will receive an email notification when sessions are available for viewing. The email will include a link to the Denver Virtual Conference. If you do not have your password go to [www.ashrae.org/denvervirtual](http://www.ashrae.org/denvervirtual) and click on the link to access the Virtual Conference and put in your email address to request your password.

Virtual Conference registration includes:

- Synced audio and PowerPoint presentations from all technical paper sessions, conference paper sessions and seminars.
- Ability to post comments and rate presentations.
- Print presentation slides in notes format.

Ability to post questions or answers for selected sessions through Wednesday, July 10. Presentations available online through January 2015.

A full slate of technical programs will be posted beginning Monday, June 24, of the sessions that were presented the previous day, with additional content posted through Thursday, June 27.

Access to the Denver Virtual Conference is free with your paid conference registration. To register only for the Virtual Conference, go to ASHRAE Registration, Plaza Exhibit/Foyer, Plaza Building, Concourse Level.

\$299 ASHRAE member

\$464 non member or register online.

## MEMBERS' NIGHT OUT RESERVED SEATING Sheraton Denver, Grand Ballroom, Tower Level, Second level

Members' Night Out will be in the Sheraton Denver on Tuesday, June 25. If you have purchased a ticket for this event, you will receive an exchange coupon. Take this coupon to the Reserved Seating desk, located in the ASHRAE registration and exchange it for a reserved seat ticket by 2:00 p.m., Monday, June 24. Each table seats ten. A seating chart is available to help in deciding table preference. Seats are available on a first-come, first-served basis. When reserving your seat, please advise us of any special dietary requirements at that time to ensure that we are able to accommodate your requests during the evening.

Detailed information on the entertainment for Members' Night Out is located in this program.

## DENVER SUSTAINABILITY PROJECT

The sustainability footprint program was launched by the Salt Lake City Host Committee at the 2008 Annual Conference.

Those wishing to donate to the Denver sustainability project can do so via online conference registration. Take a moment to stop by and thank the committee for their efforts. A complete description of the project is located in this program.

## MEDICAL EMERGENCY

Hotel emergencies should be directed to the hotel operator. Hotel security is trained in emergency response and can get to the scene of an emergency quickly. The closest hospital is St. Luke's Medical Center, located at 1719 East 19th Avenue.

## notes

---

## ROOMS/HOURS

### FINDING YOUR ASSIGNED MEETING ROOM

To assist you in finding your meeting room at the Annual Conference, please refer to the floor plans located in this program. Meeting space is located in both the Tower and Plaza Building. The buildings connect on either the second floor via a cross walk and underground on the Concourse Level.

### MEETING REGISTRATION

Plaza Exhibit/Foyer, Concourse Level

Registration is required for all meeting participants. Official badges must be worn at all functions and for admission into the technical sessions. ASHRAE meeting registration will be open during the following hours:

Friday, June 21	10:00 a.m. – 5:00 p.m.
Saturday, June 22	7:15 a.m. – 6:00 p.m.
Sunday, June 23	7:00 a.m. – 5:00 p.m.
Monday, June 24	7:30 a.m. – 5:00 p.m.
Tuesday, June 25	7:30 a.m. – 4:30 p.m.
Wednesday, June 26	7:30 a.m. – 10:15 a.m.

### ASHRAE BOOKSTORE

Plaza Exhibit/Foyer, Concourse Level

More than 300 books, meeting papers and other recent publications will be available for purchase in the ASHRAE Bookstore. The bookstore provides HVAC&R technical literature from ASHRAE and other publishers. The ASHRAE Bookstore will be open during the following hours:

Friday, June 21	10:00 a.m. – 5:00 p.m.
Saturday, June 22	7:15 p.m. – 6:00 p.m.
Sunday, June 23	7:00 a.m. – 5:00 p.m.
Monday, June 24	7:30 a.m. – 5:00 p.m.
Tuesday, June 25	7:30 a.m. – 4:30 p.m.
Wednesday, June 26	7:30 a.m. – 1:00 p.m.

ASHRAE's eLearning system, from the ASHRAE Learning Institute, will be demonstrated at the bookstore. Take a hands-on demonstration and learn more about new ways to earn PDHs/CEUs, on demand, online.

### SPEAKER'S LOUNGE

Plaza Ballroom D, Concourse Level

The Speakers' Lounge will be open during the following hours:

Saturday, June 22	1:00 p.m. – 3:00 p.m.
Sunday, June 23	7:00 a.m. – 5:00 p.m.
Monday, June 24	7:00 a.m. – 12:15 p.m. and 1:30 – 5:00 p.m.
Tuesday, June 25	7:00 a.m. – 5:00 p.m.
Wednesday, June 26	7:00 a.m. – 1:00 p.m.

### PRESS ROOM

Plaza Exhibit/Foyer, Concourse Level

The Press Room will be open as follows:

Saturday, June 22	9:00 a.m. – 2:30 p.m.
Sunday, June 23	7:30 a.m. – 5:00 p.m.
Monday, June 24	7:30 a.m. – 11 a.m. and 2:00 p.m. – 4:00 p.m.
Tuesday, June 25	7:30 a.m. – 4:00 p.m.

### MEMBERSHIP DESK

Plaza Exhibit/Foyer, Concourse Level

The membership information desk is available for paying dues, applying for membership, updating membership information and purchasing ASHRAE logo items. This desk is open during the same hours as registration, so feel free to stop by if you have any questions concerning your ASHRAE membership.

### HEADQUARTER OFFICE

Vail, Tower Building Majestic Level

The ASHRAE Headquarter office offers members complimentary copying, services of a typist and access to printers for laptop computers.

Friday, June 21	Noon – 5:00 p.m.
Saturday, June 22	8:00 a.m. – 5:00 p.m.
Sunday, June 23	8:00 a.m. – 5:00 p.m.
Monday, June 24	8:00 a.m. – 5:00 p.m.
Tuesday, June 25	8:00 a.m. – 5:00 p.m.
Wednesday, June 26	8:00 a.m. – 1:00 p.m.

### YEA ACTIVITY

Young Engineers in ASHRAE (YEA) Hospitality Suite  
Tower Building, North Convention Lobby, Second Level  
Attention young professional members age 35 and younger!  
You are invited to visit the YEA Hospitality Suite on Sunday, June 23, from 4:00 p.m. – 7:00 p.m. The suite offers social and networking opportunities and light refreshments will be served.

### ASHRAE LOUNGE

Windows, Tower Building Second Level

The ASHRAE Lounge offers an opportunity to network with friends or stop for a cup of coffee between technical sessions. Coffee will be offered throughout the day and anyone who is registered for the meeting is welcome in the lounge.

The lounge will be open to all registered attendees during the following hours:

Saturday, June 22	7:30 a.m. – 3:00 p.m.
Sunday, June 23	7:30 a.m. – 4:00 p.m.
Monday, June 24	7:30 a.m. – 4:00 p.m.
Tuesday, June 25	7:30 a.m. – 4:00 p.m.
Wednesday, June 26	7:30 a.m. – 1:00 p.m.

## DENVER HOST COMMITTEE DESK

Plaza Exhibit/Foyer, Concourse Level

The Host Committee will have an information desk located near the ASHRAE registration area. General information about the sights of the city will be available and a host committee member will be present to answer questions about Denver. The information desk will be open:

Friday	1:00 p.m. – 3:00 p.m.
Saturday	8:00 a.m. – 3:00 p.m.
Sunday	8:00 a.m. – 3:00 p.m.
Monday	9:00 a.m. – Noon

## NEW YORK 2014 WINTER CONFERENCE INFORMATION

Plaza Exhibit/Foyer, Concourse Level

Information on the upcoming Winter Conference scheduled for January 18–22, 2014 at the New York Hilton in New York, NY will be available in the registration area. AHR Expo dates are January 21–23, 2014 and will be held at the Javits Convention Center.

## 16TH ST. SHUTTLE SCHEDULE

**Experience the sights and sounds of downtown Denver with RTD’s FREE 16th Street MallRide. The shuttle bus is your ride to great restaurants, shops, theatre, galleries, tourist attractions, and businesses up and down the mall.**

Traveling from one end of Denver’s bustling 16th Street Mall to the other, the FREE MallRide runs seven days a week and stops on every block between Civic Center and Union Station. The FREE MallRide starts running at 5:00 am on weekdays, 5:30 am on Saturdays and 6:30 am on Sundays/holidays. Service continues throughout the day with the last complete round-trip every night at 1:06 am.

Approximate minutes until next shuttle

Time	Weekday	Saturday	Sunday	Time	Weekday	Saturday	Sunday
5:00am	6	15	--	3:30pm	1.4	4.5	4.5
5:30am	4.5	15	--	4:00pm	1.5	4.5	4.5
6:00am	3	15	15	4:30pm	1.5	4.5	4.5
6:30am	1.5	15	15	5:00pm	1.5	4.5	4.5
7:00am	1.5	15	15	5:30pm	3	4.5	6
7:30am	1.5	7.5	7.5	6:00pm	3	4.5	6
8:00am	1.5	6	6	6:30pm	3	4.5	7.5
8:30am	3	6	6	7:00pm	4.5	6	7.5
9:00am	4.5	4.5	6	7:30pm	4.5	6	7.5
9:30am	4.5	4.5	6	8:00pm	6	6	7.5
10:00am	3	4.5	6	8:30pm	6	6	7.5
10:30am	3	4.5	6	9:00pm	7.5	7.5	7.5
11:00am	1.5	4.5	4.5	9:30pm	7.5	7.5	7.5
11:30am	1.5	4.5	4.5	10:00pm	7.5	7.5	7.5
Noon	1.5	4.5	4.5	10:30pm	9	7.5	7.5
12:30pm	1.5	4.5	4.5	11:00pm	12	12	12
1:00pm	1.5	4.5	4.5	11:30pm	12	12	12
1:30pm	3	4.5	4.5	Midnight	15	15	15
2:00pm	3	4.5	4.5	12:30am	18	18	18
2:30pm	3	4.5	4.5	1:00am	14	14	14
3:00pm	3	4.5	4.5	1:30am			

*Last complete round-trip every night starts out at 1:21am from Union Station to Civic Center and back.*

Effective April 28, 2013

Note: Actual schedule is based on traffic signal timings, in seconds.

Times shown here are rounded to the longest interval in each half-hour.

Service will be adjusted for special events.

## SPOUSE/GUEST GUIDE

### SATURDAY, JUNE 22

7:30 a.m.-3:00 p.m.

ASHRAE Member Lounge

Denver Sheraton, Windows, Tower Building, Level 2

The ASHRAE Lounge is open daily for all individuals who are registered for the meeting. Refreshments are available from 7:30 to 9:30 a.m. each day and beverages are available all afternoon.

### SUNDAY, JUNE 23

7:30 a.m.-4:00 p.m.

ASHRAE Member Lounge

Denver Sheraton, Windows, Tower Building, Level 2

### MONDAY, JUNE 24

7:30 a.m.-4:00 p.m.

ASHRAE Lounge

Denver Sheraton, Windows, Tower Building, Level 2

### MONDAY, JUNE 24

9:30 a.m.-11:00 a.m.

ASHRAE Lounge

Denver Sheraton, Windows, Tower Building, Level 2

#### Meet and Greet

##### *Cowboy Poetry*

Today you will get the opportunity to hear some cowboy poetry performed by Susie Knight.

A genuine cowgirl who has worked on ranches in Colorado, Wisconsin, Illinois, and South Dakota, Susie has developed a character: "Lasso the Cowgirl". Audiences from pre-schoolers to senior citizens have been caught hootin' and hollerin' during her all-original, knee-slappin', toe-tappin' shows.

Cowboy poetry is rhymed, metered verse written by someone who has lived a significant portion of his or her life in Western North American cattle culture. The verse reflects an intimate knowledge of that way of life, and the community from which it maintains itself in tradition. Cowboy poetry may or may not in fact be anonymous in authorship but must have qualities, content, and style that permit it to be accepted into the repertoire of the cultural community as reflecting that community's aesthetics in style, form, and content. The structural style of cowboy poetry has its antecedents in the ballad style of England and the Appalachian South. It is similar to popular works of authors such as Robert W. Service and Rudyard Kipling.

### TUESDAY, JUNE 25

7:30 a.m.-4:00 p.m.

ASHRAE Lounge

Denver Sheraton, Windows, Tower Building, Level 2

### WEDNESDAY, JUNE 26

7:30 a.m.-1:00 p.m.

ASHRAE Lounge

Denver Sheraton, Windows, Tower Building, Level 2

## FUTURE ASHRAE MEETINGS

Winter	Date	Annual
New York January 18-22	2014	Seattle June 28-July 2
Chicago January 24-28	2015	Atlanta June 27-July 1
Orlando January 23-27	2016	St. Louis June 25-29

## PAST ASHRAE MEETINGS

Los Angeles	1980	Denver
Chicago	1981	Cincinnati
Houston	1982	Toronto
Atlantic City	1983	Washington
Atlanta	1984	Kansas City
Chicago	1985	Honolulu
San Francisco	1986	Portland
New York	1987	Nashville
Dallas	1988	Ottawa
Chicago	1989	Vancouver
Atlanta	1990	St. Louis
New York	1991	Indianapolis
Anaheim	1992	Baltimore
Chicago	1993	Denver
New Orleans	1994	Orlando
Chicago	1995	San Diego
Atlanta	1996	San Antonio
Philadelphia	1997	Boston
San Francisco	1998	Toronto
Chicago	1999	Seattle
Dallas	2000	Minneapolis
Atlanta	2001	Cincinnati
Atlantic City	2002	Honolulu
Chicago	2003	Kansas City
Anaheim	2004	Nashville
Orlando	2005	Denver
Chicago	2006	Quebec City
Dallas	2007	Long Beach
New York	2008	Salt Lake City
Chicago	2009	Louisville
Orlando	2010	Albuquerque
Las Vegas	2011	Montreal
Chicago	2012	San Antonio
Dallas	2013	Denver

## WELCOME PARTY

6:30-8:30 p.m.

Saturday, June 22

Denver Art Museum

Cost: \$57

The Welcome Party takes place at the Denver Art Museum, a half-mile walk from the Sheraton. In addition to several galleries being open, a caricature artist is there to capture the fun!

Exhibits open during the Welcome Party are the Native American and Western collections.

The Denver community has long embraced its western roots, and, as the city's premier visual arts institution, the Denver Art Museum has collected and exhibited western American art for over 50 years. In the early 1950s the first curator of western art was appointed and several masterworks acquired, including Alfred Jacob Miller's "Shoshone Indians at a Mountain Lake."

The Denver Art Museum's American Indian collection allows visitors to experience the artistic vision of generations of American Indian artists from across North America. From ancient puebloan ceramics, to 19th century Arapaho beaded garments, to contemporary glass work, the museum offers a look at the rich diversity of art forms, histories, and artistic styles coming from American Indian artists and communities.

Tickets are required and are available for purchase with registration.

### Walking directions to Denver Art Museum

1. Head **southwest** on **Court Pl** toward **15th St** 0.2 mi
2. Turn left onto **14th St** 331 ft
3. Turn right onto **Bannock St** 0.1 mi
4. Turn left onto **W 14th Ave**  
Destination will be on the right 344 ft

**A small shuttle bus will also be available at the street-level exit by Zoups Restaurant and will run from 6:30-8:30 pm.**

### Denver Art Museum

100 W 14th Ave Pkwy

## PRESIDENT'S LUNCHEON

Noon-2 p.m.

Monday, June 24

Sheraton Denver

Grand Ballroom, Tower Building Second Level

Cost: \$44

2013-14 ASHRAE President William P. "Bill" Bahnfleth, Ph.D., P.E., Fellow ASHRAE, ASME Fellow, presents his presidential theme, Shaping the Next. The theme focuses on embracing our responsibility to "Our World" – fellow humans and the earth, to make buildings safe, healthy, productive, comfortable

## MEMBERS' NIGHT OUT

6:15-7:15 p.m.

Reception

Grand Ballroom Foyer

7:15-10:30 p.m.

Dinner and Entertainment

Grand Ballroom

Tuesday, June 25

Sheraton Denver

Cost: \$52

Paint has never been so exciting to watch dry!

Paint the town at Canvas and Cocktails, an upbeat class for both the artistic and not-so-artistic. Enjoy a glass of wine while instructors guide you in recreating the evening's featured painting. By the end of the night, you will be amazed at the artwork you have created!

There may even be a little friendly competition between regions to see who has the most talent. Whether you consider yourself an artist or not, form teams and watch as the masterpieces come together.

Dress for the evening will be business casual. Aprons will be provided to assist in keeping the paint on the canvas and not you.

Make sure you fill out the raffle ticket you will receive with your badge and turn it in when you exchange your voucher for a reserved seat. Prizes will be given out throughout the evening and, yes, you must be present to win!

environments in harmony with nature. To do this, he believes we must develop "Ourselves" – the human resource of the professional community, and transform "Our Work" – what we do, how we do it, and who we do it with, by becoming more global in outlook, broader in scope, and more collaborative in approach.

Certificates of appreciation to retiring Board members are presented, and the 2013-14 officers and Board of Directors installed. Spouses and guests are invited to attend.

Tickets are required and are available for purchase with registration.

# 10 Things to Know About DENVER

1

Denver is near the mountains, not in them. There are 200 named peaks visible from Denver, including 32 that soar to 13,000 feet (4,000 meters) and above. The mountain panorama visible from Denver is 140 miles (225 km) long.

2

Denver really is exactly one mile high. There is a step on the State Capitol Building that is exactly 5,280 feet (1,609 meters) above sea level. In Denver's rarified air, golf balls go ten percent farther. So do cocktails. Alcoholic drinks pack more of a wallop than at sea level. The sun feels warmer, because you're closer to it, but your coffee is cooler, because water boils at 202 degrees (94 degrees Celsius).

3

Denver has one of the most walkable downtowns in the nation. Denver boasts the 10th largest downtown in America and one of the most exciting and walkable. Within a mile radius, downtown Denver has three major sports stadiums, the nation's second largest performing arts center, three colleges with 30,000 students, an assortment of art and history museums, a mint producing 10 billion coins a year, a river offering white water rafting, more than 8,400 hotel rooms, a \$140 million amusement park, a \$100 million aquarium and 300 restaurants.

4

Denver has 300 days of sunshine a year. Located east of a major mountain range, Denver has a mild, dry and sunny climate with more annual hours of sun than San Diego or Miami Beach. In winter, Denver is dryer than Phoenix with an average daily high of 45 degrees (7 degrees Celsius) in February. Golf courses remain open all year and have been played as many as 30 days in January.

5

Denver's history is short, but colorful. In 1858, there was not a single person living in the Denver metro area. Thirty years later, Colorado was a state with a population of almost 200,000. It was a Gold Rush that caused this boom, and in a 30 year period Denver saw some of the wildest events in the Wild, Wild West. This fascinating period lives again in museums, old gold mining villages and hundreds of elegant Victorian buildings.

6

Denver has one of the most unique city park systems in the nation. Denver has more than 200 parks within the city and 20,000 acres of parks in the nearby mountains, including spectacular Red Rocks Park & Amphitheatre. The city has its own buffalo herd and every year plants more than 200,000 flowers in 26 formal flower gardens. Other mountain parks include Echo Lake, at the base of the Mount Evans highway – the highest road in North America and Buffalo Bill's Grave on top of Lookout Mountain.

# 7

Denver is a cultural city with the second highest educated population in America. In its Old West days, Denver had a performance of Macbeth before it had a school or a hospital. Today, the Denver Performing Arts Complex has nine theatres seating 10,000 people and is second only to New York's Lincoln Center. The seven county metro area has a self-imposed sales tax for the arts that raises up to \$40 million a year, which is distributed to 300 arts organizations and facilities. Denver's live music scene entertains all year-round, ranging from intimate venues like the Paramount Theatre to legendary open-air spots like Red Rocks Park & Amphitheatre, where the Beatles, U2 and many more have played.

# 8

Denver is one of only a few cities to have seven professional sports teams. Denver loves its sports, from basketball to football to soccer to baseball. Denver also has horse racing and a professional rodeo. Denver has 90 golf courses, 850 miles (1,367 km) of bike paths and the nation's most unique city park system. Visitors can explore the city using B-cycle, Denver's pioneering bike share program. Pick up a bike at one of 56 stations (located near hotels and major attractions), take a ride, and return it at any other station -- all for a small membership fee.

# 9

It's easy being "green" in Denver. From global warming and renewable energy to environmental cleanup, Denver is emerging as a model of a sustainable city. Denver Zoo's new Toyota Elephant Passage will use a biomass gasification system, which can turn human trash and animal waste into energy to power the exhibit. Denver International Airport (DEN) completed its two megawatt solar power system in 2008, a 1.6 megawatt array in 2010 and a 4.4 megawatt solar power system in 2011. In 2006, former Denver Mayor (now Colorado Governor) John Hickenlooper announced The Mile High Million, an ambitious tree-planting program with a goal of adding one million new trees in metropolitan Denver by the year 2025. So far, more than 225,000 new trees have been planted.

# 10

Denver is farm-fresh. Whether you're enjoying a night out on the town at one of Larimer Square's independently owned fine dining spots or digging into the offerings from one of the city's many gourmet food trucks, you can count on fresh, local ingredients. The city's beer world is booming, too, with new craft breweries opening up every month, along with several distilleries and wineries, too! Keep track of Denver's exciting food and drink world at [www.EatDrinkDenver.com](http://www.EatDrinkDenver.com).

## DENVER RESCUE MISSION PROJECT

### Denver Rescue Mission | Lawrence Street Shelter

Rocky Mountain ASHRAE is pleased to welcome everyone to the 2013 Annual Conference. As is custom, the city selected to host the annual conference has a goal to support sustainability. This year Rocky Mountain ASHRAE has committed to overhauling the Denver Rescue Mission's aged and deteriorating systems and replacing them systems to improve efficiency and increase occupant comfort.

The Lawrence Street Shelter is the Denver Rescue Mission's central outreach location. Tens of thousands of poor and needy people come to this facility each year for shelter, food, clothing, medical care, client services, and chapel services. Families and individuals come to their "closet" for everything from warm gloves to business attire for job interviews. Case managers help up to 2,000 individuals each month with needs such as food boxes, baby diapers, furniture, clothing, household goods, and referrals to other agencies. Program participants can receive free medical, dental, optical, and chiropractic treatment at the Mission's clinic.



## LUNCH OPTIONS

### within Walking Distance from Sheraton Downtown Denver Hotel

#### In Hotel

<b>Zoup!</b>	Soup	(In Tower building)
<b>Peet's Coffee &amp; Tea</b>	Coffee	(In Plaza building)
<b>Katie Mullen's</b>	Irish	(In Tower building)
<b>Yard House</b>	American	(In Plaza building)

#### In Republic Plaza Food Court

303 16th St. (Located across the street from hotel, at corner of 16th & Court)

<b>Chick Fil a</b>	Fast Food
<b>Saucy Bombay</b>	Indian
<b>Chinja</b>	Chinese
<b>Tokyo Express</b>	Chinese
<b>Freshii</b>	Wraps/Salads/Soups
<b>Cava Greens</b>	Salads

#### Within 2 Blocks of Hotel

<b>Starbucks Coffee</b>	Coffee	<b>303 16th St</b> (between Tremont and Court)
<b>Pizza Colore Express</b>	Pizza	<b>1647 Court Place</b> (between 16th & 17th)
<b>Jimmy Johns</b>	Sandwiches	<b>110 16th St</b> (between Cleveland & Broadway)
<b>Dazbog Coffee</b>	Coffee	<b>110 16th St</b> (between Cleveland & Broadway)
<b>Quiznos</b>	Subs	<b>216 16th Street</b> (between Court & Cleveland)

#### The Pavillions Mall

500 16th St. (includes two blocks on 16th between Tremont & Welton)

<b>Hard Rock Café</b>	American
<b>Corner Bakery Café</b>	Sandwich/salad
<b>Maggiano's</b>	Italian

#### Two Blocks from Hotel

<b>Earls Kitchen &amp; Bar</b>	Fusion	<b>1600 Glenarm Pl</b> (between 16th & 17th)
<b>Cooks Fresh Market</b>	Market	<b>1600 Glenarm Pl</b> (corner of Glenarm & 16th St)
<b>Marlowe's</b>	Steak	<b>501 16th St</b> (corner of Glenarm & 16th St)

#### Two to Four Blocks from Hotel

<b>Johnny Rocket's</b>	American	<b>401 16th St</b>
<b>Subway</b>	Subs	<b>409 16th St</b> (between Tremont and Glenarm)
<b>Bayou Bob's</b>	Cajun/Southern	<b>1635 Glenarm</b> (between 16th & 17th)
<b>Trinity Grille</b>	American	<b>1801 Broadway</b> (corner of 18th & Broadway)
<b>An's Lemongrass Grill</b>	Asian	<b>1617 California</b> (between 16th & 17th)
<b>Paramount Café</b>	American	<b>519 16th St</b> (between Glenarm & Welton)
<b>Appaloosa Grill</b>	American	<b>535 16th St</b> (between Glenarm & Welton)

## AWARDS PRESENTATION

Saturday, June 22, 3:15-5:30 p.m.  
Plenary Session, Grand Ballroom

### LINCOLN BOUILLON AWARD

*“Given in recognition of outstanding work in increasing the membership of the Society.”*

**George M. Waters, Sr.**, Buffalo, NY  
Niagara Frontier Chapter

### CHAPTER PROGRAM STAR AWARD

*“Given in recognition of excellence in chapter program endeavors.”*

**Eric M. Fullerton**, P.E., ASHRAE-Certified Healthcare Facility Design Professional, Little Rock, AR Arkansas Chapter

### DAN MILLS TECHNICAL AWARD

*“Given to the Chapter CTTC Member who excels in meeting CTT goals in technical, energy and government activities.”*

**Eric M. Fullerton**, P.E., ASHRAE-Certified Healthcare Facility Design Professional, Little Rock, AR Arkansas Chapter

### WILLIAM J. COLLINS, JR., RESEARCH PROMOTION AWARD

*“Given in recognition of the chapter RP Chair who excels in all activities supporting the campaign, including raising funds for all Society programs and promoting research at the chapter level”*

**Christopher M. Donovan**, ASHRAE-Certified High-Performance Building Design Professional, Houston, TX  
Houston Chapter

### LOU FLAGG HISTORICAL AWARD

*“Given in recognition for preparing the most outstanding historical presentation related to HVAC&R.”*

**Alexander Weiss**, P.E., Brooklyn, NY

### STANDARDS ACHIEVEMENT AWARD

*“Given in recognition for excellence in volunteer service for developing ASHRAE standards/ guidelines.”*

**Martha G. VanGeem**, P.E., Mount Prospect, IL

### RALPH G. NEVINS PHYSIOLOGY AND HUMAN ENVIRONMENT AWARD

*“Given to a member under 40 years of age in recognition for significant accomplishment in the study of physiology and human response to the environment.”*

**Stefano Schiavon**, Ph.D., P.E., Berkely, CA

### HOMER ADDAMS AWARD

*“Given in recognition of a graduate student working on an ASHRAE research project to advance engineering education.”*

**Ricardo J. Da Silva Lima**, Ph.D., Versoix, Switzerland

### ENVIRONMENTAL HEALTH AWARD

*“Given in recognition of excellence in volunteer service focused on environmental health issues”*

**Lawrence J. Schoen**, P.E., Fellow ASHRAE, Columbia, MD

### STUDENT ACTIVITIES ACHIEVEMENT AWARD

*“Given to a Chapter Student Activities Chairman for service related to the goals and growth of student activities at all levels.”*

**Ather N. Siddiqui**, I, Islamabad, Pakistan

### 2012 TECHNICAL PAPER AWARD

*“Given in recognition of the best paper presented at a Technical Paper Session at a Society Meeting in 2012”*

**John A. Bryant**, Ph.D., P.E., College Station, TX, **Michael A. Davis**, Ph.D., New York, NY and **Dennis L. O’Neal**, Ph.D., P.E., ASHRAE Fellow, Hewitt, TX for authoring “Modeling the Performance of ECM and SCR Parallel Fan-Powered Terminal Units in Single-Duct VAV Systems”

**John A. Bryant**, Ph.D., P.E., College Station, TX, **Michael A. Davis**, Ph.D., and **Dennis L. O’Neal**, Ph.D., P.E., Fellow ASHRAE, Hewitt, TX for authoring “Modeling the Performance of ECM and SCR Series Fan-Powered Terminal Units in Single-Duct VAV Systems”

**Ananth N. Nalla**, Stoughton, WI and **Stephen A. Idem**, Ph.D., Cookeville, TN for authoring “Laboratory Testing of Saddle-Tap Tees to Determine Loss Coefficients”

**Farhad Memarzadeh**, Ph.D., P.E., Bethesda, MD, for authoring “Literature Review of the Effect of Temperature and Humidity on Viruses”

### WILLIS H. CARRIER AWARD

*“Given in recognition of the best paper presented at a Society Meeting in 2012 by a member thirty-two years of age or less.”*

**Daniel C. Gibbs**, P.E., Nashville, TN for authoring “Measurements of Flat Oval Diverging-Flow Fitting Loss Coefficients”

### POSTER PRESENTATION AWARD

*“Given in recognition of the best Poster Presentation at each Winter and Annual meeting in 2012.”*

**Lorenzo Cremaschi**, Ph.D., Stillwater, OK, **Shanshan Cai**, Stillwater, OK, **Kasey W. Worthington**, Jenks, OK and **Afshin Ghajar**, Ph.D., P.E., Stillwater, OK for authoring “Measurements of Pipe Insulation Thermal Conductivity at Below Ambient Temperature Part I: Experimental Methodology and Dry Tests”

### ASHRAE JOURNAL PAPER AWARD

*“Given in recognition of the best paper published in the ASHRAE Journal in 2012.”*

**John A. Murphy**, La Crosse, WI  
Wisconsin Chapter

“Total Energy Wheel Control in a Dedicated OA System (March 2012)”

– Continued on next page –

## (AWARDS PRESENTATION, CONT.)

### CROSBY FIELD AWARD

*“Given in recognition of the best paper published by the Society in 2012 with the winner being chosen from the best Transactions and Poster papers.”*

**John A. Bryant**, Ph.D., P.E., College Station, TX, **Michael A. Davis**, Ph.D., New York, NY, and **Dennis L. O’Neal**, Ph.D., P.E., Fellow ASHRAE, Hewitt, TX for authoring “Modeling the Performance of ECM and SCR Parallel Fan-Powered Terminal Units in Single-Duct VAV Systems”

### DISTINGUISHED FIFTY-YEAR MEMBER AWARD

*“Given in recognition of fifty years of membership and distinction in the arts and sciences of heating, refrigeration, air conditioning and ventilation.”*

**Arthur H. Bennett**, P.E., Fellow ASHRAE, Life Member, Athens, GA

**Walter P. Bishop**, P.E., Fellow ASHRAE, Life Member, Long Island City, NY

**Laurence K. Brink**, Life Member, Arcadia, CA, *Award presented posthumously*

**Floyd L. Brown**, P.E., Fellow ASHRAE, Life Member, Charleston, IL

**Ronald J. Caffrey**, Life Member, St. Petersburg, FL

**Waller S. Clements**, P.E., Life Member, Evansville, IL

**Thomas A. Gilbertson**, P.E., Fellow ASHRAE, Life Member, Moraga, CA

**Donald L. Glaser**, P.E., Fellow ASHRAE, Life Member, Fort Myers, FL

**Robert R. Jones**, P.E., Fellow ASHRAE, Life Member, Winchester, VA

**James D. McFall**, P.E., Fellow ASHRAE, Life Member, Littleton, CO

**James L. Newman**, Life Member, ASHRAE-Certified Operations and Performance Management Professional and Building Energy Assessment Professional, Bloomfield Hills, MI

**Verle A. Williams**, P.E., Fellow ASHRAE, Life Member, ASHRAE-Certified Commissioning Process Management Professional, Escondido, CA

**James E. Woods**, Ph.D., P.E., Fellow ASHRAE, Life Member, Charlottesville, VA

### DISTINGUISHED SERVICE AWARD

*“Given in recognition of faithful and distinguished service on behalf of the Society.”*

**Douglass S. Abramson**, Chapin, SC

**Bruce E. Anderson**, Onalaska, WI

**Joseph R. Anderson**, P.E., Germantown, TN

**David Arnold**, Ph.D., FREng, Fellow ASHRAE, Life Member, Reading, EN, United Kingdom

**George W. Austin, Jr.**, P.E., ASHRAE-Certified High-Performance Building Design Professional, Building Energy Assessment Professional, Building Energy Modeling Professional, Commissioning Process Management Professional, Operations and Performance Management Professional, and Healthcare Facility Design Professional, Waxhaw, NC

**Ronald B. Bailey**, P.E., Jupiter, FL

**Dieter Bartel**, Winnipeg, MB, Canada

**Richard J. Bowman**, Wichita, KS

**Donald M. Brundage**, P.E., Atlanta, GA

**Paul W. Cabot**, Washington, DC

**Cynthia A. Callaway**, P.E., Long Beach, CA

**John J. Carter**, Ft. Collins, CO

**Richard E. Cawley**, P.E., Fellow ASHRAE, Life Member, Tyler, TX

**Mark E. Case**, P.E., Salt Lake City, UT

**David R. Conover**, Great Fall, VA

**Hugh Crowther**, P. Eng., Glen Williams, ON, Canada

**Charles H. Culp, III**, Ph.D., P.E., Fellow ASHRAE, Life Member, ASHRAE-Certified High-Performance Building Design Professional, College Station, TX

**Charlie D. Curlin, Jr.**, P.E., Charlotte, NC

**Daniel J. Dettmers**, Madison, WI

**James Escamilla**, P.E., Kalamazoo, MI

**Kevin W. Fallin**, P.E., Warrenton, VA

**Donald L. Fenton**, Ph.D., P.E., Manhattan, KS

**Thomas A. Gilbertson**, P.E., Fellow ASHRAE, Life Member, Moraga, CA

**Gerald C. Groff**, Fellow ASHRAE, Life Member, Cazenovia, NY

**Krishnan Gowri**, Ph.D., Bothell, WA

**Traci A. Hanegan**, P.E., ASHRAE-Certified Healthcare Facility Design Professional, Spokane, WA

**Lucas B. Hyman**, P.E., Corona, CA

**Nadar R. Jayaraman**, P.Eng., Ottawa, ON, Canada

**John L. Kuempel, Jr.**, P.E., Cincinnati, OH

**Hal Levin**, Fellow ASHRAE, Santa Cruz, CA

**Robert J. Linder**, P.E., Roseville, MN

**Lawrence C. Markel**, Fellow ASHRAE, Knoxville, TN

**Kevin L. Marple**, Aloha, OR

**Norm Maxwell**, P.E., Life Member, Great Neck, NY

**Michael J. McDermott**, Gurnee, IL

**Robert McDowall**, P. Eng., Life Member, Winnipeg, MB, Canada

**Tim J. McGinn**, P.Eng., ASHRAE-Certified High-Performance Building Design Professional, Calgary, AB, Canada

**Mark P. Modera**, Ph.D., P.E., Fellow ASHRAE, Davis, CA

**Philip J. Naughton**, P.E., Austin, TX

**Bruce I. Nelson**, P.E., Colville, WA

**John H. Nix**, II, Miami, FL

**David R. Olson**, P.E., Niwot, CO

**Chee Sheng Ow**, Ph.D., P.Eng., Fellow ASHRAE, Selangor, Malaysia

**David W. Rasmussen**, Hamilton, ON, Canada

**John A. Rieke**, P.E., Saint Paul, MN

**Harvey M. Sachs**, Ph.D., Washington, DC

**Lawrence J. Schoen**, P.E., Fellow ASHRAE, Columbia, MD

**Randy C. Schrecengost**, P.E., ASHRAE-Certified Building Energy Assessment Professional

**Michael S. Sherber**, P.E., ASHRAE-Certified High-Performance Building Design Professional, Beverly, MA

**Donald A. Siller**, P.E., Life Member, O'Fallon, MO

**Steven R. Szymurski**, Ft. Lauderdale, FL

**T. Minh Tran**, P.E., Spartanburg, SC

**Alan C. Veeck**, Virginia Beach, VA

**Saul V. Villanueva**, P.E., San Jose, CA

**Timothy G. Wentz**, P.E., Fellow ASHRAE, ASHRAE-Certified High-Performance Building Design Professional, Lincoln, NE

**Theresa A. Weston**, Ph.D., Richmond, VA

**Brandt H. Williams**, P.E., Duncan, SC

**Lee D. Woods**, Life Member, Silver Spring, MD,  
*Award presented posthumously*

**J. Richard Wright**, P.E., Fellow ASHRAE, Life Member, Cookeville, TN

**David P. Yuill**, P.E., Omaha, NE

**Jack H. Zarour**, Saratoga, CA

## EXCEPTIONAL SERVICE AWARD

*“Given in recognition of faithful service with exemplary effort on behalf of the Society.”*

**Zahid H. Ayub**, Ph.D., P.E., Fellow ASHRAE, Arlington, TX

**Lee W. Burgett**, P.E., Presidential Member, Fellow ASHRAE, LaCrosse, WI

**Dale E. Carter**, Fellow ASHRAE, Life Member, New Westminster, BC, Canada

**Raymond Cohen**, Ph.D., P.E., Fellow ASHRAE, Life Member, Valparaiso, IN

**Drury B. Crawley**, IV, Ph.D., Fellow ASHRAE, ASHRAE-Certified Building Energy Modeling Professional, Washington, DC

**K. William Dean**, P. Eng., Saskatoon, SK, Canada

**Mohammad H. Hosni**, Ph.D., Fellow ASHRAE, Manhattan, KS

**Yunho Hwang**, Ph.D., College Park, MD

**Ben A. Leppard, Jr.**, P.E., Tucker, GA

**George E. Menzies**, P.Eng., Life Member, Hamilton, ON, Canada

**Richard H. Rooley**, F.Eng., Presidential Member, Fellow ASHRAE, Life Member, ASHRAE-Certified Operations and Performance Management Professional.

**Alberto J. Sanchez**, P.E., Fellow ASHRAE, Life Member, Tampa, FL

**Sitaraman Chandra Sekhar**, Ph.D., Fellow ASHRAE, Singapore

**James K. Vallort**, Chicago, IL

## ANDREW T. BOGGS SERVICE AWARD

*“Given to a past Distinguished Service Award recipient in recognition of continuing, unselfish, dedicated and distinguished service to the Society.”*

**Richard A. Charles**, P.E., Presidential Member, Fellow ASHRAE, Life Member, Oakland, CA  
*Award presented posthumously*

## notes

---

## SCHEDULE

### Location of Meetings

To assist you in finding your meeting room at the Annual Conference, please refer to the floor plans located in the front of this program. Meetings are scheduled in the Sheraton Denver. Meeting space is located in both the Tower and Plaza Building. The buildings connect on either the second floor via a crosswalk and underground on the Concourse Level.

### Meeting Schedule

#### FRIDAY, June 21

- 8:00 am – 5:00 pm **Committee Meetings**  
*See listing on pages 53 – 72*
- 10:00 am – 5:00 pm **Registration, ASHRAE Bookstore**  
Plaza Exhibit/Foyer, Plaza Building,  
Concourse Level

#### SATURDAY, June 22

- 7:30 am – 3:00 pm **ASHRAE Lounge**, Windows,  
Tower Building, Second Level
- 7:15 am – 6:00 pm **Registration, ASHRAE Bookstore**  
Plaza Exhibit/Foyer, Plaza Building,  
Concourse Level
- 9:00 am – 2:30 pm **Press Room**, Plaza Exhibit/Foyer,  
Plaza Building, Concourse Level
- 8:00 am – 5:00 pm **Committee Meetings**  
*See listing on pages 53 – 72*
- 1:00 pm – 3:00 pm **Speakers' Lounge**, Plaza Ballroom D,  
Plaza Building Concourse Level

### Special Event

- 3:15 pm – 5:00 pm **Meeting of the Members,  
Plenary Session**, Sheraton Denver,  
Grand Ballroom, Tower Building  
Second Level
- Opening and Welcoming Remarks by  
ASHRAE President **Thomas Watson**
- Welcome by Director and Chair,  
Region IX, **Richard J. Bowman**
- Secretary's Report by Executive  
Vice President **Jeff H. Littleton**
- Awards Presentation  
*See page 19 for details.*

### Special Event

- 6:30 pm – 8:30 pm **Welcome Party**, Denver Art Museum
- Note:** \$57 ticket per person required.  
Tickets may be purchased/picked up  
at the ASHRAE Registration Desk;  
advance-purchase tickets may be picked  
up at the door if after registration hours.  
*See page 15 for details.*

#### SUNDAY, June 23

- 7:00 am – 5:00 pm **Speakers' Lounge**, Plaza Ballroom D,  
Plaza Building Concourse Level
- 7:00 am – 5:00 pm **Registration, ASHRAE Bookstore**  
Plaza Exhibit/Foyer, Plaza Building,  
Concourse Level
- 7:30 am – 4:00 pm **ASHRAE Lounge**, Windows,  
Tower Building, Second Level
- 7:30 am – 5:00 pm **Press Room**, Plaza Exhibit/Foyer,  
Plaza Building, Concourse Level
- 8:00 am – 4:45 pm **Technical Sessions**  
*See Technical Program on pages 30 – 52*
- 8:00 am – 5:00 pm **Committee Meetings**  
*See listing on pages 53 – 72*
- 9:00 am – 5:00 pm **Tour: Wings & Things**
- 1:00 pm – 5:00 pm **Tour: Red Rocks & Coors Brewery**
- 3:30 pm – 6:00 pm **Technical Tour: Pepsi Center**  
*See descriptions on page 25*
- Tours depart from street level, Tower  
Building, next to Zoup's Restaurant
- 4:00 pm – 7:00 pm **Young Engineers in ASHRAE (YEA)**  
Networking Event, Tower Building,  
North Convention Lobby, Second Level
- Attention members age 35 and younger—  
You are invited to participate in the YEA  
Networking Event, offering social and  
networking opportunities.*

#### MONDAY, June 24

- 7:00 am – 12:15 pm **Speakers' Lounge**, Plaza Ballroom D,  
Plaza Building Concourse Level
- 7:30 am – 5:00 pm **Registration, ASHRAE Bookstore**  
Plaza Exhibit/Foyer, Plaza Building,  
Concourse Level
- 7:30 am – 4:00 pm **ASHRAE Lounge**, Windows,  
Tower Building, Second Level
- 7:30 am – 11:00 am **Press Room**, Plaza Exhibit/Foyer,  
Plaza Building, Concourse Level
- 8:00 am – 5:30 pm **Technical Sessions**  
*See Technical Program on pages 30 – 52*
- 8:00 am – 5:00 pm **Committee Meetings**  
*See listing on pages 53 – 72*

## Special Event

12:15 pm – 2:00 pm **President’s Luncheon**  
(doors open at noon), Grand Ballroom,  
Tower Building, Second Level

President-Elect **William P. “Bill”  
Bahnfleth**, presents his 2013-2014  
presidential theme. Certificates of  
Appreciation will be presented to retiring  
Board members and the 2013 – 2014  
Officers and new Board members will be  
installed. Spouses and guests are cordially  
invited to attend.

**Note:** Ticket required and may be  
purchased at the ASHRAE Registration  
desk for \$44

1:30 pm – 5:00 pm **Speakers’ Lounge**, Plaza Ballroom D,  
Plaza Building Concourse Level

2:15 pm – 5:00 pm **Technical Tours: SolarTAC or  
Denver Zoo**  
*See descriptions on page 25*

Tours depart from street level, Tower  
Building, next to Zoup’s Restaurant

2:15 pm -5:15pm **Tour: Platte Riverwalk**  
*See description on page 24*

Tours depart from street level, Tower  
Building, next to Zoup’s Restaurant

2:00 pm – 4:00 pm **Press Room**, Plaza Exhibit/Foyer,  
Plaza Building, Concourse Level

**Regional Dinners** Sign up in ASHRAE registration area.

## TUESDAY, June 25

7:00 am – 5:00 pm **Speakers’ Lounge**, Plaza Ballroom D,  
Plaza Building Concourse Level

7:30 am – 4:30 pm **Registration, ASHRAE Bookstore**  
Plaza Exhibit/Foyer, Plaza Building,  
Concourse Level

7:30 am – 4:00 pm **ASHRAE Lounge**, Windows,  
Tower Building, Second Level

7:30 am – 4:00 pm **Press Room**, Plaza Exhibit/Foyer,  
Plaza Building, Concourse Level

8:00 am – 4:45 pm **Technical Sessions**  
*See Technical Program on pages 30 – 52*

8:00 am – 5:00 pm **Committee Meetings**  
*See listing on pages 53 – 72*

Noon – 1:30 pm **Life Members’ Luncheon**, Beverly,  
Tower Building, Terrace Level

**Note:** Ticket required and may be  
purchased at the ASHRAE registration  
desk for \$30.

1:00 pm – 4:00 pm **Technical Tour: NREL**

1:00 pm – 5:00 pm **Tour: Celestial Day in Boulder**

2:00 pm – 5:00 pm **Technical Tour: Repeat of NREL**  
Tours depart from street level, Tower  
Building, next to Zoup’s Restaurant  
*See descriptions on page 25*

## Special Event

6:15 pm – 7:15 pm **Reception**, Denver Sheraton,  
South Convention Lobby,  
Tower Building Second Level

7:15 pm – 10:30 pm **Members’ Night Out**, Grand Ballroom,  
Tower Building Second Level  
— **Dinner** —

**Note:** Ticket required and may be  
purchased at the ASHRAE registration  
desk for \$52.  
*See page 15 for details*

## WEDNESDAY, June 26

7:00 am – 1:00 pm **Speakers’ Lounge**, Plaza Ballroom D,  
Plaza Building Concourse Level

7:30 am – 10:15 am **Registration**, Plaza Exhibit/Foyer,  
Plaza Building, Concourse Level

7:30 am – 1:00 pm **ASHRAE Bookstore**, Plaza Exhibit/  
Foyer, Plaza Building, Concourse Level

7:30 am – 1:00 pm **ASHRAE Lounge**, Windows, Tower  
Building, Second Level

8:00 am – 12:30 pm **Technical Sessions**  
*See Technical Program on pages 30 – 52*

8:00 am – 1:00 pm **Committee Meetings**  
*See listing on pages 53 – 72*

## GENERAL TOURS

*Stand-by tour tickets will be distributed at ASHRAE registration after a tour sells out.* Stand-by tickets are provided to ensure that a tour is filled in the event of no-shows or last minute cancellations. If you have a stand-by ticket, please have the exact amount of the ticket cost available to pay at the bus. Tour tickets may be purchased at the ASHRAE registration desk, Sheraton, Plaza Exhibit/Foyer, Plaza Building Concourse Level.

**All tours depart from the Tower Building, Street Level, next to Zoups Restaurant.**

### A Day of Wings and Things – Colorado Springs

Sunday, June 23

9 a.m.-5 p.m.

Cost: \$60

Visit one of Colorado's most charming cities – Colorado Springs! The first stop is the fantastic United States Air Force Academy (USAF). From the overlook area, see the 17 spires of steel and glass rising from the Chapel. At the USAFA Visitor's Center, view exhibits on cadet life and the history of the Academy.

Next, tour one of Colorado's natural wonders, the Garden of the Gods. Only Mother Nature could have turned rocks into these unusual, majestic formations. A drive through the park and a stop at the Trading Post allows guests to enjoy lunch on their own as well as purchase souvenirs.

Also, see Old Colorado City, established in 1859 and designated the first capitol of the Colorado Territory in 1861. Old Colorado City is the oldest established city in the Pikes Peak Region. Stroll the brick sidewalks, under shady trees with 100-year old buildings providing the perfect backdrop for an exciting mix of unique cafes, restaurants, galleries, boutiques and specialty shops.

The tour also includes Seven Falls, located in South Cheyenne Canyon, Seven Falls cascades 181 feet in seven distinct steps down a solid cliff of Pikes Peak granite. Crystal clear water from the southernmost edges of the Pikes Peak watershed carved this unique scenic masterpiece over the ages in an easily accessed location.

***Closed toed shoes needed for the Falls.***

### Red Rocks and Coors Brewery

Sunday, June 23

1-5 p.m.

Cost: \$40

Take a panoramic ride into the foothills surrounding Golden, Colorado, for a visit to two of Colorado's most popular attractions. The first stop is Red Rocks Amphitheatre, an acoustical marvel, where 9,000 seats are set in the red sandstone rocks overlooking the city. Explore the Red Rocks Visitor's Center, designed as a tribute to the many musical groups that have performed at Red Rocks during its rich history.

Next stop is Miller Coors – a visit to the largest brewery west of the Mississippi includes a 35 minute self-guided tour of the facility followed by freshly brewed samples in the beer tasting room.

***Participants must be at least age 21 to participate.***

### Platte Riverwalk

Monday, June 24

2:15-5:15 p.m.

Cost: \$42

Get a unique glimpse of the city by walking through lower downtown, across the Platte River Pedestrian Bridge and along the Platte Riverwalk! Originating on the Continental Divide near Hoosier Pass, the South Platte runs 360 miles through Colorado and drains 28,584 square miles as one of Colorado's five major rivers. Its snowmelt-fed waters have fueled the growth of Denver and its surrounding suburbs. This paved trail now runs along its banks between Denver's north and south city limits.

In the North Platte District, guests can peruse the quaint shops along Platte Street such as the Savory Spice Shop, where all the spices are ground and blended in the store; Zen Dog Pet Boutique, with whimsical canine apparel and accessories for the discriminating dog lover; and Corks, with specialty wines under \$15.

The tour also includes the flagship branch of the popular REI. Located in the restored 1901 Denver Tramway building, this REI is not only a complete outdoor resource, but a historic landmark and an award-winning architectural accomplishment as well.

### A Celestial Day in Boulder

Tuesday, June 25

1-5 p.m.

Cost: \$58

This tour is a true adventure of the senses as you take in the beautiful surroundings of Boulder while enjoying afternoon tea at the Boulder Dushanbe Tea House. Designed and built by more than 40 artisans in several cities of Tajikistan, Boulder's "sister" country, the Tea House features a hand-carved, hand-painted ceiling as well as ornate, ceramic panels. In addition to a tantalizing dining experience, sip the exotic teas for which Dushanbe is known.

Next, you'll travel to Celestial Seasonings, the largest fully-integrated, herbal tea manufacturer in the United States. You'll be treated to a tour of this fascinating facility, learning about the tea-making process, searching the artwork for the famous "Sleepytime Tea" bear and experiencing the powerful aromas of the tasting room.

## TECHNICAL TOURS

*Stand-by tour tickets will be distributed at ASHRAE registration after a tour sells out (NREL will not have stand-by tickets available).* Stand-by tickets are provided to ensure that a tour is filled in the event of no-shows or last minute cancellations. If you have a stand-by ticket, please have the exact amount of the ticket cost available to pay at the bus. Tour tickets may be purchased at the ASHRAE registration desk, Sheraton, Plaza Exhibit/Foyer, Plaza Building Concourse Level.

**All tours will depart from the Tower Building, Street Level, exit next to Zoups Restaurant.**

### Pepsi Center

Sunday, June 23

3:30-6 p.m.

Cost: \$22

The 675,000-square-foot Pepsi Center is home to the Denver Nuggets (basketball), Colorado Avalanche (hockey) and the Colorado Mammoth (lacrosse). Over 200 events are scheduled each year encompassing sporting events, concerts, ice and family shows. Approximately 1,000 staff members are required to run an event. Depending on the event, the 5 level arena can hold 19,000 to 21,000 people.

The Pepsi Center first opened Oct. 1, 1999, with a Celine Dion concert. The arena cost over \$180 million in private funds and took approximately 21 months to build.

Touring Pepsi Center allows you to see the facility first-hand from a mechanical, electrical and operational point of view. This includes Pepsi Center's central cooling and heating plants, fire systems, mechanical and electrical rooms. Learn how a sheet of ice is created and maintained. Pepsi Center takes pride in energy conservation, and the tour includes many projects undertaken by Pepsi center to significantly reduce energy usage.

### Solar Technology Acceleration Center (SolarTAC)

Monday, June 24

2:15-5 p.m.

Cost: \$22

SolarTAC is the largest test facility for solar technologies in the United States. It provides an exciting venue for researching, demonstrating, testing, and validating a broad range of solar technologies at the early commercial or near-commercial stage of development. SolarTAC includes common areas for performance validation testing of new solar energy system components, including areas for proprietary testing by member companies.

SolarTAC, a partnership among private industry, the research community and government, is located on a 74-acre site in Aurora, Colo. A test facility where the industry can test, validate, demonstrate at scale and advance solar technologies. The SolarTAC mission is to increase the efficiency of solar products and rapidly deploy them to the commercial market. It has seven members with an estimated \$25 million dollars in different technologies being implemented at the site.

***Safety gear provided; wear closed toed shoes, no flip flops- dress for outdoor walking.***

### Denver Zoo

Monday, June 24

2:15-5 p.m.

Cost \$22

#### Attendance is limited

Visitors to the Denver Zoo can see 3,500 different animals, representing over 650 species on the 80 acres within Denver's historic City Park. That means the 1.6 million visitors annually have a rare look at exotic animals like amur leopards, king cobras, black rhinos, coral reef fish, elephants, zebras, vampire bats, gorillas and more. The Denver Zoo has received international attention for successfully hand-raising polar bear cubs Klondike and Snow.

The goal of the Zoo is to operate in the most environmentally, socially and economically friendly manner possible. Through the prevention of pollution, continuous improvement of operations to ensure sustainability and meeting or exceeding all environmental regulations, Denver Zoo is taking positive action to secure a healthy planet for both animals and humans.

In order to accurately measure the baseline energy usage, Denver Zoo performed an ASHRAE Level II Energy Audit in over 39 buildings and exhibits, totaling 543,000 square feet. With the information obtained from this audit, an energy conservation and management plan was developed. Through small-capital projects performed in 2009 (new motors, variable frequency drives, lighting upgrades, boilers, water heater upgrades, etc.), the zoo team has completed projects that are estimated to reduce the overall energy usage greater than 550,000 kWh.

Denver Zoo has implemented several water conservation projects over the last 10 years including xeriscaping, renovations to the water filtration systems at the sea lions exhibit, construction of a water quality wetland and recirculation system at the flamingo pond, low-flow water fixtures in restrooms and now with the opening of Toyota elephant passage, a major filtration and reuse system. The zoo is also working toward zero waste; current 1.5 million total pounds of landfill waste is diverted through gasification, which provides 20 percent of the zoo's power.

### National Renewable Energy Laboratory (NREL), U.S. Department of Energy (DOE)

Tuesday, June 25

1-4 p.m. first tour

2-5 p.m. repeat of first tour

Due to security restrictions there will be no on-site ticket sales for this tour.

NREL is the DOE's primary national laboratory for renewable energy and energy efficiency research and development. This tour features NREL's South Table Mountain research campus.

The Research Support Facility (RSF) is a 360,000 square foot office building that was designed and constructed using an innovative energy goal-based procurement process. The result is a building that uses one-half the energy of a typical building serving as a showcase for energy efficiency and renewable energy technologies.

– Continued on next page –

## (TECHNICAL TOURS, CONT.)

This new flagship building:

- U.S. Green Building Council Leadership in Energy and Environmental Design (LEED) Platinum Certified
- Incorporates on-site photovoltaic (PV) to make the building net zero annual energy.
- Includes an energy efficient data center with an annual PUE of 1.16
- Used a goal-based procurement process to achieve the energy efficiency at no extra cost.
- Radiant, hydronic heating and cooling system

NREL's multistory Energy Systems Integration Facility (ESIF) provides laboratory and office space for approximately 200 researchers and support staff. The 182,500 square foot building houses research to overcome challenges related to the interconnection of distributed energy systems and the integration of renewable energy technologies into the electricity grid. The ESIF also includes NREL scientific computing data center with no mechanical cooling and an expected PUE of 1.06.

This is an indoor and outdoor walking tour so participants should wear comfortable walking shoes and dress for the weather.

U.S. citizens must show government-issued photo identification (such as a driver's license) prior to boarding the bus to NREL.

Foreign nationals must fill out Section 1-18 and provide copies of passports or visas. Alien residents or alien permanent residents (green card holders) also need to complete the forms. Green card holders need to provide a copy of their green card and a government issued identification (driver's license). All alien residents need to provide passports or visas.

Foreign nationals (including Canadian citizens, permanent resident aliens and resident aliens) must have completed a foreign national data card before May 31 and will be asked to show their passport and visa upon arrival.

## notes

---

## ASHRAE 2013 ANNUAL CONFERENCE COURSES –

### Full-Day Seminars & Half-Day Short Courses for In-Depth Instruction

ASHRAE Learning Institute (ALI) provides high-quality training presented by industry-recognized experts. Choose from three full-day seminars and four half-day short courses to help you stay current on HVAC trends. Each seminar and short course will carry Continuing Education Units (CEUs), Professional Development Hours (PDHs), and/or American Institute of Architects Learning Units (AIA LUs) which can be applied toward maintaining your P.E. licensure. Register at <http://www.ashrae.org/denvercourses> or onsite at the ASHRAE registration booth at the Sheraton Denver Hotel.

## FULL-DAY PROFESSIONAL DEVELOPMENT SEMINARS

**Registration fees: \$485** per course; **\$395** for ASHRAE members. Completion of a seminar earns 6 PDHs/AIA LUs or .6 CEUs (*check with your state for their continuing education credit requirements*)

### SATURDAY, JUNE 22, 2013

#### The Commissioning Process in New and Existing Buildings (code 60)

**8:00 am – 3:00 pm, Sheraton Denver, Room: Director's Row I, Plaza Building, Lobby Level**

This introductory seminar focuses on how the building commissioning process can be applied cost-effectively to new construction and existing facilities, with a strong emphasis on existing facilities applications. The seminar discusses the benefits of commissioning to gain an appreciation for how the process can improve the built environment, reduce environmental impacts through responsible resource utilization, improve the quality of design and construction, and raise the professional reputations of the commissioning team members.

**Instructor: Rick Casault, P.E.**, Member ASHRAE (Casault Engineering)

#### Implementing Energy Management in New & Existing Buildings (code 61)

**8:00 am – 3:00 pm, Sheraton Denver, Room: Director's Row H, Plaza Building, Lobby Level**

Buildings use 40% of US energy, of which one-third can be easily saved. To achieve this goal, building professionals can utilize energy management. This is an orderly process in which managers use resources at their disposal to accomplish clear, energy-saving objectives. Sustained energy management is the quickest, cheapest, cleanest way to expand our world's energy supplies and reduce greenhouse gas emissions. This course weaves together energy management principles of the *ASHRAE Handbook – HVAC Applications*, Energy Star guidelines and practical experience of successful energy managers.

**Instructor: Richard J. Pearson, P.E.**, Fellow/Life Member ASHRAE (Pearson Forensic Engineering LLC)

## TUESDAY, JUNE 25, 2012

### Operations & Maintenance of High-Performance Buildings NEW! (code 66)

8:00 am – 3:00 pm, Sheraton Denver, Room: Denver, Tower Building, Mezzanine Level

A high-performance building “consistently delivers a highly productive environment without wasting resources” (ASHRAE *Guideline 32: Sustainable High-Performance Operations and Maintenance*). Operating and maintaining high-performance buildings often requires different actions than a typical commercial or institutional building. After defining what a high-performance building is, this course provides practical insights about operations and maintenance practices for both typical and high-performance buildings. The course includes an interactive group project to reinforce concepts such as how to identify and define energy and maintenance management metrics, and how to make the business case for changes to an existing building and its systems.

**Instructors:** Angela Lewis, Ph.D., P.E., Member ASHRAE (Facility Engineering Associates); and Laurie Gilmer, P.E., Member ASHRAE, LEED® AP (Facility Engineering Associates)

## HALF-DAY SHORT COURSES

**Registration fees:** \$159 per course; \$119 for ASHRAE members. Completion of a short course earns 3 PDHs/AIA LUs or .3 CEUs (check with your state for their continuing education credit requirements)

## SUNDAY, JUNE 23, 2013

### Air-to-Air Energy Recovery Applications: Best Practices (code 62)

3:30 pm – 6:30 pm, Sheraton Denver, Room: Governor’s Square 16, Plaza Building, Concourse Level

Air-to-air energy recovery provides one of the most cost-effective and efficient ways to recycle waste energy and create superior indoor environments. This course reviews real-world examples of where and how air-to-air energy recovery technologies are integrated into some of the most commonly used commercially available systems. Particular configurations that are often used in high-performance buildings and how they can best be used to meet strict goals for IEQ and energy efficiency and thermal comfort will be examined with respect to established performance metrics, peak performance results and annual energy savings.

**Instructor:** Paul Pieper, P.Eng., Member ASHRAE (Venmar CSE Inc.)

### Optimization of HVAC Systems and Their Components NEW! (code 63)

3:30 pm – 6:30 pm, Sheraton Denver, Room: Governor’s Square 17, Plaza Building, Concourse Level

Improved HVAC system designs can be obtained when a rigorous approach to optimization is employed. This course describes proven optimization techniques and introduces the concept of systematic optimization via real-world examples that show striking gains in lower manufacturing cost and/or higher performance of the resulting designs. Excel-based examples focus on duct and chilled water system designs and aim to minimize lifecycle cost while meeting performance requirements. The course further discusses optimization of individual components such as heat exchangers as well as optimization of a system (fan-coil units, air-conditioners, etc.). Attendees are encouraged to bring a laptop computer.

**Instructors:** Reinhard Radermacher, Ph.D., P.E., Fellow ASHRAE (University of Maryland); and Vikrant Aute, Ph.D., Member ASHRAE (University of Maryland)

## MONDAY, JUNE 24, 2013

### Commissioning Process & Guideline 0 (code 64)

2:30 pm – 5:30 pm, Sheraton Denver, Room: Governor’s Square 16, Plaza Building, Concourse Level

This course targets building owners, facility managers, design engineers, building designers, architects, equipment manufacturers and others interested in the commissioning process as outlined in Guideline 0. This course focuses on process, intent, activities, and deliverables. It is intended as an entry-level course that will provide attendees with a fundamental background of the ASHRAE-promoted commissioning process.

**Instructor:** Walter Grondzik, P.E., Fellow/Life Member ASHRAE, LEED® AP (Ball State University)

### Advanced High-Performance Building Design (code 65)

2:30 pm – 5:30 pm, Sheraton Denver, Room: Governor’s Square 17, Plaza Building, Concourse Level

This course focuses on advanced concepts involved in applying Standards 90.1 and 189.1 to achieve high-performance building design. Covering all phases of a building life, from concept to design, construction, operation and removal, the course explores the integrated process applications for delivering high-performance green buildings. More emphasis will be placed on specific case study examples in this course to help the students go beyond the minimum requirements of these standards. Course content is suitable for architects and engineers.

**Instructor:** Jeff Ross-Bain, P.E., Member ASHRAE, LEED® AP, BEMP (Ross-Bain Green Buildings, LLC)

## STANDING COMMITTEE CHAIRS

As our 2012-13 Society year draws to a close here at the 2013 Annual Conference, I want to say thank you for serving as a standing committee chair. Your assistance over the past year has been very important.

My presidential theme focused on Broadening ASHRAE's Horizons, which emphasizes the role of ASHRAE members as leaders in the application of sustainable design and practices in our communities worldwide.

Let us build on our strong heritage as a technical society and broaden the application of our technology to serve humanity and promote a sustainable world. In doing this, we must broaden our technology, our applications and our people.

Your contributions – past, present and future – have helped our Society create successful technologies to serve our communities worldwide. Thanks to your dedication, ASHRAE is contributing to our industry, our community and our world by sharing your knowledge to help improve the indoor and outdoor environments in which our families and our neighbors live, work and play.

On behalf of your fellow members around the world, thank you. We look forward to the continued contributions of ASHRAE volunteers and committees in helping us shape tomorrow's built environment today.

Personal regards,



Tom Watson, P.E., Fellow ASHRAE, Life Member  
ASHRAE President, 2012-13

William P. Bahnfleth, Chair  
Advocacy Committee

Cindy Callaway, Chair  
Handbook Committee

Cesar Luis Lim, Chair  
Refrigeration Committee

Amy B. Musser, Chair  
Building Energy Quotient Committee

Irene Reichert, Chair  
Historical Committee

Jaap J. Hogeling, Chair  
Research Administration Committee

David B. Meredith, Chair  
Certification Committee

Raymond E. Patenaude, Chair  
Honors and Awards Committee

Walter W. Law, Jr., Chair  
Research Promotion Committee

Wei Sun, Chair  
Chapter Technology Transfer Committee

Roger K. Jones, Chair  
Membership Promotion Committee

Patricia T. Graef, Chair  
Society Rules Committee

Ben A. Leppard, Jr., Chair  
Conferences and Expositions Committee

Kent W. Peterson, Chair  
Nominating Committee

Kenneth W. Cooper, Chair  
Standards Committee

Angela M. Lewis, Chair  
Electronic Communications Committee

William P. Bahnfleth, Chair  
President-Elect Advisory Committee

John T. Moore, Chair  
Student Activities Committee

Chandra Sekhar, Chair  
Environmental Health Committee

Donald L. Brandt, Chair  
Professional Development Committee

William F. McQuade, Chair  
Technical Activities Committee

Thomas H. Phoenix, Chair  
Finance Committee

Francis A. Mills, Chair  
Publications Committee

Carrie R. Kelty, Chair  
Young Engineers in ASHRAE Committee

# ASHRAE ANNUAL CONFERENCE TECHNICAL PROGRAM

## Denver – June 2013

Earn Professional Development Hour (PDH) credits by attending sessions listed in the Technical Program. Each hour attended in a session equals one PDH. For forums and other one-hour sessions, you must be present for the entire 50-minute program to earn a PDH. Sign-in sheets for State of Florida and North Carolina PEs and AIA LUs will be available in all session rooms for attendees to complete. ASHRAE will report your Florida PDHs on your behalf. New York State PDHs, AIA LUs and LEED AP credits are awarded for select sessions. Also, certain sessions may be acceptable for ASHRAE certification renewal. Send questions to [certification@ashrae.org](mailto:certification@ashrae.org). Your badge will be scanned as you enter the session and a summary of sessions attended will be emailed to you upon conclusion of the conference. Please keep track of the sessions that you attend at the conference. Technical sessions are in the Sheraton Denver Hotel, Plaza Tower. All sessions listed as starting at the same time are concurrent.

## ASHRAE'S CONFERENCES AND EXPOSITIONS COMMITTEE WELCOMES YOU TO THE 2013 ANNUAL CONFERENCE

Five types of sessions are presented:

**Technical Paper Sessions.** These sessions present papers on current applications or procedures, as well as papers resulting from research on fundamental concepts and basic theory. Papers presented in these sessions have successfully completed a rigorous peer review. You are invited to comment on these papers. Forms for written comment are available at each session, and if received by July 15, 2013, comments will be sent to respective authors for reply and publication in ASHRAE Transactions. PowerPoint presentations with audio descriptions of the presentations are posted online in the Virtual Conference. Preprints of papers and the ASHRAE Papers CD are available for purchase in the ASHRAE Bookstore.

**Conference Paper Sessions.** These sessions present papers on current applications or procedures, as well as papers reporting on research in process. These papers differ from technical papers in that they are shorter in length and undergo a much less stringent peer review. PowerPoint presentations with audio descriptions of the presentations are posted online in the Virtual Conference. Conference papers and the ASHRAE Papers CD are available for purchase in the ASHRAE Bookstore.

**Seminars.** Seminars feature presentations on subjects of current interest. Papers are not available from the Society; however, seminar PowerPoint presentations with audio descriptions of the presentations are posted online in the Virtual Conference. Access is free for attendees who purchase a conference registration. Additional Virtual Conference registrations can be purchased in the ASHRAE Registration. For a permanent record of the seminar presentations, the Seminar DVD will be available. Orders can be taken in the ASHRAE Bookstore.

**Forums.** Forums are “off-the-record” discussions held to promote a free exchange of ideas. Reporting of forums is limited to allow individuals to speak confidentially without concern of criticism. There are no papers attached to these forums.

**Special Sessions.** These new sessions feature panel discussions, debates, and workshops relating to subjects of current interest. Special Sessions encourage interaction between presenters and attendees. They will not be featured on the Seminar DVD but most PowerPoint presentations with audio descriptions will be posted online in the Virtual Conference.

## VIRTUAL CONFERENCE

Free for Paid Conference Registrants

ASHRAE is offering a virtual conference option so you won't miss the state-of-the-art concepts and latest design techniques presented in the Society's technical program. The Denver Virtual Conference allows you to view presentations and to interact with an online audience through a discussion board. All conference attendees paying the full registration fee will have access to the Virtual Conference, posted at [www.ashrae.org/denvervirtual](http://www.ashrae.org/denvervirtual). Click on the link to access the Virtual Conference and put in your email address to request your password.

### Virtual Conference includes:

- Synced audio and PowerPoint presentations
- Access to all seminar, technical paper and conference paper presentations and most special sessions
- Ability to post questions or answers through July 10
- Presentations available online for 18 months.

A full slate of technical programs will be posted beginning Monday, June 24 of the sessions that were presented the previous day, with additional content posted daily through Wednesday, June 26.

On-site registration is available for those who would like to purchase the Virtual Conference. To sign up, go to ASHRAE Registration, Sheraton Denver, Plaza Ballroom Exhibit/Foyer, Plaza Building Concourse Level, \$299 ASHRAE member; \$464 non member. If you register on site, you will be able to log on the [www.ashrae.org/denvervirtual](http://www.ashrae.org/denvervirtual) to request your password within 24 hours of your registration.



### ASHRAE Papers CD: 2013 ASHRAE Annual Conference (All Papers on CD)

Technical Paper and Conference Paper Session papers as presented at this Conference

\$98 (includes five FREE hard copies of preprint papers)

Available at the Conference Bookstore



### Conference Seminar DVD

46 Seminars (PowerPoint files synced with speakers' audio)

\$109 (ships July 2013)



### Conference Preprints (Individual Papers, In Print)

Technical Paper and Conference Paper Session papers as presented at this Conference

\$6 each

Available at the Conference Bookstore



### ASHRAE Transactions (Print Volume)

Technical Paper Session papers with discussion questions and answers for papers in bound, library-quality form.

\$119 (ships August 2013)



Approved for New York State Professional Development Hours (PDHs) and American Institute of Architect Learning Units (LUs)



GBCI LEED AP CE Credits

### Packages

1. ASHRAE Papers CD and *ASHRAE Transactions* (See descriptions at left)

Get five FREE hard copies of preprint papers when you purchase this package

\$159 – Available at the Conference Bookstore

2. ASHRAE Papers CD and Seminar DVD

\$159 – Purchase in the Conference Bookstore

3. Complete Annual Conference Content Package

(Seminar DVD, ASHRAE Papers CD and *ASHRAE Transactions*)

\$199 – Purchase in the Conference Bookstore

All prices are special conference-only member prices.

## Sunday, June 23

8:00 AM-9:00 AM

### SPECIAL SESSION 1 (INTERMEDIATE)

#### Panel Discussion: Shifting Landscape of Renewable Energy Systems in an Era of Low PV and Natural Gas Prices

Track: Renewable & Alternative Energy Sources

Room: Governors Square 17

Sponsor: 06.07 Solar Energy Utilization, 01.09 Electrical Systems

Chair: Ram Narayanamurthy, Member, Electric Power Research Institute, Palo Alto, CA

The past 5 years have seen a sea change in our energy landscape with the rise of shale gas and a precipitous drop in the cost of PV. Together, they have substantially changed the economics of renewable energy systems such as solar thermal in many applications. However, the impact is uneven around the world, as local energy sources vary. This panel discussion brings experts from around the world to discuss the shifting landscape and applications in various parts of the globe.

#### 1. International Trends in Renewable Energy Technologies

Marija S. Todorovic, VEA-INVI.Ltd, Zug, Switzerland

#### 2. State of US Solar Thermal Market

Tim Merrigan, National Renewable Energy Laboratory, Golden, CO

#### 3. Influence of Natural Gas on Distributed Renewable Energy Systems

Ram Narayanamurthy, Member, Electric Power Research Institute, Palo Alto, CA

8:00 AM-9:00 AM

### SPECIAL SESSION 2 (BASIC)

#### Panel Discussion: The VRF MythBuster

Track: HVAC&R Systems & Equipment

Room: Governors Square 16

Sponsor: 08.07 Variable Refrigerant Flow

Chair: Paul Solberg, Member, Trane Co., La Crosse, WI; Chris Bellshaw, Member, Daikin, Carrollton, TX; Paul L. Doppel, Mitsubishi Electric, Suwanee, GA; Brian Bogdan, LG Electronics

Variable Refrigerant Flow Systems have gained significant traction and are becoming a mainstream equipment choice because of energy efficiency, improved zoning control, and ease of installation. While acceptance of these systems is wide spread, the systems have varied idiosyncrasies between the manufacturers. This technical program is a moderated round table discussion between three factory technical representatives from Daikin, LG, and Mitsubishi. This discussion is a moderated, synergistic, non-commercialized view of VRF systems from the viewpoint of the different manufacturers. Pre-determined questions are presented to the panelists and time given to each to respond with time allocated for questions from the audience.

8:00 AM-9:00 AM

### SPECIAL SESSION 3 (BASIC)

#### Workshop: Achieving High Performance Buildings through Integrated Project Delivery and Design-Build

Track: Integrated Project Delivery

Room: Plaza Ballroom F

Sponsor: 07.01 Integrated Building Design, 07.03 Operation and Maintenance Management

Chair: Thursten D. Simonsen, P.E., Member, McKinstry, San Antonio, TX

Delivering a building that is truly high performance in design, construction, operations and maintainability requires a culture of teamwork that begins with the owner trusting and including the designers, builders and



facility management from project inception. This session explores a successful integrated project delivery design-build concept, including a case study of a new medical office building in west Texas built in this method.

### 1. Integrated Project Delivery and Design-Build Results in High Performing, Efficient, Maintainable Buildings

*Phillip Saieg, McKinstry, Denver, CO*

### 2. Case Study: Rolling Plains New Medical Office Building

*David White and Thursten D. Simonsen, P.E., Member, McKinstry, San Antonio, TX*

### 3. Integrated Project Delivery: Construction Phase

*Mike Edwards, McKinstry, Seattle, WA*

### 4. Integrated Project Delivery: Owner's Perspective

*Donna Boatright, Rolling Plains Memorial Hospital, Sweetwater, TX*

8:00 AM-9:00 AM

## SPECIAL SESSION 4 (INTERMEDIATE)

### Workshop: BIM, Commissioning, and COBie: Does Automated Building Energy Modeling Replace Measurement and Verification?



*Track: Building Energy Modeling vs. Measurement & Verification – Closing the Gap*

*Room: Governors Square 14*

*Sponsor: 01.04 Control Theory and Application, TC 1.5, TC 7.1, TC 7.3, and TC 7.4, 06.07 Solar Energy Utilization*

*Chair: Frank Shadpour, P.E., Fellow ASHRAE, SC Engineers, Inc., San Diego, CA*

Building Information Modeling (BIM), Commissioning, and Construction Operations Building Information Exchange (COBie) are powerful tools to predict and deliver high-level energy performance in today's green buildings. Have these tools advanced to the point where they can be relied upon to monitor and track actual building performance as a substitute to measurement and verification?

#### 1. Verification Required: The Dubiousness of Modeling Equipment Installation Quality and Performance

*Steve Kavanaugh, Ph.D., Fellow ASHRAE, University of Alabama, Tuscaloosa, AL*

#### 2. All You Need Is BIM and COBie

*Michael Smith, CW Driver, Ontario, CA*

#### 3. Automated Measurement and Verification: Is It Required for Renewable Energy Systems?

*Gaylen Atkinson, Member, Atkinson Electronics, Salt Lake City, UT*

8:00 AM-9:00 AM

## SPECIAL SESSION 5 (INTERMEDIATE)

### Workshop: Building Owners Share Experiences with Hydronic Radiant Cooling Systems Coupled with DOAS: What Works and What Doesn't?

*Track: HVAC&R Systems & Equipment*

*Room: Plaza Ballroom A*

*Sponsor: 06.01 Hydronic and Steam Equipment and Systems, 06.05 Radiant Heating and Cooling*

*Chair: Paul A. Torcellini, Ph.D., Member, National Renewable Energy Laboratory, Golden, CO*

Although chilled beam technology has existed for more than 60 years, it has had problems in the past. Condensation of moisture on the cooled surfaces sometimes damaged ceiling materials (e.g., plaster) and created conditions favorable to biological growth. Current systems usually require dedicated outdoor air systems (DOAS) and tight building envelopes to manage humidity. Radiant ceilings, used in combination with a DOAS, can reduce commercial building HVAC energy consumption relative to the old stand-by variable air volume (VAV) systems. This workshop allows building owners to share experiences with installed passive chilled beam DOAS hydronic systems – what works and what doesn't?

### 1. Case Study #1: NREL

*Shanti D. Pless, Member, National Renewable Energy Laboratory, Golden, CO*

### 2. Passive Beams with Underfloor Air Distribution: An American Tale

*Fred Betz, P.E., Member, PEDCO E&A Services, Cincinnati, OH*

### 3. Engineer and Technical Expert for Panel Discussion

*Peter Simmonds, Ph.D., Fellow Member<sup>1</sup> and David Okada, P.E., Member<sup>2</sup>, (1)IBE Consulting Engineers, Sherman Oaks, CA, (2)Arup, Seattle, WA*

8:00 AM-9:00 AM

## SPECIAL SESSION 6 (ADVANCED)

### Workshop: Cutting Edge Absorption and Adsorption Cooling Technologies in Cogeneration and Trigeneration

*Track: Research Summit*

*Room: Governors Square 15*

*Sponsor: 08.03 Absorption and Heat Operated Machines*

*Chair: Ersin Gercek, P.E., Associate Member, Real Engineering Services LLC, Totowa, NJ*



In this session, one of the authors describes issues with high ambient applications while the second author investigates application of absorption chillers in LNG facilities. The third and fourth authors present case studies for industrial trigeneration application of absorption chillers as well as applications with renewable energy.

#### 1. Waste Heat Recovery Using Absorption Chiller in LNG Plant With CO2 Capturing Plant

*Abdullah Alabdulkarem, Student Member, Yunho Hwang, Ph.D., Member and Reinhard Radermacher, Ph.D., Fellow ASHRAE, University of Maryland, College Park, MD*

#### 2. Separate Sensible and Latent Cooling for Trigeneration

*Kyle Gluesenkamp, Student Member, Yunho Hwang, Ph.D., Member and Reinhard Radermacher, Ph.D., Fellow ASHRAE, University of Maryland, College Park, MD*

#### 3. Solar Combined Heat Power and Cooling or Solar Trigeneration

*Rajesh Dixit, Associate Member<sup>1</sup> and Andrea Gains-Germain<sup>2</sup>, (1)Johnson Controls, York, PA, (2)Cogentra Solar, Mountain View, CA*

8:00 AM-9:00 AM

## SPECIAL SESSION 7 (BASIC)

### Workshop: The Smartest and Top Dumb Things Engineers and Designers Do to Impact Geothermal Heat Pump System Costs

*Track: Renewable & Alternative Energy Sources*

*Room: Plaza Ballroom E*

*Sponsor: 06.08 Geothermal Heat Pumps and Energy Recovery Applications*

*Chair: Lisa Meline, P.E., Member, Meline Engineering Corporation, Sacramento, CA*



One of the most popular technologies employed for LEED, Energy Star and Net Zero is ground-source or geothermal heat pumps (GHPs). Intended to be simple in operation and application, systems are often adaptations of central plant designs that include unnecessary equipment, inappropriate controls, and excess equipment capacity. Ground heat exchangers are often the exclusive focus of efforts to lower installation costs. However, recent studies indicate high quality ground loops are critical to high performance and the lowest hanging fruit for cost savings are found instead within the building. This session provides three different perspectives on design strategies that enhance GHP performance and economic value while contrasting practices that don't LEED to Energy Star or Net Zero Buildings.

#### 1. A Driller's Perspective on Good Ground Heat Exchanger Design

*Dominique Durbin, Durbin Geothermal, Beecher City, IL*

#### 2. A Mechanical Contractor's Perspective on Best Design Practices

*Mark Morelli, Air Connection, Inc., Santa Rosa, CA*

#### 3. A Historical Perspective: Working Towards Superior GHP System Designs

*Kirk T. Mescher, P.E., Member, CM Engineering, Inc., Columbia, MO*

8:00 AM-9:00 AM

**SPECIAL SESSION 8 (BASIC)****Workshop: Tools and Techniques for Avoiding Construction Moisture Problems***Track: HVAC&R Fundamentals & Applications**Room: Plaza Ballroom B***Sponsor: 01.12 Moisture Management in Buildings, 04.04 Building Materials and Building Envelope Performance***Chair: Samuel V. Glass, Ph.D., Member, U.S. Forest Products Laboratory, Madison, WI*

Tens of millions of dollars are lost each year because of insufficient attention to moisture control during building construction. When building materials and components get wet or are inherently wet (e.g. fresh concrete) and are not allowed to dry out before building enclosure, the result often is mold in the building as well as in the HVAC system. This session explores how we can ensure that buildings are dry after the building is finished and before the HVAC system is turned on.

**1. Drying Out Wet Construction***Lew Harriman III, Fellow ASHRAE, Mason Grant, Portsmouth, NH***2. Moisture Release From Concrete, Masonry and Light-Weight Concrete and How to Deal With It***Hugo Hens, Ph.D., Fellow ASHRAE, K.U.Leuven, Leuven, Belgium***3. Controlling Construction Moisture in Mid-Rise Wood-Frame Buildings***Wahid Maref, Ph.D., Member, National Research Council Canada, Ottawa, ON, Canada***4. Control of Moisture in Building Materials During Shipment and at the Building Site***Stanley Gatland, Member, Saint-Gobain, PA*

9:45 AM-10:45 AM

**TECHNICAL PLENARY (INTERMEDIATE)****Sustainable Energy:****How Do We Actually Try To Approach It?***Track: Mile-High Efficiency & Equipment**Room: Plaza Ballroom B**Chair: Srinivas Garimella, Ph.D., Member, Georgia Institute of Technology, Atlanta, GA*

Efforts at improving energy efficiency have typically involved component or device efficiency improvements, which limits energy use reductions to a few percent, for specific end uses. While such improvements are desirable, their impact on energy utilization at the national and global level is small. This talk focuses on revisiting the current global energy utilization paradigm and suggests approaches to cascade primary energy utilization over several end uses across the temperature spectrum such that waste heat is minimized to the thermodynamically unavoidable levels. Such approaches yield substantial reductions in the carbon footprint of global energy utilization. In addition, techniques to not only harvest waste heat, but to upgrade it to produce power, cooling, and upgraded heat are discussed. In the quest to use “the last Joule” from the source efficiently, a variety of technologies to harness, transform, store and transfer thermal energy are presented. In particular, research on techniques to exploit the advantages of microscale heat and mass transfer not only in small-scale devices, but also to extend them to Megawatt-scale applications are presented. Thermally cascaded energy utilization systems for automotive, space-conditioning, electronics cooling, waste heat recovery, and portable cooling for the military, fire-fighting and other hazardous duty applications are presented. The talk demonstrates that improvements on the end-use side can have a significant impact on the supply, demand and intermediate stages of the energy pathway.

11:00 AM-12:30 PM

**TECHNICAL PAPER SESSION 1 (INTERMEDIATE)****Heat Transfer Issues in Cooling and Heating Systems***Track: Research Summit**Room: Governors Square 16***Sponsor: 01.03 Heat Transfer and Fluid Flow***Chair: Yunho Hwang, Ph.D., Member, University of Maryland, College Park, MD*

This session presents fundamental heat transfer characteristics of working fluids used in vapor compression cycles, and radiant heating. A comprehensive study evaluating correction factors against a wide range of experimental data presents an assessment of predictive methods for single fluid correlations for use with multi-component refrigerant mixtures. The potential of carbon nanotubes (CNTs) to circulate throughout a vapor compression air conditioning system was experimentally investigated. The effect of a change in height on the heat flux distribution on a floor from a single-stage radiant tube heater (RTH) was investigated.

**1. General Correlation for Heat Transfer During Condensation in Plain Tubes: Further Development and Verification (DE-13-001)***M. Mohammed Shah, Ph.D., P.E., Fellow ASHRAE, Consultant, Redding, CT***2. Distribution Map of Multi-Walled Carbon Nanotubes in a Refrigerant and Oil Mixture within a 2.5 Ton (8.8 kW) Unitary Air-Conditioner (DE-13-002)***Darin W. Nutter, Ph.D., Fellow ASHRAE and Warren Long, University of Arkansas - Department of Mechanical Engineering, Fayetteville, AR***3. Effective Height Changes with Heat Flux Variation Due to a Single-Stage Infrared Tube Heater System (DE-13-003)***Samer Hassan, Ph.D., Member, Schwank Ltd., Ontario, ON, Canada***4. An Assessment of Some Predictive Methods for In-tube Condensation Heat Transfer of Refrigerant Mixtures (DE-13-004)***M. Mohammed Shah, Ph.D., P.E., Fellow ASHRAE<sup>1</sup>, Ahmad M. Mahmoud, Ph.D.<sup>2</sup> and Jaeson Lee<sup>2</sup>, (1)Consultant, Redding, CT, (2) Thermo-Fluid Dynamics Group, East Hartford, CT*

8:00 AM-9:00 AM

**FORUM (BASIC)****What Special Design Guidelines and Criteria Should be Considered for Justice Facilities?***Track: HVAC&R Fundamentals & Applications**Room: Governor's Square 10***Sponsor: 09.04 Justice Facilities***Chair: Richard Vehlow, P.E., Member, New York State Office of General Services, Albany, NY*

OPEN SESSION: no badge required; no PDHs awarded; presented during the TC's meeting. This forum promotes discussion among attendees from varied backgrounds and jurisdictions regarding the special HVAC, energy and other physical needs for prisons, jails, police stations and other secure properties. The discussion also focuses on what guidelines should go into a design guide for justice facilities. The session is open to all participants, regardless of level of expertise in secure design or role as a policymaker. All attendees are also invited to attend the preceding TC9.4 meeting at 8am.

9:00 AM-9:45 AM

**NETWORKING COFFEE BREAK  
(Outside of the Plaza Ballroom)**

Grab some coffee and network with your fellow ASHRAE conference attendees after the opening sessions in the hallway outside the Plaza Ballroom. This is a great chance to get to discuss the morning's interactive Special Sessions and form connections to make the most of your time in Denver.

11:00 AM-12:30 PM

## TECHNICAL PAPER SESSION 2 (INTERMEDIATE)

### Thermal Comfort Design Conditions: Males, Females and Data Centers

Track: *Integrated Project Delivery*



Room: *Governors Square 17*

Sponsor: **06.09 Thermal Storage**

Chair: *Samir Traboulsi, Ph.D., P.E., Member, Thermotrade/Ranec, Beirut, Lebanon*

Many factors affect the comfort design conditions. Gender is responsible for generating different tolerances towards the indoor conditions while intermittent electrical power disruptions affect the thermal energy of the cooling systems.

#### 1. Gender Differences of Thermal Comfort Perception Under Transient Environmental and Metabolic Conditions (DE-13-005)

*Ahmet Ugursal, Ph.D. and Charles Culp, P.E., Fellow ASHRAE, Texas A&M University, College Station, TX*

#### 2. Thermal Energy Storage for Emergency Cooling, Part 1 (RP-1387) (DE-13-006)

*Walter Bembry IV<sup>1</sup>, Lance E. Basgall<sup>2</sup>, and Donald Fenton, Ph.D., P.E., Member<sup>3</sup>, (1)Ceram Environmental, Overland Park, KS, (2)United States Air Force, Herndon, KS, (3)Kansas State University, Manhattan, KS*

#### 3. Thermal Energy Storage for Emergency Cooling, Part 2 (RP-1387) (DE-13-007)

*Lance E. Basgall<sup>1</sup>, Walter Bembry IV<sup>2</sup>, and Donald Fenton, Ph.D., P.E., Member<sup>3</sup>, (1)United States Air Force, Herndon, KS, (2)Ceram Environmental, Overland Park, KS, (3) Kansas State University, Manhattan, KS*

11:00 AM-12:30 PM

## CONFERENCE PAPER SESSION 1 (INTERMEDIATE)

### Energy Efficiency Modeling in Buildings

Track: *Research Summit*



Room: *Governors Square 14*

Chair: *Steven Eckels, Ph.D., Member, Kansas State University, Manhattan, KS*

This session consists of several research papers reviewing and studying energy efficiency methods and techniques in buildings. Some of these studies focus on building envelopes modeling, testing, and analysis while others deal with climate conditions and overheating issues.

#### 1. Accounting for Exposure Duration in Overheating Risk Assessment – A Chicago Retrofit Case Study (DE-13-C001)

*W. Victoria Lee and Koen Steemers, Department of Architecture, University of Cambridge, Cambridge, United Kingdom*

#### 2. Energy Efficiency of Building Walls: Thermal Modeling, Experimental Testing, Long Term Evaluation and Correlation of Building Wall Systems (DE-13-C002)

*Elena Enache-Pommer, Ph.D., Associate Member, Robert Mayer, Ph.D., Gary Parsons and Mike Mazor, Ph.D., Dow Chemical Company, Midland, MI. 3. An Enhanced Simulation Model for Building Envelopes with Phase Change Materials (DE-13-C003)*

*Ramprasad Chandrasekharan, Student Member, Edwin S. Lee, Student Member, Dan Fisher and Pratik S. Deokar, Oklahoma State University, Stillwater, OK*

#### 4. Determining the Thermal Resistance of Buried and Encapsulated Ducts (DE-13-C004)

*Carl Shapiro, Steven Winter Associates, Inc., Norwalk, CT*

#### 5. Evaluation of A Climate Modelling Procedure Against Observed Meteorological Data (DE-13-C005)

*Xin Qiu, Ph.D., Member<sup>1</sup>, Michael Roth, Ph.D.<sup>2</sup>, Fuquan Yang, Ph.D.<sup>1</sup>, Hamish Hains<sup>1</sup> and Jason Slusarczyk<sup>1</sup>, (1)Novus Environmental Inc., Guelph, ON, Canada, (2)Klimaat, Guelph, ON, Canada*

11:00 AM-12:30 PM

## CONFERENCE PAPER SESSION 2 (INTERMEDIATE)

### Smart Grid: Demand Response Measures, the Human Element, Building Management Systems, and Smart Appliances

Track: *Research Summit*



Room: *Governors Square 15*

Chair: *Richard Brooks, Florida Power & Light, Fort Myers, FL*

This session presents how alternative sets of Demand Response measures are examined according to the magnitude of load reductions; explores an advanced technique to save energy in buildings by tracking the movement of people in a building using wireless sensors, monitoring, and actuating systems; and takes a unique look at developing a Multi-Agent comfort and energy system to supplement or replace the traditional Building Management System.

#### 1. Short-Term Reduction of Peak Loads in Commercial Buildings in a Hot and Dry Climate (DE-13-C006)

*Amruta Khanolkar<sup>1</sup>, T. Agami Reddy, Ph.D., P.E., Fellow ASHRAE<sup>2</sup> and Marlin Addison, Member<sup>3</sup>, (1)Smith Group JJR, Phoenix, AZ, (2)The Design School/The School of Sustainable Engineering and the Built Environment, Tempe, AZ, (3)Arizona State University, Tempe, AZ*

#### 2. Smart Micro Grids: Wireless Sensor Technology and Building Energy Management System to Optimize the Occupant's Dynamic Demand Pattern within the Building (DE-13-C007)

*Wim Zeiler and Gert Boxem, TU Eindhoven, Eindhoven, Netherlands*

#### 3. Smart Grid – Building Energy Management System; Multi Agent Systems for Optimized Cooperation Between Energy Supply and Comfort Demand (DE-13-C008)

*Wim Zeiler, TU Eindhoven, Eindhoven, Netherlands*

#### 4. A New Process Control Strategy: The Human Leading the Thermal Comfort Control (DE-13-C009)

*Wim Zeiler, TU Eindhoven, Eindhoven, Netherlands*

#### 5. Testing the Demand Response Capabilities of Residential Refrigerators (DE-13-C010)

*Scott A. Mitchell, P.E., Member, Southern California Edison, Irwindale, CA*

11:00 AM-12:30 PM

## SEMINAR 1 (INTERMEDIATE)

### Energy Efficient Design through Integrated Project Delivery: A Case Study

Track: *Integrated Project Delivery*



Room: *Plaza Ballroom F*

Sponsor: **07.01 Integrated Building Design**

Chair: *Elyse Malherek, Associate Member, The Weidt Group, Minneapolis, MN*

Integrated building design brings all the players from the building life cycle into the design process early on. This melds the accumulated knowledge from the architect, mechanical engineer, energy modeler, commissioning agent, and facility manager, which results in a more informed design that can be sustained through operations. This seminar follows a LEED gold elementary school project in Colorado with high efficiency energy design goals from design conception through occupancy.

#### 1. Using IPD to Deliver an Energy Efficient School Building Design

*Barry Stamp, P.E., Shaffer-Baucom Engineering, Lakewood, CO*

#### 2. Energy Modeling to Inform Design

*Dana Kose, The Weidt Group, Denver, MN*

#### 3. Maintaining the Design Intent Through Occupancy

*Erik Jeannette, Eaton Energy Solutions, Boulder, CO*

#### 4. IPD Process Panel Discussion

*Todd Piccone<sup>1</sup>, Matt Swenka, P.E.<sup>2</sup> and Stephanie Barr<sup>3</sup>, (1)St. Vrain Valley School District, Longmont, CO, (2)The Weidt Group, Des Moines, IA, (3)Institute for the Built Environment, Fort Collins, CO*

11:00 AM-12:30 PM

## SEMINAR 2 (INTERMEDIATE)

### Investigation of Replacement Refrigerants for R410A and Test Results from the Alternative Refrigerant Evaluation Program

Track: Research Summit

Room: Plaza Ballroom E



**Sponsor: 08.11 Unitary and Room Air Conditioners and Heat Pumps, MTG, TC 10.6, 08.04 Air-to-Refrigerant Heat Transfer Equipment**

Chair: *Raymond Rite, Ph.D., Member, Ingersoll Rand – Residential Solutions, Tyler, TX*

Low global warming potential (GWP) refrigerants have garnered much interest because of concerns about climate change and the possibility of increased regulation for existing refrigerants, namely R410A. The HVAC&R industry is working together through AHRI's Low-GWP Alternate Refrigerants Evaluation Program (AREP) to evaluate lower GWP options and share results. This seminar reviews test results on split AC and heat pump systems with alternatives to R410A.

#### 1. Modification and Testing of a Split-System R-410A Heat Pump for Use With R-1234yf

*Robert Ueslton, P.E., Fellow ASHRAE, Lennox Industries Inc., Carrollton, TX*

#### 2. Test Results of Low GWP Alternatives to R-410A in a Residential Heat Pump

*Larry Burns, Associate Member, Carrier Corp., Indianapolis, IN*

#### 3. Drop-In Performance Evaluation of Three Alternative Refrigerant Candidates for R-410A

*Abdullah Alabdulkarem, Student Member, Yunho Hwang, Ph.D., Member and Reinhard Radermacher, Ph.D., Fellow ASHRAE, University of Maryland, College Park, MD*

#### 4. Low GWP Replacements for R-410A in Air Conditioning Applications

*Samuel F. Yana Motta, Ph.D., Member and Ankit Sethi, Honeywell, Buffalo, NY*

11:00 AM-12:30 PM

## SEMINAR 3 (BASIC)

### Moving Buildings and the Grid to a Renewable Future

Track: Renewable & Alternative Energy Sources

Room: Plaza Ballroom A



**Sponsor: 02.08 Building Environmental Impacts and Sustainability**

Chair: *Shanti D. Pless, Member, National Renewable Energy Laboratory, Golden, CO*

Buildings consume almost 70% of the electricity in the United States. Colorado established renewable energy portfolio standards which created a market for grid-scale renewables as well as building scale photovoltaic systems. This seminar presents the current fuel mixes for Colorado and the potential future direction highlighting the technologies and research underway to move to a renewable grid.

#### 1. The Colorado Electrical Grid

*Paul A. Torcellini, Ph.D., Member, National Renewable Energy Laboratory, Golden, CO*

#### 2. Large Scale Wind Farms

*Ian Baring-Gould, National Renewable Energy Laboratory, Golden, CO*

#### 3. Solar Energy - Photovoltaics (PV)

*Otto VanGeet, P.E., Member, National Renewable Energy Laboratory, Golden, CO*

11:00 AM-12:30 PM

## SEMINAR 4 (INTERMEDIATE)

### Realizing Sustainability with Commissioning

Track: HVAC&R Fundamentals & Applications

Room: Plaza Ballroom B



**Sponsor: 07.09 Building Commissioning**

Chair: *Norm Nelson, P.E., Member, CH2M Hill, Portland, OR*

The value of building commissioning is a well-documented and recognized process. The United States Green Building Council (USGBC) has recognized this value and made Fundamental Commissioning a mandate on most LEED projects (V3). USGBC also offers Enhanced Commissioning point options for starting the commissioning process before 50 percent construction documents (V3) and is seeking to name by reference the National Institute of Building Sciences (NIBS) Guideline 3, Commissioning The Building Enclosure (V4). However, do any of these commissioning processes fully address moisture control and some of the risks associated with Green high performance buildings? While green buildings have many positive benefits, there is also strong evidence to suggest a direct correlation between new products/innovative design and building failures.

#### 1. Expansion of Integrated Design and Commissioning Scope

*H. Jay Enck, Member, Commissioning & Green Build Solutions Inc., Buford, GA*

#### 2. Commissioning Issues and Benefits Log

*Charles Dorgan, University of Wisconsin, Madison, WI*

#### 3. Expanded Commissioning Processes and Preventing Moisture Problems in High Performance Green Buildings

*Donald Snell, Member, Liberty Building Forensics Group, Zellwood, FL*

#### 4. Expanding the Commissioning Process

*Norman Nelson, P.E., Member, CH2M Hill, Portland, OR*

1:30 PM-3:00 PM

## TECHNICAL PAPER SESSION 3 (INTERMEDIATE)

### Building Energy Modeling and Calculations

Track: Building Energy Modeling vs. Measurement & Verification – Closing the Gap

Room: Governors Square 17



**Sponsor: 04.07 Energy Calculations**

Chair: *Dan Weimar, Member, Chem-Aqua, Tallahassee, FL*

Predicting and verifying energy consumption from HVAC systems within energy modeling programs is as important as ever. However not all modeling programs are accurate due to abridged calibration and verification against the modeling data. There are computer programs developed based on single-zone modeling, but zonal models have the best chance at predicting energy consumption where non-uniformity parameters exist. Energy modeling for heat pump systems with variable refrigerant flow (VRF) within the Energy Plus model is also a part of these session papers. This model includes data for full and part load performances based on manufacturer's data. Another energy user in a building are electric motors. See the mathematic relationships between motor efficiency and power factor data when estimating an induction motor circuit parameters and the efficacy under variable frequencies. Building simulation software for solar energy utilization may result in energy savings and energy production, however solar gains can result in an increase in air conditioning energy consumption. One model provides useful insight of the effect of accuracy of absorbed solar gains combines ray-tracing simulation and modified radiosity for the diffusely transmitted part.

#### 1. Evolutionary Tuning of Building Models to Monthly Electrical Consumption (DE-13-008)

*Aaron Garrett, Ph.D.<sup>1</sup>, Joshua New, Ph.D., Member<sup>2</sup> and Theodore Chandler<sup>1</sup>, (1)Jacksonville State University, Jacksonville, AL, (2)Oak Ridge National Laboratory, Oak Ridge, TN*

#### 2. Thermostat Setpoint Temperature Prediction Using an Integrated Zonal Model (DE-13-009)

*Ahmed Cherif Megri<sup>1</sup> and Yang Yao, Ph.D., P.E.<sup>2</sup>, (1)University of Wyoming, Laramie, WY, (2)Institute of Heat Pump and Air Conditioning Technology, Harbin Institute of Technology, Harbin, China*

### 3. Verification of A VRF Heat Pump Computer Model in EnergyPlus (DE-13-010)

*Bereket A. Nigusse and Richard Raustad, Florida Solar Energy Center, Cocoa, FL*

### 4. Estimation of Induction Motor Circuit Parameters and Efficiency Under Variable Frequencies (DE-13-011)

*Gang Wang, Ph.D., P.E., Member<sup>1</sup>, Li Song, Ph.D., P.E., Member<sup>2</sup> and Sung-Won Park<sup>3</sup>, (1)University of Miami, Coral Gables, FL, (2)University of Oklahoma, Norman, OK, (3)Texas A&M University-Kingsville, Kingsville, TX*

### 5. Analysis and Comparison of Absorbed Solar Radiation Distribution Models in Perimeter Building Zones (DE-13-012)

*Athanasios Tzempelikos, Associate Member and Ying-Chieh Chan, Purdue University, West Lafayette, IN*

1:30 PM-3:00 PM

## CONFERENCE PAPER SESSION 3 (INTERMEDIATE)

### Field Research of Energy Conservation Modeling Fidelity of Window Shades and Plug Load Control

*Track: Research Summit*

*Room: Governors Square 14*

*Chair: Elyse Malherek, Associate Member, The Weidt Group, Minneapolis, MN*



This session seeks to address the capability of modeling to reflect field-measured data. The information presented focuses on accurate modeling of heat transfer through slat blinds, as well as how occupants interact with window shades as compared to typical modeling assumptions. Control sequences are examined as well with discussion on optimizing and integrating HVAC, lighting, and blind controls.

#### 1. ASHRAE 1478: Measuring Air-Tightness of Mid- and High-Rise Non-Residential Buildings (DE-13-C011)

*Terry Brennan<sup>1</sup>, Wagdy Anis, Member<sup>2</sup>, Gary Nelson<sup>3</sup> and Collin Olson, Ph.D.<sup>3</sup>, (1)Camroden Associate, Westmoreland, NY, (2)Wiss, Janney, Elstner Associates, Inc., Boston, MA, (3)Energy Conservatory, Minneapolis, MN*

#### 2. The Influence of Slat-Type Blinds On Energy Consumption in Office Buildings: Results of Experiments and Parallel Simulations (DE-13-C012)

*Gregory N. Arcangeli, Student Member, and Attila Novoselac, Ph.D., Member, University of Texas at Austin, Austin, TX*

#### 3. The Influence of Occupant Behavior On Facade Solar Transmission: Discrepancies Between Observed Shade Control Behavior and Simulation-Based Shade Control Models (DE-13-C013)

*Kyle Konis, Ph.D., Member, University of Southern California, Los Angeles, CA*

#### 4. Integrated Control System for HVAC, Lighting and Blind As an Energy Saving Strategy in Office Building (DE-13-C014)

*Kinam Kang, Dr.Eng., Student Member<sup>1</sup>, Doosam Song, Ph.D., Member<sup>1</sup>, Kyumin Kang, M.D.<sup>1</sup> and Brain S. Kim, Dr.Eng., Member<sup>2</sup>, (1)Sungkyunkwan University, Suwon, South Korea, (2)Samsung Electronics Co. Ltd., Suwon, South Korea*

1:30 PM-3:00 PM

## CONFERENCE PAPER SESSION 4 (INTERMEDIATE)

### Making Advances in Efficiency: Air-Conditioning Equipment and Design Research Results

*Track: Mile-High Efficiency & Equipment*

*Room: Governors Square 15*

*Chair: Geoffrey C. Bares, Associate Member, CB&I, Plainfield, IL*



One of the most significant challenges for today's HVAC industry is reducing electrical energy consumption while maintaining comfort. Meeting that challenge means finding new ways to boost energy efficiency in both air conditioning equipment and design strategies. This session highlights four research projects where such efficiency gains have been achieved through improvements to residential air conditioning equipment design and control.

#### 1. Efficiency Improvement of Residential Air-Conditioning System (DE-13-C015)

*Jiazhen Ling, Yunho Hwang, Ph.D., Member and Reinhard Radermacher, Ph.D., Fellow ASHRAE, University of Maryland, College Park, MD*

#### 2. Transformation of a Baseline Affordable House Into a Partially Conditioned Atrium House in a Hot-Humid Climate (DE-13-C016)

*Simge Andolsun, Student Member and Charles Culp, P.E., Fellow ASHRAE, Texas A&M University, College Station, TX*

#### 3. Cooling Efficiency Comparison Between Residential Variable-Capacity and Single-Speed Heat Pump (DE-13-C017)

*Walter E. Hunt, Associate Member<sup>1</sup>, Ronald Domitrovic, Ph.D., Associate Member<sup>1</sup> and Ammi Amarnath<sup>2</sup>, (1)Electric Power Research Institute, Knoxville, TN, (2)Electric Power Research Institute, Palo Alto, CA*

#### 4. Improvement of IEER Rating and Dehumidification Capability in Unitary DX Equipment (DE-13-C018)

*Michael K. West, Ph.D., P.E., Member<sup>1</sup> and Tom Brooke, P.E., Member<sup>2</sup>, (1)Advantek Consulting Engineering, Melbourne, FL, (2)Advantek Consulting Engineering, Inc., Ocala, FL*

1:30 PM-3:00 PM

## CONFERENCE PAPER SESSION 5 (INTERMEDIATE)

### CFD Modeling of Occupant Comfort and Health in Diverse Applications

*Track: Research Summit*

*Room: Governors Square 16*

*Sponsor: 04.10 Indoor Environmental Modeling*

*Chair: James VanGilder, P.E., Member, APC by Schneider Electric, Billerica, MA*



This session presents the use of Computational Fluid Dynamics (CFD) for the design of patient rooms, residential living spaces, and places of worship. Detailed airflow modeling allows occupant comfort and health to be ensured at all locations throughout the space. The unique modeling challenges of each class of application are discussed.

#### 1. Role of HVAC System Configuration on Probable Flow Path of Airborne Pathogens in a Patient Room (DE-13-C019)

*Kishor Khankari, Ph.D., Member, AnSight LLC, Ann Arbor, MI*

#### 2. Air Distribution Performance Analyses in Enclosures (DE-13-C020)

*Essam E. Khalil, Ph.D., Fellow ASHRAE<sup>1</sup> and Alaa Mahfouz, P.E.<sup>1</sup>, (1)Cairo University, Cairo, Egypt*

#### 3. Air Flow in Places of Worship (DE-13-C021)

*Essam E. Khalil, Ph.D., Fellow ASHRAE<sup>1</sup> and Ramy Ragab, P.E.<sup>1</sup>, (1)Cairo University, Cairo, Egypt*

1:30 PM-3:00 PM

## SEMINAR 5 (INTERMEDIATE)

### Effect of Frosting and Water Condensation on Microchannel Heat Exchangers

*Track: HVAC&R Systems & Equipment*

*Room: Plaza Ballroom A*

*Sponsor: 08.04 Air-to-Refrigerant Heat Transfer Equipment, 01.03 Heat Transfer and Fluid Flow*

*Chair: Sankar Padhmanabhan, Ph.D., Member, Danfoss HX, Baltimore, MD*



Microchannel heat exchangers have been recently adopted by the HVAC industry because of their compactness and efficiency when used in AC systems for residential applications. Recently significant research effort is focused on understanding the phenomenon of water retention and frost growth on microchannel heat exchangers. This seminar presents the effect of surface coating, refrigerant distribution, heat exchanger orientation, etc. in the condensate drainage and frost growth phenomenon on microchannel heat exchangers.

#### 1. How to Apply Microchannel Heat Exchangers as Evaporators

*Mark Johnson, Associate Member, Modine Mfg., Racine, WI*

#### 2. Effect of Surface Coatings on Frost Growth on Microchannel Heat Exchangers

*Lorenzo Cremaschi, Ph.D., Member<sup>1</sup>, Ehsan Moallem<sup>1</sup>, Sankar Padhmanabhan, Ph.D., Member<sup>2</sup> and Dan Fisher<sup>1</sup>, (1)Oklahoma State University, Stillwater, OK, (2)Danfoss HX, Baltimore, MD*

#### 3. Effect of Inclination on the Air-Side Performance of Microchannel Heat Exchangers Under Dry and Wet Conditions

*Man-Hoe Kim, Ph.D., Member, Kyungpook National University, Buk-gu, Daegu, South Korea*

#### 4. Effects of Water Retention and Refrigerant Flow Distribution on Microchannel Heat Exchanger

*Chad Bowers, Ph.D., Associate Member, Creative Thermal Solutions, Urbana, IL*

#### 5. Managing Condensate and Frost on Heat Exchanger Surfaces: A Condensed View of Surface Wettability Modification and Control

*Andrew Sommers, Ph.D., Miami University, Oxford, OH*

1:30 PM-3:00 PM

### SEMINAR 6 (INTERMEDIATE)

#### Field and Equipment Issues that Impact Economizer Control Performance

*Track: HVAC&R Systems & Equipment*

*Room: Plaza Ballroom E*

*Sponsor: 06.03 Central Forced Air Heating and Cooling Systems, 02.08 Building Environmental Impacts and Sustainability*

*Chair: Kevin B. Mercer, P.E., Associate Member, Carrier Corp., Indianapolis, IN*

This seminar discusses results related to common economizer control practices and such implications. Field data and results are also presented to show benefits of advanced controls. The seminar also aims to expand on faults and controls integration of economizers and the effects on building operation.

#### 1. Air-Side Economizer Improvements and New Regulations

*Richard Lord, Member, Carrier Corp., Murfreesboro, TN*

#### 2. Field Testing Advanced Economizer Applications

*Reid Hart, P.E., Member, PNNL, Richland, WA*

#### 3. Impacts of Damper Leakage on Economizer Performance

*Jon Douglas, Member, Lennox Industries, Carrollton, TX*

#### 4. Efforts to Detect Faults in Economizers

*Kristin Heinemeier, Ph.D., P.E., Member, Western Cooling Efficiency Center, Davis, CA*

1:30 PM-3:00 PM

### SEMINAR 7 (INTERMEDIATE)

#### Measured and Simulated Building Performance with Emphasis on Existing Building Commissioning

*Track: Building Energy Modeling vs. Measurement & Verification – Closing the Gap*

*Room: Plaza Ballroom B*

*Sponsor: 07.06 Building Energy Performance*

*Chair: Bruce D. Hunn, Ph.D., Fellow ASHRAE, Hunn Building Energy, Raleigh, NC*

This seminar presents experiences in measuring and simulating the performance of commercial buildings, with emphasis on the results of commissioning. Included are descriptions of the development of databases for archiving,

analyzing, comparing, benchmarking, and reporting measured building performance data. Metrics protocols, data quality control, and security procedures, for a range of levels of detail, are described; approaches to data sharing through an automated XML platform are presented.

#### 1. Energy Modeling in Hindsight: A San Francisco High Rise Case Study

*Lisa Gartland, Ph.D., Member, kW Engineering, Oakland, CA*

#### 2. Measuring Triple Bottom Line Performance With DASH: Database for Analyzing Sustainable and High Performance Buildings

*Aurora Sharrard, Ph.D., Green Building Alliance, Pittsburgh, PA*

#### 3. Analysis of Commissioning Cost/Benefit Data in the DASH Database

*Bruce D. Hunn, Ph.D., Fellow ASHRAE, Hunn Building Energy, Raleigh, NC*

#### 4. A New Open-Source Protocol for Sharing Information on Proposed Energy Efficiency and Renewable Energy Projects

*Jim Kelsey, P.E., Member, kW Engineering, Oakland, CA*

1:30 PM-3:00 PM

### SEMINAR 8 (ADVANCED)

#### The Rules of Engagement for a New Game: IPD Contract “Styles” and You!

*Track: Integrated Project Delivery*

*Room: Plaza Ballroom F*

*Sponsor: 01.07 Business, Management & General Legal Education, TC07.01*

*Chair: E. Mitchell Swann, P.E., Member, MDC Systems, Paoli, PA*

Integrated project delivery is rolling across the nation in waves. The goal is to get better efficiency and better quality with fewer change orders and much less aggravation. Pooled profits, shared risks and ‘covenants not to sue’ can be part of that brave new world. But to work so well together means that the payers will need to drop their traditional guards to support the ‘openness’ that IPD demands. How is that done? How do I do THE job while protecting MY job? This program highlights several of the most commonly used IPD contract forms, addresses how you keep track, and tells you what to do if “issues” do arise.

#### 1. Integrating the Boots On the Ground: The Contractor’s Perspective

*Roland Nikles, J.D., Rogers Joseph O’Donnel, San Francisco, CA*

#### 2. Am I the Brains of the Outfit?: The Designer’s Perspective

*Julie Sneed Muller, J.D., Wyatt, Tarrant & Combs, LLP, Jackson, MS*

#### 3. Over the Finish Line Together: The Owner’s Perspective

*John Theiss, J.D., Davis Wright Tremaine, Seattle, WA*

3:15 PM-4:45 PM

### SEMINAR 9 (BASIC)

#### Sky High Efficient Case Studies

*Track: Mile-High Efficiency & Equipment*

*Room: Plaza Ballroom E*

*Sponsor: 09.01 Large Building Air-Conditioning Systems*

*Chair: Kelley Cramm, P.E., Member, Henderson Engineers, Lenexa, KS*

This program presents case studies for two high profile buildings where existing HVAC systems were upgraded. The new systems were designed to significantly reduce operating costs. The presentations will highlight practical approaches to upgrading systems in existing buildings to improve performance.

#### 1. High Efficiency, Direct-Indirect Cooling Application for High Performance Office Building (Trimble), Denver, CO

*Kevin Madigan, P.E., Member, MTech Mechanical Technologies Group, Denver, CO*

#### 2. High-Efficiency Ventilation Air Upgrade at Major Convention Facility

*Stephen W. Duda, P.E., Member, Ross & Baruzzini, Inc., St. Louis, MO*

#### 3. High Efficiency, High Profile Riverfront Restaurant HVAC Replacement Without Missing a Serving

*John Kuempel Jr., P.E., Member, DeBra-Kuempel, Mechanical/Electrical, Cincinnati, OH*

8:00 AM-9:30 AM

## TECHNICAL PAPER SESSION 4 (INTERMEDIATE)

### Fire and Smoke Management in High-Rise Buildings

Track: Research Summit

Room: Governors Square 17

Sponsor: 05.06 Control of Fire and Smoke

Chair: Kai Kang, Ph.D., Member, KAI Consulting Engineers, Nutley, NJ

Successful development of an integrated fire safety plan is inseparable from a good knowledge of airflow and smoke movement in the event of a fire in high-rise buildings. An application is presented using a computer program designed specifically to track smoke movement, taking into account system and equipment such as stairwell pressurization fans. This is supported by an evaluation of the computer modeling capabilities substantiating its appropriate use.

#### 1. An Integrated Fire Safety Plan to Manage Smoke Movement during a High-Rise Fire (DE-13-013)

William Black, Ph.D., P.E., Member, Georgia Institute of Technology, Atlanta, GA

#### 2. Comparison of Simulation Programs for Airflow and Smoke Movement during High-Rise Fires (DE-13-014)

Liangzhu (Leon) Wang, Ph.D., Member<sup>1</sup>, William Black, Ph.D., P.E., Member<sup>2</sup> and Guanchao Zhao, Student Member<sup>1</sup>, (1)Concordia University, Montreal, QC, Canada, (2)Georgia Institute of Technology, Atlanta, GA



8:00 AM-9:30 AM

## TECHNICAL PAPER SESSION 5 (INTERMEDIATE)

### Improvements to Climatic Data for ASHRAE Design Calculations

Track: HVAC&R Fundamentals & Applications

Room: Plaza Ballroom A

Sponsor: 04.02 Climatic Information

Chair: Joe Huang, Member, White Box Technologies, Moraga, CA

As part of its continuing activity to update the Climatic Design Values in the ASHRAE Handbook of Fundamentals, ASHRAE TC 4.2 (Climatic Information) has also conducted research to improve the derivation of climatic design condition, adding new data elements such as monthly average temperatures, heating and cooling degree days, and creating a new clear-sky solar radiation model. Two of the papers in this technical session give an overview of the 2009 climatic design condition tables and an explanation of the new ASHRAE Clear-Sky Model. A third paper describes the use of NOAA's MERRA satellite-derived data to supplement ASHRAE climatic design tables that are based on ground observations.

#### 1. Predicting Annual Energy Use in Buildings Using Short-Term Monitoring: The Hybrid Inverse Model Using Daily Data (HIM-D) (DE-13-015)

T. Agami Reddy, Ph.D., P.E., Fellow ASHRAE<sup>1</sup>, Vipul Singh, Student Member<sup>2</sup> and Bass Abushakra, Ph.D., P.E., Member<sup>3</sup>, (1)The Design School/The School of Sustainable Engineering and the Built Environment, Tempe, AZ, (2)The Green Engineer, Concord, MA, (3)Milwaukee School of Engineering, Milwaukee, WI

#### 2. Revising ASHRAE Climatic Data for Design and Standards, Part 1: Overview and Data (RP-1613) (DE-13-016)

Didier Thevenard, Ph.D., P.E., Member<sup>1</sup> and Steve Cornick, Member<sup>2</sup>, (1) Numerical Logics Inc., Waterloo, ON, Canada, (2)National Research Council Canada, Ottawa, ON, Canada

#### 3. Revising ASHRAE Climatic Data for Design and Standards, Part 2: Clear-Sky Solar Radiation Model (RP-1613) (DE-13-017)

Didier Thevenard, Ph.D., P.E., Member, Numerical Logics Inc., Waterloo, ON, Canada

#### 4. An Analysis of NASA's MERRA Meteorological Data to Supplement Observational Data for Calculation of Climatic Design Conditions (DE-13-018)



David Westberg<sup>1</sup>, Paul W. Stackhouse Jr., Ph.D.<sup>1</sup>, Drury Crawley, Ph.D., Fellow ASHRAE<sup>2</sup>, James Hoell<sup>1</sup>, William Chandler<sup>1</sup> and Taiping Zhang<sup>1</sup>, (1)SSAI/NASA Langley Research Center, Hampton, VA, (2)Bentley Systems, Inc., Washington, DC

8:00 AM-9:30 AM

## CONFERENCE PAPER SESSION 6 (INTERMEDIATE)

### Analysis for Optimization of Thermal and Renewable Energy Systems

Track: Renewable & Alternative Energy Sources

Room: Governors Square 14

Chair: Michele Friedrich, P.E., Member, ODOE, Salem, OR

Increases in energy and power efficiency can be found through system optimization. This session presents models and analysis on optimizing 3 different thermal and renewable energy systems. Included are methods for optimizing a ground source heat pump system, a solar flat plate thermosyphon tracking system and an electric power grid with intermittent renewable power supply.

#### 1. Energy Analyses of a District Cooling Plant with a Proposed Energy Saving Using Open Loop Geothermal Substitution (DE-13-C022)

Essam E. Khalil, Ph.D., Fellow ASHRAE, Mahmoud Fouad, Ph.D., P.E., Member and Hesham Safwat, Ph.D., P.E., Member, Cairo University, Cairo, Egypt

#### 2. Post-Occupancy Assessment of Energy-Pile and Open-Well Ground Source Heat Pump (GSHP) System: Case Study (DE-13-C023)

Denis Garber, Ruchi Choudhary and Kenichi Soga, University of Cambridge, Cambridge, United Kingdom

#### 3. Modelling Annual Yields of a Solar-Tracking Solarsyphon Using ASHRAE's Weather Data for Tropical Africa (DE-13-C024)

Kant E. Kanyarusoke, Jasson Gryzagoridis and Graeme Oliver, Cape Peninsula University of Technology, Cape Town, South Africa

#### 4. Renewable Integration by End-Use Thermal Devices (DE-13-C025)

Harshal Upadhye, Associate Member<sup>1</sup>, Ronald Domitrovic, Ph.D., Associate Member<sup>1</sup>, Nohealani Hirahara<sup>2</sup>, Mathew Goo<sup>2</sup>, Earle Ifuku<sup>2</sup>, John Somdecerrf<sup>2</sup> and Yoh Kawanami<sup>2</sup>, (1)Electric Power Research Institute, Knoxville, TN, (2)Hawaiian Electric Company, Honolulu, HI



8:00 AM-9:30 AM

## CONFERENCE PAPER SESSION 7 (INTERMEDIATE)

### Reducing the Climate Impacts of Refrigeration Systems

Track: Research Summit

Room: Governors Square 15

Chair: Cynthia Gage, Ph.D., Fellow ASHRAE, EPA, Research Triangle Park, NC

Achieving safe, efficient, and environmentally friendly refrigeration will require studies in several areas including modeling and experimental evaluation of refrigerants and systems, as well as investigations ensuring the safe use of alternatives. This session presents recent results on performance testing of low GWP refrigerants in various applications; the relationship of the leak rate of Class 2L refrigerants to developing the LFL concentration; and various supermarket systems using LCCP.

#### 1. Retrofit of R-410A in Air to Water Heat Pumps: Test of Two Low GWP Candidates (DE-13-C026)

Assaad Zoughaib, Dr. Ing. and Karim Besbes, Center for Energy and Processes, Mines Paristech, Paris, France

#### 2. Testing of Low-GWP Alternative Refrigerants for Refrigeration Applications (DE-13-C027)

Xudong Wang, Member and Karim Amrane, Ph.D., Member, Air-Conditioning, Heating and Refrigeration Institute (AHRI), Arlington, VA



### 3. An Analytical Investigation of Class 2L Refrigerants (DE-13-C028)

*Dennis Dorman, Member, Trane, LaCrosse, WI*

### 4. Energy Efficiency and Environmental Impact Analyses of Supermarket Refrigeration Systems (DE-13-C029)

*Brian A. Fricke, Ph.D., Member<sup>1</sup>, Pradeep Bansal, Ph.D., Fellow ASHRAE<sup>1</sup> and Shitong Zha, Ph.D., Member<sup>2</sup>, (1)Oak Ridge National Laboratory, Oak Ridge, TN, (2)Hill PHOENIX, Covington, GA*

8:00 AM-9:30 AM

## CONFERENCE PAPER SESSION 8 (INTERMEDIATE)



### Prove You're Green Presentation Series

*Track: Building Energy Modeling vs. Measurement & Verification – Closing the Gap*

*Room: Governors Square 16*

*Chair: James Vallort, P.E., Member, Environmental Systems Design, Chicago, IL*

Building owners want verification that the energy savings produced from energy efficient measures and designs are going to outweigh their initial cost investment. Similarly, many energy service companies and utilities offer incentives and financial packages to reduce the investment required to implement energy saving projects based on future energy savings projections. Therefore confidence in projected energy savings and then proof of actual energy savings is an essential business requirement for building owners. This collection of papers will present methods for modeling energy savings as well as means and methods for measurement and verification of the completed project.

#### 1. Understanding Building Infrastructure and Building Operation Through DOE Asset Score Model: Lessons Learned From a Pilot Project (DE-13-C031)

*Na Wang, Ph.D., Supriya Goel, Willy Gorrissen and Atefe Makhmalbaf, Pacific Northwest National Laboratory, Richland, WA*

#### 2. Cost-Effective Measurement and Verification Method for Determining Energy-Savings Under Uncertainty (DE-13-C031)

*Yeonsook Heo, Ph.D., Victor M. Zavala, Ph.D. and Diane J. Graziano, Ph.D., Argonne National Laboratory, Argonne, IL*

#### 3. Measurement and Verification for Energy Efficiency Programs (DE-13-C032)

*Roy Torbert and Kendra Tupper, P.E., Associate Member, Rocky Mountain Institute, Boulder, CO*

#### 4. Analysis and Improvements on the Estimation of Building Energy Savings Uncertainty (DE-13-C033)

*Yifu Sun and Juan-Carlos Baltazar, Ph.D., Member, Texas A&M University, College Station, TX*

8:00 AM-9:30 AM

## SEMINAR 10 (INTERMEDIATE)

### Control Your Costs and Expand Your Possibilities: Integrating Factory-Mounted Controls

*Track: HVAC&R Systems & Equipment*

*Room: Plaza Ballroom E*

*Sponsor: 01.04 Control Theory and Application*

*Chair: Marcelo Acosta, P.E., Member, SA Armstrong Ltd., Toronto, ON, Canada*

Factory mounted controllers are changing the landscape for today's building management systems (BMS). Equipment is arriving with independent operating capabilities, along with serial communication capabilities and many new data points. What are the implications for our building designs, the controls contractors and building owners? Three perspectives on the subject are presented by an equipment manufacturer, a controls contractor and a design consultant.

#### 1. Factory Mounted Controls: New Possibilities in a World of High Energy Performance Standards

*Peter Thomsen, P.Eng., Member, SAA Armstrong Ltd., Toronto, ON, Canada*

### 2. Factory Mounted Controls: New Opportunities for the BAS Contractor

*Cory Knopp, M.D., Member, Setpoint Systems Corporation, Denver, CO*

### 3. The Impact of Including Factory Mounted Controls in an HVAC Design

*Ira Goldschmidt, Goldschmidt Engineering Solutions, Denver, CO*

8:00 AM-9:30 AM

## SEMINAR 11 (INTERMEDIATE)

### Performance Based Procurement Process Case Studies

*Track: Integrated Project Delivery*

*Room: Plaza Ballroom F*

*Sponsor: 02.08 Building Environmental Impacts and Sustainability, 07.01 Integrated Building Design*

*Chair: Dunstan Macauley, P.E., Member, TAI Engineers, Owings Mills, MD*

The goal of this session is to present case studies of projects delivered using performance procurement methods such as integrated project delivery method (IPD). The session provides insight into the pros and cons of the various delivery methods.

#### 1. Using a Performance Based Procurement Process for an Energy Efficient Office Building

*Paul Torcellini, Ph.D., Member, National Renewable Energy Laboratory, Golden, CO*

#### 2. Scalability of Integrated Project Delivery, BIM, User Collaboration, and Sustainability for Smaller Laboratory Facilities: Part I

*Heather Buckberry, P.E., Member, Oak Ridge National Laboratory, Oak Ridge, TN*

#### 3. Scalability of Integrated Project Delivery, BIM, User Collaboration, and Sustainability for Smaller Laboratory Facilities: Part II

*Heather Buckberry, P.E., Member, Oak Ridge National Laboratory, Oak Ridge, TN*

8:00 AM-9:30 AM

## SEMINAR 12 (BASIC)

### Quality BIM Objects for Lifelong Building Reality in a Virtual World

*Track: Building Energy Modeling vs. Measurement & Verification – Closing the Gap*

*Room: Plaza Ballroom B*

*Sponsor: 01.05 Computer Applications, BIM MTG, 07.03 Operation and Maintenance Management*

*Chair: Tim Dwyer, Fellow ASHRAE, Bartlett School of Graduate Studies, University College London, London, United Kingdom*

Many MEP manufacturers and building system designers are struggling to develop and apply BIM objects that are truly fit for use. This seminar examines the challenges of applying architectural objects in the engineering process, the practicalities of creating usable BIM objects to deliver a manufacturer's catalogue, and the benefits of using rich BIM objects across the whole design and operations team.

#### 1. A Brave New World of BIM for Engineers

*David Branson, Compliance Services Group, Lubbock, TX*

#### 2. Calculating the Value of Quality Objects From Project Conception to Handover

*Kristine Fallon, Kristine Fallon Associates, Chicago, IL*

#### 3. Benefits and Challenges for Manufacturers Developing Meaningful and Useful BIM Objects

*Daniel Rau, P.E., Member, Ruskin Company, Grandview, MO*

9:45 AM-10:45 AM

### KEYNOTE 1

#### Energy Efficiency Research at NREL's Commercial Building Program: A Review of Programs, Laboratory Facilities, and Net Zero Energy Results

Track: Research Summit

Room: Plaza Ballroom E

Chair: Shanti D. Pless, Member, National Renewable Energy Laboratory, Golden, CO

This keynote address reviews the NREL Commercial Buildings Research focus areas over the 3 sections in the research group: Whole building Integration, Tools Development, and Fundamentals and Technologies. It reviews the research and laboratory facilities at NREL, including large scale net zero energy office buildings, advanced HVAC development and test loops, and energy systems integration facilities, from small scale labs to individual net zero buildings with electric vehicle integration, to campus scale energy integration efforts.

9:45 AM-10:45 AM

### KEYNOTE 2

#### The Business of Project Development; Risk, Returns, and IPD

Track: Integrated Project Delivery

Room: Plaza Ballroom F

Chair: Robert Springer, Concurrent Technologies Corporation, Denver, CO

Integrated Project Delivery promises greater efficiency and value through early collaboration by the design, construction, and ownership teams. Considering that early stage project efforts are subject to varying degrees of project development risk; how does IPD compete with traditional delivery methods? This question must be considered in light of the traditional risk management approaches to early stage project development. A project development is developed and discussed, then considered with respect to delivery methods, risk management, and overall value.

9:45 AM-10:45 AM

### KEYNOTE 3

#### Trends in Data Center Design: ASHRAE Leads the Way to Large Energy Savings

Track: HVAC&R Systems & Equipment

Room: Plaza Ballroom B

Chair: Otto VanGeet, P.E., Member, National Renewable Energy Laboratory, Golden, CO

ASHRAE TC 9.9 "2011 Thermal Guidelines for Data Processing Environments" have redefined the operating requirements for data center. The thermal guidelines recommend a temperature of over 80F and allow 90F at the face of the rack. The "2011 Thermal Guidelines for Liquid Cooled Data Processing Equipment" allow for "free cooling" of most liquid cooled equipment. 90.1-2010 requires air or water economizers for most data centers. The trends are much lower cooling energy use in data centers because of economizers in most climates. ASHRAE Standard 90.4 "Energy Standard for Data Centers" is covered, as well as leading data center examples.

11:00 AM-12:00 PM

### CONFERENCE PAPER SESSION 9 (INTERMEDIATE)

#### Reduced Order Modeling

Track: Research Summit

Room: Governors Square 17

Sponsor: 04.10 Indoor Environmental Modeling

Chair: James VanGilder, P.E., Member, APC by Schneider Electric, Billerica, MA



Practical airflow modeling for building design is often hindered by the balance of simulation speed and accuracy. This seminar presents the most recent state-of-the-art techniques of airflow modeling to achieve a good balance for fast and practical applications. Tools and methods discussed here are directly applicable to better practices of airflow modeling for thermal comfort and energy efficiency.

#### 1. Coarse Grid Methods for Improving Convective Heat Loss Predictions From Numerical Manikins (DE-13-C034)

Chao-Hsin Lin, Ph.D., Member<sup>1</sup>, Raymond Horstman, P.E., Fellow ASHRAE<sup>2</sup> and Michael Tonks, Ph.D., Member<sup>2</sup>, (1)The Boeing Company, Seattle, WA, (2)Boeing Commercial Airplane Group, Seattle, WA

#### 2. Inverse Determination of Air Supply Speed for Room Ventilation Based on Reduced Order Models (DE-13-C035)

Hongbiao Zhou, Tengfei Zhang, Ph.D., Member and Shugang Wang, Ph.D., Dalian University of Technology, Dalian, China

11:00 AM-12:00 PM

### CONFERENCE PAPER SESSION 10 (INTERMEDIATE)

#### Golden Nuggets from New 'Diggings' about Higher Efficiencies in Unitary and Water Heating Equipment

Track: Mile-High Efficiency & Equipment

Room: Governors Square 15

Chair: Alonzo Blalock, P.E., Member, Jacobs, Fort Worth, TX



This session includes descriptions of several new findings on improvement in technology that could be golden for projects. The first paper describes methods being applied to unitary systems which result in improved performance for systems in hot humid and hot arid environments. The second paper deals with 'surveys' being filed for model of improved Heat Pump Water Heating units that have proven operation in other lands but need consideration with homeland reviews. The third paper presents little ideas that might have double the savings with a new type heat pump water heating units. In new technology, the first runs are when the 'mined' proof begins to show up.

#### 1. Improvement of Integrated Energy Efficiency and Latent Cooling Capability by Refrigeration Cycle Variation with Evaporator Coil Optimization in R410a Unitary Equipment (DE-13-C036)

Michael K. West, Ph.D., P.E., Member and Richard Combes, Ph.D., P.E., Associate Member, Advantek Consulting Engineering, Melbourne, FL

#### 2. Modeling Advanced Heat Pump Water Heater Systems (DE-13-C037)

Dennis M. Nasuta, Associate Member<sup>1</sup>, John D. Bush, Member<sup>2</sup>, Yunho Hwang, Ph.D., Member<sup>3</sup>, Ronald Domitrovic, Ph.D., Associate Member<sup>2</sup>, Reinhard Radermacher, Ph.D., Fellow ASHRAE<sup>3</sup> and Ammi Amarnath<sup>4</sup>, (1) Optimized Thermal Systems, LLC, College Park, MD, (2)Electric Power Research Institute, Knoxville, TN, (3)University of Maryland, College Park, MD, (4)Electric Power Research Institute, Palo Alto, CA

#### 3. Field and Laboratory Evaluation of a New Integrated CO2 Heat Pump Water Heater (DE-13-C038)

John D. Bush, Member<sup>1</sup>, Ronald Domitrovic, Ph.D., Associate Member<sup>1</sup> and Ammi Amarnath<sup>2</sup>, (1)Electric Power Research Institute, Knoxville, TN, (2)Electric Power Research Institute, Palo Alto, CA

11:00 AM-12:00 PM

### CONFERENCE PAPER SESSION 11 (INTERMEDIATE)

#### Energy Modeling vs. Actual Building Energy Consumption: Why Do They Seem to be So Different?

Track: Building Energy Modeling vs.

Measurement & Verification - Closing the Gap

Room: Plaza Ballroom B

Chair: Keith Newcomer, Member, Piedmont Natural Gas, Fuquay Varina, NC



Energy modeling has become a vital part of the standard design criteria of most buildings as the owner wants to know what it is going to cost to operate his building. This session looks at some of the issues and reasons why energy modeling programs and actual energy usage in buildings, in many cases, provide different results. Some of the problems are driven by the level of energy efficiency desired, stricter code requirements, efforts to reduce CO2 emissions and commitment to sustainability. The use of BIM as an integration program and tool is discussed as well as several programs that are being used. Conflicts between modeled energy usage and actual results along with suggestions and partial solutions to the problems encountered are reviewed.

### 1. Architecture, Cartography and Energy: Mapping the Way We Share Information to Build Better Buildings (DE-13-C039)

*Matt R. Grinberg, P.E., Member and Adam Rendek, Stantec Consulting, San Francisco, CA*

### 2. Prediction and Verification of Energy Performance in Energy Efficient Multi-Family Dwellings (DE-13-C040)

*Hans Bagge, Ph.D. and Dennis Johansson, Ph.D., Lund University, Lund, Sweden*

### 3. From Design to Occupancy: Strategies to Enhance Building Performance and Prediction Accuracy (DE-13-C041)

*Anthony Hardman, P.E., Member<sup>1</sup>, Leslie Beu, Member<sup>2</sup> and Tom Riead<sup>2</sup>, (1)The Green Engineer, Concord, MA, (2)Tolin Mechanical Systems, Denver, CO*

11:00 AM-12:00 PM

## CONFERENCE PAPER SESSION 12 (INTERMEDIATE)

### Identifying Efficiency Opportunities for Refrigeration Systems

*Track: Research Summit*

*Room: Plaza Ballroom A*

*Chair: Cynthia Gage, Ph.D., Fellow ASHRAE, EPA, Research Triangle Park, NC*



An on-going field of study in refrigeration is advancing the energy performance of systems. Areas of study include investigating factors which impact the cooling load, identifying parameters which improve performance, and optimizing refrigerant selection. This session presents the results of recent research in these three areas. Research on thermoelectric refrigerators reveals the effects of TEM voltage and temperature on the system COP; and a zeotropic refrigerant blend is evaluated in a low temperature refrigeration system for biotechnology applications.

### 1. Experimental and Analytical Study of the Transient Process of Infiltration/Exfiltration in Walk-in Coolers (DE-13-C042)

*Homayun K. Navaz, Ph.D., Member<sup>1</sup>, Kristina Kamensky, Member<sup>2</sup>, Mazyar Amin, Ph.D., Member<sup>3</sup> and Ramin Faramarzi, P.E., Member<sup>4</sup>, (1)Kettering University, Flint, MI, (2)Prismitech, Flint, MI, (3)Miami University, Middletown, OH, (4)Southern California Edison Company, Irwindale, CA*

### 2. Coefficient of Performance Improvement in Small Thermoelectric Refrigerators (DE-13-C043)

*Hessam Taherian, Ph.D., Member and William L. Adams, University of Alabama at Birmingham, Birmingham, AL*

### 3. Modeling and Testing of an R23/R-134a Mixed Refrigerant System for Low Temperature Refrigeration (DE-13-C044)

*Nicholas A. Hugh, Marquette University, Milwaukee, WI*

11:00 AM-12:00 PM

## CONFERENCE PAPER SESSION 13 (INTERMEDIATE)

### Research and Developments Impacting Total Cost of Ownership (TCO) for Data Centers

*Track: HVAC&R Systems & Equipment*

*Room: Plaza Ballroom E*

*Chair: Nick Gangemi, Member, Facility Gateway Construction, Madison, WI*



This session looks at three areas where recent research and new developments could have a significant impact on the total cost of ownership of a data center. New server classes A3 and A4 operate at higher inlet temperatures and offer energy savings from reduced mechanical cooling costs but that may be offset by higher server fan speeds and leakage power. A comparison will be made across two different data centers. Improved design of chilled water thermal expansion tanks offer increased availability of chilled water during a power outage and can help reduce energy cost during peak demand periods. It is shown how 3D numerical simulation and virtual design approach both help to improve the design. Finally, recent years have seen advancements in the technology that enables the application of liquid cooling at the processor level. The newest technologies are discussed as an update to an earlier paper published.

### 1. Impact of Allowable Server Air Conditions on Data Center Economics (DE-13-C045)

*Niru Kumari, Ph.D., Associate Member<sup>1</sup>, William J. Kosik, P.E., Member<sup>2</sup> and Tahir Cader, Ph.D., Member<sup>3</sup>, (1)Hewlett-Packard Co., Palo Alto, CA, (2)Hewlett-Packard Co., Chicago, IL, (3)Hewlett-Packard Co., Spokane, WA*

### 2. Use of Numerical Simulation and Optimization to Analyze the Design and Performance of a Chilled Water Thermal Storage Tank (DE-13-C046)

*Reza Ghias, Ph.D., Member, Kris Xu, Member, Richard Ellison, P.E., Member and Curt Eisenhower, P.E., Member, Southland Industries, Dulles, VA*

### 3. Liquid Cooling in Data Centers: Part 2 (DE-13-C047)

*Vali Sorell, P.E., Member<sup>1</sup>, Phillip Tuma<sup>2</sup> and Liam Newcombe<sup>3</sup>, (1)Syska Hennessy Group, Charlotte, NC, (2)3M Corp., St. Paul, MN, (3)Romonet, LTD, London, United Kingdom*

11:00 AM-12:00 PM

## SEMINAR 13 (INTERMEDIATE)

### Chilled Water Systems for YEA Members: What the Gen Xers and Baby Boomers Have Done Wrong

*Track: HVAC&R Systems & Equipment*

*Room: Governors Square 16*

*Sponsor: 06.01 Hydronic and Steam Equipment and Systems*

*Chair: Mick Schwedler, P.E., Member, Trane Co., La Crosse, WI*



This session is ideal for YEA members so they don't repeat the mistakes the Gen Xers and baby boomers have made. In this seminar the audience helps identify mistakes too commonly made in chilled water systems. Presenters share specific job mitigation techniques as well as design methods used to overcome the issues.

### 1. Chilled Water System Design and Problem Mitigation - Part 1

*Jason A. Atkisson, P.E., Member, Ross & Baruzzini, Inc., St. Louis, MO*

### 2. Chilled Water System Design and Problem Mitigation - Part 2

*Mick Schwedler, P.E., Member, Trane Co., La Crosse, WI*

11:00 AM-12:00 PM

## SEMINAR 14 (ADVANCED)

### Heat and Resource Recovery in Industrial Air-conditioning Applications: New School or Old Hat?

*Track: Renewable & Alternative Energy Sources*

*Room: Governors Square 14*

*Sponsor: 09.02 Industrial Air Conditioning*

*Chair: Michael Connor, P.E., Member, Connor Engineering Solutions, Alpharetta, GA*



The practice of not wasting thermal or chemical resources is not new to industrial processes. This is due to the fact that many processes operate at conditions that are considered extreme compared to simple air conditioning applications. As such there is a greater opportunity for energy recovery from industrial processes than in commercial air conditioning applications. However, coupled with the opportunity for greater resource recovery is the reality

that, in some cases, this may not be possible, for the recovery airstream may be laden with dangerous or outright toxic vapors and chemicals.

### 1. Energy Savings or Energy Recovery from Industrial Waste: Eliminate Air Pollutants

*Vinod P. (V. P.) Gupta, P.E., Member, 3M Company, Saint Paul, MN*

### 2. Lowering Energy Costs in Industrial Facilities for Safety and Efficiency

*Michael Connor, P.E., Member, Connor Engineering Solutions, Alpharetta, GA*

11:00 AM-12:00 PM

## FORUM 1 (BASIC)

### How to Improve HVAC Software to Support Integrated Work Processes

*Track: Integrated Project Delivery*

*Room: Plaza Ballroom F*

*Sponsor: 01.05 Computer Applications, SGPC 20*

*Chair: Robert J. Hitchcock, Member, Hitchcock Consulting, Kelsey, CA*

ASHRAE Guideline 20-2012 defines a formal procedure for documenting Use Cases of work processes and data exchange requirements that are critical to improving HVAC software support of integrated project delivery work processes. The committee responsible for maintaining this guideline seeks your input. What's wrong with your HVAC software? What pain-points do you experience in exchanging data between tools? What Use Cases are important to you? How can ASHRAE best document these Use Cases and promote them within the industry? A brief overview of Guideline 20-2012 is followed by an open discussion seeking your input on these important questions.

2:15 PM-3:45 PM

## SEMINAR 15 (INTERMEDIATE)

### Advancements in BIM Interoperability Solutions to Aid in Integrated Project Delivery (IPD)

*Track: Integrated Project Delivery*

*Room: Plaza Ballroom E*

*Sponsor: 01.05 Computer Applications,*

*07.01 Integrated Building Design*

*Chair: Stephen Roth, P.E., Member, Carmel Software Corp., San Rafael, CA*

Building Information Modeling (BIM) software tools are being adopted by architects, engineers, and contractors for purposes of integrated project delivery. There are a number of software tools from many different vendors that provide both BIM and building analysis software. Interoperable schemas such as Green Building XML (gbXML) are open and free, and they are the "glue" that allows these tools to communicate with one another. This seminar discusses the latest advancements of such software technologies.

#### 1. How Interop Schemas are Used to Facilitate BEM and IPD

*Stephen Roth, P.E., Member, Carmel Software Corp., San Rafael, CA*

#### 2. How are BIM Vendors Expanding Their Interoperability Capabilities

*John F. Kennedy, Member, Autodesk, Santa Rosa, CA*

#### 3. How are Building Analysis Vendors Improving Interoperability Workflows

*Nathan Kegel, Member, IES, Minnetonka, MN*

4:00 PM-5:30 PM

## SEMINAR 16 (INTERMEDIATE)

### Real Operating Cost Savings from Retro-Commissioning

*Track: HVAC&R Fundamentals & Applications*

*Room: Plaza Ballroom E*

*Sponsor: 07.08 Owning and Operating Costs*

*Chair: Charles E. Dale-Derks, P.E., Member, McClure Engineering, St. Charles, MO*

While occupants and tenants demand comfort under all conditions, facility operators are challenged with efficiently operating systems with multiple variables and complex algorithms. In time, controls may get tweaked or overridden to correct a perceived problem, but these tweaks are soon forgotten and the system is operated under a different parameter than originally intended. Retro-commissioning or continuous commissioning is key to finding and correcting these operating inefficiencies.

#### 1. Retro-Commissioning the University of Nebraska Medical School

*Ken L. Hansen, P.E., University of Nebraska Medical Center, Omaha, NE*

#### 2. Community Colleges in Nebraska Re-Think Energy and Operating Costs

*Ginger Willson, Nebraska Energy Office, Lincoln, NE*

#### 3. Finding Good Fruit When the Low Hanging is Gone

*Charles E. Dale-Derks, P.E., Member, McClure Engineering, St. Charles, MO*

Tuesday, June 25

8:00 AM-9:30 AM

## TECHNICAL PAPER SESSION 6 (INTERMEDIATE)

### Reducing Environmental Impact: Ventilation with Heat Recovery and Improved Flammability Testing of Low GWP Refrigerants

*Track: Research Summit*



*Room: Governors Square 14*

*Sponsor: 03.01 Refrigerants and Secondary Coolants*

*Chair: Barbara Minor, Member, DuPont, Wilmington, DE*

The first part of the session reviews options for both energy and cost efficient ventilation systems with heat recovery. This includes opportunities for manufacturers and designers to enhance the thermal and electrical efficiency of their products as well as reduce investment and maintenance costs. The second topic focuses on flammability measurement of low GWP refrigerants with reduced environmental impact.

#### 1. Principles of Energy Efficient Ammonia Refrigeration Systems (DE-13-019)

*Abdul Qayyum Mohammed, Student Member<sup>1</sup>, Thomas Wenning<sup>2</sup>, Franc Sever, Student Member<sup>3</sup> and Kelly Kissock<sup>1</sup>, (1)University of Dayton, Dayton, OH, (2)Oak Ridge National Laboratory, Oak Ridge, TN, (3)Go Sustainable Energy, Columbus, OH*

#### 2. WITHDRAWN – Effect of Lubricant on the Distribution of Water Between Vapor and Liquid Phases of Refrigerants (RP-1495) (DE-13-020)

*John Senediak, Member, Intertek, Columbus, OH*

#### 3. Energy and Cost Efficient Ventilation Systems with Heat Recovery: State of the Art and Enhancement (DE-13-021)

*Rainer Pfluger, Ph.D.<sup>1</sup>, Wolfgang Feist, Ph.D.<sup>1</sup>, Gabriel Rojas-Kopeinig, P.E.<sup>1</sup> and Wolfgang Hasper, Ph.D.<sup>2</sup>, (1)University of Innsbruck, Innsbruck, Austria, (2)Passivhaus Institut, Hesse, Germany*

#### 4. Assessment of Burning Velocity Test Methods for Mildly Flammable Refrigerants, Part 1: Closed-Vessel Method (RP-1583) (DE-13-022)

*Kenji Takizawa, Shizue Takagi, Kazuaki Tokuhashi, Shigeo Kondo, Ph.D., Mikito Mamiya, Ph.D. and Hideaki Nagai, Ph.D., National Institute of Advanced Industrial Science and Technology (AIST), Ibaraki, Japan*

#### 5. Assessment of Burning Velocity Test Methods for Mildly Flammable Refrigerants, Part 2: Vertical-Tube Method (RP-1583) (DE-13-023)

*Kenji Takizawa, Naoharu Igarashi, Kazuaki Tokuhashi, Shigeo Kondo, Ph.D., Mikito Mamiya, Ph.D. and Hideaki Nagai, Ph.D., National Institute of Advanced Industrial Science and Technology (AIST), Ibaraki, Japan*

8:00 AM-9:30 AM

## CONFERENCE PAPER SESSION 14 (INTERMEDIATE)

### Evaporative Cooling Technologies

Track: HVAC&R Systems & Equipment

Room: Governors Square 15

Chair: Michael S. Sherber, P.E., Member, 7AC Technologies, Inc., Beverly, MA



This session covers various evaporative cooling technologies, including case studies of direct evaporative cooling systems across North American climates, methodologies for thermal modeling of indirect evaporative heat exchangers, and reviews of evaporative cooler operation, including the evaporative process, water usage, and the interaction of various water qualities.

#### 1. A General Method for Thermal Modeling of Indirect Evaporative Heat Exchangers (DE-13-C048)

Zhijun Liu, Student Member, William Allen, Ph.D. and Mark Modera, Ph.D., P.E., Fellow ASHRAE, Western Cooling Efficiency Center, University of California, Davis, CA

#### 2. Humidification, Filtration and Sound Attenuation Benefits of Rigid Media Direct Evaporative Cooling Systems While Providing Energy Savings (DE-13-C049)

Vijayanand Periannan, Member, Munters Corporation, Buena Vista, VA

#### 3. Optimal Control, Operation and Maintenance Strategies for Rigid Media Evaporative Cooling Coolers to Improve IAQ and Reduce Building Water Usage (DE-13-C050)

Patricia Graef, P.E., Munters Corp, Fort Myers, FL

#### 4. Performance Evaluation of a Multi-Stage Evaporative Cooling System for Classrooms in a Hot and Dry Climate (DE-13-C051)

Huafen Hu, Ph.D., Associate Member and Mathew Krieske, Student Member, Portland State University, Portland, OR

8:00 AM-9:30 AM

## CONFERENCE PAPER SESSION 15 (INTERMEDIATE)

### Thermal Comfort and IAQ in Indoor Environmental Design

Track: Research Summit

Room: Governors Square 16

Chair: Mikhail Koupriyanov, Price, Winnipeg, MB, Canada



Thermal comfort and Indoor Air Quality (IAQ) are important considerations when designing the indoor environment. This session covers both of these topics from both experimental and computational (CFD) angles. Computational Fluid Dynamics (CFD) is an effective and flexible tool for analyzing the indoor environment that is rapidly gaining popularity in the building design community. One of the papers addresses the use of CFD with a multi-segmented human heat transfer & thermophysiology model to predict thermal comfort and indoor air quality in a naturally ventilated classroom. Another paper uses the Fire Dynamics Simulator (FDS) code (a Large Eddy Simulation (LES) based CFD program) to assess thermal comfort and energy utilization in a full size room with a ceiling air conditioner. Experimental studies not only offer valuable insight into the physics of indoor airflow but also form the basis of most computational and empirical models used to analyze the indoor environment. The experimental studies in this session cover a wide range of topics including the person-to-person transport of pathogens and bio-effluents in an aircraft cabin as well as the ability of the aircraft's personal air outlets to control exposure.

#### 1. Modeling the Effect of HVAC Operation on Transport of Gaseous Species to Indoor Surfaces (DE-13-C052)

Jordan D. Clark, Student Member and Atila Novoselac, Ph.D., Member, University of Texas at Austin, Austin, TX

#### 2. Large Eddy Simulation of Thermal Comfort and Energy Utilization Indices for Indoor Airflows (DE-13-C053)

Dahai (Darren) Qi, Student Member, Liangzhu (Leon) Wang, Ph.D., Member and Radu Zmeureanu, Ph.D., Member, Concordia University, Montreal, QC, Canada

### 3. Impact of Personal Air Outlets On Person-to-Person Bio-Effluent Exposure in Aircraft Cabins (DE-13-C054)

M.D. Anderson, Student Member, Byron Jones, Ph.D., P.E., Fellow ASHRAE and M.H. Hosni, Ph.D., Fellow ASHRAE, Mechanical and Nuclear Engineering Department at Kansas State University (KSU), Manhattan, KS

### 4. Coupled CFD and Thermal Comfort Modelling: Predicting Indoor Air Quality in Naturally Ventilated Environments Subject to Asymmetric Long Wave Radiation (DE-13-C055)

Malcolm J. Cook, Ph.D., Member, Loughborough University, Loughborough, United Kingdom

8:00 AM-9:30 AM

## SEMINAR 17 (INTERMEDIATE)

### Benchmarking and Improving Commercial Building Energy Performance

Track: Building Energy Modeling vs. Measurement & Verification—Closing the Gap

Room: Plaza Ballroom F

Sponsor: 02.08 Building Environmental Impacts and Sustainability, 07.06 Building Energy Performance

Chair: Neil P. Leslie, P.E., Member, Gas Technology Institute, Des Plaines, IL



States and cities across the United States are enacting legislation that requires benchmarking, rating, and reporting the energy performance of existing commercial buildings. This seminar describes the Energy STAR Portfolio Manager rating method included in recent legislation, provides specific examples of rating and reporting requirements, and offers strategies for building owners and designers to improve measured energy performance over the lifetime of the building.

#### 1. Application of Energy STAR Portfolio Manager in State and Local Building Benchmarking and Disclosure Policies

Leslie Cook, U.S. Environmental Protection Agency, Washington, DC

#### 2. National Policy Landscape: Benchmarking and Disclosure in U.S. Cities

Jessica Lawrence, Institute for Market Transformation, Washington, DC

#### 3. A Building Owner's Secret Guide to Beating Energy Targets

Lew Harriman III, Fellow ASHRAE, Mason Grant, Portsmouth, NH

8:00 AM-9:30 AM

## CONFERENCE PAPER SESSION 15 (INTERMEDIATE)

### Thermal Comfort and IAQ in Indoor Environmental Design

Track: Research Summit

Room: Governors Square 16

Chair: Mikhail Koupriyanov, Price, Winnipeg, MB, Canada



Thermal comfort and Indoor Air Quality (IAQ) are important considerations when designing the indoor environment. This session covers both of these topics from both experimental and computational (CFD) angles. Computational Fluid Dynamics (CFD) is an effective and flexible tool for analyzing the indoor environment that is rapidly gaining popularity in the building design community. One of the papers addresses the use of CFD with a multi-segmented human heat transfer & thermophysiology model to predict thermal comfort and indoor air quality in a naturally ventilated classroom. Another paper uses the Fire Dynamics Simulator (FDS) code (a Large Eddy Simulation (LES) based CFD program) to assess thermal comfort and energy utilization in a full size room with a ceiling air conditioner. Experimental studies not only offer valuable insight into the physics of indoor airflow but also form the basis of most computational and empirical models used to analyze the indoor environment. The experimental studies in this session cover a wide range of topics including the person-to-person transport of pathogens and bio-effluents in an aircraft cabin as well as the ability of the aircraft's personal air outlets to control exposure.

#### 1. Modeling the Effect of HVAC Operation on Transport of Gaseous Species to Indoor Surfaces (DE-13-C052)

Jordan D. Clark, Student Member and Atila Novoselac, Ph.D., Member, University of Texas at Austin, Austin, TX

#### 2. Large Eddy Simulation of Thermal Comfort and Energy Utilization Indices for Indoor Airflows (DE-13-C053)

Dahai (Darren) Qi, Student Member, Liangzhu (Leon) Wang, Ph.D., Member and Radu Zmeureanu, Ph.D., Member, Concordia University, Montreal, QC, Canada

8:00 AM-9:30 AM

## SEMINAR 18 (INTERMEDIATE)

### Developments in Simulation

Track: Research Summit

Room: Governors Square 17

Sponsor: TGI Optimization, Education and Publishing, TGI Optimization

Chair: Reinhard Radermacher, Ph.D., Fellow ASHRAE, University of Maryland, College Park, MD



This session offers a select group of recently published papers from the ASHRAE HVAC&R Research Journal regarding new developments in simulation technology to include predictive pre-cooling, dynamic modeling for vapor compression and particle swarm optimization.

#### 1. Dynamic Modeling for Vapor Compression Systems: Literature Review and Simulation Tutorial

Bryan Rassmussen, Ph.D., P.E., Member<sup>1</sup> and Bhaskar Shenoy<sup>1</sup>, (1)Texas A&M University, College Station, TX

#### 2. Designing HVAC Systems Using Particle Swarm

Ramiro Bravo, Ph.D., Member<sup>1</sup> and Forrest Wendell Flocker, Ph.D.<sup>1</sup>, (1) University of the Permian Basin, Odessa, TX

### 3. Predictive Cooling of Thermo-Active Building Systems with Low-Lift Chillers

*Dr. Nicholas T. Gayeski, Ph.D.<sup>1</sup>, Peter Armstrong, Ph.D., Member<sup>2</sup> and Leslie Norford, Ph.D., Member<sup>3</sup>, (1)Massachusetts Institute of Technology, Watertown, MA, (2)Masdar Institute of Science and Technology, Abu Dhabi, United Arab Emirates, (3)Massachusetts Institution of Technology, Cambridge, MA*

8:00 AM-9:30 AM

## SEMINAR 19 (INTERMEDIATE)

### The New ASHRAE District Heating and District Cooling Design Guides, Part I (1267-RP)

*Track: Research Summit*



*Room: Plaza Ballroom E*

*Sponsor: 06.02 District Energy, 06.09 Thermal Storage*

*Chair: Blake Ellis, P.E., Member, Burns & McDonnell, Kansas City, MO*

This is part one of a two part seminar on the New ASHRAE District Heating and District Cooling Design Guides that were developed through ASHRAE Research Project 1267. Part I will provide an overview of the project and then discuss planning for district systems, consumer interconnections to these systems, and the design of the thermal distribution systems that connect the central plant to the consumers.

#### 1. Overview of the New ASHRAE Design Guides for District Heating and Cooling

*Gary Phetteplace, Ph.D., P.E., Member, GWA Research LLC, Lyme, NH*

#### 2. Planning: Key to a Sustainable, Energy Efficient, DHC System

*Donald Bahnfleth, P.E., Presidential Member, Bahnfleth Group Advisors, LLC, Cincinnati, OH*

#### 3. Highlights of the New ASHRAE District Heating and District Cooling Design Guides for Building Interconnections

*Steve Tredinnick, P.E., Member, Syska Hennessy Group, Madison, WI*

#### 4. Distribution Systems for District Heating and Cooling

*Vernon Meyer, P.E., Member, Heat Distribution Solutions, Omaha, NE*

8:00 AM-9:30 AM

## SEMINAR 21 (INTERMEDIATE)

### Water Side Economizers, a.k.a. Free Cooling

*Track: Mile-High Efficiency & Equipment*



*Room: Plaza Ballroom B*

*Sponsor: 08.02 Centrifugal Machines*

*Chair: Fred Betz, P.E., Member, PEDCO E&A Services, Cincinnati, OH*

This program presents design and operation considerations for Water Side Economizers that can provide chilled water when outdoor air temperature is low. This has frequently been referred to as "free cooling". Integrated and non-integrated economizers are defined and the differences and advantages presented. Cooling tower freeze protection and defrost control during sub-freezing weather and the requirements of ASHRAE Standard 90.1 for water side economizers relative to integrated economizers will be discussed.

#### 1. Integrated Water Side Economizer

*Jeff Stein, P.E., Member, Taylor Engineering, Alameda, CA*

#### 2. Chiller Technology Application with Water Side Economizer

*Charlie Putz, Carrier Corporation, Greer, SC*

#### 3. Water Side Economizer Design and Modeling

*Susanna Hanson, P.E., Member, Trane, LaCrosse, WI*

9:45 AM-10:45 AM

## CONFERENCE PAPER SESSION 16 (INTERMEDIATE)

### Understanding the IPD Process

*Track: Integrated Project Delivery*



*Room: Plaza Ballroom F*

*Chair: Ann Gregg, Associate Member, PKMR Engineers, Overland Park, KS*

Integrated Project Delivery (IPD) can be an advantageous process to engage all team members to help achieve sustainability goals. This session explores the various methods and tools to ensure a successful IPD project. A case study in Qatar and Reno, Nevada note the implementation process and lessons learned to meet sustainability measures and Passivhaus certification.

#### 1. The Many Faces of IPD/ID: A Case Study (DE-13-C056)

*Don Saal, P.E., Associate Member<sup>1</sup>, Thomas A. Fisher<sup>2</sup> and Dana Villeneuve<sup>1</sup>, (1)Architectural Energy Corporation, Boulder, CO, (2)Parsons, Washington, DC*

#### 2. Integrated Project and Metering Design for the First Passivhaus in Qatar (DE-13-C057)

*John Bryant, Ph.D., P.E., Member<sup>1</sup>, Alex Amato, Ph.D.<sup>2</sup>, Simon Law<sup>3</sup> and Ahmad Al Abdulla<sup>4</sup>, (1)Texas A&M University at Qatar, Dohar, Qatar, (2) Qatar Green Building Council, Doha, Qatar, (3)AECOM, United Kingdom, London, United Kingdom, (4)Barwa Real Estate, Doha, Qatar*

9:45 AM-10:45 AM

## SEMINAR 22 (INTERMEDIATE)

### Energy Efficiency Financing

*Track: Renewable & Alternative Energy Sources*



*Room: Plaza Ballroom A*

*Chair: James Fields, Member, Superior Mechanical Services, Inc, Greensboro, NC*

So you have a great energy efficiency project designed and ready to go, but if your client cannot finance the project, you're dead in the water. In the first part of this seminar you can learn how owners can finance their projects with no upfront cost at all. Then, learn what makes a project an attractive investment to the appraisers and bank executives likely to approve private financing. This seminar informs our members of PACE (Property Assessed Clean Energy Programs). It also looks at energy efficiency investment risk as viewed by loan approval executives as it relates to the seven primary real estate asset classes.

#### 1. PACE Property Assessed Clean Energy

*Ben Taube, Ygrene Energy Fund, Atlanta, GA*

#### 2. Innovations in Energy Efficiency Financing

*Scott Muldavin, Rocky Mountain Institute and Green Building Finance Consortium, San Rafael, CA*

9:45 AM-10:45 AM

## SEMINAR 23 (INTERMEDIATE)

### Laboratory Retrofits Case Studies: Optimizing Energy Usage Through Commissioning and Comparison of Modelled Energy Usage Using M&V Data.

*Track: Building Energy Modeling vs.*



*Measurement & Verification - Closing the Gap*

*Room: Plaza Ballroom B*

*Sponsor: 09.10 Laboratory Systems*

*Chair: Peter B. Gardner, P.E., Member, Torcon, Inc., Red Bank, NJ*

This seminar presents lessons learned from the application of calibrated simulation models and post construction M&V for energy conserving retrofits of a half dozen laboratory buildings at Stanford University and McGill University. The calibrated models were used to predict energy performance from the retrofits and to calculate the return on investment for the university.

The M&V was used to establish the rebates and confirm that the savings were realized. One of these projects earned an ASHRAE Technology Award.

**1. Application of Calibrated Models and M&V Verification for VAV and Control Retrofits for Laboratory Buildings**

*Mark Hydeman, P.E., Fellow, Taylor Engineering, LLC, Alameda, CA*

**2. Energy Modeling of University Lab: Performance Before Retrofitting Permit its Optimisation Through Measurement and Verification**

*Roland Charneau, Fellow ASHRAE, Pageau Morel et Associés inc., Montreal, QC, Canada*

9:45 AM-10:45 AM

**SEMINAR 24 (INTERMEDIATE)**

**Mile-High Evaporative Cooling: Effective, Efficient, Economical**

*Track: Mile-High Efficiency & Equipment*

*Room: Governors Square 14*

*Sponsor: 05.07 Evaporative Cooling*

*Chair: Leon Shapiro, J.D., Member, Green Building Group, Oak Park, CA*

There are a number of factors which can influence the design engineer and owner/operator to utilize evaporative cooling, including climate, water quality, and type of application. This program provides: (1) useful information from research to assist in minimizing water quality issues and usage; and (2) case studies on how the National Renewable Energy Laboratory (NREL) has effectively utilized evaporative cooling in many of its facilities, and will review its strategies and criteria used to determine the best evaporative technologies for specific applications.

**1. Evaporative Cooling Applications at the National Renewable Energy Laboratories: Strategies to Meet High Performance Energy Use Goals**

*Otto D. Van Geet, P.E., Member, National Renewable Energy Laboratory, Golden, CO*

**2. Reducing Maintenance-Water Consumption in Evaporative Cooling Equipment**

*Mark Modera, Ph.D., P.E., Fellow ASHRAE, Western Cooling Efficiency Center, University of California, Davis, CA*



9:45 AM-10:45 AM

**SEMINAR 26 (INTERMEDIATE)**

**Analysis of Chemical and Physical Effects of Ultraviolet Bulbs on Cooking Emissions**

*Track: HVAC&R Fundamentals & Applications*

*Room: Governors Square 15*

*Sponsor: 02.09 Ultraviolet Air and Surface Treatment, Yes, 05.10 Kitchen Ventilation*

*Chair: Sam Guzman, Member, American Ultraviolet Company, Schooleys Mountain, NJ*

There is a growing recognition of the risks to health, fire hazard, and air quality from cooking emissions. Recent research has identified what is emitted when foods are cooked. Some of the emitted mass is captured in the exhaust system. The balance is expelled into the atmosphere. This session evaluates the purported benefit of adding better filtration and ultraviolet (UVC) bulbs in kitchen hoods.

**1. Analysis of Chemical and Physical Effects of Ultraviolet Bulbs on Cooking Emissions**

*Tim Farrell, Independent Researcher, St. Paul, MN*

**2. UVC for Kitchen Ventilation Systems: How and Why It Works**

*Benoit Despatis, Sanuvox Corporation, St-Laurent, QC, Canada*



9:45 AM-10:45 AM

**SEMINAR 27 (INTERMEDIATE)**

**The New ASHRAE District Heating and District Cooling Design Guides, Part 2 (1267-RP)**

*Track: Research Summit*

*Room: Plaza Ballroom E*

*Sponsor: 06.02 District Energy, 06.09 Thermal Storage*

*Chair: Lucas B. Hyman, P.E., Member, Goss Engineering, Inc., Corona, CA*

This seminar focuses first on thermal design of buried heating and cooling distribution systems and then moves on to provide an overview of thermal storage systems, with separate presentations for district cooling and district heating thermal storage design.

**1. Thermal Design of Buried District Heating and Cooling Distribution Systems**

*Gary Phetteplace, Ph.D., P.E., Member, GWA Research LLC, Lyme, NH*

**2. Highlights of the Chapter on Thermal Storage from ASHRAE's New District Cooling Design Guide**

*John S. Andrepont, Life Member, The Cool Solutions Company, Lisle, IL*

**3. Highlights of the Chapter on Thermal Storage in the New ASHRAE District Heating Design Guide**

*Pernille Overbye, Rambøll, København S, Denmark*



9:45 AM-10:45 AM

**SEMINAR 25 (INTERMEDIATE)**

**New Developments in HVAC**

*Track: Research Summit*

*Room: Governors Square 17*

*Sponsor: Publications and Education*

*Chair: Reinhard Radermacher, Ph.D., Fellow ASHRAE, University of Maryland, College Park, MD*

This session offers a select group of recently published papers from ASHRAE's HVAC&R Research Journal regarding new developments in HVAC technology to include experimental and theoretical investigations and individual and ambient ventilation systems.

**1. Individual Control of a Personalized Ventilation System Integrated with an Ambient Mixing Ventilation System**

*Yixing Chen, Ph.D., Student Member<sup>1</sup>, Benny Raphael<sup>2</sup> and Chandra Sekhar, Ph.D.<sup>2</sup>, (1)Syracuse University, Syracuse, NY, (2)National University of Singapore, Singapore*

**2. Infiltration As Ventilation: Weather-Induced Dilution**

*Will Turner, Ph.D., Max Sherman, Ph.D., Fellow ASHRAE and Iain Walker, Ph.D., Member, Residential Building Systems Group, Lawrence Berkeley National Laboratory, Berkeley, CA*



9:45 AM-10:45 AM

**FORUM 2 (INTERMEDIATE)**

**Should the VRP Be Held Up to the Same Performance/Monitoring Criteria as the IAQP?**

*Track: HVAC&R Systems & Equipment*

*Room: Governors Square 16*

*Sponsor: 02.03 Gaseous Air Contaminants and Gas Contaminant*

*Removal Equipment, TRG4IAQP, 02.04 Particulate Air Contaminants and Particulate Contaminant Removal Equipment*

*Chair: Charlene Bayer, Ph.D., Member, Georgia Tech Research Institute, Atlanta, GA and Hygieia Sciences LLC, Atlanta, GA*

Standard 62.1 VRP is a prescriptive standard and the IAQP a performance standard. The assumption in 62.1 is that if the VRP is correctly applied with the prescribed ventilation rates then acceptable IAQ will be achieved. Applying the IAQP requires specification of the CoCs and proof of their control. USGBC has released the IAQ-Performance Pilot Credit recognizing that both the VRP and the IAQP should demonstrate effectiveness. Should both the

VRP and IAQP be performance-based and be verified? How should performance verification be done, and to what criteria? What remediation should be pursued if performance verification fails?

11:00 AM-12:30 PM

## TECHNICAL PAPER SESSION 7 (INTERMEDIATE)

### A Decreasing Pattern of Ventilation Design Rates

Track: Research Summit

Room: Governors Square 17

Chair: Samir Traboulsi, Ph.D., P.E., Member, Thermotrade/Ranec, Beirut, Lebanon



Cost of energy to provide adequate indoor air quality is inversely proportional to the upgrade of the ventilation rates. Standard ASHRAE 62.1 had targeted over the years towards the reduction pattern of the rates. Hence technology will support the developing of control and hardware systems to keep up the lower rates but with less energy consumption burden.

#### 1. Investigation of Appropriate Ventilation Rates for Retail Stores (DE-13-024)

David T. Grimsrud, Ph.D., Fellow ASHRAE<sup>1</sup>, Barry B. Bridges, P.E., Member<sup>2</sup>, Tony Springman<sup>3</sup>, Neil Carlson<sup>1</sup> and Scott Williams<sup>4</sup>, (1) University of Minnesota, Minneapolis, MN, (2) Sebesta Blomberg, Roseville, MN, (3) Building Efficiency Services, Minneapolis, MN, (4) Target Corp., Minneapolis, MN

#### 3. Optimized Control of Automatic Windows for Energy Savings and Occupant Comfort (RP-1597) (DE-13-025)

Ryan A. Tanner, Student Member<sup>1</sup>, Gregor Henze, Ph.D., P.E., Member<sup>1</sup> and Shanti D. Pless, Member<sup>2</sup>, (1) University of Colorado, Boulder, CO, (2) National Renewable Energy Laboratory, Golden, CO

#### 4. Energy and Exergy Analyses of a New Waste Heat Driven Cogeneration Cycle for Simultaneous Cooling and Heating Applications (DE-13-026)

Rajesh Kumar<sup>1</sup>, Abdul Khaliq<sup>2</sup> and P.B. Sharma<sup>1</sup>, (1) Delhi Technological University, Delhi, India, (2) IIT College of Engineering, Nawanshahar, India

11:00 AM-12:30 PM

## CONFERENCE PAPER SESSION 17 (INTERMEDIATE)

### Modeling and Performance of Advanced Heat Exchanger Designs

Track: Research Summit

Room: Governors Square 16

Chair: Henry A. Becker, Member, H-O-H Water Technology, Inc, Palatine, IL



This session presents information detailing new and improved modeling techniques for enhanced heat exchange surfaces and innovative heat exchanger design. A study is also presented detailing heat transfer optimization for a falling-film evaporator. This work addresses theoretical and practical considerations for better implementation of various types of heat exchange equipment.

#### 1. Improving Simulation of Outside Air Economizer and Fan Control for Unitary Air Conditioners (DE-13-C058)

Reid Hart, P.E., Member, Rahul Athalye, Associate Member and Weimin Wang, Ph.D., PNNL, Richland, WA

#### 2. Characterization and Prediction of Swirl-Induced Enhanced Heat Transfer in Sinusoidal-Corrugated Plate-Fins (DE-13-C059)

Sucharitha Rajendran, Student Member, Deepak S. Kalaikadal, Student Member and Raj M. Manglik, Ph.D., Member, University of Cincinnati, Cincinnati, OH

#### 3. Development of a Horizontal Slinky Ground Heat Exchanger Model (DE-13-C060)

Zeyu Xiong, Student Member, Edwin S. Lee, Student Member and Dan Fisher, Oklahoma State University, Stillwater, OK

#### 4. Effects of Solution Subcooling and Wall Superheat on Heat Transfer of a Horizontal-Tube, Falling-Film Heat Exchanger (DE-13-C061)

Nick Bogdan and Chanwoo Park, Ph.D., University of Nevada, Reno, NV

11:00 AM-12:30 PM

## SEMINAR 28 (INTERMEDIATE)

### The Largest Zero-Energy Building: What is Under the Hood?

Track: Mile-High Efficiency & Equipment

Room: Plaza Ballroom A

Sponsor: 02.08 Building Environmental Impacts and Sustainability, 06.01 Hydronic and Steam Equipment and Systems

Chair: Paul A. Torcellini, Ph.D., Member, National Renewable Energy Laboratory, Golden, CO



The NREL Research Support Facility claims to be the largest zero-energy office building in the world. The seminar dives into the “nuts and bolts” of the building hardware including the mechanical systems (hydronic heating and cooling with dedicated outside air using transpired collectors, a basement labyrinth, and evaporative cooling), lighting systems (daylighting and electrical), envelope (glazing and envelope systems), and design of the plug loads that integrate together to create a building that was constructed at no additional cost yielding a 50% energy savings.

#### 1. Building Program Requirements and Envelope

Tom Hootman, RNL Design, Denver, CO

#### 2. Lighting Systems

Jennifer Scheib, National Renewable Energy Laboratory, Golden, CO

#### 3. Heating, Cooling, and Ventilating Systems

David Okada, P.E., Member, Arup, Seattle, WA

#### 4. Miscellaneous and Plug Loads Cannot Be Ignored

Shanti D. Pless, Member, National Renewable Energy Laboratory, Golden, CO

11:00 AM-12:30 PM

## SEMINAR 29 (INTERMEDIATE)

### Applications and Analysis of Passive Chilled Beams

Track: HVAC&R Systems & Equipment

Room: Plaza Ballroom F

Sponsor: 05.03 Room Air Distribution

Chair: Christopher S. Lowell, Member, Halton, Scottsville, KY



Passive chilled beams are one type of beam that provides sensible cooling by relying on the negative buoyancy of room air that is cooled by the hydronic coils suspended in ceiling fixtures, causing it to descend toward floor level. Passive beams must be coupled with a separate air distribution system that delivers fresh air and maintains humidity control. This seminar presents current understanding and applications of passive chilled beams through performance testing, modeling investigations, and case studies.

#### 1. Application Cases and Design Considerations for Passive Beams

Emmanuel Bizien<sup>1</sup> and Risto Kosonen, Ph.D., Member<sup>2</sup>, (1) Halton, Ivry-sur-Seine, France, (2) Oy Halton Group, Helsinki, Finland

#### 2. Analysis of Location of Passive Chilled Beams on Thermal Comfort of Occupants

Kishor Khankari, Ph.D., Member, AnSight LLC, Ann Arbor, MI

#### 3. Passive Beams with Underfloor Air Distribution: An American Tale

Fred Betz, P.E., Member, PEDCO E&A Services, Cincinnati, OH

11:00 AM-12:30 PM

## SEMINAR 30

### Are We There Yet? A Review of the 2010 – 2018 Research Strategic Plan

Track: Research Summit

Room: Governors Square 14

Chair: Michael Vaughn, P.E., Member, ASHRAE, Atlanta, GA

This session is meant to educate individuals and groups about the 2010 – 2018 ASHRAE Research Strategic Plan, to update them on current research underway in support of some of the plan’s goals, and to encourage additional research that will help to address goals from the plan still that have not been addressed yet.

**1. 2010-2018 ASHRAE Research Strategic Plan (RSP)**  
*Jeffrey D. Spitler, Ph.D., P.E., Fellow ASHRAE, Oklahoma State University, Stillwater, OK*

**2. Current Research Underway in Support of 2010-2018 RSP and Goals from Plan Not Yet Addressed**  
*Pradeep K. Bansal, Ph.D., Fellow ASHRAE, Oak Ridge National Laboratory, Oak Ridge, TN*

**3. A Way Forward: Potential Research Topic Areas for Sustainability and High Performance Buildings**  
*Thomas M. Lawrence, Ph.D., P.E., Member ASHRAE, University of Georgia, Athens, GA*

11:00 AM-12:30 PM

## SEMINAR 31 (INTERMEDIATE)

### Laboratory Exhaust Fans and Energy Conservation

*Track: HVAC&R Systems & Equipment*

*Room: Governors Square 15*

**Sponsor: 05.01 Fans, 2.06 & 9.10, 05.09 Enclosed Vehicular Facilities**  
*Chair: Aresh Raychaudhuri, P.E., Member, US Department of Veterans Affairs, Washington, DC*

Exhaust fans for laboratories have been in use for many years. Some of the criteria in the design and application of these systems and equipment include adequate exhaust, exit velocity, plume height and dilution of the exhaust air. VAV systems for energy efficiency further challenge the control of these fans. Selection and application of these fans with current trends of energy conservation is discussed in this seminar.

#### 1. Overview of Laboratory Exhaust Systems

*Chuck Coward, P.E., Fellow ASHRAE, Waddell Engineering Co., Moorestown, NJ*

#### 2. Amca 260: Testing and Performance Rating of Fans for Laboratory Exhaust Systems

*Andy Bosscher, Member, Twin City Companies, Plymouth, MN*

#### 3. Selection and Application of Laboratory Exhaust Fans

*Ron Wendorski, P.E., Member, Greenheck Fan Corporation, Schofield, WI*

11:00 AM-12:30 PM

## SEMINAR 32 (ADVANCED)

### Test Results from the AHRI Low GWP Refrigerants Alternative Refrigerant Evaluation Program

*Track: Research Summit*

*Room: Plaza Ballroom E*

**Sponsor: 10.06 Transport Refrigeration, MTG.LowGWP, 09.03 Transportation Air Conditioning**

*Chair: Ken Schultz, Ph.D., Member, Trane Co., LaCrosse, WI*

The possibility for regulations limiting the use of existing refrigerants because of concerns about climate change has led to a great deal of interest in lower global warming potential (GWP) refrigerants. The HVAC&R industry is working together through AHRI's Low-GWP Alternate Refrigerants Evaluation Program (AREP) to evaluate lower GWP options and share results. This seminar describes the results of tests on transport systems (refrigeration and air-conditioning) and chillers (R410A and R134a).

#### 1. Performance of R410A/R22 Alternative Lower GWP Refrigerants in a Small (~5 RT) Water Chiller

*Ken Schultz, Ph.D., Member, Trane Co., LaCrosse, WI*

#### 2. System Drop-In Tests of R404A Alternative Refrigerants in a Trailer Refrigeration Unit

*Vladimir Sulc, Ph.D.<sup>1</sup> and Markéta Kopecká<sup>2</sup>, (1)Ingersoll Rand / Thermo King, Bloomington, MN, (2)Ingersoll Rand / Thermo King, Prague, Czech Republic*

#### 3. System Drop-In Tests of R407C and R134a Alternative Refrigerants in a Bus Air-Conditioning Unit

*Vladimir Sulc, Ph.D.<sup>1</sup> and Markéta Kopecká<sup>2</sup>, (1)Ingersoll Rand / Thermo King, Bloomington, MN, (2)Ingersoll Rand / Thermo King, Prague, Czech Republic*

#### 4. Performance of R134a Alternative Lower GWP Refrigerants in a Water-Cooled Screw Chiller

*Ken Schultz, Ph.D., Member, Trane Co., LaCrosse, WI*

11:00 AM-12:30 PM

## SPECIAL SESSION 9 (INTERMEDIATE)

### Panel Discussion: VFD Generated Motor Bearing Currents Got Your Equipment Screaming?

*Track: HVAC&R Fundamentals & Applications*

*Room: Plaza Ballroom B*

**Sponsor: 01.11 Electric Motors and Motor Control, 08.01 Positive Displacement Compressors**

*Chair: Thomas Lowery, Member, Schneider Electric, Denver, CO*

Even a single motor failure due to VFD-induced bearing currents can cause costly downtime in critical HVAC/R systems. Often before the motors fail, bearing noise is evident causing users to question the technology advancements in variable speed driven HVAC fans and pumps. Depending on the air handler, cooling tower or pump motor's location, failures and subsequent removal/replacement can be a very difficult and expensive maintenance problem. This session presents system designs that can mitigate the potential problem from the onset; field measurement techniques to detect if the motor bearings are doomed to fail; and mitigation devices that can be installed to eliminate potential bearing currents from developing in the motor. The session also includes an extensive panel discussion where our four expert speakers answer audience questions about VFD induced motor bearing currents.

#### 1. Proper VFD Installation is the Best Way to Avoid Motor Bearing Issues

*Michael Olson, ABB, New Berlin, WI*

#### 2. The Physics of Motor Bearing Currents

*Michael J. Melfi, Baldor Motors, Richmond Heights, OH*

#### 3. Testing Procedures for Detection of Motor Bearing Currents

*Adam Willwerth, Associate Member, Electro Static Technology, Mechanic Falls, ME*

#### 4. Protection of Bearings Against Damaging Currents

*Sylvain Humbert, SKF Maintenance Products, MT Nieuwegein, Netherlands*



1:30 PM-3:00 PM

## SEMINAR 33 (BASIC)

### How Can I Participate in the ASHRAE Research Program?

*Track: Research Summit*

*Room: Plaza Ballroom E*

**Sponsor: RAC**

*Chair: Jaap Hogeling, Fellow ASHRAE, ISSO, Lienden, Netherlands*

This session is meant to educate, motivate, and enable individuals that wish to get involved in the ASHRAE Research Program. Students learn how the research program can help support their studies financially and through research experience (Graduate Student Grant-in-Aid Program, Homer Addams Award, etc.). Researchers learn about the various routes to obtaining ASHRAE research funding (Unsolicited research proposal, solicited projects, Innovative Research Grant program, and New Investigator Award for recent PhDs). Research topic originators learn how to get their research project idea considered by ASHRAE for the research program. Potential project co-funders learn how they can help develop, initiate, and monitor an ASHRAE research project.

#### 1. A Brief Overview of the ASHRAE Research Program

*Michael Vaughn, P.E., Member, ASHRAE, Atlanta, GA*

#### 2. Student Involvement in the ASHRAE Research Program

*T. Agami Reddy, Ph.D., P.E., Fellow ASHRAE, The Design School/The School of Sustainable Engineering and the Built Environment, Tempe, AZ*

#### 3. How Can I Become an ASHRAE Researcher?

*Donald B. Bivens, Ph.D., Member, Research Administration Committee, Kennett Square, PA*

#### 4. How Can I Propose a Project Topic for ASHRAE to Research?

*Carl F. Huber, P.E., WaterFurnace International, Inc., Roanoke, IN*



3:15 PM-4:45 PM

## SEMINAR 34 (INTERMEDIATE)

### Reducing the GWP Impacts of Commercial Refrigeration

Track: HVAC&R Systems & Equipment

Room: Plaza Ballroom E

Sponsor: 10.07 Commercial Food and Beverage Cooling Display and Storage, MTG Low GWP research, Refrigeration Committee

Chair: Shitong Zha, Ph.D., Member, Hill PHOENIX, Covington, GA



Commercial refrigeration systems are searching for lower GWP refrigerant options. Systems with small charge size are moving towards natural refrigerants, such as CO<sub>2</sub> in bottle coolers and R-290 in self-contained commercial ice machines. Larger systems are investigating low GWP synthetic refrigerants. What are the important design issues for natural refrigerants? What are the thermal and capacity performances of the low GWP synthetics? Are the energy efficiencies of all these lower GWP options beneficial to lowering the total GWP impacts compared to HFC systems?

#### 1. Successful Design and Implementation of Transcritical CO<sub>2</sub> Technology for Beverage Display Coolers

Stefan Elbel, Ph.D., Member, Creative Thermal Solutions and University of Illinois at Urbana-Champaign, Urbana, IL

#### 2. Reduced GWP Commercial Ice Machines Using R-290 Refrigerant

Daryl G. Erbs, Ph.D., Member, Manitowoc Foodservice Group, Sheboygan, WI

#### 3. Low GWP Replacements for R404A in Commercial Refrigeration Applications

Samuel F. Yana Motta, Ph.D., Member, Honeywell, Buffalo, NY

#### 4. Reducing the GWP Impact on Commercial Refrigeration

Laurent Abbas, Arkema, King of Prussia, PA

8:00 AM-9:30 AM

## CONFERENCE PAPER SESSION 18 (INTERMEDIATE)

### Comfort Issues in Various Vehicles

Track: Research Summit

Room: Governors Square 16

Chair: J.R. Anderson, Anderson Engineering, Germantown, TN



The following four papers address several comfort issues in various vehicles: indoor air quality and how to achieve it in a polluted environment; thermal comfort in the winter when traveling in an urban style cabin (train for example); air conditioning technology in an electric vehicle; and the performance measurement models of automotive air conditioning systems.

#### 1. Feasibility Study on the Adsorptive Removal of Indoor CO<sub>2</sub> of Car Running in Downtown Area (DE-13-C062)

Youngmin Cho, Ph.D., Soon-Bark Kwon, Duck-Shin Park and Woo-Sung Jung, Korea Railroad Research Institute, Uiwang, South Korea

#### 2. Heat Distribution Analysis in Urban Transit Cabin Using Real-Scale Environmental Chamber (DE-13-C063)

Youngmin Cho, Ph.D., Young-Kwan Yoon, Duck-Shin Park, Soon-Bark Kwon, Tae-Wook Kim and Woo-Sung Jung, Korea Railroad Research Institute, Uiwang, South Korea

#### 3. Cooling Characteristics of New Magnetic Refrigeration System for in-Vehicle Air Conditioner (DE-13-C064)

Yoshiki Tanaka<sup>1</sup>, Maikino Hirito<sup>1</sup>, Okamura Tetsuji<sup>1</sup>, Yutaka Tasaki<sup>2</sup>, Takahashi Hidekazu<sup>2</sup>, Yasuda Yoshiteru<sup>2</sup> and Kouji Ito<sup>3</sup>, (1)Tokyo Institute of Technology, Yokohama, Japan, (2)Nissan Research Center, Nissan Motor Co., Ltd, Yokosuka, Japan, (3)Zaouseiki Co., Inc., Yokohama, Japan

#### 4. A Moving Boundary Model for Transient Simulation of an Automotive Air Conditioning System and Experimental Validation with Some Case Study (DE-13-C065)

S.P. Datta, P.K. Das, Ph.D. and S. Mukhopadhyay, Ph.D., Indian Institute of Technology Kharagpur, Kharagpur, India

Wednesday, June 26

8:00 AM-9:30 AM

## TECHNICAL PAPER SESSION 8 (INTERMEDIATE)

### Innovative Solutions for Improving Thermal Performance and Efficiency in HVAC&R Applications

Track: HVAC&R Systems & Equipment

Room: Governors Square 17

Chair: Gary C. Debes, Member, Coward Environmental Systems, Coatesville, PA



The papers in this session will examine ground source heat pump systems and present solutions for improving the overall thermal performances. This session will also examine the effect of horizontal piping on the system's performance as well as new borehole configurations to improve thermal performance. This session also examines the impact pressure drop in a system has on thermal performance and energy efficiency.

#### 1. Preliminary Investigation of the Effect of Horizontal Piping on the Performance of a Vertical Ground Heat Exchanger System (DE-13-027)

James R. Cullin, Student Member, Jeffrey Spitler, Ph.D., P.E. and Edwin Lee, Student Member, Oklahoma State University, Stillwater, OK

#### 2. A Preliminary Assessment on the Use of Phase Change Materials Around Geothermal Boreholes (DE-13-028)

Parham Eslami-nejad, Ph.D.<sup>1</sup> and Michel Bernier, Ph.D., Member<sup>2</sup>, (1)Natural Resources Canada/Canmet-Energy, Varennes, QC, Canada, (2)Ecole Polytechnique De Montreal, Montreal, QC, Canada

#### 4. Method to Compute the Enthalpy Difference of a Liquid Stream When an EOS-Based Function is Not Available (DE-13-029)

Ken Schultz, Ph.D., Member, Trane Co., LaCrosse, WI

#### 5. CFD Analysis of Pressure Losses in Flat-Oval Duct Fittings (RP-1493) (DE-13-030)

Emir Sirbubalo, Haris Lulic and Milovan Gutovic, HVAC Design, Sarajevo, Bosnia

8:00 AM-9:30 AM

## CONFERENCE PAPER SESSION 19 (INTERMEDIATE)

### Mixed-Mode (Hybrid) Natural Ventilation: Efficient, Effective, and Energy Smart

Track: HVAC&R Systems & Equipment

Room: Governors Square 14

Chair: Leon Shapiro, J.D., Member, Green Building Group, Oak Park, CA



Natural ventilation has long been a central strategy used to meet ventilation needs and provide sustainable cooling in many types of buildings. When combined with mixed-mode or hybrid mechanical systems, natural ventilation can also effectively meet comfort cooling needs. This session features papers providing case studies of the design, control, implementation, and commissioning of mixed-mode natural ventilation systems in a ten-story office building in Japan, and a 200,000 square foot yoga hall in India.

#### 1. Energy Impacts of Residential Filtration in California Homes (DE-13-C066)

Iain Walker, Ph.D., Member, Darryl Dickerhoff, David Faulkner and Will Turner, Ph.D., Residential Building Systems Group, Lawrence Berkeley National Laboratory, Berkeley, CA

#### 2. Comfort Cooling for a 200,000 Square Feet Yoga Hall (DE-13-C067)

Shyamsundar Rao Appalla<sup>1</sup> and Alvaro Treviño<sup>2</sup>, (1)Symphony Limited, Ahmedabad, India, (2)Symphony Limited, Monterrey, Mexico

#### 3. Natural Ventilation Control System and Full Scale Monitoring (DE-13-C068)

Stephen Ray, Ph.D.<sup>1</sup>, Leon Glicksman<sup>1</sup>, Masa Fukuda<sup>2</sup>, Iwao Hasegawa<sup>3</sup> and Natsuko Ochiai<sup>3</sup>, (1)Massachusetts Institute of Technology, Cambridge, MA, (2)Hulic Co. Ltd., Tokyo, Japan, (3)Nikken Sekkei, Tokyo, Japan

Wednesday, June 26 47

8:00 AM-9:30 AM

## SEMINAR 36 (ADVANCED)

### Modeling Transient Conditions

Track: Research Summit

Room: Plaza Ballroom F

Sponsor: 04.10 Indoor Environmental Modeling

Chair: Amy Musser, Ph.D., P.E., Member, Vandemusser Design, PLLC, Asheville, NC



Modeling transient events is an increasingly important part of indoor environmental modeling. This seminar explores situations in which transient effects are important and identifies numerical and modeling techniques to accurately characterize them.

#### 1. Constructing Transient CFD Boundary Conditions From Weather and Wind Tunnel Data for Estimating Cross Ventilation Rate in a Building

James Lo, Ph.D., Student Member, National Institute of Standards and Technology/University of Texas at Austin, Gaithersburg, MD

#### 2. Real-Time Data Center Transient Analysis

Xuanhang (Simon) Zhang, Member, APC by Schneider Electric, Billerica, MA

#### 3. Optimal CO2 Sensor Location for Demand-Controlled Displacement Ventilation

Mikhail Koupriyanov, Price, Winnipeg, MB, Canada

8:00 AM-9:30 AM

## SEMINAR 37 (INTERMEDIATE)

### Simple Energy Improvements in Refrigeration Systems

Track: HVAC&R Systems & Equipment

Room: Plaza Ballroom E

Sponsor: 10.01 Custom Engineered Refrigeration Systems

Chair: Wayne Borrowman, P.Eng., Member, CIMCO Refrigeration, Delta, BC, Canada



Simple improvements can frequently be made to a refrigeration system to improve its energy efficiency. All too often however these improvements are overlooked for more trendy efficiency upgrades that can be much more complex and costly with longer paybacks. Examples of simple system changes as well as operation and control improvements are presented showing how energy savings were made with little cost or effort. The importance of monitoring the operational performance of a system is also shown, and how it can be used to both identify potential improvements and verify savings.

#### 1. Simple Energy Improvements in Operating Refrigeration Systems

Daniel J. Dettmers, Member, Industrial Refrigeration Consortium, University of Wisconsin, Madison, WI

#### 2. Proper Compressor Sequencing... It Matters

Douglas Reindl, Ph.D., P.E., Member, Industrial Refrigeration Consortium, University of Wisconsin, Madison, WI

#### 3. Performance Monitoring: The Key to Maximizing the System Efficiency

Doug Scott, Member, VaCom Technologies, La Verne, CA

8:00 AM-9:30 AM

## SEMINAR 38 (BASIC)

### The Fundamentals of Radiant Cooling System Design and Construction

Track: HVAC&R Systems & Equipment

Room: Plaza Ballroom B

Sponsor: 06.05 Radiant Heating and Cooling

Chair: Devin A. Abellon, P.E., Member, Uponor, Phoenix, AZ



As more and more jurisdictions and building owners are answering the call in establishing higher energy-use standards for their new construction projects, design teams are looking beyond traditional HVAC solutions to provide greater energy efficiency while maintaining occupant comfort and safety. A system

### 4. A Case Study of Natural Ventilation Developed for Tenant Office Building in Dense Urban Core (DE-13-C069)

Natsuko Ochiai<sup>1</sup>, Iwao Hasegawa<sup>1</sup>, Masa Fukuda<sup>2</sup>, Leon Glicksman<sup>3</sup> and Stephen Ray, Ph.D.<sup>3</sup>, (1)Nikken Sekkei, Tokyo, Japan, (2)Hulic Co. Ltd., Tokyo, Japan, (3)Massachusetts Institute of Technology, Cambridge, MA

8:00 AM-9:30 AM

## CONFERENCE PAPER SESSION 20 (INTERMEDIATE)

### Energy Simulation and Verification for VRF and Heat Pump Systems

Track: Research Summit

Room: Governors Square 15

Chair: Bill Dietrich, Member, Baltimore Aircoil Company, Baltimore, MD



Building owners and designers are interested in energy saving solutions that best meet the need of the application. Heat pumps and VRF systems are often used, and touted as energy saving systems. This session offers four papers that look at simulation models and verification of models through data acquisition.

#### 1. Study of A HEAT Pump for Simultaneous Heating and Cooling Working with R290 or R1234YF and Coupled to A Building (DE-13-C070)

Redouane Ghouali<sup>1</sup>, Paul Byrne, Ph.D.<sup>1</sup>, Frédéric Bazantay<sup>2</sup> and Jacques Miriel<sup>1</sup>, (1) Université de Rennes, Rennes, France, (2)Pôle Cristal: Technical Center of Refrigeration and Air Conditioning, Dinan, France

#### 2. Computer Modeling of Variable Refrigerant Flow Heat Pumps in Commercial Buildings Using Energyplus (DE-13-C071)

Richard Raustad, Florida Solar Energy Center, Cocoa, FL

#### 3. Compare Energy Use in Variable Refrigerant Flow Heat Pumps Field Demonstration and Computer Model Using Energyplus (DE-13-C072)

Chandan Sharma, Member, Florida Solar Energy Center, Cocoa, FL

#### 4. Energy Simulation of Integrated Multiple-Zone Variable Refrigerant Flow System (DE-13-C073)

Bo Shen<sup>1</sup>, C. Keith Rice, Ph.D.<sup>1</sup>, Timothy P. McDowell, Member<sup>2</sup> and D. Baxter, P.E., Fellow ASHRAE<sup>1</sup>, (1)Oak Ridge National Laboratory, Oak Ridge, TN, (2)Thermal Energy Systems Specialists, Madison, WI

8:00 AM-9:30 AM

## SEMINAR 35 (BASIC)

### Basics of HVAC Noise Control

Track: HVAC&R Fundamentals & Applications

Room: Plaza Ballroom A

Sponsor: 02.06 Sound and Vibration Control

Chair: Erik Miller-Klein, P.E., Associate Member, SSA Acoustics, LLP, Seattle, WA



Designing HVAC systems with good acoustic performance can be a challenge. This session addresses three common issues to improve your acumen for sound and vibration: exploring the idiosyncrasies of sound power, sound pressure and sound; learning about the physics of sound propagation and sources for interior and exterior environments; and refreshing your knowledge on how vibration isolation works and what type of installations are necessary for your projects.

#### 1. Sound Power, Sound Pressure, Sound: Understanding Noise Metrics

Erik Miller-Klein, P.E., Associate Member, SSA Acoustics, LLP, Seattle, WA

#### 2. Basics of Sound Propagation

Terry Tyson, P.E., Acentech, Trevoise, PA

#### 3. Vibration Isolation: The Basics

Reginald Keith, P.E., Member, Hoover & Keith Inc., Houston, TX

approach that continues to gain momentum is in-slab radiant cooling. A radiant cooling design strategy embodies the integration of architectural design and HVAC systems design with overall energy efficiency in mind. This seminar explores the fundamental concepts of how radiant cooling systems work, how they are constructed and controlled, and how they can be used as part of an energy-efficient design solution.

### 1. Radiant Slabs: On-Site Fabricated Heat Exchangers

*Robert Bean P.L.(Eng.) R.E.T., Member, Healthy Heating, Calgary, AB, Canada*

### 2. Designing Radiant Floors From Basics

*Peter Simmonds, Ph.D., Fellow Member, IBE Consulting Engineers, Sherman Oaks, CA*

### 3. Radiant Cooling System Design From Concept to Completion

*Andrew Reilman, P.E., Member, Syska Hennessy Group, Culver City, CA*

9:45 AM-10:45 AM

## TECHNICAL PAPER SESSION 9 (INTERMEDIATE)

### Additional Concerns for the Mission Critical Data Center

*Track: Research Summit*

*Room: Governors Square 15*

*Sponsor: 09.09 Mission Critical Facilities, Technology Spaces and Electronic Equipment*

*Chair: Herb Villa, Member, DC Professional Development, Newark, NJ*

“And there is always ONE more thing to think about”. This is especially true in the life cycle of the mission critical data center space. Starting with engineering and design, progressing through product selection and installation and leading up to the long term facility operations, IT professionals involved in any of these aspects know they must plan for that one more thing. This Technical Paper Session discusses two of these topics, sometimes overlooked but still critical. The first presentation will review humidity and static electricity concerns. Under ASHRAE Research Project 1499-RP, this paper summarizes a very comprehensive series of tests designed to understand the cause, effects and risks to IT equipment from ESD in a variety of operational scenarios. Presented by a team from Missouri University of Science, the results gathered from the tests will insure ESD concerns are no longer left unanswered. The second presentation proposes a new CFD model to better simulate thermal transient scenarios and provide situational outcomes to be expected during loss of cooling events.

### 1. The Effect of Humidity on Static Electricity Induced Reliability Issues of ICT Equipment in Data Centers: Motivation and Setup of the Study (DE-13-031)

*Fayu Wan<sup>1</sup>, Michael Hillstrom<sup>1</sup>, Carlton Stayer<sup>1</sup>, David Swenson<sup>2</sup> and David Pommerenke<sup>1</sup>, (1)Missouri University of Science and Technology, Rolla, MO, (2)Affinity Static Control Consulting, LLC, Round Rock, TX*

### 2. A Compact Server Model for Transient Data Center Simulations (DE-13-032)

*James VanGilder, P.E., Member<sup>1</sup>, Christopher M. Healey, Ph.D.<sup>1</sup>, Xuanhang (Simon) Zhang, Member<sup>1</sup> and Zachary Pardey<sup>2</sup>, (1)APC by Schneider Electric, Billerica, MA, (2)Northeastern University, Boston, MA*

9:45 AM-10:45 AM

## SEMINAR 39 (INTERMEDIATE)

### Demand Response (DR) Opportunities with Commercial Ice Machines

*Track: Mile-High Efficiency & Equipment*

*Room: Governors Square 14*

*Sponsor: 10.07 Commercial Food and Beverage Cooling Display and Storage*

*Chair: Van D. Baxter, P.E., Fellow ASHRAE, Oak Ridge National Laboratory, Oak Ridge, TN*

Managing building peak electric loads represents a major opportunity for ensuring grid reliability while providing financial benefits for building



owners. In commercial operations, ice machines are early adopters of DR technologies. This seminar presents the general motivation for and types of DR programs offered by utilities. Then the application of DR on ice machines is explained, and results from a field study highlight the water, energy, and cost saving potential. This information could help Colorado utilities expand their DR programs to the smaller interruptible demands of restaurant, hospitality, and institutional customers which, when aggregated, represent a large load management opportunity.

### 1. Demand Response Program Experiences

*J. Carlos Haiad, P.E., Member, Southern California Edison, Irwindale, CA*

### 2. Demand Side Management (DSM) Opportunities with Commercial Refrigeration

*Daryl G. Erbs, Ph.D., Member, Manitowoc Foodservice Group, Sheboygan, WI*

### 3. Energy and Water Saving with Ice Machine Upgrade and Load Shifting

*David Cowen, Member, Food Service Technology Center, San Ramon, CA*

9:45 AM-10:45 AM

## SEMINAR 40 (INTERMEDIATE)

### Balancing: Practical Hydronic Balance for Designs Applying Diversity Factors

*Track: HVAC&R Fundamentals & Applications*

*Room: Plaza Ballroom E*

*Sponsor: 07.07 Testing and Balancing*

*Chair: Mark Hegberg, Member, Apollo Valve, Elmhurst, IL*

On occasion designers apply so called “diversity” factors to reduce the size of a hydronic system. Occasionally, these factors lead to improper system operation and, in the extreme, lawsuits. To balancers, they always lead to confusing processes and result in having to test and adjust a system for proper operation. This seminar addresses the application of diversity in hydronic systems and methods for testing and adjusting these systems for proper operation.

### 1. Hydronic System Diversity: The Problem and Solutions

*Mark Hegberg, Member, Apollo Valve, Elmhurst, IL*

### 2. Hydronic System Diversity: How This is Handled in the Field

*Gaylon Richardson, Fellow ASHRAE, Engineered Air Balance, Houston, TX*



9:45 AM-10:45 AM

## SEMINAR 41 (INTERMEDIATE)

### Building Energy Performance: Bridging Expectations to Reality

*Track: Building Energy Modeling vs.*

*Measurement & Verification –Closing the Gap*

*Room: Plaza Ballroom A*

*Chair: Anthony Hardman, P.E., Member, The Green Engineer, Concord, MA*

Whether a project is new construction or a partial renovation, energy conscious facility stakeholders often expect simulated performance to match operational reality. Unfortunately, a number of broken links exist across the building lifecycle that can lead to significant deviations between predicted and actual energy performance. Critical nodes in an energy project lifecycle are identified and actionable processes to fix the broken links using real world examples are presented.

### 1. Case Study: Root Cause Analysis of Simulation and Performance Dissimilarity Pinpointing Common Disconnects

*Anthony Hardman, P.E., Member<sup>1</sup> and Leslie Beu, Member<sup>2</sup>, (1)The Green Engineer, Concord, MA, (2)Tolin Mechanical Systems, Denver, CO*



9:45 AM-10:45 AM

## SEMINAR 42 (INTERMEDIATE)

### The Commissioning Process Standard

Track: HVAC&R Fundamentals & Applications

Room: Plaza Ballroom F

Sponsor: 07.09 Building Commissioning

Chair: Mike Eardley, P.E., Member, Cannon Design, Boston, MA

The new ASHRAE Standard 202, The Commissioning Process for Systems and Assemblies, is completing its public review and is about to be published. This standard will set the minimum requirements for the Commissioning Process which will be adopted by codes and other standards. It is derived from the commissioning process in ASHRAE Guideline 0-2005. This seminar explains the commissioning process requirements as well as the background, organization and contents of the standard as well as the informative annexes. It also explains its relationship to other standards and guidelines and application to construction codes and projects.

#### 1. ASHRAE Standard 202-2013

Gerald J. Kettler, P.E., Life Member, AIR Engineering and Testing, Carrollton, TX

#### 2. Delivering Performance with the Commissioning Process

H. Jay Enck, Member, Commissioning & Green Build Solutions Inc., Buford, GA



9:45 AM-10:45 AM

## FORUM 4 (ADVANCED)

### What Are the Challenges for Using Air-to-Air Energy Recovery for Commercial Kitchen Ventilation (CKV) and 90.1 Compliance?

Track: HVAC&R Systems & Equipment

Room: Governors Square 16

Sponsor: 05.10 Kitchen Ventilation, 05.05 Air-to-Air Energy Recovery

Chair: Don Fisher, Food Service Technology Center, San Ramon, CA; Paul Pieper, P.E., Member, Venmar CES, St-Leonard-d'Aston, QC, Canada

Standard 90.1 currently states (in summary) that if a kitchen/dining facility has a total kitchen hood exhaust airflow rate greater than 5,000 cfm, it shall have one of the following: at least 50% of all replacement air is transfer air; demand ventilation system(s) on at least 75% of the exhaust air; or listed energy recovery devices on at least 50% of the total exhaust airflow. Does the option for a "listed" energy recovery device challenge the design engineer? Does NFPA 96 pose a challenge? Should 90.1 revise this requirement to exclude the work "listed" to allow an engineered system?

11:00 AM-12:30 PM

## TECHNICAL PAPER SESSION 10 (INTERMEDIATE)

### New Technologies in HVAC&R Systems and Equipment

Track: HVAC&R Systems & Equipment

Room: Governors Square 16

Chair: Gary C. Debes, Member, Coward Environmental Systems, Coatesville, PA



This session presents papers that examine recent advances in HVAC&R systems and equipment. From applications of combined heat and power to reduce utility consumption in supermarkets, to the analysis of the energy implications of the pressure drop across a residential air filter, the papers in this session provide solutions for improving energy efficiency.

#### 1. Characterizing Supermarket's Thermal Demands for Integrating Combined Heat and Power Systems (DE-13-033)

Ian Doebber, Associate Member<sup>1</sup>, Dustin Lilya, P.E.<sup>2</sup> and Hugh Henderson<sup>3</sup>, (1)National Renewable Energy Laboratory, Golden, CO, (2)Consulting Engineering Services, Boise, ID, (3)CDH Energy Corp., Cazenovia, NY

#### 2. Assessing the Causes of Combustion Driven Oscillations in Boilers using a Feedback Loop Stability Model (RP-1517) (DE-13-034)

D. W. Herrin, Ph.D., P.E., Member, Limin Zhou, Student Member and Tianxiang Li, Ph.D., University of Kentucky, Lexington, KY

#### 3. Categorization and Comparison of Air Conditioning Systems from a Technology and Performance Perspective: Case Study of an Industrial Installation (DE-13-035)

Vrellas Charisis<sup>1</sup> and Karakatsanis Theoklitos<sup>2</sup>, (1)Democritus University of Thrace, Xanthi, Greece, (2)National Technical University of Athens, Athens, Greece

#### 4. Energy Implications of In-line Filtration in California Homes (DE-13-036)

Iain Walker, Ph.D., Member, David Faulkner, Darryl Dickerhoff and Will Turner, Ph.D., Residential Building Systems Group, Lawrence Berkeley National Laboratory, Berkeley, CA

#### 5. Measurement and Simulation of Acoustic Load Impedance for Boilers (RP-1517) (DE-13-037)

Limin Zhou, Student Member, D. W. Herrin, Ph.D., P.E., Member and Tianxiang Li, Ph.D., University of Kentucky, Lexington, KY

9:45 AM-10:45 AM

## SEMINAR 43 (INTERMEDIATE)

### VRF Applications in Cold Climates: Success Stories

Track: HVAC&R Systems & Equipment

Room: Plaza Ballroom B

Sponsor: 08.07 Variable Refrigerant Flow

Chair: Pam Androff, Associate Member, Mitsubishi Electric, Atlanta, GA

Variable Refrigerant Flow systems are well known for efficient performance and flexible design. But how to apply them in very cold climates? Low ambient conditions often present designers with a unique challenge. This session presents two case studies with different solutions for cold climate VRF applications.

#### 1. Best Practices for Air-Source VRF in Cold Climates

Shawn Brill, P.E., Member, Bighorn Consulting Engineers, Co., Grand Junction, CO

#### 2. Hybrid VRF and Hydronic in a Hotel Application

Maciej Sobczyk, P.E., Geoclima Mechanical Engineering Ltd., West Vancouver, BC, Canada



9:45 AM-10:45 AM

## FORUM 3 (INTERMEDIATE)

### Review of Issues in Contamination Control for Clean Room Facilities

Track: HVAC&R Fundamentals & Applications

Room: Governors Square 17

Sponsor: 09.11 Clean Spaces

Chair: Vinod P. (V. P.) Gupta, P.E., Member, 3M Company, Saint Paul, MN

As the cost of building and operating a clean room facilities continue to rise, we need to address the different innovative ideas and out of the box thinking that will help reduce the cost of energy and other maintenance costs for operating a clean room facility. The forum discusses and seeks input in: fundamentals of HVAC application in clean room/space design; reduction of the cost of energy used; the current and updated procedures for maintaining a dynamic clean room; and reduction in the overall cost of operating the clean room for maintenance.

11:00 AM-12:30 PM

## TECHNICAL PAPER SESSION 11 (INTERMEDIATE)

### Highlights in Building Envelope and Related Technology

Track: Building Energy Modeling vs.

Measurement & Verification – Closing the Gap



Room: Governors Square 17

Chair: Vance W. Payne, Ph.D., Member, NIST, Gaithersburg, MD

This technical session highlights recent research in a new fenestration technology, corrosion of wood fasteners, swimming pool evaporation, and foundation heat transfer. The works presented offer background on a wide variety of technologies that may interest a varied audience of both residential and commercial building designers and owners. The authors present correlations and models that may be used to simulate their studied technology.

#### 1. A Novel Building Component Hybrid Vacuum Glazing - A Modelling and Experimental Validation (DE-13-038)

**Yueping Fang<sup>1</sup>**, Trevor Hyde, Farid Arya and Neil Hewitt, University of Ulster, Newtonabbey, Northern Ireland

#### 2. Corrosion of Embedded Metals in Wood: An Overview of Recent Research with Implications for Building Moisture Design (DE-13-039)

**Samuel L. Zelinka, Ph.D.**, U.S. Forest Service Forest Products Laboratory, Madison, WI

#### 3. New Correlation for Prediction of Evaporation from Occupied Swimming Pools (DE-13-040)

**M. Mohammed Shah, Ph.D., P.E.**, Fellow ASHRAE, Consultant, Redding, CT

#### 4. Simplified Model for Ground Heat Transfer from Slab-On-Grade Buildings (DE-13-041)

**Kelly Kissock<sup>1</sup>**, Narendan Raghavan<sup>1</sup> and Abinesh Selvacanabady<sup>2</sup>, (1)University of Dayton, Dayton, OH, (2)Resource Solutions Group, Half Moon Bay, CA

11:00 AM-12:30 PM

## CONFERENCE PAPER SESSION 21 (INTERMEDIATE)

### Modeling & Measuring: Finding the Common Ground

Track: Building Energy Modeling vs.

Measurement & Verification – Closing the Gap



Room: Plaza Ballroom A

Chair: Justin Seter, Member, DLB Associates, Atlanta, GA

This session explores the challenges associated with calibrating energy simulation models using field measurements and data analysis in order to verify design decisions. Many factors can cause simulation results to differ from real world utility consumption, including occupant behavior and assumptions that don't translate to the field. Case studies of net zero residential construction, an office building retrofit, a grocery store and apartment buildings are presented.

#### 1. Comparison of Calculated and Measured Loads for ASHRAE Headquarters Building (DE-13-C074)

**Ramandeep Singh, Student Member**, Zeyu Xiong, Student Member, Harry Schroeder, Student Member and Dan Fisher, Oklahoma State University, Stillwater, OK

#### 2. Evaluation of Model Results and Measured Performance of Net-Zero Energy Homes in Hawaii (DE-13-C075)

**Paul Norton<sup>1</sup>**, Kosol Kiatreungwattana, P.E., Member<sup>2</sup> and Kenneth Kelly<sup>2</sup>, (1)Norton Energy R&D, Boulder, CO, (2)National Renewable Energy Laboratory, Golden, CO

#### 3. User Related Energy Use in Buildings: Results From Two Years of Measurement of Household Electricity in 1300 Apartments in Sweden (DE-13-C076)

**Hans Bagge, Ph.D.<sup>1</sup>**, **Dennis Johansson, Ph.D.<sup>1</sup>** and **Lotti Lindstrij, M.D.<sup>2</sup>**, (1)Lund University, Lund, Sweden, (2)Karlstad University, Karlstad, Sweden

#### 4. Measurement and Verification Study in Korea (DE-13-C077)

**Doosam Song, Ph.D.**, Member, Kinam Kang, Dr.Eng., Student Member and Kyumin Kang, M.D., Sungkyunkwan University, Suwon, South Korea

#### 5. Reducing Energy Consumption in Grocery Stores: Calibration of a Grocery Store Simulation Model (DE-13-C078)

**Jaya Mukhopadhyay, Student Member**, Jeff Haberl, Ph.D., P.E., Fellow ASHRAE and Juan-Carlos Baltazar, Ph.D., Member, Texas A&M University, College Station, TX

11:00 AM-12:30 PM

## CONFERENCE PAPER SESSION 22 (INTERMEDIATE)

### Predictive Energy and Comfort Simulation Methods

Track: Research Summit



Room: Plaza Ballroom E

Chair: Jennifer E. Leach, P.E., Member, Leach Engineering LLC, Baltimore, MD

In today's high performance buildings, design direction is increasingly based on the results of comprehensive energy modeling. This session features several papers which assess the techniques used by common predictive energy and comfort simulation methods.

#### 1. Revealing Occupancy Patterns in Office Buildings Through the Use of Annual Occupancy Sensor Data (DE-13-C079)

**Carlos Duarte, Student Member** and Kevin Van Den Wymelenberg, Ph.D., University of Idaho Integrated Design Lab, Boise, ID

#### 2. The Development of a Test Methodology for Transient Thermal Comfort Analysis (DE-13-C080)

**Ahmet Ugursal, Ph.D.** and Charles Culp, P.E., Fellow ASHRAE, Texas A&M University, College Station, TX

#### 3. Gaussian Mixture Regression for Building Energy Modeling and Verification (DE-13-C081)

**Abhishek Srivastav, Ph.D.**, Ashutosh Tewari, Ph.D. and Bing Dong, Ph.D., Associate Member, United Technologies Research Center, East Hartford, CT

#### 4. Development of Control-Oriented Models for Model Predictive Control in Buildings (DE-13-C082)

**Pengfei Li, Ph.D.<sup>1</sup>**, Zheng O'Neill, Ph.D., P.E., Member<sup>1</sup> and James Braun, Ph.D., Fellow ASHRAE<sup>2</sup>, (1)United Technologies Research Center, East Hartford, CT, (2)Purdue University, West Lafayette, IN

11:00 AM-12:30 PM

## SEMINAR 44 (INTERMEDIATE)

### Advanced Energy Design for Hospitals: Theory and Application

Track: Mile-High Efficiency & Equipment



Room: Plaza Ballroom B

Sponsor: 09.06 Healthcare Facilities

Chair: Bob Gulick, P.E., Member, Mazzetti Nash Lipsey Burch, Portland, OR

Significant strides have been made in how to design hospitals for significant energy reduction; however, the hospital design profession has been slow to embrace these new strategies. By communicating the theory and a successful case study, this seminar can be a catalyst to accelerate energy reduction in hospitals.

#### 1. Advanced Energy Design for Hospitals: Theory and Application

**Bob Gulick, P.E.**, Member, Mazzetti Nash Lipsey Burch, Portland, OR

#### 2. Targeting 100!

**Heather Burpee**, University of Washington Integrated Design Lab, Seattle, WA

#### 3. The Advanced Energy Design Guide for Large Hospitals

**Shanti D. Pless, Member**, National Renewable Energy Laboratory, Golden, CO

#### 4. Small Hospital, Big Idea: Case Study

**Arash Guity, P.E.**, Member, M+NLB, San Francisco, CA

11:00 AM-12:30 PM

### SEMINAR 45 (INTERMEDIATE)

#### Integrating Innovative, Large-scale Solar Thermal Systems into the Built Environment

Track: Renewable & Alternative Energy Sources

Room: Governors Square 14

Sponsor: 06.07 Solar Energy Utilization

Chair: James A. Leidel, Member, Oakland University, Rochester, MI



Three innovative and interesting projects are presented showcasing solar thermal energy on at the building level, small community level, and large district energy system level in North America. The Oakland University Human Health Building in Michigan makes use of variable refrigerant flow geothermal heat pumps assisted by a solar-thermal activated desiccant outdoor air supply. The 52-home Drake Landing Solar Community in Alberta is the first major implementation in North America of a technology known as seasonal solar thermal energy storage. Lastly, District Energy St. Paul in Minnesota has installed the Midwest's largest solar thermal installation.

##### 1. Hybrid Geothermal / Solar Thermal Energy System for a LEED Platinum Academic Facility

James A. Leidel, Member, Oakland University, Rochester, MI

##### 2. District Energy St. Paul: Solar Thermal & Biomass for Downtown St. Paul, MN

Nina Axelson, District Cooling St. Paul Inc., St. Paul, MN

##### 3. Drake Landing Solar Community with Seasonal Energy Storage

Doug McClenahan and Reda Djebbar, Ph.D., P.E., Member, Natural Resources Canada, Ottawa, ON, Canada

11:00 AM-12:30 PM

### SEMINAR 47 (INTERMEDIATE)

#### Pressure Drop Considerations in Air-to-Air Energy Recovery

Track: HVAC&R Systems & Equipment

Room: Plaza Ballroom F

Sponsor: 05.05 Air-to-Air Energy Recovery

Chair: Helen Davis, P.E., Member, AHRI, Arlington, VA



The session educates the audience on the best ways to determine fan size for a system that incorporates air-to-air energy recovery ventilation equipment (AAERVE). ASHRAE 90.1 recently added limits to the fan power used in ventilation systems that incorporate energy recovery devices.

##### 1. Adding Air-to-Air Energy Recovery: What Is the Associated Fan Energy?

Ronnie Moffitt, P.E., Member, Trane, Inc., Lexington, KY

##### 2. ERV Fan Power Limits in 90.1: Rationale and Application

Matthew L. Friedlander, Member, RenewAire LLC, Madison, WI

##### 3. Discussion of Recovery Efficiency Ratio

Tom Rice, Member, SEMCO LLC, Columbia, MO

## notes

11:00 AM-12:30 PM

### SEMINAR 46 (ADVANCED)

#### Practical Experiences with Low-GWP and Natural Refrigerants in Supermarkets

Track: HVAC&R Systems & Equipment

Room: Governors Square 15

Sponsor: Refrigeration Committee, TC3.1, TC8.1, MTG Alternative Lower GWP Refrigerant, 10.07 Commercial Food and Beverage Cooling Display and Storage

Chair: Georgi S. Kazachki, Ph.D., Fellow ASHRAE, Dayton Phoenix Group, Inc., Dayton, OH



A decade of intensive research and development in the implementation of natural refrigerants in refrigeration and air-conditioning resulted in a large number of supermarket refrigeration systems worldwide that were designed, commissioned, and have been in operation sufficient time to assess their performance, efficiency, and environmental impact. This seminar presents a review of refrigeration systems using natural and low-GWP substances as refrigerants. The real-life performance and efficiency of these systems will be provided and compared to the simulation predictions during the design phase.

##### 1. Practical Issues With Low GWP Replacements for R404A in Commercial Refrigeration Applications

Gustavo Pottker, Member, Honeywell - Buffalo Research Laboratory, Buffalo, NY

##### 2. Implementation of Natural Refrigerant R744 (CO2) in Supermarket

Shitong Zha, Ph.D., Member, Hill PHOENIX, Covington, GA

##### 3. Modeling the Expected Energy Performance and Efficiency By Design of a High Efficiency Grocery Store With Natural Refrigerants

Kyle Larson, Associate Member<sup>1</sup> and Dustin Lilya, P.E.<sup>2</sup>, (1)VaCom Technologies, San Luis Obispo, CA, (2)Consulting Engineering Services, Boise, ID

##### 4. Best Practice HFC DX Design vs. Two CO2 System Alternatives for a Small Supermarket

Kyle Larson, Associate Member, VaCom Technologies, San Luis Obispo, CA

## SOCIETY COMMITTEE MEETINGS

Codes for finding your meeting room:

Meeting space is located in both the Tower and Plaza Buildings.

The first letter in the parenthesis following the room name will designate the building location, i.e.,

(P) will be Plaza and (T) is Tower

The levels the rooms are located on are:

Tower Building

Mezzanine Level (Z)

Second Level (2)

Terrace Level (T)

Majestic Level (M)

Plaza Building

Lobby Level (L)

Concourse Level (C)

If your meeting is labeled (PC) it will be in the Plaza Building, Concourse Level. The buildings connect via the second floor or concourse level. All suites being used for meeting rooms are in the Plaza Building.

## CHRONOLOGICAL

Thursday, June 20

### Finance Investment Subcommittee

Thurs., 5:00 p.m. – 7:00 p.m., Plaza Court 1 (PC)

### Finance Planning Subcommittee

Thurs., 5:00 p.m. – 7:00 p.m., Plaza Court 3 (PC)

Friday, June 21

### Chapter Technology Transfer

Fri., 8:00 a.m. – 12:00 p.m., Director's Row E (PL)

### Standards Executive

Fri., 8:00 a.m. – 12:00 p.m., Director's Row H (PL)

### Finance

Fri., 8:00 a.m. – 1:00 p.m., Tower Court B (T2)

### Membership Promotion Subcommittees

Fri., 9:00 a.m. – 2:00 p.m., Governor's Square 16 (PC)

### Energy Efficient Buildings Hub

Fri., 10:00 a.m. – 12:00 p.m., Governor's Square 10 (PC)

### Student Activities Executive

Fri., 10:00 a.m. – 12:00 p.m., Plaza Court 6 (PC)

### Standards Training Ad Hoc

Fri., 12:00 p.m. – 1:00 p.m., Director's Row H (PL)

### Student Activities K-12

Fri., 12:00 p.m. – 2:00 p.m., Plaza Court 6 (PC)

### Research Administration Excom

Fri., 1:00 p.m. – 2:30 p.m., Governor's Square 10 (PC)

### CEC Executive

Fri., 1:00 p.m. – 3:00 p.m., Governor's Square 11 (PC)

### Standards ILS/ISAS

Fri., 1:00 p.m. – 4:00 p.m., Director's Row I (PL)

### Planning

Fri., 1:00 p.m. – 6:00 p.m., Tower Court C (T2)

### CTTC Member Services

Fri., 1:30 p.m. – 5:00 p.m., Director's Row F (PL)

### CTTC Operations

Fri., 1:30 p.m. – 5:00 p.m., Director's Row E (PL)

### Student Activities ABET/Post High

Fri., 2:00 p.m. – 4:00 p.m., Plaza Court 6 (PC)

### RP Executive Subcommittee

Fri., 2:00 p.m. – 5:00 p.m., Spruce (TZ)

### Standards PPIS

Fri., 2:00 p.m. – 6:00 p.m., Director's Row J (PL)

### Standards SPLS

Fri., 2:00 p.m. – 6:00 p.m., Director's Row H (PL)

### Region Members Council Representative/ Regional Vice

#### Chair Training

Fri., 3:00 p.m. – 5:00 p.m., Governor's Square 14 (PC)

### CEC Annual and Winter Meetings

Fri., 3:00 p.m. – 6:00 p.m., Governor's Square 11 (PC)

### Research Administration

Fri., 3:00 p.m. – 7:00 p.m., Governor's Square 10 (PC)

### CEC Specialty Conferences

Fri., 4:00 p.m. – 5:30 p.m., Plaza Court 1 (PC)

### Student Activities Design Competition

Fri., 4:00 p.m. – 6:00 p.m., Plaza Court 6 (PC)

### Student Activities Grants

Fri., 4:00 p.m. – 6:00 p.m., Plaza Court 7 (PC)

### CTTC Executive

Fri., 5:00 p.m. – 6:00 p.m., Director's Row F (PL)

Saturday, June 22

### Student Activities New Member Training

Sat., 7:00 a.m. – 8:00 a.m., Century (TZ)

### TAC/CEC Executive

Sat., 7:00 a.m. – 8:00 a.m., Governor's Square 10 (PC)

### Research Promotion

Sat., 7:30 a.m. – 2:30 p.m., Tower Court A (T2)

### Certification

Sat., 8:00 a.m. – 12:00 p.m., Plaza Court 6 (PC)

### Chapter Technology Transfer

Sat., 8:00 a.m. – 12:00 p.m., Tower Court B (T2)

### Conferences and Expositions Committee

Sat., 8:00 a.m. – 12:00 p.m., Tower Court C (T2)

### **Members Council Operations**

Sat., 8:00 a.m. – 12:30 p.m., Plaza Court 2 (PC)

### **Technical Activities**

Sat., 8:00 a.m. – 3:00 p.m., Governor's Square 10 (PC)

### **Membership Promotion**

Sat., 8:00 a.m. – 3:00 p.m., Spruce (TZ)

### **Research Administration**

Sat., 8:00 a.m. – 3:00 p.m., Governor's Square 9 (PC)

### **Standards**

Sat., 8:00 a.m. – 3:00 p.m., Governor's Square 12 (PC)

### **Student Activities**

Sat., 8:00 a.m. – 3:00 p.m., Century (TZ)

### **Executive**

Sat., 8:30 a.m. – 1:00 p.m., Colorado (TZ)

### **Publications Planning Subcommittee**

Sat., 10:00 a.m. – 12:00 p.m., Director's Row F (PL)

### **Electronic Communication**

Sat., 11:00 a.m. – 3:00 p.m., Savoy (TM)

### **Handbook Strategic Planning/Executive**

Sat., 12:00 p.m. – 3:00 p.m., Director's Row F (PL)

### **CTTC New Member Orientation**

Sat., 12:30 p.m. – 2:30 p.m., Tower Court B (T2)

### **Grassroots Government Activities Committee Ad Hoc**

Sat., 1:00 p.m. – 2:30 p.m., Terrace (TT)

### **CEC Training**

Sat., 1:00 p.m. – 3:00 p.m., Plaza Court 1 (PC)

### **Foundation Executive Subcommittee**

Sat., 1:00 p.m. – 3:00 p.m., Director's Row G (PL)

### **PEC E-Learning**

Sat., 1:30 p.m. – 3:00 p.m., Director's Row J (PL)

Sunday, June 23

### **Advocacy**

Sun., 6:30 a.m. – 8:30 a.m., Aspen (TZ)

### **Standards PC Chair Breakfast**

Sun., 7:00 a.m. – 9:00 a.m., Grand Ballroom (T2)

### **YEA**

Sun., 7:00 a.m. – 12:00 p.m., Spruce (TZ)

### **Handbook Electronic Media**

Sun., 8:00 a.m. – 9:00 a.m., Plaza Court 2 (PC)

### **Handbook Functional**

Sun., 8:00 a.m. – 9:00 a.m., Plaza Court 3 (PC)

### **Handbook Liaison Training**

Sun., 8:00 a.m. – 9:00 a.m., Century (TZ)

### **Handbook Publicity**

Sun., 8:00 a.m. – 9:00 a.m., Plaza Court 7 (PC)

### **Nominating**

Sun., 8:00 a.m. – 12:00 p.m., Governor's Square 12 (PC)

### **Publications Committee**

Sun., 8:00 a.m. – 12:00 p.m., Beverly (TT)

### **Refrigeration**

Sun., 8:00 a.m. – 12:00 p.m., Columbine (TT)

### **Student Activities CRC Training**

Sun., 8:00 a.m. – 12:00 p.m., Gold (TZ)

### **College of Fellows Board/Advisory**

Sun., 8:30 a.m. – 10:00 a.m., Denver (TZ)

### **Building Energy Quotient**

Sun., 8:30 a.m. – 11:30 a.m., Tower Court A (T2)

### **Historical**

Sun., 8:30 a.m. – 12:00 p.m., Plaza Court 6 (PC)

### **Handbook 2014 Refrigeration TCs/Volume SC**

Sun., 9:00 a.m. – 10:00 a.m., Plaza Court 2 (PC)

### **Handbook 2015 HVAC Applications**

Sun., 9:00 a.m. – 10:00 a.m., Aspen (TZ)

### **Handbook 2016 HVAC Systems & Equipment**

Sun., 9:00 a.m. – 10:00 a.m., Plaza Court 7 (PC)

### **TC/TG Chair's Training Workshop**

Sun., 9:45 a.m. – 10:45 a.m., Governor's Square 14 (PC)

### **Handbook Volume Subcommittees**

Sun., 10:00 a.m. – 10:30 a.m., Century (TZ)

### **College of Fellows**

Sun., 10:00 a.m. – 12:00 p.m., Denver (TZ)

### **Handbook**

Sun., 10:30 a.m. – 1:00 p.m., Century (TZ)

### **Honors & Awards Orientation**

Sun., 12:30 p.m. – 1:30 p.m., Plaza Court 7 (PC)

### **Board of Directors**

Sun., 1:00 p.m. – 5:00 p.m., Grand Ballroom (T2)

### **Honors & Awards**

Sun., 1:30 p.m. – 5:00 p.m., Plaza Court 7 (PC)

### **Refrigeration: PMS for 1634 – RP**

Sun., 5:00 p.m. – 7:00 p.m., Gold (TZ)

### **Standards Code Interaction**

Sun., 7:00 p.m. – 10:00 p.m., Tower Court C (T2)

Monday, June 24

### **Research Subcommittee Chairs**

Mon., 6:30 a.m. – 8:00 a.m., Grand Ballroom (T2)

### **Environmental Health Executive**

Mon., 7:00 a.m. – 8:00 a.m., Director's Row E (PL)

### **Technology Council: Special Projects**

Mon., 7:30 a.m. – 9:30 a.m., Tower Court A (T2)

**Technology Council: Document Review**  
Mon., 8:00 a.m. – 9:00 a.m., Tower Court B (T2)

**Environmental Health Education/Research**  
Mon., 8:00 a.m. – 10:00 a.m., Director's Row E (PL)

**ASHRAE Foundation**  
Mon., 8:00 a.m. – 10:30 a.m., Tower Court D (T2)

**Professional Development**  
Mon., 8:00 a.m. – 12:00 p.m., Spruce (TZ)

**Technology Council: Operations**  
Mon., 9:00 a.m. – 11:30 a.m., Tower Court B (T2)

**Environmental Health Handbook/Program**  
Mon., 10:00 a.m. – 12:00 p.m., Director's Row E (PL)

**PEC Research Journal**  
Mon., 11:00 a.m. – 12:00 p.m., Plaza Court 6 (PC)

**PEC Fiscal Planning**  
Mon., 2:00 p.m. – 3:30 p.m., Savoy (TM)

**Region-at-Large Planning**  
Mon., 2:15 p.m. – 4:15 p.m., Suite 3366 (P3)

**Technology Council: AEDG Steering Committee**  
Mon., 2:15 p.m. – 5:00 p.m., Plaza Court 6 (PC)

**Honors & Awards**  
Mon., 2:15 p.m. – 5:30 p.m., Plaza Court 1 (PC)

**Environmental Health**  
Mon., 2:15 p.m. – 6:15 p.m., Director's Row E (PL)

**PEC Functional Planning**  
Mon., 3:30 p.m. – 5:00 p.m., Savoy (TM)

**Associate Society Alliance**  
Mon., 4:15 p.m. – 6:00 p.m., Director's Row J (PL)

**IAQ 2013 Steering Committee**  
Mon., 6:30 p.m. – 8:30 p.m., Director's Row E (PL)

**Technology Council: Airborne Infectious Diseases Position Document Committee**  
Mon., 8:30 p.m. – 10:00 p.m., Director's Row E (PL)

Tuesday, June 25

**Scholarship Trustees**  
Tues., 8:00 a.m. – 10:00 a.m., Savoy (TM)

**Members Council**  
Tues., 8:00 a.m. – 12:00 p.m., Majestic Ballroom (TM)

**Publishing and Education Council**  
Tues., 8:00 a.m. – 12:00 p.m., Columbine (TT)

**Technology Council**  
Tues., 8:00 a.m. – 12:00 p.m., Terrace (TT)

**Life Members' Executive Board**  
Tues., 9:00 a.m. – 11:00 a.m., Beverly (TT)

**Standards PPIS**  
Tues., 11:00 a.m. – 1:00 p.m., Director's Row J (PL)

**Technology Council: Air Filtration & Cleaning Position Document Committee**  
Tues., 11:00 a.m. – 1:00 p.m., Suite 3366 (P3)

**TC Program Subcommittee Training**  
Tues., 11:15 a.m. – 12:00 p.m., Plaza Court 3 (PC)

**PEAC**  
Tues., 12:00 p.m. – 2:00 p.m., Savoy (TM)

Standards SPLS  
Tues., 1:30 p.m. – 3:30 p.m., Director's Row J (PL)

**Member Council Orientation**  
Tues., 2:00 p.m. – 4:00 p.m., Majestic Ballroom (TM)

**Publishing and Education Council Orientation**  
Tues., 2:00 p.m. – 4:00 p.m., Columbine (TT)

**Technology Council Orientation**  
Tues., 2:00 p.m. – 4:00 p.m., Terrace (TT)

**Society Rules**  
Tues., 4:00 p.m. – 5:30 p.m., Director's Row G (PL)

**Standards SRS/TCLS**  
Tues., 5:00 p.m. – 6:00 p.m., Director's Row J (PL)

Wednesday, June 26

**Technical Activities**  
Wed., 7:00 a.m. – 10:00 a.m., Tower Court B (T2)

**Research Administration**  
Wed., 7:00 a.m. – 11:00 a.m., Tower Court A (T2)

**Executive**  
Wed., 7:30 a.m. – 9:00 a.m., Plaza Court 4 (PC)

**Standards**  
Wed., 7:30 a.m. – 9:30 a.m., Majestic Ballroom (TM)

**Technology Council**  
Wed., 9:00 a.m. – 11:00 a.m., Tower Court D (T2)

### CODES FOR FINDING YOUR MEETING ROOM:

*Meeting space is located in both the Tower and Plaza Buildings.*

The first letter in the parenthesis following the room name will designate the building location, i.e.,

(P) will be Plaza and (T) is Tower  
The levels the rooms are located on are:

**Tower Building**  
Mezzanine Level (Z)  
Second Level (2)  
Terrace Level (T)  
Majestic Level (M)

**Plaza Building**  
Lobby Level (L)  
Concourse Level (C)

### **Board of Directors**

Wed., 2:00 p.m. – 6:00 p.m., Majestic Ballroom (TM)

Thursday, June 27

### **Executive**

Thurs., 7:30 a.m. – 11:00 a.m., Director's Row E (PL)

## **ALPHABETICAL**

### **Advocacy**

Sun., 6/23, 6:30 a.m. – 8:30 a.m., Aspen (TZ)

### **ASHRAE Foundation**

Mon., 6/24, 8:00 a.m. – 10:30 a.m., Tower Court D (T2)

### **Associate Society Alliance**

Mon., 6/24, 4:15 p.m. – 6:00 p.m., Director's Row J (PL)

### **Board of Directors**

Sun., 6/23, 1:00 p.m. – 5:00 p.m., Grand Ballroom (T2)

Wed., 6/26, 2:00 p.m. – 6:00 p.m., Majestic Ballroom (TM)

### **Building Energy Quotient**

Sun., 6/23, 8:30 a.m. – 11:30 a.m., Tower Court A (T2)

### **Certification**

Sat., 6/22, 8:00 a.m. – 12:00 p.m., Plaza Court 6 (PC)

### **Chapter Technology Transfer**

Fri., 6/21, 8:00 a.m. – 12:00 p.m., Director's Row E (PL)

Sat., 6/22, 8:00 a.m. – 12:00 p.m., Tower Court B (T2)

### **CTTC Executive**

Fri., 6/21, 5:00 p.m. – 6:00 p.m., Director's Row F (PL)

### **CTTC Member Services**

Fri., 6/21, 1:30 p.m. – 5:00 p.m., Director's Row F (PL)

### **CTTC New Member Orientation**

Sat., 6/22, 12:30 p.m. – 2:30 p.m., Tower Court B (T2)

### **CTTC Operations**

Fri., 6/21, 1:30 p.m. – 5:00 p.m., Director's Row E (PL)

### **College of Fellows**

Sun., 6/23, 10:00 a.m. – 12:00 p.m., Denver (TZ)

### **College of Fellows Board/Advisory**

Sun., 6/23, 8:30 a.m. – 10:00 a.m., Denver (TZ)

### **Conferences and Expositions Committee**

Sat., 6/22, 8:00 a.m. – 12:00 p.m., Tower Court C (T2)

### **CEC Annual and Winter Meetings**

Fri., 6/21, 3:00 p.m. – 6:00 p.m., Governor's Square 11 (PC)

### **CEC Executive**

Fri., 6/21, 1:00 p.m. – 3:00 p.m., Governor's Square 11 (PC)

### **CEC Specialty Conferences**

Fri., 6/21, 4:00 p.m. – 5:30 p.m., Plaza Court 1 (PC)

### **CEC Training**

Sat., 6/22, 1:00 p.m. – 3:00 p.m., Plaza Court 1 (PC)

### **Electronic Communication**

Sat., 6/22, 11:00 a.m. – 3:00 p.m., Savoy (TM)

### **Energy Efficient Buildings Hub**

Fri., 6/21, 10:00 a.m. – 12:00 p.m., Governor's Square 10 (PC)

### **Environmental Health**

Mon., 6/24, 2:15 p.m. – 6:15 p.m., Director's Row E (PL)

### **Environmental Health Education/Research**

Mon., 6/24, 8:00 a.m. – 10:00 a.m., Director's Row E (PL)

### **Environmental Health Executive**

Mon., 6/24, 7:00 a.m. – 8:00 a.m., Director's Row E (PL)

### **Environmental Health Handbook/Program**

Mon., 6/24, 10:00 a.m. – 12:00 p.m., Director's Row E (PL)

### **Executive**

Sat., 6/22, 8:30 a.m. – 1:00 p.m., Colorado (TZ)

Wed., 6/26, 7:30 a.m. – 9:00 a.m., Plaza Court 4 (PC)

Thurs., 6/27, 7:30 a.m. – 11:00 a.m., Director's Row E (PL)

### **Finance**

Fri., 6/21, 8:00 a.m. – 1:00 p.m., Tower Court B (T2)

### **Finance Investment Subcommittee**

Thurs., 6/20, 5:00 p.m. – 7:00 p.m., Plaza Court 1 (PC)

### **Finance Planning Subcommittee**

Thurs., 6/20, 5:00 p.m. – 7:00 p.m., Plaza Court 3 (PC)

### **Foundation Executive Subcommittee**

Sat., 6/22, 1:00 p.m. – 3:00 p.m., Director's Row G (PL)

### **Grassroots Government Activities Committee Ad Hoc**

Sat., 6/22, 1:00 p.m. – 2:30 p.m., Terrace (TT)

### **Handbook**

Sun., 6/23, 10:30 a.m. – 1:00 p.m., Century (TZ)

### **Handbook 2014 Refrigeration TCs/Volume SC**

Sun., 6/23, 9:00 a.m. – 10:00 a.m., Plaza Court 2 (PC)

### **Handbook 2015 HVAC Applications**

Sun., 6/23, 9:00 a.m. – 10:00 a.m., Aspen (TZ)

### **Handbook 2016 HVAC Systems & Equipment**

Sun., 6/23, 9:00 a.m. – 10:00 a.m., Plaza Court 7 (PC)

### **Handbook Electronic Media**

Sun., 6/23, 8:00 a.m. – 9:00 a.m., Plaza Court 2 (PC)

### **Handbook Functional**

Sun., 6/23, 8:00 a.m. – 9:00 a.m., Plaza Court 3 (PC)

### **Handbook Liaison Training**

Sun., 6/23, 8:00 a.m. – 9:00 a.m., Century (TZ)

### **Handbook Publicity**

Sun., 6/23, 8:00 a.m. – 9:00 a.m., Plaza Court 7 (PC)

### **Handbook Strategic Planning/Executive**

Sat., 6/22, 12:00 p.m. – 3:00 p.m., Director's Row F (PL)

### **Handbook Volume Subcommittees**

Sun., 6/23, 10:00 a.m. – 10:30 a.m., Century (TZ)

**Historical**

Sun., 6/23, 8:30 a.m. – 12:00 p.m., Plaza Court 6 (PC)

**Honors & Awards**

Sun., 6/23, 1:30 p.m. – 5:00 p.m., Plaza Court 7 (PC)  
 Mon., 6/24, 2:15 p.m. – 5:30 p.m., Plaza Court 1 (PC)

**Honors & Awards Orientation**

Sun., 6/23, 12:30 p.m. – 1:30 p.m., Plaza Court 7 (PC)

**IAQ 2013 Steering Committee**

Mon., 6/24, 6:30 p.m. – 8:30 p.m., Director's Row E (PL)

**Life Members' Executive Board**

Tues., 6/25, 9:00 a.m. – 11:00 a.m., Beverly (TT)

**Members Council**

Tues., 6/25, 8:00 a.m. – 12:00 p.m., Majestic Ballroom (TM)

**Members Council Operations**

Sat., 6/22, 8:00 a.m. – 12:30 p.m., Plaza Court 2 (PC)

**Members Council Orientation**

Tues., 6/25, 2:00 p.m. – 4:00 p.m., Majestic Ballroom (TM)

**Membership Promotion**

Sat., 6/22, 8:00 a.m. – 3:00 p.m., Spruce (TZ)

**Membership Promotion Subcommittees**

Fri., 6/21, 9:00 a.m. – 2:00 p.m., Governor's Square 16 (PC)

**Nominating**

Sun., 6/23, 8:00 a.m. – 12:00 p.m., Governor's Square 12 (PC)

**PEAC**

Tues., 6/25, 12:00 p.m. – 2:00 p.m., Savoy (TM)

**Publishing and Education Council**

Tues., 6/25, 8:00 a.m. – 12:00 p.m., Columbine (TT)

**PEC E-Learning**

Sat., 6/22, 1:30 p.m. – 3:00 p.m., Director's Row J (PL)

**PEC Fiscal Planning**

Mon., 6/24, 2:00 p.m. – 3:30 p.m., Savoy (TM)

**PEC Functional Planning**

Mon., 6/24, 3:30 p.m. – 5:00 p.m., Savoy (TM)

**PEC Research Journal**

Mon., 6/24, 11:00 a.m. – 12:00 p.m., Plaza Court 6 (PC)

**Planning**

Fri., 6/21, 1:00 p.m. – 6:00 p.m., Tower Court C (T2)

**P.M.S for 1634-RP**

Sun., 6/23, 5:00 p.m. – 7:00 p.m., Gold (TZ)

**Professional Development**

Mon., 6/24, 8:00 a.m. – 12:00 p.m., Spruce (TZ)

**Publications Committee**

Sun., 6/23, 8:00 a.m. – 12:00 p.m., Beverly (TT)

**Publications Planning Subcommittee**

Sat., 6/22, 10:00 a.m. – 12:00 p.m., Director's Row F (PL)

**Publishing and Education Council Orientation**

Tues., 6/25, 2:00 p.m. – 4:00 p.m., Columbine (TT)

**Refrigeration**

Sun., 6/23, 8:00 a.m. – 12:00 p.m., Columbine (TT)

**Region Members Council Representative/ Regional Vice Chair Training**

Fri., 6/21, 3:00 p.m. – 5:00 p.m., Governor's Square 14 (PC)

**Region-at-Large Planning**

Mon., 6/24, 2:15 p.m. – 4:15 p.m., Suite 3366 (P3)

**Research Administration**

Fri., 6/21, 3:00 p.m. – 7:00 p.m., Governor's Square 10 (PC)  
 Sat., 6/22, 8:00 a.m. – 3:00 p.m., Governor's Square 9 (PC)  
 Wed., 6/26, 7:00 a.m. – 11:00 a.m., Tower Court A (T2)

**Research Administration Excom**

Fri., 6/21, 1:00 p.m. – 2:30 p.m., Governor's Square 10 (PC)

**Research Promotion**

Sat., 6/22, 7:30 a.m. – 2:30 p.m., Tower Court A (T2)

**RP Executive Subcommittee**

Fri., 6/21, 2:00 p.m. – 5:00 p.m., Spruce (TZ)

**Research Subcommittee Chairs**

Mon., 6/24, 6:30 a.m. – 8:00 a.m., Grand Ballroom (T2)

**Scholarship Trustees**

Tues., 6/25, 8:00 a.m. – 10:00 a.m., Savoy (TM)

**Society Rules**

Tues., 6/25, 4:00 p.m. – 5:30 p.m., Director's Row G (PL)

**Standards**

Sat., 6/22, 8:00 a.m. – 3:00 p.m., Governor's Square 12 (PC)  
 Wed., 6/26, 7:30 a.m. – 9:30 a.m., Majestic Ballroom (TM)

**Standards Code Interaction**

Sun., 6/23, 7:00 p.m. – 10:00 p.m., Tower Court C (T2)

**CODES FOR FINDING YOUR MEETING ROOM:**

*Meeting space is located in both the Tower and Plaza Buildings.*

The first letter in the parenthesis following the room name will designate the building location, i.e.,

(P) will be Plaza and (T) is Tower

The levels the rooms are located on are:

**Tower Building**

Mezzanine Level (Z)  
 Second Level (2)  
 Terrace Level (T)  
 Majestic Level (M)

**Plaza Building**

Lobby Level (L)  
 Concourse Level (C)

**Standards Executive**

Fri., 6/21, 8:00 a.m. – 12:00 p.m., Director's Row H (PL)

**Standards ILS/ISAS**

Fri., 6/21, 1:00 p.m. – 4:00 p.m., Director's Row I (PL)

**Standards PC Chair Breakfast**

Sun., 6/23, 7:00 a.m. – 9:00 a.m., Grand Ballroom (T2)

**Standards PPIS**

Fri., 6/21, 2:00 p.m. – 6:00 p.m., Director's Row J (PL)  
Tues., 6/25, 11:00 a.m. – 1:00 p.m., Director's Row J (PL)

**Standards SPLS**

Fri., 6/21, 2:00 p.m. – 6:00 p.m., Director's Row H (PL)

**Standards SPLS**

Tues., 6/25, 1:30 p.m. – 3:30 p.m., Director's Row J (PL)

**Standards SRS/TCLS**

Tues., 6/25, 5:00 p.m. – 6:00 p.m., Director's Row J (PL)

**Standards Training Ad Hoc**

Fri., 6/21, 12:00 p.m. – 1:00 p.m., Director's Row H (PL)

**Student Activities**

Sat., 6/22, 8:00 a.m. – 3:00 p.m., Century (TZ)

**Student Activities ABET/Post High**

Fri., 6/21, 2:00 p.m. – 4:00 p.m., Plaza Court 6 (PC)

**Student Activities CRC Training**

Sun., 6/23, 8:00 a.m. – 12:00 p.m., Gold (TZ)

**Student Activities Design Competition**

Fri., 6/21, 4:00 p.m. – 6:00 p.m., Plaza Court 6 (PC)

**Student Activities Executive**

Fri., 6/21, 10:00 a.m. – 12:00 p.m., Plaza Court 6 (PC)

**Student Activities Grants**

Fri., 6/21, 4:00 p.m. – 6:00 p.m., Plaza Court 7 (PC)

**Student Activities K-12**

Fri., 6/21, 12:00 p.m. – 2:00 p.m., Plaza Court 6 (PC)

**Student Activities New Member Training**

Sat., 6/22, 7:00 a.m. – 8:00 a.m., Century (TZ)

**TC Program Subcommittee Training**

Tues., 6/25, 11:15 a.m. – 12:00 p.m., Plaza Court 3 (PC)

**TC/TG Chair's Training Workshop**

Sun., 6/23, 9:45 a.m. – 10:45 a.m., Governor's Square 14 (PC)

**Technical Activities**

Sat., 6/22, 8:00 a.m. – 3:00 p.m., Governor's Square 10 (PC)  
Wed., 6/26, 7:00 a.m. – 10:00 a.m., Tower Court B (T2)

**TAC/CEC Executive**

Sat., 6/22, 7:00 a.m. – 8:00 a.m., Governor's Square 10 (PC)

**Technology Council**

Tues., 6/25, 8:00 a.m. – 12:00 p.m., Terrace (TT)  
Wed., 6/26, 9:00 a.m. – 11:00 a.m., Tower Court D (T2)

**Technology Council: AEDG Steering Committee**

Mon., 6/24, 2:15 p.m. – 5:00 p.m., Plaza Court 6 (PC)

**Technology Council: Air Filtration & Cleaning Position Document Committee**

Tues., 6/25, 11:00 a.m. – 1:00 p.m., Suite 3366 (P3)

**Technology Council: Airborne Infectious Diseases Position Document Committee**

Mon., 6/24, 8:30 p.m. – 10:00 p.m., Director's Row E (PL)

**Technology Council: Document Review**

Mon., 6/24, 8:00 a.m. – 9:00 a.m., Tower Court B (T2)

**Technology Council: Operations**

Mon., 6/24, 9:00 a.m. – 11:30 a.m., Tower Court B (T2)

**Technology Council: Orientation**

Tues., 6/25, 2:00 p.m. – 4:00 p.m., Terrace (TT)

**Technology Council: Special Projects**

Mon., 6/24, 7:30 a.m. – 9:30 a.m., Tower Court A (T2)

**YEA**

Sun., 6/23, 7:00 a.m. – 12:00 p.m., Spruce (TZ)

**CODES FOR FINDING YOUR MEETING ROOM:**

*Meeting space is located in both the Tower and Plaza Buildings.*

The first letter in the parenthesis following the room name will designate the building location, i.e.,

(P) will be Plaza and (T) is Tower

The levels the rooms are located on are:

**Tower Building**

Mezzanine Level (Z)

Second Level (2)

Terrace Level (T)

Majestic Level (M)

**Plaza Building**

Lobby Level (L)

Concourse Level (C)

## WHAT IS A TECHNICAL COMMITTEE?

The technical expertise of ASHRAE is concentrated in its **Technical Committees (TCs), Task Groups (TGs), Technical Resource Groups (TRGs) and Multidisciplinary Task Group (MTGs)**. These groups are responsible in various degrees for:

- preparing the text of ASHRAE Handbook chapters
- originating, coordinating, and supervising Society-sponsored research projects
- presenting programs at ASHRAE meetings
- reviewing technical papers
- evaluating the need for standards
- and advising the Society on all aspects of the technology it embraces

ASHRAE TCs consist of people who have a recognized proficiency in a specific field of interest. TGs, similar to TCs, are formed when a subject of current interest is not covered in the scope of an existing TC or when the subject encompasses the scope of more than one TC. A TG is usually the first step towards becoming a TC when the TG's scope is not covered under a TC. TRGs are similar to TCs except that their responsibilities are limited to preparing, reviewing, or revising technical material. They do not have responsibility for programs, research, or standards. MTGs are different from TCs, TGs, and TRGs. A MTG is formed when the Society has determined a need for limited activity in a broad field of interest that encompasses the expertise of TCs from two or more sections and/or from non-TC groups such as Standing Standard Project Committees (SSPCs) or outside organizations. The functions of a MTG may include Handbook, Program, Publications, Research and Standards to various degrees, but the customary function of the MTG will be to coordinate those activities within the TCs and other groups, and organizations represented on the MTG.

## APPLYING FOR MEMBERSHIP ON A TECHNICAL COMMITTEE

*ASHRAE welcomes new members to its technical committees.*

To be considered for technical committee membership, you must:

- Notify ASHRAE staff at [TCStaff@ashrae.net](mailto:TCStaff@ashrae.net) of your interest in a particular TC, TG, TRG, or MTG.
- “Manage Your Membership” link from the ASHRAE Web site

### **Please note:**

If you do not have an ASHRAE ID, are or not applying for ASHRAE membership, and are applying for a position that requires an ASHRAE bio to be on file, please go to [www.ashrae.org](http://www.ashrae.org) and click on the Log In tab at the top of the page. Next click on need a login? to request an ID and PIN. You may also use that link if you already have an ASHRAE ID as a non-member, but you do not have a record of what that number is.

You will immediately be assigned as a Provisional Corresponding Member. The acceptance of provisional corresponding membership implies participation in committee activities through correspondence or in-person involvement. Provisional corresponding members serve 2 year terms. Although provisional corresponding members are not voting members, at the end of your term and based on participation in the committee, you may be considered for future voting membership.

*Notification of acceptance to a TC is emailed upon your appointment.*

## ATTENDING TECHNICAL COMMITTEE MEETINGS

### **During the Annual and Winter Conference**

The ASHRAE Technical Committees, Task Groups and Technical Resource Groups meet at each Society Winter and Annual Conference. Attendance at these meetings is open to all society members, to all registered guests at scheduled Society Conferences, and to those invited by the chair at the request of a member. You are encouraged to attend any of these meetings in which you have a technical interest. TC chairs are reminded prior to each meeting to make a special effort to welcome visitors (potential members), particularly international members, to TC meetings – A TC can never have too many willing and able volunteers.

## TC/TG

Meetings listed in color are confirmed

### TC/TG Chair's Breakfast

**Sun. 6:30 a.m. – 8:00 a.m.**

- Section 1 Tower Court A (T2)
- Section 2 Plaza Court 7 (PC)
- Section 3 Terrace (TT)
- Section 4 Director's Row F (TL)
- Section 5 Governor's Square 11 (PC)
- Section 6 Colorado (TZ)
- Section 7 Director's Row J (PL)
- Section 8 Denver (TZ)
- Section 9 Sun. Director's Row H (PL)
- Section 10 Sun. Director's Row I (PL)

## TECHNICAL COMMITTEES (TC)

### TC/TG Chair's Training Workshop

**Sun. 9:45 a.m. – 10:45 a.m.** Governor's Square 14, Plaza Building (Concourse Level)

### Research Subcommittee Breakfast

**Mon. 6:30 a.m. – 8:00 a.m.** Grand Ballroom (T2)

### TC Program Subcommittee Training

**Tues. 11:15 a.m. – 12:00 p.m.** Plaza Court 3 (PC)

### TC 1.1 Thermodynamics & Psychrometrics (10/15)

**Mon. 2:15 p.m. – 4:15 p.m.** Plaza Court 7 (PC)

### TC 1.2 Instruments & Measurements (15/0)

**Tues. 1:00 p.m. – 3:30 p.m.** Suite 3366, Plaza Building (Third Floor)

#### TC 1.2 Standards/Handbook (8/2)

**Mon. 4:15 p.m. – 6:30 p.m.** Suite 3512, Plaza Building (Fifth Floor)

### TC 1.3 Heat Transfer & Fluid Flow (25/15)

**Tues. 1:00 p.m. – 3:30 p.m.** Century (TZ)

*Sponsoring: Technical Paper Session 1: Heat Transfer and Seminar 5: Effect of Frosting and Water Condensation on Microchannel Heat Exchangers*

#### TC 1.3 Handbook

**Sun. 1:00 p.m. – 3:00 p.m.** Suite 3266, Plaza Building (Second Floor)

#### TC 1.3/8.5 Research

**Sun. 3:00 p.m. – 7:00 p.m.** Governor's Square 15 (PC)

### TC 1.4 Control Theory & Application (20/20) Screen/E

**Tues. 1:00 p.m. – 3:30 p.m.** Governor's Square 15 (PC)  
*Sponsoring: Special Session 4: Workshop: BIM, Commissioning, and COBie: Does Automated Building Energy Modeling Replace Measurement and Verification? and Seminar 10: Control Your Costs and Expand Your Possibilities: Integrating Factory-Mounted Controls*

#### TC 1.4 RP 1597 (6/2) Screen/E

**Sun. 10:00 a.m. – 11:00 a.m.** Aspen (TZ)

#### TC 1.4 Control Components and Applications (20/5)

**Sun. 3:00 p.m. – 4:45 p.m.** Century (TZ)

#### TC 1.4 Program (20/5)

**Sun. 4:45 p.m. – 5:30 p.m.** Century (TZ)

#### TC 1.4 RP 1455 (8/0)

**Mon. 9:00 a.m. – 10:30 a.m.** Director's Row G (PL)

#### TC 1.4 Research (20/5) Screen/E

**Mon. 2:15 p.m. – 4:15 p.m.** Denver (TZ)

#### TC 1.4 Handbook (10/5) Screen/E

**Mon. 4:15 p.m. – 6:30 p.m.** Denver (TZ)

#### TC 1.4 Executive (8/0)

**Tues. 7:00a – 8:00 a.m.** Director's Row G (PL)

### TC 1.5 Computer Applications (20/5)

**Mon. 6:30 p.m. – 9:00 p.m.** Plaza Court 6 (PC)

#### TC 1.5 Emerging Applications

**Sun. 5:00 p.m. – 6:00 p.m.** Director's Row H (PL)

#### TC 1.5 Research

**Sun. 6:00 p.m. – 7:00 p.m.** Director's Row H (PL)

#### TC 1.5 Program

**Sun. 7:00 p.m. – 8:00 p.m.** Director's Row H (PL)

#### TC 1.5 Handbook

**Mon. 6:00 p.m. – 6:30 p.m.** Plaza Court 6 (PC)

### TC 1.6 Terminology (5/10) Screen/E

**Mon. 4:15 p.m. – 6:30 p.m.** Capitol (TT)

#### TC 1.6 Wiki Subcommittee Screen/E

**Mon. 8:00 a.m. – 12:00 p.m.** Beverly (TT)

### TC 1.7 Business, Management & General Legal Education

**Mon. 10:15 a.m. – 12:00 p.m.** Tower Court A (T2)

*Sponsoring: Seminar 8: The Rules of Engagement for a New Game: IPD Contract Styles and You!*

### TC 1.8 Mechanical Systems Insulation

**Mon. 4:15 p.m. – 6:30 p.m.** Governor's Square 9 (PC)

#### TC 1.8 Research

**Sun. 8:00 a.m. – 9:30 a.m.** Director's Row G (PL)

#### TC 1.8 Handbook

**Sun. 9:30 a.m. – 10:30 a.m.** Director's Row G (PL)

#### TC 1.8 Program

**Sun. 10:30 a.m. – 11:00 a.m.** Director's Row G (PL)

### TC 1.9 Electrical Systems (8/4)

**Tues. 3:30 p.m. – 6:00 p.m.** Suite 3766, Plaza Building (Seventh Floor)

*Sponsoring: Special Session 1: Panel Discussion: Shifting Landscape of Renewable Energy Systems in an Era of Low PV and Natural Gas Prices*

### TC 1.10 Cogeneration Systems (20/10)

**Tues. 3:00 p.m. – 5:00 p.m.** Plaza Court 3 (PC)

#### TC 1.10 Program/Handbook/Research

**Tues. 1:00 p.m. – 3:00 p.m.** Plaza Court 3 (PC)

### TC 1.11 Electric Motors and Motor Control (13/7)

**Tues. 1:00 p.m. – 3:30 p.m.** Director's Row F (PL)

*Sponsoring: Special Session 9: Panel Discussion: VFD Generated Motor Bearing Currents Got Your Equipment Screaming?*

### TC 1.12 Moisture Management in Buildings (15/25)

**Sat. 1:00 p.m. – 3:00 p.m.** Director's Row E (PL)

*Sponsoring: Special Session 8: Workshop: Tools and Techniques for Avoiding Construction Moisture Problems*

#### TC 1.12 Program/Handbook/Research

**Sat. 8:00 a.m. – 12:00 p.m.** Director's Row E (PL)

### TC 2.1 Physiology & Human Environment (12/18)

**Tues. 1:00 p.m. – 3:30 p.m.** Capitol (TT)

#### TC 2.1 Research

**Sun. 1:00 p.m. – 3:00 p.m.** Tower Court A (T2)

#### TC 2.1 Programs

**Sun. 3:00 p.m. – 14:00 p.m.** Tower Court A (T2)

#### TC 2.1 Handbook

**Sun. 4:00 p.m. – 5:00 p.m.** Tower Court A (T2)

**TC 2.2 Plant and Animal Environment (10/5)**  
**Mon. 4:15 p.m. – 6:30 p.m. Suite 3766, Plaza Building (Seventh Floor)**

**TC 2.3 Gaseous Air Contaminants /Removal Equip. (18/20) Screen**

**Tues. 1:00 p.m. – 3:30 p.m. Tower Court B (T2)**

*Sponsoring: Forum 2: Should the VRP Be Held Up to the Same Performance/Monitoring Criteria as the IAQP?*

**TC 2.3 Research (20/20) Screen/Flipchart**  
**Sun. 5:00 p.m. – 7:00 p.m. Silver (TZ)**

**TC 2.3 Handbook (10/10) Screen/Flipchart**  
**Mon. 4:15 p.m. – 6:00 p.m. Terrace (TT)**

**TC 2.3 Standards (15/10)**  
**Mon. 6:00 p.m. – 8:00 p.m. Tower Court A (T2)**

**TC 2.3 Planning (15/0) Flipchart**  
**Tues. 6:30 a.m. – 8:00 a.m. Tower Court C (T2)**

**TC 2.3 Program (20/20) Screen/Flipchart**  
**Tues. 12:00 p.m. – 12:45 p.m. Tower Court B (T2)**

**TC 2.4 Particulate Air Contaminants /Removal Equip. (18/30)**

**Tues. 3:30 p.m. – 6:00 p.m. Tower Court B (T2)**

*Sponsoring: Forum 2: Should the VRP Be Held Up to the Same Performance/Monitoring Criteria as the IAQP?*

**TC 2.4 Handbook (10/10) Flipchart**  
**Sat. 1:00 p.m. – 2:30 p.m. Governor's Square 15 (PC)**

**TC 2.4 Research (20/20) Screen/Flipchart**  
**Sun. 3:00 p.m. – 5:00 p.m. Silver (TZ)**

**TC 2.4 Planning (20/10) Screen/Flipchart**  
**Mon. 8:00 a.m. – 10:00 a.m. Century (TZ)**

**TC 2.4 Program (20/10) Flipchart**  
**Mon. 10:00 a.m. – 11:00 a.m. Century (TZ)**

**TC 2.4 Standards (20/20) Screen**  
**Mon. 4:15 p.m. – 6:00 p.m. Tower Court A (T2)**

**TC 2.5 Global Climate Change (20/10)**

**Tues. 1:30 p.m. – 3:30 p.m. Plaza Court 2 (PC)**

**TC 2.6 Sound & Vibration Control (20/30)**

**Mon. 2:15 p.m. – 4:15 p.m. Tower Court C (T2)**

*Sponsoring: Seminar 35: Basics of HVAC Noise Control and Seminar 31: Laboratory Exhaust Fans and Energy Conservation*

**TC 2.6 RP 1408 PMS**  
**Sun. 9:00 a.m. – 10:00 a.m. Terrace (TT)**

**TC 2.6 PES RP 1529**  
**Sun. 10:00 a.m. – 11:00 a.m. Terrace (TT)**

**TC 2.6 Research**  
**Sun. 11:00 a.m. – 12:00 p.m. Terrace (TT)**

**TC 2.6 Hot Topic**  
**Sun. 1:00 p.m. – 2:00 p.m. Terrace (TT)**

**TC 2.6 Criteria**  
**Sun. 2:00 p.m. – 3:30 p.m. Terrace (TT)**

**TC 2.6 Excom**  
**Sun. 3:30 p.m. – 4:30 p.m. Terrace (TT)**

**TC 2.6 Vibration Isolation**  
**Mon. 9:00 a.m. – 10:00 a.m. Tower Court C (T2)**

**TC 2.6 Publications**  
**Mon. 10:00 a.m. – 11:00 a.m. Tower Court C (T2)**

**TC 2.6 Programs**  
**Mon. 11:00 a.m. – 12:00 p.m. Tower Court C (T2)**

**TC 2.7 Seismic and Wind Restraint Design (16/20) Screen/E**  
**Tues. 3:30 p.m. – 6:00 p.m. Spruce (TZ)**

**TC 2.7 Publications/Handbook (16/20)**  
**Tues. 1:00 p.m. – 2:00 p.m. Spruce (TZ)**

**TC 2.7 Research/Wind**  
**Tues. 2:00 p.m. – 3:00 p.m. Spruce (TZ)**

**TC 2.8 Building Environmental Impacts and Sustainability (20/50)**

**Sun. 5:00 p.m. – 7:00 p.m. Plaza Ballroom B/C (PC)**

*Sponsoring: Seminar 3: Moving Buildings and the Grid to a Renewable Future, Seminar 11: Performance Based Procurement Process Case Studies, Seminar 17: Benchmarking and Improving Commercial Building Energy Performance, Seminar 28: The Largest Zero-Energy Building: What is Under the Hood?, and Seminar 6: Field and Equipment Issues that Impact Economizer Control Performance*

**TC 2.8 International**  
**Sun. 12:00 p.m. – 12:45 p.m. Plaza Court 1 (PC)**

**TC 2.8 Green Guide**  
**Sun. 12:45 p.m. – 1:45 p.m. Plaza Court 1 (PC)**

**TC 2.8 Research**  
**Sun. 1:45 p.m. – 2:45 p.m. Plaza Court 1 (PC)**

**TC 2.8 Handbook**  
**Sun. 2:45 p.m. – 3:30 p.m. Plaza Court 1 (PC)**

**TC 2.8 Program**  
**Sun. 3:30 p.m. – 4:15 p.m. Plaza Court 1 (PC)**

**TC 2.8 Existing Buildings**  
**Sun. 4:15 p.m. – 16:50:00 Plaza Court 1 (P C)**

**TC 2.9 Ultraviolet Air and Surface Treatment (20/10)**

**Mon. 10:00 a.m. – 12:00 p.m. Silver (TZ)**

*Sponsoring: Seminar 20: UVC: Radiating into the Future and Seminar 26: Analysis of Chemical and Physical Effects of Ultraviolet Bulbs on Cooking Emissions*

**TC 2.9 Program, Handbook, Standards**  
**Sun. 8:00 a.m. – 1:30 p.m. Silver (TZ)**

**TC 2.9 Research**  
**Mon. 8:00 a.m. – 10:00 a.m. Silver (TZ)**

**TC 3.1 Refrigerants & Secondary Coolants (20/15) Screen/E**  
**Mon. 4:15 p.m. – 6:30 p.m. Plaza Ballroom B/C (PC)**

*Sponsoring: Technical Paper Session 6: Reducing Environmental Impact: Ventilation with Heat Recovery and Improved Flammability Testing of Low GWP Refrigerants and Seminar 46: Practical Experiences with Low-GWP and Natural Refrigerants in Supermarkets*

**TC 3.1 Research (10/10) Screen/E**  
**Mon. 11:00 a.m. – 12:00 p.m. Plaza Court 3 (PC)**

**TC 3.1 Program and Handbook (10/10) Screen/E**  
**Mon. 2:15 p.m. – 3:45 p.m. Plaza Court 3 (PC)**

**TC 3.2 Refrigerant System Chemistry (12/40)**

**Mon. 2:15 p.m. – 4:15 p.m. Plaza Ballroom B/C (PC)**

**TC 3.2 Research (12/14)**  
**Sun. 4:00 p.m. – 5:00 p.m. Tower Court B (T2)**

**TC 3.3 Refrigerant Contaminant Control (20/30)**

**Tues. 3:30 p.m. – 6:00 p.m. Governor's Square 14 (PC)**

**TC 3.3 Research (12/14)**  
**Sun. 5:00 p.m. 5:30 p.m. Tower Court B (T2)**

**TC 3.4 Lubrication (20/40)**

**Tues. 1:30 p.m. – 3:30 p.m. Plaza Ballroom B/C (PC)**

**TC 3.4 Research (12/14)**  
Sun. 5:30 p.m. – 6:00 p.m. Tower Court B (T2)

**TC 3.6 Water Treatment (18/10)**  
Tues. 1:00 p.m. – 3:30 p.m. Director's Row I (PL)

TC 3.6 Handbook/Program/Research  
Sun. 3:00 p.m. – 5:00 p.m. Suite 3366, Plaza Building  
(Third Floor)

**TC 3.8 Refrigerant Containment (9/5)**  
Mon. 4:15 p.m. – 6:30 p.m. Suite 3366, Plaza Building  
(Third Floor)

**TC 4.1 Load Calculation Data and Procedures (20/10)**  
Mon. 2:15 p.m. – 4:15 p.m. Governor's Square 9 (PC)

TC 4.1 Handbook  
Sun. 3:00 p.m. – 4:00 p.m. Suite 3766, Plaza Building (Seventh  
Floor)

TC 4.1 Research  
Sun. 4:00 p.m. – 5:00 p.m. Suite 3766, Plaza Building (Seventh  
Floor)

TC 4.1 Programs & Standards  
Sun. 5:00 p.m. – 7:00 p.m. Suite 3766, Plaza Building (Seventh  
Floor)

**TC 4.2 Climatic Information (20/10) Screen/Flipchart**  
Tues. 1:00 p.m. – 3:30 p.m. Plaza Court 6 (PC)

*Sponsoring: Technical Paper Session 5: Improvements to  
Climatic Data for ASHRAE Design Calculations*

TC 4.2 1561 PES (20/0) Screen/Flipchart  
Sun. 3:00 p.m. – 4:30 p.m. Columbine (TT)

TC 4.2 1413-RP (20/0) Screen/Flipchart  
Sun. 9:30 a.m. – 10:30 a.m. Colorado (TZ)

TC 4.2 1613-TRP PES (20/0) Screen/Flipchart  
Sun. 1:00 p.m. – 2:00 p.m. Columbine (TT)

TC 4.2 Program (20/0) Screen/Flipchart  
Sun. 2:00 p.m. – 3:00 p.m. Columbine (TT)

TC 4.2 Research (20/0) Screen/Flipchart  
Mon. 4:15 p.m. – 6:00 p.m. Century (TZ)

**TC 4.3 Ventilation Requirements & Infiltration (14/20)**  
Mon. 4:15 p.m. – 6:30 p.m. Tower Court C (T2)

**TC 4.4 Bldg. Materials and Bldg. Envelope Performance  
(20/20)**

Mon. 2:15 p.m. – 4:15 p.m. Silver (TZ)

*Sponsoring: Special Session 8: Workshop: Tools and Techniques  
for Avoiding Construction Moisture Problems*

TC 4.4 Research (12/20) Screen/E  
Sun. 1:00 p.m. – 3:00 p.m. Governor's Square 12 (PC)

TC 4.4 Handbook (12/20) Screen/E  
Sun. 3:00 p.m. – 4:00 p.m. Governor's Square 12 (PC)

TC 4.4 Program (12/20) Screen/E  
Sun. 4:00 p.m. – 5:00 p.m. Governor's Square 12 (PC)

TC 4.4 Standards (12/20) Screen/E  
Sun. 5:00 p.m. – 5:30 p.m. Governor's Square 12 (PC)

**TC 4.5 Fenestration (10/10)**  
Mon. 2:15 p.m. – 4:15 p.m. Capitol (TT)

TC 4.5 Computational Methods  
Sun. 1:00 p.m. – 3:00 p.m. Director's Row I (PL)

TC 4.5 Research & Long Range Planning  
Sun. 3:15 p.m. – 4:00 p.m. Director's Row I (PL)

TC 4.5 Program  
Sun. 4:00 p.m. – 5:00 p.m. Director's Row I (PL)

**TC 4.5 Handbook**  
Sun. 5:00 p.m. – 6:00 p.m. Director's Row I (PL)

**TC 4.7 Energy Calculations (25/50)**  
Tues. 6:00 p.m. – 8:30 p.m. Plaza Ballroom B/C (PC)

*Sponsoring: Technical Paper Session 3: Building Energy  
Modeling and Calculations*

TC 4.7 Simulation and Component Models  
Mon. 6:15 p.m. – 7:30 p.m. Director's Row F (PL)

TC 4.7 Data-Driven Models  
Mon. 7:30 p.m. – 9:00 p.m. Director's Row F (PL)

TC 4.7 Applications  
Tues. 3:30 p.m. – 5:00 p.m. Plaza Ballroom B/C (PC)

TC 4.7 Handbook  
Tues. 5:00 p.m. – 6:00 p.m. Plaza Ballroom B/C (PC)

**TC 4.10 Indoor Environmental Modeling (20/20)**  
Mon. 2:15 p.m. – 4:15 p.m. Terrace (TT)

*Sponsoring: Conference Paper Session 5: CFD Modeling  
of Occupant Comfort and Health in Diverse Applications,  
Conference Paper Session 9: Reduced Order Modeling,  
and Seminar 36: Modeling Transient Conditions*

TC 4.10 RP 1512 PMS (15/0)  
Sun. 2:30 p.m. – 3:30 p.m. Plaza Court 3 (PC)

TC 4.10 Program  
Sun. 3:30 p.m. – 4:30 p.m. Plaza Court 3 (PC)

TC 4.10 Handbook  
Sun. 4:30 p.m. – 5:00 p.m. Plaza Court 3 (PC)

TC 4.10 Research  
Sun. 5:00 p.m. – 6:00 p.m. Plaza Court 3 (PC)

**TC 5.1 Fans (20/5)**

Mon. 4:15 p.m. – 6:15 p.m. Plaza Court 3 (PC)

*Sponsoring: Seminar 31: Laboratory Exhaust Fans and Energy  
Conservation*

TC 5.1 Research, Handbook, Program (5/15)  
Sun. 3:00 p.m. – 5:00 p.m. Denver (TZ)

TC 5.1 PMS 1420 (5/15)  
Sun. 5:00 p.m. – 7:00 p.m. Denver (TZ)

**TC 5.2 Duct Design (12/20)**

Tues. 3:30 p.m. – 6:00 p.m. Century (TZ)

TC 5.2 Duct Leakage  
Sun. 12:30 p.m. – 1:00 p.m. Beverly (TT)

## CODES FOR FINDING YOUR MEETING ROOM:

*Meeting space is located in both the Tower and Plaza Buildings.*

The first letter in the parenthesis following the room name  
will designate the building location, i.e.,

(P) will be Plaza and (T) is Tower  
The levels the rooms are located on are:

**Tower Building**  
Mezzanine Level (Z)  
Second Level (2)  
Terrace Level (T)  
Majestic Level (M)

**Plaza Building**  
Lobby Level (L)  
Concourse Level (C)

**TC 5.2 Duct Fitting Database**  
 Sun. 1:00 p.m. – 1:30 p.m. Beverly (TT)

**TC 5.2 Research**  
 Sun. 1:30 p.m. – 2:30 p.m. Beverly (TT)

**TC 5.2 Handbook**  
 Sun. 2:30 p.m. – 3:00 p.m. Beverly (TT)

**TC 5.2 Standards**  
 Sun. 3:00 p.m. – 3:30 p.m. Beverly (TT)

**TC 5.2 Programs**  
 Sun. 3:30 p.m. – 4:00 p.m. Beverly (TT)

**TC 5.3 Room Air Distribution (30/30) Screen/E**  
**Tues. 1:00 p.m. – 3:30 p.m. Director's Row E (PL)**  
*Sponsoring: Seminar 29: Applications and Analysis of Passive Chilled Beams*

**TC 5.3 Handbook (20/20) Screen/E**  
 Fri. 8:00 a.m. – 5:00 p.m. Denver (TZ)

**TC 5.3 Handbook (20/20) Screen/E**  
 Sat. 8:00 a.m. – 3:00 p.m. Governor's Square 16 (PC)

**TC 5.3 Fan Coils (30/20) Screen/E**  
 Sun. 8:30 a.m. – 9:30 a.m. Governor's Square 11 (PC)

**TC 5.3 Chilled Beams (30/20) Screen/E**  
 Sun. 9:30 a.m. – 10:30 a.m. Governor's Square 11 (PC)

**TC 5.3 Research (30/20) Screen/E**  
 Sun. 10:30 a.m. – 12:00 p.m. Governor's Square 11 (PC)

**TC 5.3 Research/Handbook/Program (30/20) Screen/E**  
 Sun. 12:00 p.m. – 2:00 p.m. Governor's Square 11 (PC)

**TC 5.3 Underfloor Air Distribution (20/10) Screen/E**  
 Tues. 8:00 a.m. – 10:00 a.m. Tower Court B (T2)

**TC 5.4 Industrial Process Air Cleaning (11/6)**  
**Mon. 2:15 p.m. – 4:15 p.m. Suite 3466, Plaza Building (Fourth Floor)**

**TC 5.5 Air-to-Air Energy Recovery (22/4)**  
**Tues. 3:30 p.m. – 6:00 p.m. Plaza Court 2 (PC)**  
*Sponsoring: Seminar 47: Pressure Drop Considerations in Air-to-Air Energy Recovery and Forum 4: What Are the Challenges for Using Air-to-Air Energy Recovery for Commercial Kitchen Ventilation (CKV) and 90.1 Compliance?*

**TC 5.5 Handbook, Program, Research, Standards (12/4)**  
 Mon. 4:15 p.m. – 6:30 p.m. Plaza Court 2 (PC)

**TC 5.6 Control of Fire & Smoke (23/30)**  
**Mon. 4:15 p.m. – 6:30 p.m. Governor's Square 15 (PC)**  
*Sponsoring: Technical Paper Session 4: Fire and Smoke Management in High-Rise Buildings*

**TC 5.6 Program**  
 Sun. 3:00 p.m. – 4:00 p.m. Colorado (TZ)

**TC 5.6 Research**  
 Sun. 4:00 p.m. – 5:30 p.m. Colorado (TZ)

**TC 5.6 Handbook**  
 Sun. 5:30 p.m. – 7:00 p.m. Colorado (TZ)

**TC 5.6 Guideline 5 Subcommittee**  
 Mon. 2:15 p.m. – 4:15 p.m. Plaza Ballroom A (PC)

**TC 5.7 Evaporative Cooling (20/10)**  
**Mon. 4:15 p.m. – 6:30 p.m. Plaza Court 7 (PC)**  
*Sponsoring: Seminar 24: Mile-High Evaporative Cooling: Effective, Efficient, Economical*

**TC 5.7 Programs, Handbook, Research**  
 Sun. 3:00 p.m. – 5:00 p.m. Suite 3591, Plaza Building (Fifth Floor)

**TC 5.8 Industrial Ventilation Systems (20/5)**  
**Mon. 4:15 p.m. – 6:30 p.m. Gold (TZ)**

**TC 5.8 Ventilation of Hazardous Spaces**  
 Sun. 7:00 p.m. – 9:00 p.m. Director's Row G (PL)

**TC 5.9 Enclosed Vehicular Facilities (30/10)**  
**Tues. 3:30 p.m. – 6:00 p.m. Director's Row H (PL)**  
*Sponsoring: Seminar 31: Laboratory Exhaust Fans and Energy Conservation*

**TC 5.9 Program, Handbook, Research**  
 Tues. 1:00 p.m. – 3:30 p.m. Director's Row H (PL)

**TC 5.10 Kitchen Ventilation (30/15)**  
**Mon. 10:00 a.m. – 12:00 p.m. Columbine (TT)**  
*Sponsoring: Forum 4: What Are the Challenges for Using Air-to-Air Energy Recovery for Commercial Kitchen Ventilation (CKV) and 90.1 Compliance? and Seminar 26: Analysis of Chemical and Physical Effects of Ultraviolet Bulbs on Cooking Emissions*

**TC 5.10 Handbook (20/0)**  
 Sun. 8:00 a.m. – 9:00 a.m. Plaza Court 1 (PC)

**TC 5.10 Program**  
 Mon. 8:00 a.m. – 9:00 a.m. Columbine (TT)

**TC 5.10 Research**  
 Sun. 9:00 a.m. – 10:00 a.m. Plaza Court 1 (PC)

**TC 5.10 Codes & Standards**  
 Mon. 9:00 a.m. – 10:00 a.m. Columbine (TT)

**TC 5.11 Humidifying Equipment (10/3)**  
**Mon. 2:15 p.m. – 4:15 p.m. Suite 3591, Plaza Building (Fifth Floor)**

**TC 5.11 Handbook/Program**  
 Mon. 10:30 a.m. – 12:00 p.m. Colorado (TZ)

**TC 6.1 Hydronic & Steam Htg. Equip & Sys (20/25)**  
**Tues. 1:00 p.m. – 3:30 p.m. Plaza Ballroom F (PC)**  
*Sponsoring: Special Session 5: Workshop: Building Owners Share Experiences with Hydronic Radiant Cooling Systems coupled with DOAS: What Works and What Doesn't?, Seminar 13: Chilled Water Systems for YEA Members: What the Gen Xers and Baby Boomers Have Done Wrong, and Seminar 28: The Largest Zero-Energy Building: What is Under the Hood?*

**TC 6.1 Handbook (10/10)**  
 Sun. 5:00 p.m. – 7:00 p.m. Beverly (TT)

**TC 6.1 Chilled Water Plant**  
 Sun. 7:00 p.m. – 8:00 p.m. Beverly (TT)

**TC 6.1 Program**  
 Mon. 2:15 p.m. – 3:15 p.m. Tower Court B (T2)

**TC 6.1 Research**  
 Mon. 3:15 p.m. – 4:15 p.m. Tower Court B (T2)

**TC 6.2 District Energy**  
**Sun. 3:00 p.m. – 5:00 p.m. Plaza Court 6 (PC)**  
*Sponsoring: Seminar 19: The New ASHRAE District Heating and District Cooling Design Guides, Part I (1267-RP) and Seminar 27: The New ASHRAE District Heating and District Cooling Design Guides, Part 2 (1267-RP)*

**TC 6.2 Programs, Research, Handbook, Planning,**  
 Sun. 2:00 p.m. – 3:00 p.m. Plaza Court 6 (PC)

**TC 6.3 Central Forced Air Htg. & Cooling Sys (20/10)**  
**Tues. 1:00 p.m. – 4:30 p.m. Plaza Court 1 (PC)**  
*Sponsoring: Seminar 6: Field and Equipment Issues that Impact Economizer Control Performance*

**TC 6.5 Radiant Heating and Cooling (17/10)****Mon. 2:15 p.m. – 4:15 p.m. Governor’s Square 15 (PC)***Sponsoring: Seminar 38: The Fundamentals of Radiant Cooling System Design and Construction and Special Session 5:**Workshop: Building Owners Share Experiences with Hydronic Radiant Cooling Systems coupled with DOAS: What Works and What Doesn’t?***TC 6.5 RP-1383****Sun. 2:15 p.m. – 3:00 p.m. Plaza Court 4****TC 6.5 Research, Spec Pubs, Journal, Program, Handbook (8/20)****Sun. 3:00 p.m. – 5:00 p.m. Plaza Court 4 (PC)****TC 6.6 Service Water Heating Systems (18/15)****Mon. 4:15 p.m. – 6:30 p.m. Plaza Court 4 (PC)****TC 6.6 Research/Program****Mon. 2:15 p.m. – 4:15 p.m. Plaza Court 4 (PC)****TC 6.7 Solar Energy Utilization (20/10)****Tues. 1:00 p.m. – 3:30 p.m. Plaza Court 5 (PC)***Sponsoring: Special Session 1: Panel Discussion: Shifting Landscape of Renewable Energy Systems in an Era of Low PV and Natural Gas Prices, Seminar 45: Integrating Innovative, Large-scale Solar Thermal Systems into the Built Environment., and Special Session 4: Workshop: BIM, Commissioning, and COBie: Does Automated Building Energy Modeling Replace Measurement and Verification?***TC 6.7 Research****Mon. 2:15 p.m. – 3:15 p.m. Aspen (TZ)****TC 6.7 Program****Mon. 4:15 p.m. – 5:30 p.m. Aspen (TZ)****TC 6.7 Handbook****Mon. 6:30 p.m. – 8:30 p.m. Aspen (TZ)****TC 6.8 Geothermal Heat Pump and Energy Recovery Applications (16/25)****Tues. 3:30 p.m. – 6:30 p.m. Director’s Row E (PL)***Sponsoring: Special Session 7: Workshop: The Smartest and Top Dumb Things Engineers and Designers Do to Impact Geothermal Heat Pump System Costs***TC 6.8 Handbook Subcommittee (8/0)****Sat. 12:00 p.m. – 3:00 p.m. Plaza Court 4 (PC)****TC 6.8 Research/Handbook/Program (15/0)****Sun. 5:00 p.m. – 7:00 p.m. Plaza Court 5 (PC)****TC 6.9 Thermal Storage (20/5)****Mon. 4:30 p.m. – 6:00 p.m. Plaza Court 5 (PC)***Sponsoring: Technical Paper Session 2: Thermal Comfort Design Conditions: Males, Females and Data Centers, Seminar 19: The New ASHRAE District Heating and District Cooling Design Guides, Part I (1267-RP), and Seminar 27: The New ASHRAE District Heating and District Cooling Design Guides, Part 2 (1267-RP)***TC 6.9 Standards (15/0)****Mon. 2:15 p.m. – 2:40 p.m. Plaza Court 5 (PC)****TC 6.9 Program (15/0)****Mon. 2:40 p.m. – 13:10:00 p.m. Plaza Court 5 (PC)****TC 6.9 Handbook, (15/0)****Mon. 3:10 p.m. – 3:30 p.m. Plaza Court 5 (PC)****TC 6.9 LRP /Website (15/0)****Mon. 3:30 p.m. – 3:50 p.m. Plaza Court 5 (PC)****TC 6.9 Research (10/0)****Mon. 3:50 p.m. – 4:30 p.m. Plaza Court 5 (PC)****TC 6.10 Fuels & Combustion (20/10)****Tues. 3:30 p.m. – 6:00 p.m. Plaza Court 1 (PC)****TC 6.10 Handbook (4/4)****Mon. 2:15 p.m. – 4:15 p.m. Client Office 2 (PC)****TC 7.1 Integrated Building Design (25/10)****Mon. 8:15 a.m. – 10:30 a.m. Director’s Row H (PL)***Sponsoring: Special Session 3: Workshop: Achieving High Performance Buildings through Integrated Project Delivery and Design-Build, Seminar 1: Energy Efficient Design through Integrated Project Delivery: A Case Study, Seminar 11: Performance Based Procurement Process Case Studies, Seminar 15: Advancements in BIM Interoperability Solutions to Aid in Integrated Project Delivery (IPD), Special Session 4: Workshop: BIM, Commissioning, and COBie: Does Automated Building Energy Modeling Replace Measurement and Verification?, and Seminar 8: The Rules of Engagement for a New Game: IPD Contract Styles and You!***TC 7.1 Subcommittees****Sun. 5:00 p.m. – 7:00 p.m. Tower Court A (T2)****TC 7.2 HVAC Construction and Design Build Technology (10/5)****Sun. 10:00 a.m. – 12:00 p.m. Plaza Court 1 (PC)****TC 7.3 Operations & Maintenance Management (25/7)****Tues. 1:00 p.m. – 3:30 p.m. Gold (TZ)***Sponsoring: Special Session 3: Workshop: Achieving High Performance Buildings through Integrated Project Delivery and Design-Build, Seminar 12: Quality BIM Objects for Lifelong Building Reality in a Virtual World, and Special Session 4: Workshop: BIM, Commissioning, and COBie: Does Automated Building Energy Modeling Replace Measurement and Verification?***TC 7.3 Standards/Program****Mon. 2:15 p.m. – 4:15 p.m. Suite 3412, Plaza Building (Fourth Floor)****TC 7.3 Research/Handbook/Education****Mon. 4:15 p.m. – 6:30 p.m. Suite 3412, Plaza Building (Fourth Floor)****CODES FOR FINDING YOUR MEETING ROOM:***Meeting space is located in both the Tower and Plaza Buildings.*

The first letter in the parenthesis following the room name will designate the building location, i.e.,

(P) will be Plaza and (T) is Tower  
The levels the rooms are located on are:

**Tower Building**

Mezzanine Level (Z)

Second Level (2)

Terrace Level (T)

Majestic Level (M)

**Plaza Building**

Lobby Level (L)

Concourse Level (C)

**TC 7.4 Exergy Analysis for Sustainable Buildings (14/8)**

**Sun. 8:00 a.m. – 10:00 a.m. Biltmore (TT)**

*Sponsoring: Special Session 4: Workshop: BIM, Commissioning, and COBie: Does Automated Building Energy Modeling Replace Measurement and Verification?*

**TC 7.5 Smart Building Systems (16/24)**

**Tues. 3:30 p.m. – 6:00 p.m. Tower Court D (T2)**

**TC 7.5 Fault Detection & Diagnosis**  
Sun. 3:00 p.m. – 3:45 p.m. Governor's Square 14 (PC)

**TC 7.5 Wireless Applications**  
Sun. 3:45 p.m. – 4:30 p.m. Governor's Square 14 (PC)

**TC 7.5 Smart Grid**  
Sun. 4:30 p.m. – 5:15 p.m. Governor's Square 14 (PC)

**TC 7.5 Handbook**  
Sun. 5:15 p.m. – 6:00 p.m. Governor's Square 14 (PC)

**TC 7.5 Buildings Operations Dynamics**  
Mon. 4:00 p.m. – 5:30 p.m. Colorado (TZ)

**TC 7.5 Research**  
Mon. 5:30 p.m. – 6:30 p.m. Colorado (TZ)

**TC 7.6 Building Energy Performance (20/30)**

**Tues. 1:00 p.m. – 3:30 p.m. Tower Court C (T2)**

*Sponsoring: Seminar 7: Measured and Simulated Building Performance with Emphasis on Existing Building Commissioning and Seminar 17: Benchmarking and Improving Commercial Building Energy Performance*

**TC 7.6 Research**  
Sun. 1:00 p.m. – 2:00 p.m. Suite 3666, Plaza Building (Sixth Floor)

**TC 7.6 Commercial Building Energy Audit**  
Sun. 2:00 p.m. – 3:00 p.m. Suite 3666, Plaza Building (Sixth Floor)

**TC 7.6 Handbook**  
Sun. 3:00 p.m. – 4:00 p.m. Suite 3666, Plaza Building (Sixth Floor)

**TC 7.6 Monitoring & Energy Performance (10/2)**  
Mon. 2:15 p.m. – 4:15 p.m. Registration Office (PC)

**TC 7.6 Energy Management**  
Mon. 4:15 p.m. – 5:15 p.m. Registration Office (PC)

**TC 7.6 Standards**  
Mon. 5:15 p.m. – 6:15 p.m. Registration Office (PC)

**TC 7.6 Executive**  
Mon. 6:15 p.m. – 6:45 p.m. Registration Office (PC)

**TC 7.7 Testing & Balancing (20/30)**

**Mon. 2:15 p.m. – 4:15 p.m. Beverly (TT)**

*Sponsoring: Seminar 40: Balancing: Practical Hydronic Balance for Designs Applying Diversity Factors*

**TC 7.7 Program/Handbook (8/2)**  
Sat. 1:00 p.m. – 3:00 p.m. Beverly (TT)

**TC 7.8 Owning & Operating Costs (20/5)**

**Mon. 2:15 p.m. – 4:15 p.m. Tower Court A (T2)**

*Sponsoring: Seminar 16: Real Operating Cost Savings from Retro-Commissioning*

**TC 7.8 Program, Handbook, Research (6/6) Screen/E**  
Sun. 3:00 p.m. – 5:00 p.m. Plaza Court 5 (PC)

**TC 7.9 Building Commissioning (20/50)**

**Sun. 3:00 p.m. – 5:00 p.m. Plaza Ballroom F (PC)**

*Sponsoring: Seminar 4: Realizing Sustainability with Commissioning and Seminar 42: The Commissioning Process Standard*

**TC 7.9 Handbook (6/0)**  
Sat. 8:00 a.m. – 9:00 a.m. Plaza Court 4 (PC)

**TC 7.9 Research (10/0)**  
Sat. 9:00 a.m. – 10:30 a.m. Plaza Court 4 (PC)

**TC 7.9 Program (15/0)**  
Sun. 9:00 a.m. – 10:30 a.m. Governor's Square 9 (PC)

**TC 8.1 Positive Displacement Compressors (12/14)**

**Tues. 3:30 p.m. – 6:00 p.m. Plaza Court 5 (PC)**

*Sponsoring: Special Session 9: Panel Discussion: VFD Generated Motor Bearing Currents Got Your Equipment Screaming? and Seminar 46: Practical Experiences with Low-GWP and Natural Refrigerants in Supermarkets*

**TC 8.1 Research**  
Mon. 2:15 p.m. – 4:15 p.m. Suite 3666, Plaza Building (Sixth Floor)

**TC 8.2 Centrifugal Machines (20/8)**

**Mon. 2:15 p.m. – 4:15 p.m. Tower Court D (T2)**

*Sponsoring: Seminar 21: Water Side Economizers, a.k.a. Free Cooling*

**TC 8.2 Research and Program**  
Sun. 5:00 p.m. – 7:00 p.m. Suite 3666, Plaza Building (Sixth Floor)

**TC 8.2 Handbook**  
Sun. 7:00 p.m. – 8:00 p.m. Suite 3666, Plaza Building (Sixth Floor)

**TC 8.3 Absorption and Heat Operated Machines (20/10)**

**Mon. 3:30 p.m. – 6:00 p.m. Director's Row H (PL)**

*Sponsoring: Special Session 6: Workshop: Cutting Edge Absorption and Adsorption Cooling Technologies in Cogeneration and Trigenation*

**TC 8.3 Research/Handbook**  
Mon. 2:00 p.m. – 3:30 p.m. Director's Row H (PL)

**TC 8.4 Air-to-Refrigerant Heat Transfer Equip (20/10)**

**Tues. 3:30 p.m. – 6:00 p.m. Plaza Court 7 (PC)**

*Sponsoring: Seminar 5: Effect of Frosting and Water Condensation on Microchannel Heat Exchangers and Seminar 2: Investigation of Replacement Refrigerants for R410A and Test Results from the Alternative Refrigerant Evaluation Program*

**TC 8.4 Research**  
Mon. 6:30 p.m. – 9:30 p.m. Director's Row H (PL)

**TC 8.5 Liquid to Refrigerant Heat Transfer (25/10)**

**Mon. 4:15 p.m. – 6:30 p.m. Silver (TZ)**

**TC 8.5/1.3 Research**  
Sun. 3:00 p.m. – 7:00 p.m. Governor's Square 15 (PC)

**TC 8.6 Cooling Towers and Evaporative Condensers (10/10)**

**Mon. 2:15 p.m. – 4:15 p.m. Plaza Court 2 (PC)**

**TC 8.6 Research**  
Sun. 5:00 p.m. – 7:00 p.m. Director's Row G (PL)

**TC 8.6 Handbook/Program/Research (10/0)**  
Mon. 8:00 a.m. – 10:00 a.m. Client Office 2 (PC)

**TC 8.7 Variable Refrigerant Flow (20/30)**

**Mon. 4:15 p.m. – 6:30 p.m. Beverly (TT)**

*Sponsoring: Special Session 2: Panel Discussion: The VRF MythBuster and Seminar 43: VRF Applications in Cold Climates: Success Stories*

**TC 8.8 Refrigerant System Controls & Accessories (10/10)**

**Tues. 1:00 p.m. – 3:30 p.m. Governor's Square 14 (PC)**

**TC 8.8 Program, Research, Handbook (6/4)**  
Mon. 2:15 p.m. – 4:15 p.m. Suite 3766, Plaza Building  
(Seventh Floor)

**TC 8.9 Residential Refrigerators and Food Freezers (6/10)**  
Mon. 2:15 p.m. – 4:15 p.m. Director's Row J (PL)

**TC 8.10 Mechanical Dehumidifiers & Heat Pipes (12/4)**  
Tues. 3:30 p.m. – 6:00 p.m. Aspen (TZ)

**TC 8.10 Program/Handbook/Research/Standards**  
Tues. 2:00 p.m. – 3:30 p.m. Aspen (TZ)

**TC 8.11 Unitary and Room Air Conditioners & Heat Pumps (20/30)**

Mon. 4:15 p.m. – 6:30 p.m. Columbine (TT)

*Sponsoring: Seminar 2: Investigation of Replacement Refrigerants for R410A and Test Results from the Alternative Refrigerant Evaluation Program*

**TC 8.11 Handbook/Program/Research**  
Sun. 3:00 p.m. – 6:00 p.m. Suite 3466, Plaza Building  
(Fourth Floor)

**TC 8.12 Desiccant Dehumidification Equipment and Components (15/15)**

Mon. 2:15 p.m. – 4:15 p.m. Columbine (TT)

**TC 9.1 Large Building Air-Conditioning Systems (23/5)**  
Tues. 1:00 p.m. – 3:30 p.m. Plaza Court 4 (PC)

*Sponsoring: Seminar 9: Sky High Efficient Case Studies*

**TC 9.1 Research/Program/Handbook**  
Tues. 12:00 p.m. – 1:00 p.m. Plaza Court 4 (PC)

**TC 9.2 Industrial Air Conditioning (25/10)**

Tues. 1:00 p.m. – 3:30 p.m. Tower Court D (T2)

*Sponsoring: Seminar 14: Heat and Resource Recovery in Industrial Air-conditioning Applications: New School or Old Hat?*

**TC 9.2 Program/Research/Handbook**  
Sun. 4:00 p.m. – 7:00 p.m. Director's Row F (PL)

**TC 9.2 Nuclear**  
Mon. 2:15 p.m. – 4:15 p.m. Director's Row G (PL)

**TC 9.3 Transportation Air Conditioning (25/20)**

Mon. 3:30 p.m. – 6:00 p.m. Spruce (TZ)

**TC 9.3 RP-1603 PMS**  
Mon. 8:00 a.m. – 9:00 a.m. Plaza Court 3

*Sponsoring: Seminar 32: Test Results from the AHRI Low GWP Refrigerants Alternative Refrigerant Evaluation Program*

**TC 9.3 Handbook**  
Sun. 9:00 a.m. – 10:00 a.m. Director's Row J (PC)

**TC 9.3 Aviation**  
Sun. 10:00 a.m. – 12:00 p.m. Director's Row J (PC)

**TC 9.3 Automotive**  
Sun. 5:00 p.m. – 7:00 p.m. Suite 3366, Plaza Building  
(Third Floor)

**TC 9.3 Research**  
Mon. 2:15 p.m. – 3:30 p.m. Spruce (TZ)

**TC 9.3 RP-1603 PMS**  
Mon. 8:00 a.m. – 9:00 a.m. Plaza Court 3

**TC 9.4 Justice Facilities (20/5)**

Sun. 8:00 a.m. – 10:00 a.m. Governor's Square 10 (PC)

**TC 9.6 Health Care Facilities 20/60 Screen**

Sun. 5:00 p.m. – 7:00 p.m. Plaza Ballroom F (PC)

*Sponsoring: Seminar 44: Advanced Energy Design for Hospitals: Theory and Application and Seminar 20: UVC: Radiating into the Future*

**TC 9.6 Handbook (20/0) Screen**  
Sun. 8:15 a.m. – 10:00 a.m. Director's Row E (PL)

**TC 9.6 Infectious Diseases (20/15) Screen**  
Sun. 10:00 a.m. – 12:00 p.m. Director's Row E (PL)

**TC 9.6 Research (20/5) Screen**  
Sun. 12:30 p.m. – 2:30 p.m. Director's Row E (PL)

**TC 9.6 Energy (20/5) Screen**  
Sun. 2:30 p.m. – 4:00 p.m. Director's Row E (PL)

**TC 9.6 Program (20/0)**  
Sun. 4:00 p.m. – 5:00 p.m. Director's Row E (PL)

**TC 9.7 Educational Facilities (13/10)**

Sun. 1:00 p.m. – 3:00 p.m. Plaza Court 2 (PC)

**TC 9.8 Large Building Air-Conditioning Applications (20/10)**

Mon. 2:15 p.m. – 4:15 p.m. Century (TZ)

**TC 9.8 Museums, Galleries, Archives & Libraries**  
Mon. 8:00 a.m. – 9:00 a.m. Director's Row F (PL)

**TC 9.8 Research**  
Mon. 9:00 a.m. – 10:00 a.m. Director's Row F (PL)

**TC 9.8 Handbook**  
Mon. 10:00 a.m. – 11:00 a.m. Director's Row F (PL)

**TC 9.8 Program**  
Mon. 11:00 a.m. – 12:00 p.m. Director's Row F (PL)

**TC 9.9 Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment (25/50)**

Mon. 2:15 p.m. – 8:30 p.m. Plaza Ballroom F (PC)

*Sponsoring: Technical Paper Session 9: Additional Concerns for the Mission Critical Data Center*

**TC 9.9 Research -Energy Modeling Statement Review (6/4) Screen**  
Sun. 3:00 p.m. – 5:00 p.m. Director's Row H (PL)

**TC 9.9 Program/ Handbook/ Research (25/10) Screen**  
Sun. 5:00 p.m. – 7:00 p.m. Tower Court D (T2)

**TC 9.10 Laboratory Systems (20/50) Screen/E**

Tues. 3:30 p.m. – 6:00 p.m. Plaza Ballroom F (PC)

*Sponsoring: Seminar 23: Laboratory Retrofits Case Studies: Optimizing Energy Usage Through Commissioning and Comparison of Modelled Energy Usage Using M&V Data. and Seminar 31: Laboratory Exhaust Fans and Energy Conservation*

**TC 9.10 Standards (10/10) Screen/E**  
Sun. 3:00 p.m. – 3:45 p.m. Governor's Square 11 (PC)

**TC 9.10 Research**  
Sun. 3:45 p.m. – 4:30 p.m. Governor's Square 11 (PC)

## CODES FOR FINDING YOUR MEETING ROOM:

*Meeting space is located in both the Tower and Plaza Buildings.*

The first letter in the parenthesis following the room name will designate the building location, i.e.,

(P) will be Plaza and (T) is Tower  
The levels the rooms are located on are:

**Tower Building**  
Mezzanine Level (Z)  
Second Level (2)  
Terrace Level (T)  
Majestic Level (M)

**Plaza Building**  
Lobby Level (L)  
Concourse Level (C)

**TC 9.10 Program**  
Sun. 4:30 p.m. – 5:15 p.m. Governor’s Square 11 (PC)

**TC 9.10 Lab Classification**  
Sun. 5:15 p.m. – 6:00 p.m. Governor’s Square 11 (PC)

**TC 9.10 Design Guide (10/10) Screen/E**  
Tues. 1:00 p.m. – 2:30 p.m. Biltmore (TT)

**TC 9.10 Handbook**  
Tues. 2:30 p.m. – 3:30 p.m. Biltmore (TT)

**TC 9.11 Clean Spaces (30/45)**  
Mon. 2:15 p.m. – 4:00 p.m. Governor’s Square 14 (PC)  
*Sponsoring: Forum 3: Review of Issues in Contamination Control for Clean Room Facilities*

**TC 9.11 Handbook**  
Mon. 4:00 p.m. – 4:30 p.m. Governor’s Square 14 (PC)

**TC 9.11 Design Guide**  
Mon. 4:30 p.m. – 5:30 p.m. Governor’s Square 14 (PC)

**TC 9.11 Short Course**  
Mon. 5:30 p.m. – 6:00 p.m. Governor’s Square 14 (PC)

**TC 9.12 Tall Buildings (12/5)**  
Tues. 3:30 p.m. – 6:00 p.m. Director’s Row F (PL)

**TC 10.1 Custom Engineered Refrig Systems 20/10)**  
Mon. 2:15 p.m. – 4:15 p.m. Colorado (TZ)  
*Sponsoring: Seminar 37: Simple Energy Improvements in Refrigeration Systems*

**TC 10.1 Research/Handbook, Standards/ Program**  
Sun. 5:00 p.m. – 7:00 p.m. Suite 3266, Plaza Building (Second Floor)

**TC 10.1 Cryogenic Refrigerants**  
Sun. 3:00 p.m. – 5:00 p.m. Suite 3266, Plaza Building (Second Floor)

**TC 10.2 Automatic Ice Making Plants/Skating Rinks (12/3)**  
Mon. 4:15 p.m. – 6:30 p.m. Suite 3666, Plaza Building (Sixth Floor)

**TC 10.2 Research/Handbook (3/2)**  
Mon. 8:00 a.m. – 10:00 a.m. Plaza Court 3 (PC)

**TC 10.3 Refrigerant Piping, Controls and Accessories (20/10)**  
Tues. 1:00 p.m. – 3:30 p.m. Plaza Court 7 (PC)

**TC 10.5 Refrigeration Distrib and Storage Facilities (15/10)**  
Tues. 3:30 p.m. – 6:00 p.m. Director’s Row I (PL)

**TC 10.6 Transport Refrigeration (8/10)**  
Mon. 4:45 p.m. – 7:00 p.m. Suite 3266, Plaza Building (Third Floor)  
*Sponsoring: Seminar 32: Test Results from the AHRI Low GWP Refrigerants Alternative Refrigerant Evaluation Program and Seminar 2: Investigation of Replacement Refrigerants for R410A and Test Results from the Alternative Refrigerant Evaluation Program*

**TC 10.6 Handbook**  
Mon. 2:15 p.m. – 3:00 p.m. Suite 3266, Plaza Building (Third Floor)

**TC 10.7 Commercial Food and Beverage Refrigeration Equipment (25/25)**  
Mon. 2:15 p.m. – 4:15 p.m. Governor’s Square 10 (PC)  
*Sponsoring: Seminar 34: Reducing the GWP Impacts of Commercial Refrigeration, Seminar 39: Demand Response (DR) Opportunities with Commercial Ice Machines, and Seminar 46: Practical Experiences with Low-GWP and Natural Refrigerants in Supermarkets*

**TC 10.7 1467-RP PMS**  
Sun. 7:00a – 8:00 a.m.

**TC 10.7 Program (5/5)**  
Sun. 5:15 p.m. – 6:00 p.m. Plaza Court 2 (PC)

**TC 10.7 Research (8/5)**  
Sun. 6:00 p.m. – 6:45 p.m. Plaza Court 2 (PC)

**TC 10.7 Handbook**  
Sun. 6:45 p.m. – 7:30 p.m. Plaza Court 2 (PC)

**TC 10.8 Refrigeration Load Calculations (10/10)**  
Sun. 3:00 p.m. – 5:00 p.m. Director’s Row G (PL)

## TASK GROUPS (TG), TECHNICAL RESOURCE GROUPS (TRG), AD MULTIDISCIPLINARY TASK GROUPS (MTG)

**TG1.Optimization (10/5)**  
Sun. 1:00 p.m. – 3:00 p.m. Plaza Court 5 (PC)  
*Sponsoring: Seminar 18: Developments in Simulation*

**TG2.HVAC Security (20/6)**  
Tues. 9:00 a.m. – 12:00 p.m. Plaza Court 1 (PC)

**TRG4 Sustainable Building Guidance & Metrics (17/10)**  
Sat. 1:00 p.m. – 3:00 p.m. Plaza Court 2 (PC)

**TRG4.IAQP (12/8)**  
Sun. 10:30 a.m. – 12:30 p.m. Plaza Court 2 (PC)  
*Sponsoring: Forum 2: Should the VRP Be Held Up to the Same Performance/Monitoring Criteria as the IAQP?*

**MTG Building Performance Metrics**  
Sun. 1:00 p.m. – 4:00 p.m. Director’s Row F (PL)

**MTG Energy Efficiency Classification of General Ventilation Air-Cleaning Devices**  
Tues. 8:00 a.m. – 12:00 p.m. Director’s Row H (PL)

**MTG Building Information Modeling**  
Sat. 1:00 p.m. – 3:00 p.m. Denver (TZ)

**MTG Energy Targets Multidisciplinary Task Group (10/0)**  
Tues. 12:00 p.m. – 2:00 p.m. Director’s Row G (PL)

**MTG Cold Climate Design Guide (20/5)**  
Tues. 4:00 p.m. – 6:00 p.m. Plaza Court 4 (PC)

**MTG Cold Climate Design Guide**  
Wed. 1:00 p.m. – 4:00 p.m. Plaza Court 2 (PC)

## STANDARD PROJECT COMMITTEES (SPC) AND STANDING STANDARD PROJECT COMMITTEES (SSPC)

**SPC Chair Training Breakfast**  
Sun. 7:00a – 9:00 a.m. Grand Ballroom (T2)

**SSPC 15 Safety Standards for Refrigeration Systems (18/30) Screen**  
Sun. 8:00 a.m. – 5:00 p.m. Tower Court D (T2)

**SPC 16/58 MOT/Rating Room Air Conditioners and PTAC/ PTHP (5/3) Screen/E**  
Tues. 8:00 a.m. – 12:00 p.m. Plaza Court 4 (PC)

SPC 17 MOT/Capacity of TEV's -6  
**Sun. 5:00 p.m. – 7:00 p.m. Aspen (TZ)**

SPC 20 MOT/Rating Remote Mechanical-Draft Air-Cooled Refrigerant Condensers (5/5) Screen  
**Sun. 12:00 p.m. – 2:00 p.m. Plaza Court 4 (PC)**

SPC 22 MOT/Water-cooled Refrigerant Condensers (7/10) Screen  
**Sun. 9:00 a.m. – 12:00 p.m. Savoy (TM)**

SPC 23.1 MOT/for Performance Rating Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Temperatures of the Refrigerant (8/6)  
**Mon. 2:15 p.m. – 4:15 p.m. Suite 3512, Plaza Building (Fifth Floor)**

SPC 23.2 MOT/Rating Positive Displacement Compressors that Operate at Supercritical Temperatures of the Refrigerant (7/5)  
**Mon. 10:00 a.m. – 12:00 p.m. Suite 3266, Plaza Building (Sixth Floor)**

SPC 29 MOT/Automatic Ice Makers (12/8) Screen  
**Mon. 4:15 p.m. – 7:15 p.m. Governor's Square 10 (PC)**

SPC 30 MOT Liquid Chilling Packages (7/10) Screen  
**Wed. 8:00 a.m. – 11:00 a.m. Plaza Court 2 (PC)**

SSPC 34 Designation & Safety Class. of Refrig. (30/20) Screen/E  
**Mon. 6:30 p.m. – 10:00 p.m. Plaza Ballroom B/C (PC)**

SSPC 34 Designation Nomenclature (10/10) Screen/E  
**Sat. 7:00a – 10:00 a.m. Plaza Court 5 (PC)**

SSPC 34 Flammability (15/20) Screen/E  
**Sat. 10:00 a.m. – 3:00 p.m. Plaza Court 5 (PC)**

SSPC 34 Toxicity (10/20) Screen/E  
**Sun. 6:30 p.m. – 10:00 p.m. Tower Court B (T2)**

SPC 37 MOT for Rating Electrically Driven Unitary Air-Conditioners and Heat Pump Equipment (7/12) Screen/E  
**Wed. 8:00 a.m. – 10:00 a.m. Plaza Court 3 (PC)**

SPC 40 MOT/Rating Heat Operated Unitary Air-Conditioning and Heat-Pump Equipment (5/5)  
**Mon. 10:00 a.m. – 12:00 p.m. Savoy (TM)**

SSPC 41 Standard Methods for Measurement (15/10)  
**Sun. 1:00 p.m. – 4:00 p.m. Biltmore (TT)**

SSPC 41.2 Laboratory Airflow-Standard Method for Laboratory Airflow Measurement (10/5)  
**Mon. 8:00 a.m. – 12:00 p.m. Plaza Court 4 (PC)**

SSPC 41.3 Pressure-Standard Method for Pressure Measurement (10/5)  
**Sun. 4:00 p.m. – 6:00 p.m. Biltmore (TT)**

SSPC 41.4 Lubricant Content-Standard Method for Measurement of Proportion of Lubricant in Liquid Refrigerant (6/4) (10/5)  
**Mon. 8:00 a.m. – 10:00 a.m. Plaza Court 6 (PC)**

SSPC 41.6 Humidity-Standard Methods (10/5)  
**Sun. 10:00 a.m. – 12:00 p.m. Biltmore (TT)**

SSPC 41.7 Standard Methods for Gas Flow Measurement (10/5)  
**Tues. 8:00 a.m. – 10:00 a.m. Plaza Court 2 (PC)**

SSPC 41.8 Standard Methods for Liquid Flow Measurement (10/5)  
**Tues. 10:00 a.m. – 12:00 p.m. Plaza Court 2 (PC)**

SPC 51 Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating (15/10) Screen/Flipchart  
**Sun. 12:30 p.m. – 3:00 p.m. Denver (TZ)**

SSPC 52.2P MOT/Part Size Eff. Proc. for Testing Air Cleaning Devices (20/50) Screen/E  
**Sat. 8:00 a.m. – 12:00 p.m. Silver (TZ)**

SSPC 55 Thermal Env Cond. for Human Occupancy (19/6) Screen  
**Sat. 8:00 a.m. – 3:00 p.m. Capitol (TT)**  
**Sun. 9:00 a.m. – 12:00 p.m. Director's Row H (PL)**

SSPC 62.1 Ventilation and Acceptable IAQ in Commercial, Institutional and High-Rise Residential Buildings (30/30) Screen/E  
**Sat. 9:00 a.m. – 3:00 p.m. Governor's Square 14 (PC)**  
**Sun. 1:00 p.m. – 7:00 p.m. Majestic Ballroom (TM)**

SSPC 62.1 Education Subcommittee (15/15) Screen  
**Fri. 1:00 p.m. – 5:00 p.m. Beverly (TT)**

SSPC 62.1 Administration Subcommittee (15/15) Screen  
**Fri. 1:00 p.m. – 5:00 p.m. Capitol (TT)**

SSPC 62.2 Ventilation for Acceptable IAQ in Low-Rise Residential Buildings (28/13) Screen/E  
**Fri. 1:00 p.m. – 2:30 p.m. Tower Court A (T2)**  
**Sat. 8:30 a.m. – 3:00 p.m. Tower Court D (T2)**

SSPC 62.2 IAQ Subcommittee -12  
**Fri. 9:00 a.m. – 12:00 p.m. Plaza Court 3 (PC)**

SSPC 62.2 IAQ Subcommittee  
**Fri. 2:30 p.m. – 5:00 p.m. Plaza Court 3 (PC)**

SSPC 62.2 System Subcommittee -12  
**Fri. 2:30 p.m. – 5:00 p.m. Plaza Court 2 (PC)**

SSPC 62.2 Envelope Subcommittee -20  
**Fri. 2:30 p.m. – 5:00 p.m. Tower Court A (T2)**

SPC 72 MOT/Commercial Refrigerators and Freezers (12/12)  
**Sun. 1:00 p.m. – 6:00 p.m. Director's Row J (PC)**

SPC 79 Room Fan Coil Standard Committee (6/10) Screen/E  
**Sat. 8:00 a.m. – 12:00 p.m. Plaza Court 7 (PC)**

SPC 84-2008 MOT/Air-to-Air Heat/Energy Exchangers (10/4) Screen/E  
**Tues. 8:00 a.m. – 12:00 p.m. Gold (TZ)**

SSPC 90.1 Energy Eff. Design of New Bldg. (50/60)

### CODES FOR FINDING YOUR MEETING ROOM:

*Meeting space is located in both the Tower and Plaza Buildings.*

The first letter in the parenthesis following the room name will designate the building location, i.e.,

(P) will be Plaza and (T) is Tower  
 The levels the rooms are located on are:

**Tower Building**  
 Mezzanine Level (Z)  
 Second Level (2)  
 Terrace Level (T)  
 Majestic Level (M)

**Plaza Building**  
 Lobby Level (L)  
 Concourse Level (C)

Sat. 8:00 a.m. – 12:00 p.m. Majestic Ballroom (TM)  
Sun. 9:00 a.m. – 12:00 p.m. Majestic Ballroom (TM)  
Mon. 8:00 a.m. – 12:00 p.m. Majestic Ballroom (TM)

SSPC 90.1 Format & Compliance Subcommittee (4/6)  
Fri. 5:00 p.m. – 10:00 p.m. Beverly (TT)  
Sat. 1:00 p.m. – 5:00 p.m. Plaza Court 6 (PC)  
Sun. 4:00 p.m. – 7:00 p.m. Capitol (TT)

SPC 90.1 Mechanical Subcommittee  
Fri. 9:00 a.m. – 10:00 p.m. Columbine (TT)  
Sat. 1:00 p.m. – 7:00 p.m. Majestic Ballroom (TM)  
Sun. 1:00 p.m. – 8:00 p.m. Spruce (TZ)

SSPC 90.1 Lighting Subcommittee (12/10)  
Fri. 9:00 a.m. – 10:00 p.m. Savoy (TM)  
Sat. 1:00 p.m. – 7:00 p.m. Governor's Square 11 (PC)  
Sun. 1:00 p.m. – 8:00 p.m. Savoy (TM)

SSPC 90.1 ECB Subcommittee (8/10)  
Fri. 5:00 p.m. – 10:00 p.m. Biltmore (TT)  
Sat. 1:00 p.m. – 5:00 p.m. Plaza Court 7 (PC)  
Sun. 1:00 p.m. – 4:00 p.m. Capitol (TT)

SSPC 90.1 Envelope Subcommittee (15/30)  
Fri. 9:00 a.m. – 10:00 p.m. Terrace (TT)  
Sat. 1:00 p.m. – 7:00 p.m. Tower Court C (T2)  
Sun. 1:00 p.m. – 7:00 p.m. Governor's Square 9 (PC)

SSPC 90.1 User Manual Review Committee  
Sat. 5:00 p.m. – 7:00 p.m. Plaza Court 7 (PC)

SSPC 90.2 Energy Eff. Design of New Low Rise Res. Bldg. (29/20) Screen/E  
Mon. 2:15 p.m. – 6:15 p.m. Governor's Square 11 (PC)  
Tues. 1:00 p.m. – 5:00 p.m. Governor's Square 11 (PC)

SSPC 90.2 Lighting (4/4) Screen/E  
Mon. 6:15 p.m. – 9:15 p.m. Plaza Court 1 (PC)

SSPC 90.2 Lighting  
Tues. 8:00 a.m. – 12:00 p.m. Plaza Court 6 (PC)

SSPC 90.2 Mechanical (6/6) Screen/E  
Mon. 6:15 p.m. – 9:15 p.m. Plaza Court 3 (PC)

SSPC 90.2 Mechanical  
Tues. 8:00 a.m. – 12:00 p.m. Plaza Court 5 (PC)

SSPC 90.2 Envelope (11/15) Screen/E  
Mon. 6:15 p.m. – 9:15 p.m. Governor's Square 11 (PC)

SSPC 90.2 Envelope  
Tues. 8:00 a.m. – 12:00 p.m. Plaza Court 7 (PC)

SPC 90.4 Energy Standard for Data Centers and Telecommunications Buildings (25/40) Screen/E  
Sat. 9:00 a.m. – 1:00 p.m. Denver (TZ)  
Mon. 7:00a – 11:00 a.m. Terrace (TT)

SPC 97 Sealed Glass Tube Method to Test the Chemical Stability of Materials for Use Within Refrigerant Systems  
Tues. 9:30 a.m. – 11:00 a.m. Aspen (TZ)

SPC 99 Refrigeration Oil Description (25/40) Screen/E  
Mon. 8:00 a.m. – 9:00 p.m. Director's Row 1 (PL)

SPC 100 Energy Efficiency in Existing Buildings (20/60) Screen  
Tues. 8:00 a.m. – 12:00 p.m. Governor's Square 12 (PC)

SPC 103/MOT Annual Fuel Utilization Efficiency (12/10)  
Sun. 6:00 p.m. – 10:00 p.m. Plaza Court 7 (PC)

~~SPC 105 Standard Methods for Measuring and Expressing Building Energy (15) Screen  
Sun. 9:00 a.m. – 12:00 p.m. Plaza Court 3 (PC)~~

SPC 110 MOT/Performance of Laboratory Fume Hoods  
Tues. 8:00 a.m. – 12:00 p.m. Capitol (TT)

SPC 111 Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation and Air-Conditioning Systems (12) (12/0) Screen/E

Fri. 8:00 a.m. – 12:00 p.m. Beverly (TT)

SPC 116 MOT/for Rating Seasonal Efficiency of Unitary Air-Conditioners and Heat Pumps (7/12) Screen/E

Wed. 10:00 a.m. – 12:00 p.m. Plaza Court 3 (PC)

SPC 118.1 MOT/Commercial Water Heaters (6/6)  
Sun. 9:00 a.m. – 12:00 p.m. Plaza Court 4

SPC 118.2R MOT/Rating Residential Water Heaters  
Tues. 1:00 p.m. – 5:00 p.m. Governor's Square 12 (PC)

SPC 124 MOT/Rating Combinations Space-Heating an Water Heating Appliances

Wed. 8:00 a.m. – 12:00 p.m. Denver (TZ)

SPC 126 MOT/HVAC Air Ducts  
Sun. 8:00 a.m. – 10:00 a.m. Suite 3666, Plaza Building (Sixth Floor)

SPC 129 Measuring Air Change Effectiveness  
Sun. 5:00 p.m. – 7:00 p.m. Terrace (TT)

SPC 130 MOT/for Rating Ducted Air Terminal Units (12/15) Screen/E

Sun. 2:00 p.m. – 6:00 p.m. Governor's Square 10 (PC)

SSPC 135 BACnet (15/5)  
Thurs. 1:00 p.m. – 5:00 p.m. Plaza Court 1 (PC)

SSPC 135 BACnet (20/5)  
Fri. 8:00 a.m. – 5:00 p.m. Century (TZ)

SSPC 135 BACnet (20/5)  
Fri. 8:00 a.m. – 5:00 p.m. Gold (TZ)

SSPC 135 BACnet 45/15) microphone  
Sat. 8:00 a.m. – 3:00 p.m. Columbine (TT)

SSPC 135 BACnet Working Group (20/5)  
Sun. 8:00 a.m. – 3:30 p.m. Tower Court B (T2)

SSPC 135 BACnet (20/5)  
Sun. 8:00 a.m. – 5:00 p.m. Tower Court C (T2)

SSPC 135 BACnet (45/15) microphone  
Mon. 8:00 a.m. – 12:00 p.m. Governor's Square 12 (PC)

SPC 139R MOT/for Rating Desiccant Dehumidifiers Utilizing Heat for the Regeneration Process  
Mon. 8:00 a.m. – 10:00 a.m. Savoy (TM)

SSPC 140 Standard MOT for Evaluation of Bldg. Energy Analysis Computer Program (12/10) Screen  
Mon. 2:15 p.m. – 6:15 p.m. Director's Row F (PL)

SPC 145P Test Methods for Assessing Performance of Gas Phase Air Clean. Equip. (12/15)  
Sun. 12:00 p.m. – 3:00 p.m. Director's Row H (PL)

SPC 147 Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment  
Sun. 6:00 p.m. – 10:00 p.m. Century (TZ)

SPC 150 MOT/Performance of Cool Storage Systems -10  
Sun. 5:30 p.m. – 7:00 p.m. Director's Row J (PC)

SPC 152R MOT/Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems (8/6)  
Sun. 8:00 a.m. – 10:00 a.m. Suite 3766, Plaza Building (Seventh Floor)

**SPC 153 MOT/ for Mass Flow Capacity of Four-Way Refrigerant Reversing Valves (5/3)**  
**Sun. 5:00 p.m. – 7:00 p.m. Aspen (TZ)**

**SPC 154 Ventilation for Commercial Cooking Operations (11/10) Screen**  
**Mon. 2:15 p.m. – 6:15 p.m. Director’s Row I (PL)**

**SPC 155P MOT/Rating Commercial Space Heating Boiler Systems (10/6)**  
**Sun. 1:00 p.m. – 5:00 p.m. Aspen (TZ)**

**SSPC 160 Criteria for Moisture Control Design Analysis (12/6)**  
**Tues. 9:00 a.m. – 12:00 p.m. Suite 3766, Plaza Building (Seventh Floor)**

**SPC 161P Air Quality Within Commercial Aircraft (22/5) Screen/E**  
**Sun. 1:00 p.m. – 5:00 p.m. Gold (TZ)**  
**Mon. 8:00 a.m. – 12:00 p.m. Director’s Row J (PL)**

**SPC 164.3 MOT/Commercial and Industrial Humidifiers (10/4)**  
**Mon. 9:30 a.m. – 11:30 a.m. Plaza Court 2 (PC)**

**SSPC 169 Weather Data for Building Design Standards (10/5) Screen**  
**Mon. 10:00 a.m. – 12:00 p.m. Director’s Row I (PL)**

**SSPC 170 Ventilation of Healthcare Facilities (20/25) Screen**  
**Tues. 8:00 a.m. – 1:00 p.m. Governor’s Square 9 (PC)**

**SSPC 170 Clinical Subcommittee (20/25) Screen**  
**Mon. 4:15 p.m. – 6:15 p.m. Tower Court B (T2)**

**SPC 171 MOT/ of Seismic Restraint Devices for HVAC&R Equipment (7/5) (15/10)**  
**Tues. 8:00 a.m. – 12:00 p.m. Director’s Row I (PL)**

**172P MOT/Insoluble Materials in Synthetic Lubricants And HFC Refrigerant Sysytems (6/4)**  
**Mon. 8:00 a.m. – 12:00 p.m. Aspen (TZ)**

**SPC 174R MOT/ for Rating Desiccant – Based Dehumidification Equipment**  
**Mon. 8:00 a.m. – 10:00 a.m. Capitol (TT)**

**SPC 175 Metal Pressure Vessel Testing (5/5)**  
**Mon. 4:15 p.m. – 6:15 p.m. Director’s Row G (PL)**

**SPC 177P MOT/Fractionation Measurement of Refrigerant Blends (6/8)**  
**Mon. 8:00 a.m. – 12:00 p.m. Plaza Court 5 (PC)**

**SPC 179P MOT/Life Testing Positive Displaced Compressors**  
**Sun. 1:00 p.m. – 5:00 p.m. Suite 3412, Plaza Building (Fourth Floor)**

**SPC 181 MOT/Liquid-to-Liquid Heat Exchangers (8/10) Screen**  
**Mon. 9:00 a.m. – 12:00 p.m. Biltmore (TT)**

**SPC 184 MOT/Field Test of Liquid Package Chillers (9/5) Screen**  
**Tues. 8:00 a.m. – 12:00 p.m. Director’s Row F (PL)**

**SPC 185 MOT/UVC Lights for Use in Air Handling Units or Air Ducts to Inactivate Airborne Microorganisms**  
**Sat. 8:00 a.m. – 3:00 p.m. Biltmore (TT)**

**SPC 188 Prevention of Legionellosis Associated with Building Water Systems (22/30)**  
**Tues. 9:00 a.m. – 12:00 p.m. Tower Court C (T2)**  
**Tues. 3:30 p.m. – 6:00 p.m. Tower Court C (T2)**

**SSPC 189.1 ASHRAE/USGBC/IES Standard for the Design of High-Performance Green Buildings except Low-Rise Residential Buildings (40/40)**  
**Tues. 7:30 a.m. – 9:30 a.m. Silver (TZ)**  
**Wed. 8:00 a.m. – 12:00 p.m. Silver (TZ)**

**SSPC 189.1 Working Group 6 (Water Use)**  
**Tues. 9:30 a.m. – 11:30 a.m. Silver (TZ)**

**SSPC 189.1 Working Group 5 (Site Sustainability)**  
**Tues. 12:00 p.m. – 2:00 p.m. Silver (TZ)**

**SSPC 189.1 Working Group 9 (Materials and Resources)**  
**Tues. 2:30 p.m. – 4:30 p.m. Silver (TZ)**

**SSPC 189.1 Working Group 10**  
**Tues. 5:00 p.m. – 7:00 p.m. Silver (TZ)**

**SSPC 189.1 Working Group 7 (Energy Efficiency)**  
**Tues. 9:30 a.m. – 12:30 p.m. Tower Court A (T2)**

**SSPC 189.1 Working Group 7.5**  
**Tues. 1:00 p.m. – 4:00 p.m. Tower Court A (T2)**

**SSPC 189.1 Working Group 8 (IEQ)**  
**Tues. 4:00 p.m. – 7:00 p.m. Tower Court A (T2)**

**SPC 189.3 Design, Construction and Operation of High – Performance Green Healthcare Facilities**  
**Mon. 8:00 a.m. – 12:00 p.m. Gold (TZ)**  
**Mon. 2:15 p.m. – 4:00 p.m. Gold (TZ)**

**SPC 190 MOT/Rating Indoor Pool Dehumidifiers for Moisture Removal Capacity and Moisture Removal Efficiency (6/6)**  
**Tues. 1:30 p.m. – 2:00 p.m. Suite 3766, Plaza Building (Seventh Floor)**

**SPC 191 Water Conservation**  
**Sun. 9:00 a.m. – 11:00 a.m. Director’s Row F (PL)**  
**Tues. 8:00 a.m. – 12:00 p.m. Century (TZ)**

**SPC 194 MOT/Direct-Expansion Ground Souce Heat Pumps**  
**Sun. 1:00 p.m. – 2:00 p.m. Suite 3366, Plaza Building (Third Floor)**

**SPC 195P MOT/for Airflow Controls (7/3) Screen**  
**Tues. 8:00 a.m. – 9:30 a.m. Biltmore (TT)**

**SPC 196P MOT/ Measuring Refrigerant Leak Rates (15/3)**  
**Sun. 6:00 p.m. – 10:00 p.m. Plaza Court 4 (PC)**

#### **CODES FOR FINDING YOUR MEETING ROOM:**

*Meeting space is located in both the Tower and Plaza Buildings.*

The first letter in the parenthesis following the room name will designate the building location, i.e.,

(P) will be Plaza and (T) is Tower  
 The levels the rooms are located on are:

**Tower Building**  
 Mezzanine Level (Z)  
 Second Level (2)  
 Terrace Level (T)  
 Majestic Level (M)

**Plaza Building**  
 Lobby Level (L)  
 Concourse Level (C)

SPC 197 MOT/Attenuation Characteristics of Vibration Isolators (8/4) (10/2) Screen/E  
 Mon. 4:30 p.m. – 6:30 p.m. Suite 3591, Plaza Building (Fifth Floor)

SPC 198 MOT/Rating DX Dedicated Outdoor-Air Systems (6/6)  
 Tues. 12:00 p.m. – 1:00 p.m. , ()

SPC 199 MOT/Rating the performance of Industrial Pulse Cleaned Dust Collectors  
 Fri. 1:00 p.m. – 5:00 p.m. Director’s Row G (PL)  
 Sun. 8:00 a.m. – 12:00 p.m. Suite 3366, Plaza Building (Third Floor)

SPC 200 MOT/Chilled Beams (25/25) Screen/E  
 Mon. 8:00 a.m. – 12:00 p.m. Governor’s Square 11 (PC)

SPC 201P: Facility Smart Grid Information Model (25/15) Screen/E  
 Mon. 2:15 p.m. – 6:30 p.m. Majestic Ballroom (TM)  
 Tues. 8:00 a.m. – 12:00 p.m. Governor’s Square 11 (PC)

SPC 202 Commissioning Process for Buildings & Systems (15/10)  
 Mon. 8:00 a.m. – 12:00 p.m. Colorado (TZ)

SSPC 203P MOT/Determining Heat Gain of Office Equip. Used in Buildings (10/4) Screen  
 Sat. 1:00 p.m. – 3:00 p.m. Gold (TZ)

SPC 204P MOT/Rating Micro Combined Heat and Power Devices (13/7)  
 Mon. 6:30 p.m. – 8:30 p.m. Spruce (TZ)

SPC 205 Standard Representation of Performance Simulation Data for HVAC&R and Other Facility Equipment (20/20) Screen  
 Tues. 8:00 a.m. – 11:00 a.m. Tower Court D (T2)  
 Sun. 9:00 a.m. – 12:00 p.m. Director’s Row I (PL)

SPC 206 MOT/for Rating of Multi-Purpose Residential Heat Pumps for Space Conditioning, Water Heating and Dehumidification (14/10) Screen  
 Mon. 2:15 p.m. – 6:15 p.m. Biltmore (TT)

SPC 207P Laboratory Method of Test of Fault Detection and Diagnostics Applied Commercial Air-Cooled Packaged Systems (20/20) Screen  
 Mon. 8:00 a.m. – 10:00 a.m. Governor’s Square 10 (PC)

SPC 207 Airflow Working Group (10/0) Screen  
 Mon. 10:00 a.m.– 12:00 p.m. Governor’s Square 10 (PC)

SPC 207 Economizer Working Group (10/0) Screen  
 Mon. 4:30 p.m. – 6:30 p.m

SPC 207 Refrigerant Working Group (10/0) Screen  
 Mon. 6:30 p.m. – 8:30 p.m. Director’s Row I (PL)

SPC 209 Energy Simulation Aided Design (30/25) Screen  
 Mon. 2:15 p.m. – 6:15 p.m. Governor’s Square 12 (PC)

SPC 209 Predesign Subcommittee (10/5) Screen  
 Sun. 6:00 p.m. – 10:00 p.m. Plaza Court 3 (PC)

SPC 209 Design Development/Construction Documents (10/5) Screen  
 Sun. 6:00 p.m. – 10:00 p.m. Plaza Court 6 (PC)

SPC 209 Construction/Commissioning/As-Built/Operation (10/5) Screen  
 Sun. 6:00 p.m. – 10:00 p.m. Plaza Court 1 (PC)

SPC 209 Resources/References/Definitions Subcommittee (10/5) Screen  
 Mon. 8:00 a.m. – 12:00 p.m. Plaza Court 1 (PC)

SPC 209 Conceptual design/Schematic design (10/5) Screen  
 Mon. 8:00 a.m. – 12:00 p.m. Plaza Court 7 (PC)

SPC 210 MOT/for Rating Commercial Walk-in Refrigerators and Freezers (3/24)  
 Mon. 8:00 a.m. – 12:00 p.m. Denver (TZ)

SPC 211 Commercial Building Energy Audits (13/12) Screen/E  
 Mon. 8:00 a.m. – 12:00 p.m. Governor’s Square 9 (PC)

SPC 212 Evaporative Pre-Cooler Test Standard (6/5)  
 Tues. 8:00 a.m. – 12:00 p.m. Spruce (TZ)

## GUIDELINE PROJECT COMMITTEE

SGPC 0-General Commissioning Process  
 Sat. 8:00 a.m. – 12:00 p.m. Beverly (TT)

GPC 1.2 Commissioning Process for Existing HVAC&R Systems (22/10) Screen/E  
 Fri. 8:00 a.m. – 5:00 p.m. Governor’s Square 17, Plaza Building (Mezzanine Level)

GPC 1.3 Building Operation and Maintenance Training for the HVAC&R Commissioning Process (10/5)  
 Tues. 1:00 p.m. – 5:00 p.m. Suite 3266, Plaza Building (Second Floor)

GPC 1.4 Systems Manual Preparation for the Commissioning Process (10/6) Screen/E  
 Sat. 1:00 p.m. – 3:00 p.m. Plaza Court 3 (PC)

GPC 1.5 Commissioning Smoke Control Systems  
 Mon. 2:15 p.m. – 4:15 p.m. Plaza Ballroom A (PC)

GPC 6, Refrigerant Information Recommended (6/3)  
 Sun. 12:00 p.m. – 1:00 p.m. Suite 3466, Plaza Building (Fourth Floor)

SGPC 10 Interaction Affecting the Achievement of Acceptable Indoor Environments (13/7) Screen  
 Sun. 8:00 a.m. – 12:00 p.m. Capitol (TT)

GPC 11 Field Testing of HVAC Controls Components Electric  
 Sat. 10:00 a.m. – 12:00 p.m. Director’s Row J (PL)

SGPC 13 Guideline for Specifying Direct Digital Control Systems (9/5) Screen/E  
 Sat. 8:00 a.m. – 12:00 p.m. Plaza Court 1 (PC)

GPC 14 Measuring Energy Demand and Water (9/5) Screen/E  
 Sun. 6:00 p.m. – 9:00 p.m. Director’s Row I (PL)

SGPC 20 Documenting HVAC&R Work Processes and Data Exchange Requirements (7/7)  
 Mon. 10:15 a.m. – 12:15 p.m. Suite 3366, Plaza Building (Third Floor)  
*Sponsoring: Forum 1: How to Improve HVAC Software to Support Integrated Work Processes*

GPC 23 Guideline for the Design/Application of HVAC Equip. for Rail Passenger Vehicles (10/3) Screen  
 Tues. 8:00 a.m. – 12:00 p.m. Director’s Row E (PL)

**GPC 27P Procedures for Measurement of Gases in Indoor Environments (5/5) Flipchart**  
**Sun. 3:00 p.m. – 5:00 p.m. Suite 3512, Plaza Building (Fifth Floor)**

**GPC 33 Guideline for Documenting Indoor Airflow and Contaminant Transport**  
**Tues. 11:00 a.m. – 12:00 p.m. Suite 3266, Plaza Building (Second Floor)**

**GPC 34P Energy Guideline for Historical Buildings and Structures (12/0)**  
**Tues. 7:00a – 9:00 a.m. Director’s Row J (PL)**

**OTHER**

**US TAG to ISO/TC 142 (30/10) Screen**  
**Sat. 2:30 p.m. – 3:15 p.m. Tower Court B (T2)**

**US TAG to ISO/TC 205 (20/0) Screen**  
**Tues. 12:30 p.m. – 2:30 p.m. Governor’s Square 10 (PC)**

**USNC/IIR (20/10)**  
**Tues. 2:00 p.m. – 4:00 p.m. Governor’s Square 9 (PC)**

**USNT/IEA (20/10)**  
**Tues. 4:00 p.m. – 6:00 p.m. Governor’s Square 9 (PC)**

**CODES FOR FINDING YOUR MEETING ROOM:**

*Meeting space is located in both the Tower and Plaza Buildings.*

The first letter in the parenthesis following the room name will designate the building location, i.e.,

(P) will be Plaza and (T) is Tower  
 The levels the rooms are located on are:

- Tower Building**  
 Mezzanine Level (Z)  
 Second Level (2)  
 Terrace Level (T)  
 Majestic Level (M)

- Plaza Building**  
 Lobby Level (L)  
 Concourse Level (C)

## ASHRAE STAFF

### Accounting

Annamarie Wilhoit, Manager  
Marie Ingram, Supervisor  
Jamond Madison  
Wayne Madkins  
Lily Cheng

### Administration

Jeff Littleton, Executive Vice President  
Lois Benedict  
Mary Townsend, Asst. to BOD  
Claire Neme

### Administrative Services

Cindy Simmons, Director  
Linda Gdovin

### Advertising Sales

Greg Martin, Manager  
Vanessa Johnson  
Jim Colton

### Certification

Jim Scarborough, Manager  
Erin Dupree

### Chapter Programs

Rosy Douglas, Manager  
Tammy Cathings  
Candace Pettigrew

### Communications

Jodi Scott, Manager  
Amanda Dean

### Conferences

Tony Giometti, Manager  
Tiffany Cox  
Judy Marshall, Manager  
Jan Young, Assistant Manager  
Tracy Keller, Assistant Manager  
Alison Loughman

### Data Center

Candice Richards, Manager  
Camiel Schroeter  
Pacia Wright

### Development

Margaret Smith, Manager

### Electronic Communications and Applications

Joselyn Ratcliff, Manager  
Krystin Gilstrap  
Batecia Loveland  
Emily Sigman  
Bruce Kimball

### Fund Raising

Patricia Adelmann, Manager  
Megan Hezlep  
Amber Wojcik

### Government Affairs – DC Office

Doug Read, Program Director  
Pat Ryan  
Mark Ames  
Mark Wills

### Handbook

Mark Owen, Handbook Editor  
Heather Kennedy  
Nancy Thysell

### Human Resources

Sharon Priebe, Manager

### Information Technology

Brian Unrein, Manager  
Roxanne Jackson  
Kristi Baer  
Amy Lin  
Tom Cahill  
Shawn Hall  
Daniel Robinson

### Journal

Fred Turner, Editor, ASHRAE Journal  
Sarah Foster  
Rebecca Matyasovski  
Christopher Weems  
Jeri Eader  
Charlotte Tubbs  
Tani Palefski

### Mailroom

Lamont Jackson

### Member Services

Joyce Abrams, Director

### Membership Development and Customer Service

Daniel Gurley, Manager  
Rhiannon Loomis,  
Assistant Mgr., Membership  
Jackie Roessler,  
Assistant Mgr., Customer Service  
Anne Cannone  
Linda Allen-Meriweather  
Tracee Dowdell  
Nancy Kasey

### Professional Development

Karen Murray, Manager  
Marty Kraft  
Kelly Arnold

### Publications & Education

Steve Comstock, Publisher/Director  
Julie Harr  
Bryan Haynes

### Publishing Services

David Soltis, Group Manager  
Kimberly Gates,  
Inventory and Subscription Manager  
Tracy Becker  
Jayne Jackson  
Kristina Rayford  
Emma Senyah

### Region Activities

Vickie Grant, Manager  
Jeanie Kirksey

### Research & Technical Services

Michael Vaughn, Manager  
Steve Hammerling  
Tara Thomas  
Donna Daniel

### Special Projects

Lilas Pratt, Manager  
Bert Etheredge

### Special Publications

Cindy Michaels, Managing Editor  
Michshell Phillips  
Matt Walker  
Robertta Hirschbuehler  
Susan Boyle

### Standards

Stephanie Reiniche, Manager  
Steve Ferguson, Assistant Mgr., Codes  
Doug Tucker, Assistant Mgr., Int'l  
Mark Weber, Assistant Mgr., U.S.  
Beverly Fulks  
Angela McFarlin  
Tanisha Meyers-Lisle  
Susan LeBlanc  
Katrina Shingles  
Carmen Manning

### Student Activities

Justin Ledford, Assistant Manager

### Technology

Claire Ramspeck, Director  
Denise Latham

## SPEAKERS LIST

### A

Abbas, Laurent, *Seminar 34*  
Anderson, M.D., *Conference Paper Session 15*  
Andolsun, Simge, *Conference Paper Session 4*  
Andrepoint, John S., *Seminar 27*  
Anis, Wagdy, *Conference Paper Session 3*  
Arcangeli, Gregory N., *Conference Paper Session 3*  
Atkinson, Gaylen, *Special Session 4*  
Atkisson, Jason A., *Seminar 13*  
Axelson, Nina, *Seminar 45*

### B

Bagge, Hans, *Conference Paper Session 11*  
Bahnfleth, Donald, *Seminar 19*  
Bansal, Pradeep, *Seminar 30*  
Baring-Gould, Ian, *Seminar 3*  
Barr, Stephanie, *Seminar 1*  
Bayer, Charlene, *Forum 2*  
Bean, Robert, *Seminar 38*  
Bembry, Walter, *Technical Paper Session 2*  
Betz, Fred, *Seminar 29 and Special Session 5*  
Beu, Leslie, *Seminar 41*  
Bivens, Donald B., *Seminar 33*  
Bizien, Emmanuel, *Seminar 29*  
Black, William, *Technical Paper Session 4*  
Boatright, Donna, *Special Session 3*  
Bogan, Nick, *Conference Paper Session 17*  
Bosscher, Andy, *Seminar 31*  
Bowers, Chad, *Seminar 5*  
Boxem, Gert, *Conference Paper Session 2*  
Branson, David, *Seminar 12*  
Bravo, Ramiro, *Seminar 18*  
Bridges, Barry B., *Technical Paper Session 7*  
Brill, Shawn, *Seminar 43*  
Bryant, John, *Conference Paper Session 16*  
Buckberry, Heather, *Seminar 11*  
Burns, Larry, *Seminar 2*  
Burpee, Heather, *Seminar 44*  
Bush, John D., *Conference Paper Session 10*

### C

Chan, Ying-Chieh, *Technical Paper Session 3*  
Chandrasekharan, Ramprasad, *Conference Paper Session 1*  
Charisis, Vrellas, *Technical Paper Session 10*  
Charneux, Roland, *Seminar 23*  
Cho, Youngmin, *Conference Paper Session 18*  
Clark, Jordan D., *Conference Paper Session 15*  
Connor, Michael, *Seminar 14*  
Cook, Leslie, *Seminar 17*  
Cook, Malcolm J., *Conference Paper Session 15*  
Coward, Chuck, *Seminar 31*  
Cowen, David, *Seminar 39*  
Cremaschi, Lorenzo, *Seminar 5*  
Cullin, James R., *Technical Paper Session 8*

### D

Dale-Derks, Charles E., *Seminar 16*  
Datta, S.P., *Conference Paper Session 18*  
Despatis, Benoit, *Seminar 26*  
Dettmers, Daniel J., *Seminar 37*  
Dixit, Rajesh, *Special Session 6*  
Djebbar, Reda, *Seminar 45*  
Doebber, Ian, *Technical Paper Session 10*  
Dorgan, Charles, *Seminar 4*  
Dorman, Dennis, *Conference Paper Session 7*  
Douglas, Jon, *Seminar 6*  
Duarte, Carlos, *Conference Paper Session 22*  
Duda, Stephen W., *Seminar 9*  
Durbin, Dominique, *Special Session 7*

### E

Edwards, Mike, *Special Session 3*  
Elbel, Stefan, *Seminar 34*  
Enck, H. Jay, *Seminar 4 and Seminar 42*  
Erbs, Daryl G., *Seminar 34 and Seminar 39*  
Eslami-nejad, Parham, *Technical Paper Session 8*

### F

Fallon, Kristine, *Seminar 12*  
Fang, Yueping, *Technical Paper Session 11*  
Farrell, Tim, *Seminar 26*  
Fenton, Donald, *Technical Paper Session 2*  
Fisher, Don, *Forum 4*  
Fisher, Thomas A., *Conference Paper Session 16*  
Fricke, Brian A., *Conference Paper Session 7*  
Friedlander, Matthew L., *Seminar 47*

### G

Garber, Denis, *Conference Paper Session 6*  
Garimella, Srinivas, *Technical Plenary*  
Gartland, Lisa, *Seminar 7*  
Gatland, Stanley, *Special Session 8*  
Gayeski, Dr. Nicholas T., *Seminar 18*  
Ghias, Reza, *Conference Paper Session 13*  
Ghoubali, Redouane, *Conference Paper Session 20*  
Goldschmidt, Ira, *Seminar 10*  
Graef, Patricia, *Conference Paper Session 14*  
Guity, Arash, *Seminar 44*  
Gulick, Bob, *Seminar 44*  
Gupta, Vinod P. (V. P.), *Forum 3 and Seminar 14*

### H

Haiad, J. Carlos, *Seminar 39*  
Hansen, Ken L., *Seminar 16*  
Hanson, Susanna, *Seminar 21*  
Hardman, Anthony, *Conference Paper Session 11*  
Harriman, Lew, *Seminar 17 and Special Session 8*  
Hart, Reid, *Conference Paper Session 17 and Seminar 6*  
Hassan, Samer, *Technical Paper Session 1*  
Hasegawa, Iwao, *Conference Paper Session 19*  
Hegberg, Mark, *Seminar 40*  
Heinemeier, Kristin, *Seminar 6*

Hens, Hugo, *Special Session 8*  
Heo, Yeonsook, *Conference Paper Session 8*  
Herrin, D. W., *Technical Paper Session 10*  
Hitchcock, Robert J., *Forum 1*  
Hootman, Tom, *Seminar 28*  
Horstman, Raymond, *Conference Paper Session 9*  
Hu, Huaifen, *Conference Paper Session 14*  
Huber, Carl F., *Seminar 33*  
Hugh, Nicholas A., *Conference Paper Session 12*  
Humbert, Sylvain, *Special Session 9*  
Hunn, Bruce D., *Seminar 7*  
Hunt, Walter E., *Conference Paper Session 4*  
Hwang, Yunho, *Seminar 2 and Special Session 6*  
Hydeman, Mark, *Seminar 23*

## J

Jeannette, Erik, *Seminar 1*  
Johansson, Dennis, *Conference Paper Session 21*  
Johnson, Mark, *Seminar 5*

## K

Kamensky, Kristina, *Conference Paper Session 12*  
Kang, Kinam, *Conference Paper Session 3*  
Kanyarusoke, Kant E., *Conference Paper Session 6*  
Kavanaugh, Steve, *Special Session 4*  
Kawanami, Yoh, *Conference Paper Session 6*  
Kegel, Nathan, *Seminar 15*  
Keith, Reginald, *Seminar 35*  
Kelsey, Jim, *Seminar 7*  
Kennedy, John F., *Seminar 15*  
Kettler, Gerald J., *Seminar 42*  
Khalil, Essam E., *Conference Paper Session 5 and  
Conference Paper Session 6*  
Khankari, Kishor, *Conference Paper Session 5 and Seminar 29*  
Khanolkar, Amruta, *Conference Paper Session 2*  
Kim, Man-Hoe, *Seminar 5*  
Kissock, Kelly, *Technical Paper Session 11*  
Knopp, Cory, *Seminar 10*  
Konis, Kyle, *Conference Paper Session 3*  
Kose, Dana, *Seminar 1*  
Koupriyanov, Mikhail, *Seminar 36*  
Kuempel, John, *Seminar 9*  
Kumar, Rajesh, *Technical Paper Session 7*  
Kumari, Niru, *Conference Paper Session 13*

## L

Larson, Kyle, *Seminar 46*  
Lawrence, Jessica, *Seminar 17*  
Lawrence, Thomas, *Seminar 30*  
Lee, W. Victoria, *Conference Paper Session 1*  
Leidel, James A., *Seminar 45*  
Li, Pengfei, *Conference Paper Session 22*  
Ling, Jiazhen, *Conference Paper Session 4*  
Liu, Zhijun, *Conference Paper Session 14*  
Lo, James, *Seminar 36*  
Lord, Richard, *Seminar 6*

## M

Madigan, Kevin, *Seminar 9*  
Maref, Wahid, *Special Session 8*  
Mazor, Mike, *Conference Paper Session 1*  
McDowell, Timothy P., *Conference Paper Session 20*  
Megri, Ahmed Cherif, *Technical Paper Session 3*  
Melfi, Michael J., *Special Session 9*  
Merrigan, Tim, *Special Session 1*  
Mescher, Kirk T., *Special Session 7*  
Meyer, Vernon, *Seminar 19*  
Miller-Klein, Erik, *Seminar 35*  
Mitchell, Scott A., *Conference Paper Session 2*  
Modera, Mark, *Seminar 24*  
Moffitt, Ronnie, *Seminar 47*  
Mohammed, Abdul Qayyum, *Technical Paper Session 6*  
Morelli, Mark, *Special Session 7*  
Mukhopadhyay, Jaya, *Conference Paper Session 21*  
Muldavain, Scott, *Seminar 22*

## N

Narayanamurthy, Ram, *Special Session 1*  
Nasuta, Dennis M., *Conference Paper Session 10*  
Nelson, Norman, *Seminar 4*  
New, Joshua, *Technical Paper Session 3*  
Nigusse, Bereket A., *Technical Paper Session 3*  
Nikles, Roland, *Seminar 8*  
Norton, Paul, *Conference Paper Session 21*  
Nutter, Darin W., *Technical Paper Session 1*

## O

Okada, David, *Seminar 28 and Special Session 5*  
Olson, Michael, *Special Session 9*  
Overbye, Pernille, *Seminar 27*

## P

Periannan, Vijayanand, *Conference Paper Session 14*  
Pflugger, Rainer, *Technical Paper Session 6*  
Phetteplace, Gary, *Seminar 19 and Seminar 27*  
Piccone, Todd, *Seminar 1*  
Pieper, Paul, *Forum 4*  
Pless, Shanti D., *Keynote 1, Seminar 28, Seminar 44,  
and Special Session 5*  
Pommerenke, David, *Technical Paper Session 9*  
Pottker, Gustavo, *Seminar 46*  
Putz, Charlie, *Seminar 21*

## Q

Qiu, Xin, *Conference Paper Session 1*

## R

Radermacher, Reinhard, *Special Session 6*  
Rajendran, Sucharitha, *Conference Paper Session 17*  
Rassmussen, Bryan, *Seminar 18*  
Rau, Daniel, *Seminar 12*  
Raustad, Richard, *Conference Paper Session 20*  
Ray, Stephen, *Conference Paper Session 19*  
Reddy, T. Agami, *Seminar 33 and Technical Paper Session 5*

Reilman, Andrew, *Seminar 38*  
Reindl, Douglas, *Seminar 37*  
Rendek, Adam, *Conference Paper Session 11*  
Rice, Tom, *Seminar 47*  
Richardson, Gaylon, *Seminar 40*  
Roth, Stephen, *Seminar 15*

## S

Saal, Don, *Conference Paper Session 16*  
Saieg, Phillip, *Special Session 3*  
Scheib, Jennifer, *Seminar 28*  
Schultz, Ken, *Seminar 32 and Technical Paper Session 8*  
Schwedler, Mick, *Seminar 13*  
Scott, Doug, *Seminar 37*  
Sekhar, Chandra, *Seminar 25*  
Sethi, Ankit, *Seminar 2*  
Shah, M. Mohammed, *Technical Paper Session 1 and  
Technical Paper Session 11*  
Shapiro, Carl, *Conference Paper Session 1*  
Sharma, Chandan, *Conference Paper Session 20*  
Sharrard, Aurora, *Seminar 7*  
Simmonds, Peter, *Seminar 38 and Special Session 5*  
Singh, Ramandeep, *Conference Paper Session 21*  
Sirbubalo, Emir, *Technical Paper Session 8*  
Smith, Michael, *Special Session 4*  
Sneed Muller, Julie, *Seminar 8*  
Snell, Donald, *Seminar 4*  
Sobczyk, Maciej, *Seminar 43*  
Sommers, Andrew, *Seminar 5*  
Song, Doosam, *Conference Paper Session 21*  
Sorell, Vali, *Conference Paper Session 13*  
Spitler, Jeffrey, *Seminar 30*  
Springer, Robert, *Keynote 2*  
Srivastav, Abhishek, *Conference Paper Session 22*  
Stamp, Barry, *Seminar 1*  
Stein, Jeff, *Seminar 21*  
Sulc, Vladimir, *Seminar 32*  
Sun, Yifu, *Conference Paper Session 8*  
Swenka, Matt, *Seminar 1*

## T

Taherian, Hessam, *Conference Paper Session 12*  
Takizawa, Kenji, *Technical Paper Session 6*  
Tanaka, Yoshiki, *Conference Paper Session 18*  
Tanner, Ryan A., *Technical Paper Session 7*  
Taube, Ben, *Seminar 22*  
Theiss, John, *Seminar 8*  
Thevenard, Didier, *Technical Paper Session 5*  
Thomsen, Peter, *Seminar 10*

Todorovic, Marija S., *Special Session 1*  
Torbert, Roy, *Conference Paper Session 8*  
Torcellini, Paul A., *Seminar 3 and Seminar 11*  
Tredinnick, Steve, *Seminar 19*  
Trevino, Alvaro, *Conference Paper Session 19*  
Turner, Will, *Seminar 25*  
Tyson, Terry, *Seminar 35*

## U

Ugursal, Ahmet, *Conference Paper Session 22 and  
Technical Paper Session 2*  
Uselton, Robert, *Seminar 2*

## V

Van Geet, Otto D., *Keynote 3, Seminar 3 and Seminar 24*  
VanGilder, James, *Technical Paper Session 9*  
Vaughn, Michael, *Seminar 33*  
Villeneuve, Dana, *Conference Paper Session 16*

## W

Walker, Iain, *Conference Paper Session 19 and  
Technical Paper Session 10*  
Wang, Gang, *Technical Paper Session 3*  
Wang, Liangzhu (Leon), *Conference Paper Session 15 and  
Technical Paper Session 4*  
Wang, Na, *Conference Paper Session 8*  
Wang, Xudong, *Conference Paper Session 7*  
Wendorski, Ron, *Seminar 31*  
West, Michael K., *Conference Paper Session 4 and  
Conference Paper Session 10*  
Westberg, David, *Technical Paper Session 5*  
White, David, *Special Session 3*  
Willson, Ginger, *Seminar 16*  
Willwerth, Adam, *Special Session 9*

## X

Xiong, Zeyu, *Conference Paper Session 17*

## Y

Yana Motta, Samuel F., *Seminar 34*

## Z

Zeiler, Wim, *Conference Paper Session 2*  
Zelinka, Samuel L., *Technical Paper Session 11*  
Zha, Shitong, *Seminar 46*  
Zhang, Tengfei, *Conference Paper Session 9*  
Zhang, Xuanhang (Simon), *Seminar 36*  
Zoughaib, Assaad, *Conference Paper Session 7*