ASHRAE 2018 Winter Conference

January 20th - January 24th, 2018

ashrae.org/Chicago

The Technical Program will take place at the Palmer House Hilton except for the AHR Expo Sessions, which will be held at McCormick Place on Monday, January 22, 2018.

Updated December 13, 2017

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Saturday, January 20

3:15 PM – 5:30 PM

Keynote

Plenary

Debbie Sterling is the Founder and CEO of GoldieBlox, an award winning company on a mission to "disrupt the pink aisle" with toys, games, and media for girls. Debbie is an engineer, entrepreneur, and one of the leaders in the movement toward getting girls interested in science, technology, engineering, and math. She was named TIME's "Person of the Moment," Business Insider's "30 Women Who Are Changing the World," and was recently added to Fortune Magazine's prestigious "40 Under 40" list. In early 2015, Debbie was inducted as a Presidential Ambassador for Global Entrepreneurship and honored by the National Women's History Museum with a "Living Legacy" Award for her work to empower girls around the world. Debbie received her degree in Engineering at Stanford University in 2005.

Sunday, January 21

Sunday, January 21, 8:00 AM - 9:00 AM

Debate 1 (Intermediate)

Building Automation System Graphics: Integrating Multiple Masters, Who Is the Boss?

Track: Systems and Equipment

Room: Adams

Sponsor: 1.4 Control Theory and Application, 7.3 Operation and Maintenance Management

Chair: Marcelo Acosta, P.E., Member, Armstrong Fluid Technology, Toronto, ON, Canada, Frank Shadpour, P.E., Fellow ASHRAE, SC Engineers, Inc., San Diego, CA and Larry Scholl Jr., Member, Automated Logic, Kennesaw, GA

Building automation graphics are the users' primary interface with the system. As such, the interface should support the users effectively and efficiently in accomplishing their work. When an owner expands or adds automation capability, the Graphical User Interface should painlessly extend too. BACnet was established to promote free enterprise for open, non-proprietary building automation, but does seamless integration exist for user interfaces? One speaker argues the graphic interface is the "hook" controls companies use to control the owners. The other speaker argues properly specified user interfaces and data sharing allow today for vendor independence, and shows how it's done.

8:00 AM - 9:00 AM

Seminar 1 (Intermediate) NY PDH G

Campus Operators Reflect on Using Guideline 22 and Standard 90.1 for Chiller Plant Monitoring

Track: Standards, Guidelines and Codes

Room: State

Sponsor: 8.2 Centrifugal Machines, 9.1 Large Building Air-Conditioning Systems

Chair: Dwayne Johnson, Trane, La Crosse, WI

Ever wonder how ASHRAE guidelines and standards make a difference? In this session you'll hear testimony from two facility managers who use ASHRAE guidance to get the right data to make informed decisions about their chiller plant operation.

1. University Campus Chiller Plants: ASHRAE Guideline 22 and Standard 184P in Operation

***John Vucci, Member**, University of Maryland, College Park, MD*

This seminar gives real examples of the benefits of measuring chiller plant performance following ASHRAE Guideline 22 and Standard 90.1, a case study presented of performance for multiple plants, including variable primary, primary secondary and a hybrid electric and steam chiller plant at University of Maryland.

2. Healthcare Chiller Plants: ASHRAE 90.1 Chiller Plant Monitoring and Beyond

***Tim Peglow, P.E., Associate Member**, MD Anderson, Houston, TX*

MD Anderson has been using data to decide how to run their chiller plants for years. ASHRAE 90.1 chiller plant monitoring requirements set down the basics of the kinds of information necessary for informed decisions. A recent project went further into using advanced analytics to operate a complex, multiple chiller and-multiple building loop to improve and better monitor chiller plant performance. This session describes lessons learned and the outcome of their overall energy efficiency improvements.

8:00 AM - 9:00 AM

Seminar 2 (Advanced)

Stack Effect: Friend or Foe in Tall Buildings

Track: Tall Buildings

Room: Empire

Sponsor: 9.12 Tall Buildings

Chair: Dennis Wessel, Ph.D., P.E., Fellow Life Member, Retired, Cleveland, OH

Stack effect in tall buildings is caused by the combination of the building height and buoyancy of air caused by temperature difference between inside and outside. Stack effect causes convective air flow in tall buildings and when combined with wind forces, elevator piston effects, and internal airflow path resistance of building elements, the associated pressure differences can cause detrimental effects or can potentially assist natural ventilation possibilities. This seminar discusses issues, both positive and negative, caused by stack effect in tall, super tall and mega tall buildings for select cities around the world.

1. Methods to Mitigate Stack Effect in Supertall and Megatall Buildings

***Mehdi Jalayerian, P.E., Member**, ESD, Chicago, IL*

Stack effect is movement of air in buildings due to air buoyancy caused by indoor/outdoor temperature. Uncontrolled airflow and pressure related to stack effect always exists but is exacerbated by outdoor ambient conditions and building height/configuration. This presentation provides a parametric review of stack effect conditions for realistic configuration of megatall towers and establishes design considerations related to geographic design conditions, envelope construction, lobby configuration, space pressurization, sky-lobbies, observation level access and stairwells/shafts. The financial and disruptive risks of stack effect can be effectively mitigated if analyzed holistically and addressed early in the design of supertall and megatall towers.

2. Measurements of Stack Effect in Existing Tall and Supertall Buildings

***Duncan Phillips, Ph.D., P.E., Associate Member**, RWDI, Guelph, ON, Canada*

Stack effect is a phenomenon that exists in all buildings and structures that are at a different temperature, thus air density, from outdoors. While the effects of stack effect can be estimated, measurements from tall buildings are rare. This seminar presents measurements of stack effect in tall and supertall buildings, for both hot and cold climates. The measurements include vertical profiles of pressure from elevator shafts to ambient through multiple barriers/partitions. These measurements show that some of the assumptions maintained during design are incorrect and that solving the stack effect phenomenon is complex.

8:00 AM - 9:00 AM

Forum 1

Ventilation Effectiveness: What Is It?

Track: Fundamentals and Applications

Room: Monroe

Sponsor: MTG.ACR, 9.10 Laboratory Systems, 9.11 Clean Spaces, 9.6 Healthcare Facilities

Chair: Kishor Khankari, Ph.D., Fellow ASHRAE, AnSight LLC, Ann Arbor, MI

Ventilation effectiveness is often perceived as an efficiency measure of air distribution. However, the definition and application of ventilation effectiveness can vary from application to application. Is there a universal definition of ventilation effectiveness? Can it be measured? Can it be monitored? Can air change rate alone affect the ventilation effectiveness? What other parameters affect the ventilation effectiveness? How can it be implemented as a design parameter? This session brainstorms these questions and will attempt to identify current state of the art of ventilation effectiveness and future needs in HVAC industry.

8:00 AM - 9:00 AM

Workshop 1 (Intermediate)

District Chilled Water and Building Systems Heat Exchange Equipment and Impact on Operations

Track: Heat Exchange Equipment

Room: Honore

Sponsor: 7.3 Operation and Maintenance Management

Chair: John Constantinide, Member, Alpha MRC Architects Engineers, Merritt Island, FL

New refrigerant types, design of heat exchange equipment and district energy systems offer opportunities for savings in operations and maintenance of central plants. Chilled water district cooling systems as a service can improve mechanical equipment room space and electrical requirements to a variety building sizes and types for new and existing customer's buildings. Other operational efficiencies include less wasted energy, savings in operating costs and opportunities for combined heat and power. This allows operations and maintenance improvements, resulting in energy and cost savings in commercial, institutional, industrial, municipalities, cities and university infrastructure.

1. District Energy and Facility Management Operations

***Terrence Rollins, Member**, RHC Global Energy Solutions, Corpus Christi, TX*

The impact of new refrigerants provides opportunities to explore new chiller plant design, construction, operations and maintenance and the capital investment solutions improve commercial, institutional, industrial, municipalities, cities and university infrastructures. Chilled water district cooling systems as a service can improve mechanical equipment room space and electrical requirements to a variety building sizes and types for new and existing customer's buildings. Direct and indirect heat exchange equipment design plays a vital role when deciding to invest in a District Chilled Water Plant.

8:00 AM - 9:00 AM

Workshop 2 (Intermediate)

Taking the (Fuel) Blinders Off Energy Codes: Pathways for Moving to Carbon-Based Codes

Track: Standards, Guidelines and Codes

Room: Chicago

Chair: Jim Edelson, Associate Member, New Buildings Institute, Portland, OR

When the current generation of building energy codes was born in the 1970s and 1980s, the policy imperative was resource conservation. Energy codes were written on a basis of overall site energy consumption. Today, it is clear that we need to expand our focus and consider the societal and global impacts of energy usage at the building. This workshop examines how climate policy now impacts energy code policy, and examines the long-held taboo of favoring one type of fuel over another in regulatory mechanisms. Is it time for energy codes to transition from energy efficiency to emissions efficiency?

1. The Carbon Emission Requirements in ASHRAE Standard 189.1

***Charles Eley, P.E., BEMP, Member**, Eley Consulting, San Francisco, CA*

Since its inception, the energy performance requirements of ASHRAE's green building standard have addressed both energy cost and resulting emissions. Methane and nitrous oxide are also considered, not just carbon dioxide. The metric is equivalent carbon emissions (CO2e). Upstream impacts related to mining, extraction, refinement, transportation and distribution are also considered. This presentation reviews the procedures used to develop the emission factors and how they are periodically updated to address changes in electric generation, e.g. less coal and more gas and renewables.

2. Beneficial Electrification: What, Why, How and What It Means at the Building Level

***Kenneth A Colburn**, Regulatory Assistance Project, Montpelier, VT*

There is a lot of talk today about electrification. Its focus tends toward either the need to address climate change, the impact of rapidly developing technologies disrupting the energy sector or both. This presentation discusses why electrification of previously fossil-fueled end uses is now upon us, how we can ensure that it is beneficial (and not just load growth) and how this outcome can be ensured and measured.

9:45 AM - 10:45 AM

Conference Paper Session 1 (Intermediate)

Operation and Design for Resilient and Responsive Buildings

Track: Earth, Wind & Fire

Room: Honore

Chair: Alamelu Brooks, Member, ICF International, Columbia, MD

This conference paper session explains how sustainable results are created through resilient building design combined with digital technology.

1. Building Automation System Alarm Management for Operation and Maintenance Decision Making (CH-18-C001)

***Han Li**, Azizan Aziz, Erica Cochran, Ph.D. and Bertrand Lasternas, Center for Building Performance and Diagnostics, School of Architecture, Carnegie Mellon University, Pittsburgh, PA*

Building Automation Systems (BAS) generate an overwhelming number of alarms. The alarms are often not prioritized and lack actionable information thus making the building Operation and Maintenance (O&M) very challenging. This paper presents a solution to optimize alarm management to provide more efficient O&M. Additionally, the deficiencies of current alarm management functions in BAS are analyzed and a data-mining framework to categorize and prioritize alarms from BAS is proposed. The paper also includes a case study from a campus building at Carnegie Mellon University and describes the categorization and prioritization of BAS alarms based on occupant comfort and energy consumption.

2. Resilient Building System Design (CH-18-C002)

***Sean Lawler, P.E., Member**[1], Joseph Hurford, CEng[2] and Willa Kuh[3], (1)Affiliated Engineers Inc., Seattle, WA, (2)Affiliated Engineers Inc., Madison, WI, (3)Affiliated Engineers, Inc., Boston, MA*

A hospital system charged its critical care facility design team with meeting local code, which classifies this facility as "post disaster", and the owner's more expansive resilience and other high performance design criteria. This presentation describes aspects of the facility's resilience design. In revealing connections made between addressing risk and satisfying other performance criteria, the presenters recommend means of approaching the issue of quantifying risk. In so doing, they provide a methodology that establishes design value in this setting and readily lends itself to testing the transferability of aspects of this facility's design in other locations.

3. Resilient Design, Commissioning and Operation of the Canadian High Arctic Research Station (CH-18-C003)
Jean-Francois Pelletier, P.Eng., CPMP, Member[1], *Michael D. Brown, Student Member*[2], *Guillaume Castonguay, P.Eng.*[1] *and Cynthia Cruickshank, Ph.D.*[2], *(1)Ædifica Consultants, Montreal, Canada, (2)Carleton University, Ottawa, ON, Canada*
The Canadian High Arctic Research Station, currently under construction in Ikaluktutiak, Nunavut, will be a world-class, interdisciplinary facility that will anchor a strong research presence in Canada's north. This paper describes the use of energy modeling to support resilient design and operation of the facility. Energy simulations were conducted early and throughout the design process using a life-cycle cost analysis approach, supporting optimal sizing of systems and emergency power requirements. The design approach coupled with planning for future renewable energy integration contributes to improved resiliency of the facility and superior performance in the harsh environment of the Canadian Arctic.

9:45 AM - 10:45 AM
Seminar 3 (Basic)

ASHRAE Conference Crash Course
Track: Fundamentals and Applications
Room: Empire
Sponsor: Young Engineers in ASHRAE
Chair: Jake Kopocis, Member, Control Services, Inc, Omaha, NE
First time at an ASHRAE Conference? And an ASHRAE Meeting?? Been coming for years, but still confused? Attend this session to learn how to make the best use of your time! This crash course provides an introduction to all the ASHRAE Conference and Meeting activities, explains how you can get involved and allows you to ask questions to experienced attendees, such as "What is a TC? What is a Standing Committee? Who can attend what? What is the AHR Expo? And why is all of this going on at the same time and in so many places?!"
1. The Ins and Outs of ASHRAE
Rachel Romero, P.E., Member*, National Renewable Energy Laboratory, Golden, CO*
Many of you may be familiar with ASHRAE at the Chapter level. This seminar covers the structure of Society from committees to councils and everything in between. We love our acronyms and when we're done, you'll finally know what they all mean and how you can get involved.
2. Make the Most of Your Conference Experience
Vanessa Freidberg, Member*, Siemens Building Technologies, Austin, TX*
Now that you've got your bearings and know the difference between a TC and a TG, this seminar tells you about the softer side of ASHRAE. You'll find out what social events you shouldn't miss and how to make the most of your conference experience.

9:45 AM - 10:45 AM
Seminar 4 (Intermediate)

Modeling and Testing: Do Air Change Rates Have Lab Safety Covered?
Track: Modeling Throughout the Building Life Cycle
Room: Adams
Sponsor: 9.10 Laboratory Systems, SSPC 62.1
Chair: Kelley Cramm, P.E., Member, Henderson Engineers, Overland Park, KS
Current design guidance for laboratories generally relies on specifying minimum air change rates (ACR) to insure indoor air quality and lab safety. This session presents a case study that used modeling and empirical testing combined to demonstrate the limitations of relying on air change rates alone when designing laboratory ventilation systems. The case study also explores what criteria is important, and how it should be used to design a safe and effective air distribution system.
1. Case Study of a Model to Evaluate Ventilation Effectiveness in Labs.
Kishor Khankari, Ph.D., Fellow ASHRAE*, AnSight LLC, Ann Arbor, MI*
This presentation highlights a case study where computational fluid dynamics (CFD) is used to model chemical spills with varying ACR and supply and exhaust configurations in a laboratory. The results demonstrate that conditions are not typically well-mixed or uniform, and making this assumption may produce erroneous results. The discussion includes the effect of airflow paths, strengths and locations of contaminant sources and locations of heat sources. Strategies for measures to improve effective contaminant removal will be included.
2. Case Study of an Empirical Test to Evaluate Ventilation Effectiveness in Labs
Thomas Smith, Member*, Exposure Control Technologies, Inc., Cary, NC*
Laboratory ventilation systems serve to reduce exposure risk and provide environmental conditioning. Air change rates (ACR) are often specified to achieve these objectives. This presentation discusses the same case study where an empirical tracer gas test was developed and used to evaluate whether ACR alone provided dilution and removal of airborne chemicals. Parameters were analyzed over the same range of rates with varying supply and exhaust coverage that were used in the CFD model previously presented. Recommendations on additional strategies to improve ventilation effectiveness in labs are also presented.

9:45 AM - 10:45 AM

Seminar 5 (Advanced)

Optimization Tools for Heat Exchanger Design

Track: Heat Exchange Equipment

Room: Monroe

Sponsor: 1.13 Optimization

Chair: David Yashar, Ph.D., P.E., Member, NIST, Gaithersburg, MD

This session presents two novel tools that can be used to optimize the design of heat exchangers. Each presentation focuses on one tool, and discusses the merits of its approach and its applicability for various problems. Each presentation also demonstrates how to effectively use the tools with a practical application.

1. GenOpt and Heat Pump Design Model to Optimize Heat Exchangers for Low-GWP Alternative Refrigerants

***Bo Shen, Ph.D., Member**, Oak Ridge National Laboratory, Oak Ridge, TN*

GenOpt, developed by Lawrence Berkeley National Lab, and Heat Pump Design Model (HPDM), developed by Oak Ridge National Lab, are both public-domain software. GenOpt facilitates arbitrary optimizations and it can be linked with any simulation program using input and output text files. HPDM is a widely-used modeling and design tool for vapor compression equipment and components. This presentation introduces applications of the GenOpt optimizer coupled with HPDM. The program optimizes heat exchangers for low GWP refrigerants by altering heat exchanger tube connections, tube diameter, length etc. and considering cost and operation constraints.

2. Multi-Scale Novel Heat Exchanger Design Using Approximation Assisted Optimization

***Zhiwei Huang, Student Member**, University of Maryland, College Park, MD*

This concept makes it possible to predict the performance of a new heat exchanger design using segmented HX simulation tools. This streamlines the design process with a fast, flexible, low-cost approach that can be applied to any HX designs. To demonstrate the methodology, a novel air-cooled heat exchanger consisting of bifurcated bare tubes with two different tube diameters is designed under this framework. The novel bifurcated bare tube heat exchanger was found to have 15% higher air-side heat transfer coefficient and 4~12% lower air-side pressure drop than baseline heat exchanger with the same diameter, frontal area, volume and air velocity.

9:45 AM - 10:45 AM

Seminar 6 (Intermediate)

Cutting-Edge Japanese Technologies SHASE Annual Award for System and Equipment in 2017: Zero-Energy Building

Track: Systems and Equipment

Room: State

Chair: Shin-ichi Tanabe, Ph.D., Fellow ASHRAE, Department of Architecture, Waseda University, Tokyo, Japan

We introduce two buildings of the ZEB family with the SHASE Award. One is achieved ZEB in Yokohama in 2015. This ZEB comprises both passive and active energy-saving measures, including daytime lighting, natural ventilation, green work approaches, radiant cooling and fuel cells as well as an energy-generation system including a photovoltaic wraparound façade. Another one is nearly ZEB, which achieved annual energy consumption of 1,117MJ per square meter. This building is a mid-size office in Tokyo, so it's important to ensure the VRV system is both innovative and user-friendly. The ZEB family includes ZEB, ZEB ready and nearly ZEB.

1. Targeting Urban ZEB in Japan

***Takuya Tanaka**, Taisei Corporation, Tokyo, Japan*

This presentation introduces a demonstration project that aims to realize ZEB in urban areas. Its key achievement is showcasing the potential of ZEB, even in confined spaces and high-rise buildings. In this building, an innovative "energy-saving system" combining passive (daylighting, natural ventilation and green work style) and active methods and an "energy-generation system" which wraps a building in photovoltaic cells are adopted. Knowledge concerning energy management during the operation phase is also shared. This project is set to achieve an annual energy balance of zero (75% reduction in energy consumption).

2. An Air-Conditioning Plan Pursuing Energy Conservation within Urban Medium-Sized Office with an Individual Air-Conditioning System

***Hideki Morita**, Shimizu Corporation, Tokyo, Japan*

This project aims to create environmental technologies and improve intellectual productivity by achieving significant energy-saving while approaching "Zero-Energy Building" in medium-sized offices with individual air-conditioning systems in urban areas. The first key point is, natural energy using features such as natural daylighting, ventilation and outside-air cooling by adopting an environmental façade and an eco-void. The second key point is, comfortable energy-saving air-conditioning system by combining "whole-floor air-conditioning", "central outside AHU for latent heat processing" and "high-efficiency VRV." This building achieved annual energy consumption of 1,117MJ/square meter.

11:00 AM - 12:30 PM

Conference Paper Session 2 (Intermediate)

Advancements in Energy Savings

Track: Fundamentals and Applications

Room: Empire

Chair: Michael Pate, Ph.D., Life Member, Texas A&M University, College Station, TX

This session presents an in depth view of the effectiveness of energy conservation measures (ECMs), demonstrates a cost effective HVAC solution combining multiple systems and outlines various factors that can help save costs and reduce heat load when designing a cooling system.

1. Energy Saving Performance of Buoyancy-Driven Natural and Hybrid Ventilation (CH-18-C004)

Yoshihide Yamamoto, Ph.D., Member[1], *Shuzo Murakami, Ph.D., Fellow ASHRAE*[2], *Hisaya Ishino, Ph.D., Member*[3] *and Kimiko Kohri, Ph.D., Member*[4], *(1)Nihon Sekkei Co., Ltd, Tokyo, Japan, (2)Institute for Building Environment and Energy Conservation, Tokyo, Japan, (3)Tokyo Metropolitan University, Tokyo, Japan, (4)Utsunomiya University, Utsunomiya, Japan*

In Japan, many existing naturally ventilated buildings have a hybrid ventilation system for energy saving as well as comfortable room thermal environment by supplementing cooling of natural ventilation with air-conditioners. However, the appropriate design method of hybrid ventilation has not been clarified. This paper presents the energy saving performance of buoyancy-driven natural and hybrid ventilation on simulations, and design methods to achieve effective energy saving without operational problems. Studies were conducted in two methods: 1) fact-finding survey on the existing naturally ventilated buildings in Japan, 2) simulation analysis of natural ventilation and hybrid ventilation system.

2. Nationwide Savings Analysis of a Variety of Energy Conservation Measures (CH-18-C005)

Defeng Qian, Student Member*, Yanfei Li, Student Member, Fuxin Niu, Student Member and Zheng O'Neill, Ph.D., P.E., Member, University of Alabama, Tuscaloosa, AL*

This study focuses on the nationwide savings estimation from 20 different Energy Conservation Measures (ECMs) in the United States. The presentation introduces the analysis baselines, building types, climate zones and different ECMs. Then, the corresponding ECM saving potentials are presented as discussed.

3. Heat Energy Recovery Potential from Urban Underground Infrastructures (CH-18-C006)

Graeme Maidment, Ph.D., P.E.[1], *Gareth Davies*[1], *Nicholas Boot-Handford*[2], *Joseph Grice*[3], *William Dennis*[2], *Abayomi Ajileye*[2] *and Akos Revesz, Student Member*[1], *(1)London South Bank University, London, United Kingdom, (2)Transport for London, London, United Kingdom, (3)Islington Council, London, United Kingdom*

This presentation introduces two collaborative research projects in the UK, aiming to identify and quantify the potential for heat energy recovery from urban sub-terrain structures, such as sewers, cable tunnels and underground railway tunnels. Preliminary results from an initial feasibility study which used London as a case study is discussed. Methodologies of further work and potential outcomes are also highlighted.

4. Identifying Peak and Base Energy Consumption Hour Ranges for Commercial Buildings Using a Non-Parametric Method (CH-18-C007)

Hongxiang Fu, Student Member*, Juan-Carlos Baltazar, Ph.D., P.E., BEMP, Member and David Claridge, Ph.D., P.E., Fellow ASHRAE, Texas A&M University, College Station, TX*

The proposed method identifies peak and base energy consumption of chilled water, heating hot water and electricity through an embedded non-parametric pairwise statistic comparison test and provides the time periods during which consumption stays at a statistically similar level. This method shows robustness when a building energy use has a highly skewed distribution, and when the hourly building consumption level does not significantly vary it is capable of flagging “false” peak. The results of all the pairwise comparison tests are also visualized in a matrix that displays the significance of the difference for each pair.

5. Precise Process Air Conditioning Solution for a Pharma Industry Warehouse with a System Design Enabling up to 60% Energy Savings (CH-18-C008)

Dinesh Jaikumar, J.D.*, SunGreen Ventilation Systems Pvt Ltd, Chennai, India*

Reducing energy consumption is the need of the hour, not just as a cost effective measure but also as a necessity towards a sustainable future. This paper explains the methodology used to achieve extensive savings in providing the required indoor air quality and conditioning for a pharmaceutical warehouse where the temperature and humidity requirements have to be maintained precisely. Aspects such as geographical location, orientation of the warehouse, the material of construction, heat load details etc. were used to design the system. Initial data collection, design approach of the system, design details and final commissioning of the system are discussed.

11:00 AM - 12:30 PM

Conference Paper Session 3 (Intermediate)

Improvements in Heat Transfer Equipment

Track: Heat Exchange Equipment

Room: Chicago

Sponsor: 1.3 Heat Transfer and Fluid Flow

Chair: Lorenzo Cremaschi, Ph.D., Member, Auburn University, Auburn, AL

Conference Papers presented in this session explore a new approach for condenser design and condensate management. New surfaces that combine water-attracting and water-repelling regions to an experimental study have been conducted to investigate the thermal-hydraulic performance of wavy fin heat exchangers under dehumidifying operating conditions. This session covers a theoretical method for determining the required expansion amount to achieve the necessary interference fit for maximum heat transfer. Experimental laboratory results for a variety of tube and fin combinations and the impact of surface wettability on frost properties with a focus on recent experimental data are also presented.

1. Liquid Removal through Vibrations on a Flexible Film for Condensing/Dehumidification (CH-18-C009)
***Ryan Huber, Student Member**, Giselle Guanes and Melanie Derby, Ph.D., Member, Kansas State University, Manhattan, KS*

Condensers are frequently large and bulky components of HVAC&R systems. This paper explores a new approach for condenser design and condensate management; small vibrations vibrate flexible films, thereby shedding droplet and clearing area for new Condensation heat transfer rates are presented for a vibrating Teflon film (contact angle of 105°). The film will be placed in an environmental chamber with relative humilities between 40-80% at a temperature of 30°C (86°F) and vibrated at frequencies ranging from 0-100 Hz. Vibrating films are compared to the stationary case to observe the increase in heat transfer rate.

2. A New Model for Frost Growth Incorporating Droplet Condensation and Crystal Growth Phases (CH-18-C010)
***Ellyn Harges, Student Member** and Lorenzo Cremaschi, Ph.D., Member, Auburn University, Auburn, AL*

Frost formation is a common occurrence that penalizes energy consumption: it builds up in freezers and prevents heat pump systems from properly functioning. This presentation discusses new surfaces that combine water-attracting and water-repelling regions to prevent and control frost formation. A new model of frost nucleation under flow convective conditions is presented. By using surfaces with optimally positioned interlaced patterns of super-hydrophilic and super-hydrophobic regions, the transport of the water is controlled before it freezes. The interlaced coatings pragmatically relocate the droplets and mitigate frost growth, controlling the frost loading for high energy conversion efficiencies.

3. Thermal-Hydraulic Performance of Wavy-Fin Heat Exchanger under Dehumidifying Conditions (CH-18-C011)
***Kashif Nawaz, Associate Member**[1] and Dr. Mohammad Sultan Khan, Member[2], (1)Oak Ridge National Laboratory, Oak Ridge, TN, (2)Mohammad Ali Jinnah University, Islamabad, Pakistan*

Condensate accumulation on the heat exchangers has been identified as a critical problem. An experimental study has been conducted to investigate the thermal-hydraulic performance of wavy fin heat exchangers under dehumidifying operating conditions. The relative comparison of pressure drop and heat transfer rate has been made at different inlet flow conditions. The phenomena of condensate carry-over and condensate retention in relevance to the geometry of heat exchanger have been investigated. The thermal-hydraulic performance of wavy fin heat exchangers under dehumidifying conditions has been compared to several other fin designs and the impact of surface treatment has been reported.

4. Frost Growth on Hydrophilic and Hydrophobic Substrates: The Role of Surface Wettability (CH-18-C012)
***Andrew D. Sommers, Ph.D., Associate Member**[1], Colton W. Gebhart[1] and Christian J.L. Hermes[2], (1)Miami University, Oxford, OH, (2)Federal University of Santa Catarina, Florianópolis, Brazil*

In this work, the impact of the surface contact angle on the properties of a growing frost layer (specifically frost density and frost thickness) is presented with a special focus on experimental data and recent modeling work. Three different surfaces ranging in static contact angle from 45° to 160° were studied, with differences of 0.5-0.6 mm in frost thickness (typical) and 20-40% in frost density being observed. A new semi-empirical model for the frost thickness which is a function of the time as well as the modified Jakob number and surface contact angle is also presented.

5. Round-Tube-Plate-Fin Heat Exchanger Joining Process: Determining Interference Fit Between Tubes and Fin Collars Resulting from the Expansion Process (CH-18-C013)
***Rocky Smith**, Burr Oak Tool Inc., Sturgis, MI*

Round-Tube-Plate-Fin (RTPF) heat exchangers consist of multiple tubes and stacks of plate fins. These are put together with clearance between the tube diameter and the inside fin hole for ease of lacing tubes into the fins. The tubes and fins are joined by expanding the tubes, creating an interference fit so that heat will conduct through this interface. This paper presents a theoretical method for determining the required expansion amount to achieve the necessary interference fit for maximum heat transfer. This paper also presents experimental laboratory results validating the theoretical model for a variety of tube and fin combinations.

11:00 AM - 12:30 PM

Seminar 7 (Intermediate)

ASHRAE Standard 189.1: NEW Acoustic Control Section

Track: Standards, Guidelines and Codes
Room: Monroe
Sponsor: 2.6 Sound and Vibration
Chair: Jeff Boldt, P.E., Fellow ASHRAE, IMEG Corporation, Madison, WI

The 2017 ASHRAE 189.1 High-Performance Building Standard includes a major update to the acoustical control section. This section of the standard provides a performance and prescriptive path to acoustical compliance, and includes either acoustic commissioning or visual inspections to ensure the materials and assemblies are built to optimize acoustical performance. This seminar outlines the importance of this new standard, reviews the basic parameters of the acoustical performance requirements, and how this standard can be used for your next projects.

1. Summary of Acoustic Section of ASHRAE Standard 189.1
***Erik Miller-Klein, P.E., Member**, A3 Acoustics, LLP, Seattle, WA*

Over the past 3 years ASHRAE members have collaborated to compose an updated acoustical control section for the ANSI/ASHRAE/IES/USGBC Standard 189.1 Standard for the Design of High-Performance Green Buildings. The acoustical control section of ASHRAE 189.1 provides a performance and prescriptive path to acoustical compliance, and includes either acoustic commissioning or visual inspections to ensure the materials and assemblies are built to optimize acoustical performance. This session outlines the importance of this new standard and reviews the basic parameters of the acoustical performance requirements.

2. Understanding the Referenced Standards and Guidelines in the Acoustics Section of ASHRAE Standard 189.1
***Joseph Bridger, Member**, Stewart Acoustical Consultants, Raleigh, NC*

This presentation provides an overview of the standards and guidelines referenced in ASHRAE Standard 189.1, what the intent is behind these standards and highlights critical items to be aware of. Standards with acoustical design criteria, requirements and guidelines discussed include ANSI/ASA S12.60 Classroom Acoustics and FGI Guidelines for Design and Construction of Healthcare Facilities. Testing standards for both lab and field is discussed. These include standards for airborne sound isolation (ASTM E90 STC and E336 NIC), impact/tapping for floor/ceilings (ASTM E492 IIC and E1007 ISR) and measuring noise levels (ANSI/ASA S12.72 and S1.13).

3. The ASHRAE Standard 189.1 User's Manual and Acoustics
***Michael Schmeida, Associate Member**, Gypsum Association, Hyattsville, MD*

In the 2017 edition of ASHRAE 189.1, significant modifications were made requiring enhanced acoustical performance in high performance buildings. These are more stringent than most other code documents, and often beyond the expertise of the typical designer. As such, the User's Manual is being used as means of educating designers about acoustics, as well as how to implement the requirements in their building designs. Through review of the topics being discussed in the User's Manual, the user will be able to effectively design a building that will meet the criteria and perform as intended.

11:00 AM - 12:30 PM

Seminar 8 (Intermediate) NY PDH G

Impact of Regulatory and Market Trends on Compressor and System Design

Track: Systems and Equipment
Room: Adams
Sponsor: 8.1 Positive Displacement Compressors
Chair: Greg Chilcote, P.E., Member, Trane - Ingersoll Rand, La Crosse, WI
Evaluate how the latest trends are impacting HVAC system design, particularly compressor design and application. Review HVAC regulatory and market "mega trends", focusing on refrigerants and part load efficiency. Present choices HVAC equipment designers have when selecting major components such as compressors and heat exchangers. Then focus on compressor design, including modulation through variable speed and mechanical components. Conclude with the impact of new refrigerants on compressor design.

1. HVAC Regulatory and Market Trends
***Brian Smith**, Johnson Controls Advanced Development and Engineering Development Center, York, PA*

Amidst a rather tumultuous social and political backdrop, this presentation explores some of the key trends in the regulatory landscape, and the relevant market trends related to energy and the environment that will shape our industry's future. This session touches upon both U.S. domestic and international actions and challenges over the past couple years with forecasts for the future.

2. Compressor and System Design Integration
***William Dietrich, Member**, Daikin Applied, Staunton, VA*

This presentation focuses on the review and selection of components that make up a chiller package and how choices for compressor and heat exchanger designs are inter-related and the impact they have on other system components as well. Mechanical and electrical components are examined.

3. Compressor Modulation
***Alberto Scala**, Trane - Ingersoll Rand, La Crosse, WI*

New refrigerants and new regulations are weapons against climate change. But is the compressor technology ready to be more flexible and efficient? This presentation analyzes the state of the art in HVAC Screw Compressors at part load condition, using Mechanical Unload Devices or VFD. The presentation also explains how the Variable Built in Volume Ratio (Vi) can play an important role on saving energy at part load.

4. Impact of Refrigerants on Compressor Design

***Hung Pham**, Emerson Commercial & Residential Solutions, Sidney, OH*

This presentation reviews available refrigerants that can offer “interim” near drop-in solutions with a reasonable balance of trade-offs among low global warming potential (GWP), efficiency, A2L flammability, and system cost. The potential “long term” path options and tradeoffs are also provided. The compressor design strategy and cycle enhancement options for short and long term paths is discussed.

11:00 AM - 12:30 PM

Seminar 9 (Intermediate)

Pressurization Systems for Protecting Exit Stairwells during a Fire

Track: Earth, Wind & Fire

Room: Honore

Sponsor: 5.6 Control of Fire and Smoke

Chair: Paul Turnbull, Member, Siemens Building Technologies, Inc., Buffalo Grove, IL

Many building codes require protection of exit stairwells so they are available for evacuation of building occupants during a fire. This session describes the fundamentals of stair pressurization, and discusses challenges to be addressed in the design of these systems. Multiple design approaches are described, including single and multiple injection, compartmentation, vestibules, fire floor exhaust, and compensated pressurization systems. It includes a detailed look at different types of life safety dampers, and offers guidance in selecting dampers for different applications. Real world examples are used to illustrate these concepts translated into practice, and show how to identify an appropriate solution.

1. Basic Concepts of Stairwell Pressurization

***John Klote, P.E., Fellow Life Member**, John Klote Fire and Smoke Consulting, Leesburg, VA*

The intent of pressurized stairwells is to provide tenable conditions in stairwells for the evacuation or relocation of occupants during a fire. Pressurized stairwells are designed to operate between a minimum and maximum pressure difference. Stack effect and building complexity are major challenges to achieving acceptable pressurization. Pressurization systems consist of single and multiple injection systems, compartmentalization, stairwells with vestibules, stairwells with fire floor exhaust and compensated stairwells. The extent of a design analysis depends on the extent of the challenges that have to be dealt with and design analysis can range from very simple calculations to sophisticated network modeling.

2. Life Safety Dampers

***Larry Felker, Life Member**, Belimo Americas, Sparks, NV, USA, Sparks, NV*

There are four types of life safety dampers recognized in the International Building Code (IBC) and International Fire Code and certified to the UL 555 family of standards. Within these four types, there are many variations. This presentation defines each type, discusses the requirements for each type in IBC Chapter 7 (structural elements of fire and smoke protection) and Chapter 9 (systems for fire and smoke protection), and clarifies the application for each type of life safety damper.

3. Applications of Stairway and Elevator Pressurization Systems: Is It Really That Easy?

***Peter W McDonnell, P.E., Member**, McClure Engineering, St Louis, MO*

This session uses real world designs and installations to illustrate what aspects of stair pressurization really are as easy as they look and which aspects contain greater challenges. Topics are addressed that answer questions such as: Are pressure relief dampers needed? Is a gravity damper good enough? How many stories can air be supplied to with one injection point? What dampers are needed on the injection points? What about testing, summer, winter, with or without smoke?

1:30 PM - 3:00 PM

Conference Paper Session 4 (Intermediate)

HVAC: Tales of the Tape

Track: Fundamentals and Applications

Room: Empire

Chair: David Yashar, Member, NIST, Gaithersburg, MD

Design decisions and calculations for HVAC systems are critical to the success of implementing the right system for each building. Analysis and considerations are presented for a few system types, including computational fluid dynamic simulation for optimization of active chilled beams and considerations for design and operation of an ice thermal storage system. A case study of an inter-disciplinary team focused on building automation system and HVAC system issues is shared. A review of acoustical performance based design and standards is also presented. Finally, common HVAC load calculation mistakes and considerations related to energy models are considered.

1. Design Optimization of Active Chilled Beam for an Office Space Using Large Eddy Simulation (CH-18-C014)

***Abdullah Karimi, Associate Member**, Southland Industries, Dulles, VA*

Use of active chilled beams for cooling and heating applications has drawn significant interest in North America in recent years due to its benefits like easier integration with ceiling, lower air-flow, less ductwork and lower cost. In the present work, high fidelity large eddy simulations are carried out to optimize active chilled beam design for a typical office space application. A

number of design-parameters like primary air-flow, nozzle throw angle, chilled beam placement, and induced air-flow are investigated and their sensitivity analysis are performed for optimal performance using metrices like thermal comfort, draft-risk, and indoor-air quality (IAQ).

2. An Optimal Integrated Approach to Design and Operate Ice Thermal Storage for Typical HVAC Systems (CH-18-C015)

Nabil Nassif, Ph.D., P.E., Member[1]*, Fouad AlRifaie, Student Member*[2] *and Nihal Al Raees, Student Member*[1]*, (1)North Carolina A&T State University, Greensboro, NC, (2)North Carolina A&T University, Greensboro, NC*

This paper proposes an integrated approach to size and operate the ice thermal storage with different loads and weather conditions. Different building types, locations, utility rate structure are investigated. The study considers the effect of the ice thermal storage on the chiller performance and the associated energy cost and demonstrates the cost saving achieved from optimal ice storage design. Several load estimation techniques are evaluated, including linear and non-linear regression models and artificial neural networks. The results show a significant cost energy saving can be obtained by optimal ice storage design through the proposed approach.

3. The BAS/HVAC Office: Organizing People to Use BAS to Optimize Building Performance (CH-18-C016)

Orvil Dillenbeck, P.Eng., Member *and Don Sheppard, Canadian Nuclear Laboratories, Chalk River, ON, Canada*

The main campus of a Canadian national laboratory struggled with connecting tenants, operations, maintenance and management, so in 2015/16 they organized a Campus BAS/HVAC office, an interdisciplinary team using BAS and interactive operator reporting to optimize indoor conditions by targeting maintenance. This paper describes the office, its staff, the techniques and where they fit in the organization. Readers are challenged to consider how they might exploit BAS, routine inspections and interactive reporting to economically achieve the best indoor environment for their people and processes.

4. How Focusing on the Acoustics in the Human Environment Improves Standards and Guidelines and Creates Better Buildings (CH-18-C017)

Erik Miller-Klein, P.E., Member*, A3 Acoustics, LLP, Seattle, WA*

Many building standards, guidelines and codes focus on the structure, envelope and energy use of the building, but do not detail or explore the environment through the lens of building occupants and their experience of the interior environment. These documents help owners and designers meet the requirements for quality design and dictate a certain standard of care but fall short with respect to acoustics. This paper discusses the current state of research associated with human centric design for acoustics in the built environment. Explore how we can improve the occupant experience and propose improved acoustic performance goals.

5. Commercial HVAC Load Sizing Calculations Gone Wrong (CH-18-C018)

Liam Buckley, CEng, BEMP, Member*, IES Ltd., Oakland, CA*

Commercial software vendors of building performance tools receive over 10,000 technical support queries per year. This presentation attempts to provide some lessons learned from the common mistakes being made by the consulting engineering community. In addition, the presentation provides summaries of common HVAC sizing workflow issues, misunderstood methodology queries and typical mistakes associated to the process of HVAC system sizing. Technical analytical areas of the presentation will include zoning for various HVAC system types, solar shading, thermal mass, infiltration, internal gain diversity and schedules; unmet load hours and design day calculations vs hourly energy simulation.

1:30 PM - 3:00 PM

Seminar 10 (Intermediate) NY PDH G

Building Energy Modeling for Power Grids and Energy Code Compliance

Track: Modeling Throughout the Building Life Cycle

Room: Honore

Sponsor: 4.7 Energy Calculations

Chair: Ralph Muehleisen, Ph.D., P.E., Member, Midwest Energy Efficiency Alliance, Chicago, IL

Building energy modeling is often used in building design, within building maintenance and operations, and when evaluating retrofit opportunities. But did you know that building energy modeling is being used for estimating grid loads and power factors at the campus level and the grid distribution level? And did you know that building energy modeling can be a key part of building energy code assessment? This seminar shows some great uses of building energy modeling beyond building design, operation and retrofit analysis.

1. Additional Electric Power Capacity without on-Site Generation Using Power Factor Correction

Bass Abushakra, Ph.D., Member*, United States Military Academy, West Point, NY*

A forgotten benefit of correcting the electric power factor is the release of system capacity in addition to avoiding low power factor penalties or lowering the kVAR charges in utility bills. This presentation starts with the fundamentals of the power factor correction and shows a case study of a facility where improving the PF by roughly 6% releases 0.7 MW of electric capacity that doesn't have to be generated on-site, doesn't have to be bought from the utility company, and partially solves a problem by buying out time before the power lines feeding the facility exceed their normal rating limit.

2. Using Building Modeling to Determining Statewide Residential Energy Code Compliance: A Kentucky Case Study
***Chris Burgess, AIA**, Midwest Energy Efficiency Alliance, Chicago, IL*

Building energy modeling is becoming increasingly prevalent in establishing energy code compliance. By discussing and reviewing a recently completed three-year, three phase DOE funded residential compliance improvement study in Kentucky, this presentation shows how building energy modeling was instrumental to the success of the project.

3. Development of a Web-Based, Code Compliant 2015 IECC Residential Simulator for Texas
***Jeff S. Haberl, Ph.D., BEMP, Fellow ASHRAE**, Texas A&M University, College Station, TX*

This seminar describes the development of a web-based, code-compliant 2015 IECC residential single-family simulation for Texas.The seminar describes the software and database platform used in the web application and how this software is attached to some legacy software running on the cloud. Additional information is included about how a residence is dynamically updated by the web-page, using a flexible yet fixed-schematic input file. This tool is currently in use by builders in Texas to check code compliance of new residential single-family construction. It also calculates NOx, SOx and CO2 emissions reductions from the energy savings of the proposed house.

1:30 PM - 3:00 PM

Seminar 11 (Intermediate)

Next Generation Tall Buildings HVAC Design

Track: Tall Buildings
Room: Monroe
Sponsor: 9.12 Tall Buildings
Chair: John Carter, Member, CPP, Fort Collins, CO

Chicago has a strong heritage of tall buildings, from turn of the century Home Insurance Building, to John Hancock Center and Willis Tower. What are the Chicago tall buildings HVAC designers up to today? This session introduces the next generation tall building design, from new weather files, new environment contaminant files, low energy tall building, healthy tall building, to new stack effect studies, modular building, etc. Three Chicago firms, including three HVAC designers of the top 20 tallest buildings in the world by 2020, discuss what they see on the tall building horizon.

1. The Current Tallest Building Design Update
***Mehdi Jalayerian, P.E., Member**, ESD, Chicago, IL*

This session discusses the HVAC and primary building systems design and current update on the next tallest building in the world – Kingdom Tower. The session reviews next generation design parameters and system zoning and configuration to achieve systems reliability and efficiency including stack effect management, envelope performance, lobby configuration and space pressurization. Building Systems design for super-tall buildings must be developed through early integration with the structural and architectural design as configuration and organization of the building can significantly influence the building systems solutions, systems operation and ultimately installation cost.

2. Low Energy Tall Building Design and Modular Tall Buildings
***Robert Tazlaar, Member**, ARUP, Chicago, IL*

This presentation provides some insight into how HVAC systems are changing to meet the drive towards lower energy usage. It primarily focuses on trends in designs which have been highlighted in research journals and project work. A case study is provided which highlights how some of the trends have been implemented on a current design.

3. Low Carbon and Healthy Tall Buildings
***Luke Leung, P.E.**, Skidmore Owings & Merrill, Chicago, IL*

From the environmental information, including microclimate to contaminants variation with height, to the wellness and integration to urban habitats, our current tall building design needs to be strengthened for the next generation of taller and more diversified buildings. This discussion focuses on the areas that need to be strengthened and how we can achieve that in the next generation tall building design that delivers lower energy and healthier tall buildings.

1:30 PM - 3:00 PM

Seminar 12 (Intermediate)

Residential Ventilation Experiences in Europe and North America towards NZEB Design and Operation

Track: Fundamentals and Applications
Room: Chicago
Sponsor: 2.1 Physiology and Human Environment, REHVA

Chair: Jaap Hogeling, Dr.Ing., Fellow ASHRAE, REHVA, Brussels, Belgium
Residential ventilation systems for nearly zero energy building design and operation requires new approaches. New European energy performance standards supporting these design procedures are being presented. Smart residential ventilation systems to reduce energy use in North America are discussed. European design guidelines on high performance mechanical ventilation systems with heat recovery with room based airflow rate selection procedure and sizing principles with compensated cooker hood are provided. Common installations in new and renovated buildings are shown. An example of a design solutions is illustrated. Procedures for assessing ventilation rates based on CO2 as tracer are presented.

1. Mechanical Ventilation in NZEB Cortau House in Italy: Theoretical Performance, Real Effects and Occupants' Expectations
***Stefano Corgnati, Ph.D., P.E., Associate Member**, REHVA, Brussels, Belgium*

CorTau House is a building design and constructed following the NZEB principles. One of the key challenges of the design was the integration of mechanical ventilation with heat recovery and dehumidification in summer, allowing the suitable integration with radiant floor used for cooling purposes too. The regulation and control of mechanical ventilation in actual operation conditions is fundamental if the energy performances calculated at design stage wants to be obtained in reality. Training of occupants is needed, as a change of the habits related to opening/closing windows and to interacting with control systems is crucial.

2. CEN Standard Methodology for Energy Requirements in Residential Ventilation
***Livio Mazzarella, Ph.D., P.E.**, Politecnico di Milano, Milano, Italy*

Under European Commission mandate, CEN had just publishing new updated standards to support the energy performance assessment of Nearly Zero Energy Buildings. Among these, several standards have been developed on energy requirement for ventilation for both residential and non-residential buildings. This presentation focuses on the impact that the CEN performance calculation procedure can have on designing NZEB buildings, which energy performance have to comply with performance limits assessed through such standards.

3. Residential Ventilation Standards and NZEB Homes in North America
***Max Sherman, Ph.D., Fellow ASHRAE**, LBL, Berkeley, CA*

As high-performance homes reduce the thermal loads through the envelope, the energy required to provide minimum ventilation because a more and more important fraction of the total energy. ASHRAE Standard 62.2 provides a relatively high-degree of flexibility that allows homes to provide acceptable indoor air quality at significantly reduced energy costs. In addition to heat or energy recovery systems, standards 62.2 allows dynamic controls of ventilation rates to respond to demand and outdoor conditions. Such smart ventilation systems are discussed during this presentation.

4. New REHVA Guidebook on Residential Heat Recovery Ventilation: System Layouts, Sizing and Typical Solutions
***Jarek Kurnitski**, Tallinn University of Technology, Tallinn, Estonia*

NZEBs are well insulated, airtight and with good sound insulation. Therefore, balancing of ventilation, including the operation of cooker hood, as well as low noise levels are much more crucial issues than in older buildings. New information for designers and contractors to design and size a high performance mechanical supply and extract ventilation system with heat recovery is presented. Room based airflow rate selection procedure and sizing principles for constant pressure system with compensated cooker hood are provided. A simplified noise calculation procedure is introduced. The specific energy consumption and new ISO filter classification are introduced.

5. Implementing New and Classical CO2 Tracer Gas Methods for the Assessment of Ventilation Indicators in Residential Buildings
***Manuel Gameiro da Silva, Ph.D., Member**, University of Coimbra, Coimbra, Portugal*

Being naturally generated by buildings' occupants, CO_2 is many times selected as the tracer gas. A mathematical model for the time evolution of a contaminant in a uni-zone confined compartment is presented. The most common CO_2 meters are addressed. Various possibilities to develop AER from the curve fitting of experimental data will be explained, discussed and compared. A recent method based upon the response of CO_2 indoor concentration to the cyclic changes of its outdoor concentration, during non-occupancy periods, are introduced. Pros and cons of proposed methods will be discussed

1:30 PM - 3:00 PM

Seminar 13 (Intermediate) NY PDH G

Sound Humidification Supports Health and Comfort

Track: Fundamentals and Applications
Room: Adams
Sponsor: 5.11 Humidifying Equipment, 5.7 Evaporative Cooling
Chair: Raul Simonetti, Member, Carel Industries SpA, Brugine, Italy
Recent research shows that a proper level of humidity significantly reduces the risk of airborne infections. Humidity control solutions offer significant health benefits for occupants, especially when it is designed, installed and commissioned correctly. This seminar, after recalling the results of the research, presents some of the currently available humidification solutions along with their main characteristics and best practices.

1. 40 Is the New 20: Balanced Indoor Air-Hydration for Health!

***Stephanie Taylor, M.D., Member**, Healthcare Acquired Infections Organization, Boston, MA*

Today, indoor humidification is used in commercial buildings to protect materials and aid in manufacturing processes, however, data tells us that proper air-hydration is also essential for the health of people. Short term dehydration symptoms such as a dry mouth prompt us to drink fluids when we feel thirsty. Conversely, chronic dehydration resulting from water evaporation through our skin and respiratory tissues in dry air is unperceivable, yet causes serious problems for our blood circulation, thinking ability and resistance to infections and allergies. This presentation discusses exciting new and existing data to show the health benefits of proper indoor-air humidification.

2. Getting Humidity Control Right

***Nicholas Lea, P.Eng., Associate Member**, Nortec Humidity Ltd., A Member of the Condair Group, Ottawa, ON, Canada*

With the vast quantity of research demonstrating how to keep buildings and materials dry it may seem counter intuitive to add water to the indoor environment. However recent research has shown clear health benefits from maintaining mid-range humidity levels. This presentation dispels the myths associated with humidification and discusses crucial elements for a safe and successful design. Learn about where humidity is needed, controlling risks of condensation and avoiding bacterial contamination. The seminar concludes with practical design tips.

3. VAV with IAQ and a Cure for the Spread of the Airborne Flu Virus

***Thomas Weaver, P.E., Member**, CMSI Headquarters, Hercules, CA*

Supplying dry winter outdoor air to a room decreases its relative humidity (RH). Recent research shows that when room RH drops below 40 %, the droplet nuclei containing the pathogens stay buoyant in the human breathing zone longer, with increased risk for susceptible humans. Overhead VAV air systems remain the most popular HVAC cooling design for schools and office buildings in California. The use of a Heat-Recovery Economizer and an adiabatic Direct Evaporative Cooler/Humidifier offers a remedy. This all-outdoor-air design offers the building owner significant cooling and heating energy savings while furnishing all outdoor air for better Indoor Air Quality.

4. Steam Humidification: Main Systems and Characteristics

***Raul Simonetti, Member**, Carel Industries SpA, Brugine, Italy*

Steam humidifiers can be used as alternative to evaporative-cooling equipment in many applications, or must be used instead of evaporative-cooling systems for dedicated purposes (e.g., surgery theatres, cheese maturing). This seminar presents the most common steam humidifiers describing their performances, supply-water constraints, as well as hygiene and maintenance requirements.

3:15 PM - 4:45 PM

Technical Paper Session 1 (Intermediate) NY PDH G

New Advancements for Energy Efficient Heat Transfer

Track: Fundamentals and Applications

Room: Honore

Chair: Jaya Mukhopadhyay, Ph.D., Member, Montana State University, Bozeman, MT

This technical paper session discusses innovations in energy transfer ranging from radiant heating to thermal storage and even magnetic refrigeration. With the aid of modelling and simulations, it takes a deeper look at the efficiency of current technologies and offers insight to proposed developments.

1. Strategies to Increase Deployment of Renewables Using Cool Thermal Energy Storage (RP-1607) (CH-18-001)

***Amy Van Asselt, Student Member**, University of Wisconsin-Madison, Madison, WI*

Cool Thermal Energy Storage (CTES) decouples the production of cooling from the coincident demand. A control strategy is employed that aims to utilize the generation of electricity from intermittent wind and solar energy resources. The analysis is performed for a secondary school employing an ice storage system. The results show a trade-off between maximizing renewable power use and minimizing life-cycle cost, but a system designed to optimize the use of renewables will be more cost effective and better at utilizing renewable electricity than a system without storage. Widespread implementation of CTES may assist utilities in reaching their renewable penetration targets.

2. Analysis of Magnetic Refrigeration Designs with Different Magnet Array Geometries (CH-18-002)

***Serdar Celik, Member**, Southern Illinois University, Edwardsville, IL*

Magnetic refrigeration is one of the promising alternative cooling technologies in terms of its theoretical limits. However applications of these systems yield much lower COP values than the Carnot COP values that can be achieved at room temperatures. The main challenges are the limited magnetocaloric effect of the magnetocaloric material, and space limitations. To address the magnetic field and heat transfer enhancement problems, three different geometries (circular, octagonal, and hexagonal) of Halbach magnet array and magnetocaloric material assemblies were simulated with aid of theoretical analysis. Magnetic flux intensities within the apertures of each hollow design were obtained using Finite Element Method Magnetics (FEMM) software.

3:15 PM - 4:45 PM

Seminar 14 (Intermediate)

Controlling Pollutant Sources in Residential Buildings

Track: Fundamentals and Applications

Room: Empire

Sponsor: 4.3 Ventilation Requirements and Infiltration, SSPC62.2

Chair: Steven J. Emmerich, Fellow ASHRAE, National Institute of Standards and Technology, Gaithersburg, MD

People spend the majority of their time at home and, as a result, that is where indoor air quality (IAQ) improvements have the potential to yield the largest health and comfort benefits. This seminar presents the results of the latest research and development in controlling residential pollutant sources including information on avoiding transfer of garage contaminants into living space, opportunities and limitations for improved air cleaning in houses, the development of smart range hoods and evaluation of low-cost IAQ monitors.

1. Keeping the Car out of the Living Room: What Works (RP-1450)

***Paul W. Francisco, Member**, University of Illinois at Urbana-Champaign, Champaign, IL*

Attached garages are a staple of convenience in many homes. However, this leads to the potential for contaminants from vehicles and products stored in the garages to migrate into the home, potentially impacting the health of the residents. This presentation reviews the results from ASHRAE RP-1450 which evaluated the effectiveness of various strategies at minimizing contaminant transfer from garages to homes, including sealing of the garage, sealing of any ducts in the garage, passive ventilation and garage exhaust ventilation with several control strategies. Factors influencing the effectiveness and suggested solutions that could be adopted into standards will be discussed.

2. The Limitations and Opportunities for Filtration and Air Cleaning in Residences

***Jeffrey Siegel, Ph.D., Fellow ASHRAE**, University of Toronto, Toronto, ON, Canada*

Particles are an important indoor air contaminant and filtration/air cleaning is one approach used to control particles in residences. Central filtration is appealing because of its simplicity and large flow rates. However, many residential systems lack the duty cycle and filtration efficiency (or lack forced air systems altogether) to address most contaminants. This has led many consumers to use portable air cleaners. Like central filtration, these devices suffer from a variety of issues. This presentation focuses on both, exploring these limitations as well as suggesting approaches to use filtration well in residences.

3. Is a Two Hundred Dollar Indoor Air Quality Monitor Good Enough to Keep You Safe?

***Brett Singer, Ph.D., Member**, LBNL, Berkeley, CA*

Indoor air quality monitors based on low-cost sensors are now available for under $200. These devices report measurements of temperature, relative humidity and concentrations of one or more air pollutants. LBNL conducted experiments to determine how well these consumer-grade monitors detect and quantify concentrations of particles emitted from various common indoor sources. The output of low-cost monitors was compared to mass-based measurements using a Federal Equivalent Method and several research-grade light scattering monitors. This presentation presents results and discusses implications for using low-cost particle sensors to protect IAQ in homes.

4. Development of a Smart Range Hood

***Mike Moore, P.E., Associate Member**, Newport Partners LLC, Loveland, CO*

Consumer surveys show that range hoods are seldom used and investigations into residential IAQ point to cooking activities as one of the largest sources of indoor pollutants. What if we could develop a smart range hood that could sense critical pollutants and automatically respond to them, delivering kitchen ventilation quietly, efficiently and cost effectively? DOE is funding research into the development and demonstration of a smart range hood that has this as its objective. This presentation provides an update on the project status.

3:15 PM - 4:45 PM

Seminar 15 (Intermediate)

Model Predictive Control Case Studies in Commercial and Institutional Buildings

Track: Modeling Throughout the Building Life Cycle

Room: Monroe

Sponsor: 7.5 Smart Building Systems

Chair: Andreas Athienitis, Ph.D., P.E., Fellow ASHRAE, Concordia University, Montreal, QC, Canada

This session focuses on case studies of novel model-based predictive control applications for a range of building types and HVAC systems, ranging from sets of rooftop air conditioners in small commercial buildings, a perimeter zone that includes a radiant floor cooling system, a small net-zero energy institutional building and a 17-story high university building with a hybrid ventilation system. Novel aspects of the case studies include a learning cloud-based supervisory controller and web-enabled thermostats, a distributed system identification approach for control-oriented models, and optimization of grid interaction for a novel net-zero energy building with building-integrated photovoltaics and a geothermal system.

1. Model Predictive Control of Multiple Rooftop Air Conditioners in Small Commercial Buildings

***Jim Braun, Ph.D., P.E., Fellow ASHRAE**, Purdue University, West Lafayette, IN*

This presentation describes the development and application of a model-predictive controller for coordinating the operation of multiple rooftop unit (RTU) air conditioners that typically serve small commercial buildings. The cloud-based supervisory

controller only requires web-enabled thermostats with no additional sensors. The controller learns the responses of the thermostats to RTU staging and uses the learned responses along with rated RTU power to determine RTU staging that minimizes total energy use and peak power over a relatively short control horizon. The presentation also presents results for energy and demand savings from a number of field demonstrations.

2. Model Predictive Control of a Radiant Floor Cooling System in an Office Space
***Panagiota Karava, Ph.D., Associate Member**, Purdue University, West Lafayette, IN*

This presentation introduces agent-based approaches that address practical limitations associated with the scalability and engineering cost of MPC solutions for high performance buildings. A newly developed distributed system identification approach for control-oriented models that can be integrated in a plug-and-play manner is discussed and demonstrated using a case-study of an open plan office space with multiple building sub-systems. The second part of the presentation introduces centralized and distributed optimal control formulations along with a case study of an open-plan office space with several control units for local air and radiant comfort delivery with humans in the loop.

3. Model Predictive Control of a Net-Zero Energy Institutional Building and a Hybrid Ventilation System
***Andreas Athienitis, Ph.D., P.E., Fellow ASHRAE**, Concordia University, Montreal, QC, Canada*

Application of predictive control strategies based on calibrated models for two Canadian case studies is overviewed: 1) A novel net-zero energy institutional library building that includes a building, integrated photovoltaic system, a geothermal heat pump system and floor radiant slabs; a key objective of the predictive control is to optimize interaction with the grid by precooling or preheating the building; 2) A hybrid ventilation system in a 17-story high university building with high thermal mass used in predictive night cooling mode to reduce the cooling load during the next day's prediction horizon, while taking into account comfort constraints.

3:15 PM - 4:45 PM
Seminar 16 (Intermediate)

New Developments in Ice Rink Refrigeration Systems

Track: Systems and Equipment
Room: Chicago
Sponsor: 10.2 Automatic Icemaking Plants and Skating Rinks
Chair: Greg Scrivener, Member, Cold Dynamics, Meadow Lake, SK, Canada

There are many challenges facing the ice rink refrigeration industry including rising energy costs, phase out of refrigerants and stricter operator requirements. This seminar addresses each of these issues and provides a clear path to the future design of refrigeration systems that are sustainable, safe and minimize operator requirements.

1. Ammonia/Carbon Dioxide Secondary Systems
***Arthur Sutherland, Member**, Accent Refrigeration Systems, Victoria, BC, Canada*

Over 20 recreational ice facilities in Europe and Asia have adopted indirect refrigeration systems utilizing ammonia as the primary refrigerant and Carbon Dioxide (CO2) as the secondary coolant. Ammonia, well known for its high efficiency, when combined with CO2 as a secondary coolant creates a Hybrid system that enjoys tremendous efficiencies on both sides of the indirect system. Learn why the University of Alaska's, Wells Fargo Arena was the ideal candidate for an energy saving Ammonia / CO2 system and how they reclaimed to 100% of their available low grade heat during the process.

2. Ice Arena Refrigeration Energy Comparison of Low-GWP and Natural Refrigerants
***Kyle Larson, P.E., Associate Member**, Vacom Technologies, LaVene, CA*

Regulations are driving changes in refrigerants and forcing engineers and owners to think about what is best option for their ice arena. The refrigeration system design usually narrows down the type of refrigerant to a handful, but there still remains plenty of options to choose from including low-GWP and natural refrigerants. This seminar explores the energy impacts of different refrigerant options for a typical size ice arena. Building energy modeling will be performed to evaluate the utility costs. The simulation model includes the refrigeration system, the ice surface, space conditioning, envelope and other heat loads for the rink area.

3. Heat Recovery in Curling Facilities: Keep It Simple
***Daniel Dettmers, P.E., Member**, University of Wisconsin, Madison, WI*

This seminar explores typical refrigeration systems used in dedicated curling facilities, how they can easily be designed or modified to provide economic heat recovery and present a case study on a heat recovery retrofit application and the savings it derived. The seminar explains that in this case, the simpler solutions are often the best to implement.

4. Heat Pumps in Ice Arena Refrigeration Systems
***Wayne Borrowman, P.Eng., Member**, Cimco Refrigeration, Toronto, ON, Canada*

Traditionally, waste heat from the refrigeration system was recovered only if it was convenient to do so. In the modern Ice Arena refrigeration systems, waste heat is recovered in a variety of manners. Heat pumps and their variations are one solution. This presentation explores the various heat pump configurations available including utilizing the refrigeration plant itself as a large heat pump, coupling a second stage of compression to the existing refrigeration plant to make a hybrid heat pump, using

stand-alone water to water heat pumps, as well as utilizing terminal heat pumps that can provide both heating and summer cooling.

3:15 PM - 4:45 PM

Seminar 17 (Intermediate)

Designing VRF Systems for Code Compliance

Track: Standards, Guidelines and Codes

Room: Adams

Sponsor: 8.7 Variable Refrigerant Flow (VRF)

Chair: Madison Schultz, P.E., Member, Guernsey Engineers/Architects/Consultants, Oklahoma City, OK

Standards, guidelines and codes committees are regularly releasing new revisions. Some of these have specific provisions for VRF systems and some leave things…open to interpretation. This session covers the need-to-knows on how the requirements of IECC 2015, ASHRAE 90.1-2016 and ASHRAE 15/34-2016 apply to the design of VRF systems. The presentations also cover ventilation options for VRF for compliance with ASHRAE 62.1, and specific requirements to comply with the City of Chicago mechanical code.

1. Designing VRF Systems for Compliance with IECC-2015 and ASHRAE Standard 90.1-2016

***Nick Manusos, Affiliate**, Lennox International, Chicago, IL*

This presentation introduces VRF systems, followed by a review of the important compliance requirements for IECC-2015 and ASHRAE 90.1-2016 as it relates to VRF systems.

2. Designing VRF Systems for Compliance with ASHRAE Standard 15 and ASHRAE Standard 34-2016

***Keith Hammelman, P.E., Member**, Cannon Design, Chicago, IL*

This presentation discusses the important compliance requirements for ASHRAE 15/34-2016 as it relates to VRF systems.

3. Ventilation Options When Designing VRF Systems

***Bill Artis, Member**, Daikin, New York, NY*

This presentation explores cover system design options for ventilation with VRF systems for compliance with ASHRAE 62.1.

4. Designing VRF Systems for Compliance with City of Chicago Codes

***Andy Hubner**, Premier Mechanical, Addison, IL*

This presentation examines the important compliance requirements for City of Chicago mechanical code as it relates to VRF systems.

Monday, January 22

8:00 AM - 9:30 AM

Conference Paper Session 5 (Intermediate)

Designing Building Systems for Thermal Comfort

Track: Fundamentals and Applications

Room: Honore

Chair: Christopher Laughman, Member, Waltham, MA

Changes in building occupancy and the differing requirements of occupants can be major challenges in the design of building systems. One focus of this session is the potential for occupancy to be directly measured using a vision-based system. Next, a case study documenting the implementation of the ASHRAE Standard 62.1 Indoor Air Quality Procedure to address building comfort issues is shared. A study of thermal preference characteristics for building occupants is presented. Finally, the impact of electric demand response on occupant comfort is explored.

1. Dynamic HVAC Operations with Real-Time Vision-Based Occupant Recognition System (CH-18-C019)

***Siliang Lu, Ph.D., Student Member**, Erica Cochran Hameen, Ph.D. and Azizan Aziz, Center for Building Performance and Diagnostics, School of Architecture, Carnegie Mellon University, Pittsburgh, PA*

HVAC is one of the most important components to determining energy consumption and comfort level in a building. Currently, most of existing HVAC systems are being operated without the ability to adjust in response to dynamic occupancy profiles. Due to this inefficiency, much of energy is wasted. To solve this problem, the presentation proposes a real-time vision-based occupant pattern recognition system by realizing occupancy counting and activity level classification. The results showed accuracy for

counting and activity level classification could be over 90% without many occlusions and dynamic schedules indeed can bring about energy savings and increase comfort level.

2. Case Study: How to Handle a 50 Percent Increase in Occupancy While Maintaining Indoor Air Quality (CH-18-C020)
***Mike McFarland**, enVerid Systems, Inc., Needham, MA*

Originally designed to support an occupancy of 850 people, the 190,000 ft^2 corporate headquarters at ArcBest has grown to 1,085 people plus visitors. The increased occupancy required more outside air to maintain indoor air quality per ASHRAE 62.1: VRP (Ventilation Rate Procedure). All of this extra outside air significantly increased electrical energy costs and HVAC load, plus caused draftiness year round – generating lots of complaints to facilities management. ASHRAE 62.1 IAQP (Indoor Air Quality Procedure) was implemented along with HVAC Load Reduction (HLR) technology, delivering improved indoor air quality, much improved comfort (all complaints stopped!), and energy savings.

3. Inference of Thermal Preference Profiles for Personalized Thermal Environments (CH-18-C021)
***Seungjae Lee, Student Member**, Panagiota Karava, Ph.D., Associate Member, Athanasios (Thanos) Tzempelikos, Ph.D., Member and Ilias Bilionis, Purdue University, West Lafayette, IN*

This paper discusses how to develop smart environmental control systems for office buildings that incorporate occupant thermal preferences. It presents a novel method for developing personalized thermal preference profiles with improved accuracy and efficiency, using sensor data for indoor environment variables and occupant feedback collected using human-building interfaces. The approach is fully-Bayesian and it is based on the classification of the occupants in a typical office building population based on their "hidden" thermal preference characteristic and the inference of the profile for a new occupant using a mixture of probabilistic models for each cluster.

4. Field Studies of the Impact of Demand Response on Occupant's Thermal Comfort and Their Adaptive Behavior in a University Campus (CH-18-C022)
***Sama Aghniaey, Ph.D., Student Member**[1] and Thomas M. Lawrence, Ph.D., P.E., Fellow ASHRAE[2], (1)UGA, Athens, GA, (2)University of Georgia, Atlanta, GA*

Demand response has the potential to reduce peak demand, a customer's electric bill and overall energy consumption in buildings. This paper presents the results of an ongoing study investigating the impact of increased cooling setpoint temperature during demand response events on building occupants at a university campus in the southeastern U.S., and the occupant's adaptive behaviors for reducing thermal discomfort.

8:00 AM - 9:30 AM

Seminar 18 (Intermediate) NY PDH G

Building-Integrated Photovoltaic Systems: Enabling Net-Zero Energy Performance and Beyond

Track: Fundamentals and Applications
Room: State
Sponsor: 6.7 Solar Energy Utilization, TC 4.4, TC 4.5, TC 7.1, TC 7.6
Chair: Thanos Tzempelikos, Ph.D., Member, Purdue University, West Lafayette, IN

As the building sector is moving toward net-zero energy targets, building-integrated photovoltaic (BIPV) technologies are going to play an essential role in achieving these goals. BIPV are building envelope components that generate on-site electricity and in some cases, thermal energy. This seminar covers the design and performance of existing BIPV case studies in North America. Through this seminar, the attendees gain an understanding of: BIPV fundamentals; examples of BIPV applications; design, implementation challenges and proposed solutions; and associated costs. This seminar focuses on commercial, institutional and high-rise residential buildings.

1. How to Accelerate Architectural Solar in the US Market: From Building-Integrated Photovoltaic to Building Component
***Chris Klinga, P.Eng.**, Architectural Solar Association, Boulder, CO*

The BIPV market is an opportunity to change the commoditized solar paradigm. BIPV products have been available for many years but have lacked widespread adoption due to several barriers that make them less viable than traditional solar technologies. These barriers can be summarized in four areas that need to be further matured and understood; Building Industry Integration, Code's and Standards, Economics and Education. This presentation reviews each of these barriers and educates the listeners on ways that they can be overcome.

2. Building-Integrated Photovoltaic Windows and Envelope Solutions for New and Retrofit Buildings
***Costa Kapsis, Ph.D.**, Natural Resources Canada, Varennes, QC, Canada*

Building envelope is an essential element in energy-conserving and energy-efficient building design. As the building industry is moving toward net-zero energy performance targets, BIPV are expected to play a key role in transforming buildings from energy consumers to energy producers. Thus, during the design and implementation stage, all BIPV performance characteristics (e.g., electrical, thermal and daylighting) should be quantified individually and together in order to capture their impact on the building energy performance and occupant comfort. This presentation reviews various BIPV envelope solutions available for commercial, institutional and high-rise residential buildings and provides design and performance assessment guidelines.

3. Challenges and Opportunities in the Design of Building-Integrated Photovoltaic/Thermal Systems
***Andreas Athienitis, Ph.D., P.E., Fellow ASHRAE**, Concordia University, Montreal, QC, Canada*

In building-integrated photovoltaic with heat recovery (BIPV/T), absorbed solar energy that is converted into heat is recovered actively by flowing air on its rear side. As the air circulates, it cools down the cells reducing their temperature and increasing their electrical efficiency. Design principles of open loop air-BIPV/T systems are presented, focusing on key requirements for optimizing electricity generation and useful heat, integrating with HVAC systems and ensuring a robust and durable building envelope. Case studies include an office building with a BIPV/T facade that heats ventilation air and a net-zero energy institutional building with a BIPV/T roof.

4. Building Integrated Photovoltaic Systems: Value, Aesthetics and Standards
***Anthony Pereira**, altPOWER, New York, NY*

BIPV is among the fastest growing sectors within the PV industry. The popularity of green buidlings and especially true net-zero buildings will require energy production from as many building surfaces as possible. This presentation looks at the uses of BIPV, the challenges BIPV faces with regard to codes and standards and reviews the economic analysis of a potential BIPV project.

8:00 AM - 9:30 AM

Seminar 19 (Intermediate) NY PDH G

Navigating the Changing Landscape of Regulations, Codes and "Best Practices" Around Legionella and Building Water Safety

Track: Standards, Guidelines and Codes
Room: Chicago
Sponsor: 3.6 Water Treatment, Environmental Health Committee, SSPC188
Chair: Joshua Ince, P.Eng.,Member, Eldon Water Inc, West Chester, OH

This session reviews the most current and recent codes and regulations pertaining to Legionella and building water safety, how to follow and adhere to these regulations and discuss how effective they are. The expert panel answers questions pertaining to why these regulations are required to control Legionella, strategies for executing management plans to comply with codes and regulations and discusses which codes and regulations have had the greatest impact for the management team and improving water safety.

1. Where Legionella Lurks in Building Water Systems: How Codes and Regulations Seek to Control Amplification
***Janet Stout, Ph.D., Associate Member**, Special Pathogens Laboratory, Pittsburgh, PA*

The aim of regulatory documents is to manage the conditions within potable and utility water systems that allow uncontrolled growth of this bacteria. This session provides you with a unique perspective – Legionella's perspective. Understanding the water systems from this vantage point will enable owners and managers to effectively manage these systems, understand previous failures, set achievable goals and to have greater success in controlling the growth of this waterborne pathogen.

2. Water Safety Plans, Who Does What? The Role of Water Treatment, Engineering and Facility Management
***William Pearson, Member**, Special Pathogens Laboratory, Pittsburgh, PA*

For almost four decades, the facility manager, the engineer and the water treater were essentially without any specific or enforceable Legionella-related building water safety codes, regulations or published Standard (of care). The past two years have seen significant change, starting with the June 2015 publishing of the first US (Legionella) Standard, ANSI/ASHRAE 188, quickly followed by regulations enacted in NYC and NYS following an outbreak of Legionnaires' disease in the South Bronx and with a June 2017 directive from CMS (Centers for Medicare and Medicaid Services) that spells out very specific Legionella-related building water safety policies and procedures requirements.

3. Legionella: The Drive for More Effective Codes
***Tim Keane, Member**, Legionella Risk Management Inc., Chalfont, PA*

With ASHRAE Standard 188 published and supported by CDC as well as others, CMS finally weighed in and immediately required all healthcare facilities including all hospitals and nursing homes in the US to have a Legionella risk management plan. This is a huge change from where we were just three years ago. So what's next? What other codes will this replace, what other codes will need to change and what will be the effect on design engineers.

8:00 AM - 9:30 AM

Seminar 20 (Intermediate) NY PDH G

Performance-Based Procurement: A Focus on Real Performance from Beginning to End

Track: Modeling Throughout the Building Life Cycle
Room: Red Lacquer (4th Floor)
Sponsor: 7.6 Building Energy Performance, 7.5 Smart Building Systems
Chair: Scott Hackel, P.E., Member, Seventhwave, Madison, WI

With interest of driving real energy usage continually lower in new buildings and renovations, there is a growing trend to procure buildings using performance requirements such as EUI. Performance-based procurement is now being used by many large owners including federal, state and local governments, healthcare and even developers. All actors in the procurement, design, construction and operations of the building must have some focus on the building's eventual EUI. And energy modeling plays a

significant role in most stages. This session provides insight into best practices for this process from the standpoint of owner, energy consultant and modeler.

1. Introduction to Performance-Based Procurement
***Scott Hackel, P.E., Member**, Seventhwave, Madison, WI*

This seminar begins by introducing and defining a performance-based procurement. The fundamental tenets are outlined, so that the subsequent presentations will be very useful even for those with no prior experience with the concept.

2. Using Performance Targets to Procure a Bed Tower Expansion at Mayo Clinic
***Ken Potts R.A.**, Mayo Clinic, Rochester, MN*

One of Mayo Clinic's core values is Stewardship: managing and sustaining our human, natural, and material resources. In support of that value, Mayo has committed to lower its carbon emissions 20% by 2020. For the Generose Building expansion project, Mayo used an Energy Use Intensity performance goal early in project planning. The EUI goal was part of the design team RFP, the contractor selection process, as well as included in the contract language. This approach has allowed Mayo to optimize the balance between aesthetics, performance, and budget to serve the needs of its patients while maximizing performance of the facility.

3. Best Practices for Performance-Based Procurement
***Ben Heymer, P.E., Member**, Seventhwave, Chicago, IL*

In just the past few years there have arisen a critical mass of projects utilizing a performance-based procurement method of delivery. This presentation documents the practices that have emerged for owner, design and construction teams to utilize this process with a focus on those that have demonstrated clear success. Practices are shared for steps such as clear documentation of owner's goals in RFPs and contracts, choosing of performance targets, substantiation at various steps of design and construction and development of an M&V plan for performance-based projects.

4. Modeling and Designing Buildings to a Target EUI
***Joseph Clair, P.E.**, dbHMS, Chicago, IL*

Policy makers and owners have turned to guaranteed EUI contracts as a method for delivering low energy buildings within the cost of construction. In order to accomplish this, owners and designers must work together with a focus on performance at each step, as is currently done for budget. Using the backdrop of a recent dormitory project, this seminar helps the attendee identify the elements of standard building project delivery that have to change in order for guaranteed EUI contracts to work, while providing performance data to show whether the project team delivered on its goal.

8:00 AM - 9:30 AM

Seminar 21 (Intermediate) NY PDH G

Air, Water and Wind: Controlling the Indoor Environment with Excellent Design Strategies

Track: Systems and Equipment
Room: Monroe
Sponsor: 6.1 Hydronic and Steam Equipment and Systems, 5.1 Fans
Chair: Carrie Anne Crawford, Associate Member, Not Applicable, Austin, TX

Fan energy optimization, efficient heating systems installed properly and long-term envelope protection are key elements of an integrated building system design for efficient, quiet, comfortable, resilient, airtight construction. Challenges, solutions and case studies for proper fan selection for comfort, energy efficiency and proper air distribution in commercial building applications are provided. High performance hydronic systems to complement airside delivery in these applications are discussed. Strategies for proper integration of the air and water barrier with the envelope and perimeter mechanical systems for airtight construction and durable performance are reviewed.

1. Fan Laws Are Broken at Your Peril: Strategies for Comfort with Careful Fan Selection
***Ginger Scoggins, P.E., Member**, Engineering Designs, Cary, NC*

This presentation discusses the history and importance of understanding the three basic fan laws (“affinity” laws) when designing and specifying fans, as well as duct layout do’s and don’ts to keep engineers out of trouble. System effect is described with a demonstration of the impact of system effect on improper designs. A case study is provided on a project completed recently that caused significant headaches for all parties involved in the project which could have been avoided if the design engineer had known and utilized the fan laws in advance of the project.

2. Designing for System Efficiency: Are You Making the Grade?
***Jennifer E. Leach, P.E., Member**, Cummins-Wagner Co, Inc., Annapolis Junction, MD*

Ultra-High Efficiency heating water systems are often not operating at design efficiency once the system is turned over to the building owners. With some simple changes to system design and maintenance tasks they can ensure that design efficiency will be maintained through the life of the building. This presentation covers how the utilities connected to the boiler (water, air, vent and gas) can have a great impact on the overall system efficiency.

3. Keeping out the Bad Stuff, Keeping in the Good Stuff: Envelope Systems That Work with Mechanical Systems
***Theresa A. Weston, Ph.D., Member**, DuPont Building Innovations, Richmond, VA*

Energy demand and comfort in high performance buildings relies on minimizing loads and maximizing system efficiency to meet the load. Envelope performance, especially air and water barriers, can have a dramatic effect on space conditioning and air distribution requirements, sizing, and durability. This presentation provides real-world installations that show the positive impact of good envelope designs, and the negative impact of design flaws on HVAC system designs and overall system performance.

8:00 AM - 9:30 AM

Seminar 22 (Intermediate) NY PDH G

How to Thrive During Your Next Natural Disaster: Three Operational Combined Heat and Power Case Studies

Track: Earth, Wind & Fire
Room: Adams
Sponsor: 1.10 Cogeneration Systems
Chair: Timothy Wagner, Ph.D., Member, United Technologies Research Center, East Hartford, CT

Designing for extreme weather events and other possible disasters often requires thinking beyond the norm. Building design and materials are critical for resilient operation, however, assuring building systems operate when the electric grid is down requires increased scrutiny of onsite power systems. Hurricane Katrina, Superstorm Sandy and Winter Storm Nemo provide informative case studies on the CHP installation economics, normal operation and performance during a major natural disaster and the impact of operations during these events.

1. Hurricane Katrina and Jackson Memorial Hospital's 3.5 MW CHP System
***Gearoid Foley, Member**, Integrated CHP Systems Corp., Princeton Junction, NJ*

Jackson Memorial Hospital was one of the few facilities that operated throughout Hurricane Katrina and the aftermath when the electric grid was down. The hospital's main source of power during this period was their CHP plant which provided electric as well as thermal energy in grid isolation mode. This seminar provides insight into the design of the CHP system for this facility as well as general design guidelines for resilient CHP applications at hospitals that allow for near normal operation through natural disasters.

2. Superstorm Sandy and Princeton University's 15 MW CHP System
***Richard Sweetser, Life Member**, Exergy Partners Corp., Herndon, VA*

The heart of Princeton's microgrid is a gas turbine CHP system capable of producing 15 MW. On sunny days, this power is supplemented by a 4.5-MW solar field. Princeton's microgrid normally operates connected with the local utility. The initial motivation to build a CHP plant was to reduce lifecycle costs, the school also benefits from a much lower carbon footprint and higher reliability. During Super Storm Sandy Princeton's critical research projects and computing services continued uninterrupted by the storm. This seminar describes the CHP based microgrid, its normal operation, economics and performance through Super Storm Sandy.

3. Winter Storm Nemo and Frito- Lay's 4.2 MW CHP System
***Bruce Hedman, Dr.Ing.**, Entropy LLC, Alexandria, VA*

Frito-Lay North America, Inc. installed a gas turbine CHP system at its food processing plant in Killingly, Connecticut, in 2009. Designed to be electric load following, the system meets 100% of the plant's electrical power needs and provides a majority of the annual steam need. The system has kept the plant running through numerous outages since its installation, including Winter Storm Nemo, the February 2013 blizzard that paralyzed much of the Northeast. This seminar describes the decision process to install CHP, and its performance through the storm that covered the area with three feet of snow.

8:00 AM - 9:30 AM

Seminar 23 (Intermediate) NY PDH G

New Code Requirements for Protecting HVAC&R Components from Extreme Events

Track: Standards, Guidelines and Codes
Room: Empire
Sponsor: 2.7 Seismic and Wind Resistant Design
Chair: Harold Dubensky, Member, Johnson Controls, Inc., York, PA

The presentations cover the latest building codes with regards to protecting HVAC components from seismic and wind events, as well as the International Building Code requirements and specific rules addressed by ASCE 7. Seismic and wind loading on HVAC components is reviewed and restraints that keep the components in place after these events. The presentations also include an overview of the best practices, industry recommendations, and clarification of ASCE 7 updates. Finally, research that is on the forefront of the HVAC&R industry is introduced.

1. Overview (FEMA) of Best Practices and Industry Recommendations
***Scott Campbell, Ph.D., Member**, Structural Analysis Consulting Group, Milwaukee, WI*

Current practice in wind and seismic restraint of HVACR equipment goes beyond formal codes and standards to include guidelines and rules of thumb. In addition, some of the requirements are not easy to find and often overlooked. This seminar discusses those items affecting HVAC restraint design that are outside of ASCE 7, and also includes information on upcoming changes in those documents.

2. Updates of Seismic Load Design Requirements for HVACR Components
***Karl Peterman, Member**, Vibro-Acoustics, Markham, ON, Canada*

Standard ASCE/SEI 7, Minimum Design Loads for Buildings and Other Structures, is the basis for the structural load design requirements in most national, state, and local building codes. The previous version, ASCE/SEI 7-10, is adopted by reference in the 2012 and 2015 IBC's. The newest edition of the standard, which was published last year, will be the basis of the 2018 IBC. ASCE/SEI 7-16 includes changes to the seismic load provisions that will affect the design and selection of various HVACR components and restraints. This presentation highlights the significant changes that will have an impact on the HVACR industry.

3. Significant Changes to the Wind Load Design Requirements for HVACR Components
***Panos Papavizas, Member**, Baltimore Aircoil Company, Jessup, MD*

Standard ASCE/SEI 7, Minimum Design Loads for Buildings and Other Structures, is the basis for the structural load design requirements in model and most national, state, and local building codes. The 2010 edition, ASCE/SEI 7-10, is adopted by reference in the 2012 and 2015 IBC's. The latest edition of the standard, ASCE/SEI 7-16, will be the basis of the 2018 IBC. ASCE/SEI 7-16 includes changes to the wind load provisions that will affect the design and selection of wind-exposed HVACR components and restraints. This presentation highlights the significant changes that will have an impact on the HVACR industry.

9:45 AM - 10:45 AM

Technical Paper Session 2 (Intermediate)

Airflow Modeling and the Effect on Energy Conservation

Track: Systems and Equipment
Room: Chicago
Chair: Yunho Hwang, Ph.D., Member, University of Maryland, College Park, MD

Papers presented in this session address using a performance model to measure and test the efficiency of standard HVAC airflow system equipment, such as DX coils and fan powered-terminal units. Each paper has a different focus including series and parallel terminal units.

1. Modeling Variable Airflow Series Fan-Powered Terminal Units in a Mass and Energy Balance Approach (CH-18-003)
***Peng Yin, Ph.D., Associate Member**, University of Louisiana at Lafayette, Lafayette, LA*

A performance model of series fan-powered terminal units (FPTUs) was developed by combining individual component models of the heating coil, fan/motor combination, and mixer utilizing a basic mass and energy balance approach. The fans and motors for the FPTUs were modeled as a combined fan/motor assembly based on prior published work. The fan motors were all electronically commutated motors (ECMs) and covered a range in size from 1/3 to 1 hp (248 to 746 W). The fan/motor combinations in the FPTU could vary airflow to the zone to meet variation in the zone loads. Two control approaches in cooling mode operations were modeled.

2. Modeling Variable Airflow Parallel Fan-Powered Terminal Units in a Mass and Energy Balance Approach (CH-18-004)
***Peng Yin, Ph.D., Associate Member**, University of Louisiana at Lafayette, Lafayette, LA*

A performance model that is capable of characterizing parallel fan-powered terminal units (FPTUs) in the variable airflow operation was developed in this paper by assembling its component models, namely a heating coil, a mixer, and a variable speed fan, in the mass and energy balance approach. Two configurations of parallel FPTUs were considered with the difference being the heating coil location. In addition, the performance impact of the air leakage from the FPTU housing to the plenum space was captured by integrating a leakage fraction into the model development.

3. Modeling and Testing of Single-Speed DX Air Conditioning System (CH-18-005)
***Nabil Nassif**, North Carolina A&T University, Greensboro, NC*

This paper discusses the development and testing of a single speed DX air coil model to predict compressor power, heat capacity, coefficient of performance COP and supply air temperature and humidity ratio as a function of airflow rate, air conditions entering the coil and outside air temperature. The proposed model is calibrated using nonlinear regression analysis of online data collected from a typical building automation system if installed, short time data measurements, or manufacture's data. The model parameters are determined through nonlinear regression instead of traditional methods with parameters defined at rating conditions.

9:45 AM - 10:45 AM

Conference Paper Session 6 (Intermediate)

Fire Safety Effects on IAQ

Track: Earth, Wind & Fire

Room: Honore
Chair: Samir Traboulsi, Dr.Ing., P.Eng., Fellow Life Member, Thermotrade/Ranec, Beirut, Lebanon
With smoke being the most fatal factor in the event of fire in enclosed areas as it reduces visibility and can cause fatalities by asphyxiation, it is important to be in tune with current research to increase tenability conditions at human level. This session updates attendees on related essentials of green buildings, system designs, technology approaches and high-volume low-speed (HVSL) fan systems.

1. Numerical Investigation of Smoke Control in Switchgear Room (CH-18-C023)
***Essam E. Khalil, Fellow ASHRAE**, Esmail ElBialy, Ph.D., P.E., Mohamed Ibrahim, Dr.Ing. and Mohamed A. Fares, P.Eng., Cairo University, Cairo, Egypt*

Smoke is the most fatal factor in the event of switchgear room fire in power plants. This research presents a numerical study of smoke spread in switchgear rooms. This research investigates the effect of heat release rate resulted from High Energy Arcing Fault (HEAF) on studied parameters which include visibility, carbon monoxide concentration, and temperature at human level Z=1.8 m. Also, effect of exhausting smoke by multi point extraction on the same studied parameters. Fire Dynamics Simulator (FDS) software is used to simulate 7 case studies in 16 m long, 10 m wide and 4.5 m height for switchgear room.

2. Use CFD Modeling Tool to Study Impact of Energy-Saving HVLS Fans on Fire Safety in Large Space (CH-18-C024)
***Xiaolei Chen, Ph.D.**[1] and Frank Wang, P.E.[2], (1) California State University, Los Angeles, CA, (2) Jensen Hughes, Anaheim, CA*

Energy-saving ventilation system has become an essential component of green buildings. Among various systems/approaches, high-volume-low-speed (HVSL) fan systems, are considered effective means of reducing energy consumption/operation cost. This study adopts a performance-based approach, a CFD tool-FDS to evaluate whether the intense airflow of HVLS fans would affect activation of fire detection systems such as beam/smoke detectors, aggravate smoke/fire development at early stage of fire, and impose stress on smoke control systems. It is recommended that the implementation of such systems draw attention from all stakeholders regarding its fire safety risks, and design guidelines be provided in future edition of codes/standards.

3. Atrium Smoke Management in Commercial Buildings (CH-18-C025)
***Essam E. Khalil, Fellow ASHRAE**, Mohamed M.A. Hassan, Ph.D., Hatem O. Haridi, Ph.D. and Mohamed M. Ahmed, P.Eng., Cairo University, Cairo, Egypt*

Smoke is the major killer in the event of building fire.This research investigates the effect of exhausting smoke by multi point extraction through rooftop exhaust fans on smoke layer height and tenability conditions at human level. Fire Dynamics Simulator (FDS) software version 6.1.2 is utilized for four study cases in an atrium with triangular shape with area 400 m^2 and 25m height Parameters in this paper are visibility, temperature and carbon monoxide concentration inside the atrium. Finally, results show that increasing the distance between atrium floor and make-up air inlets adversely affect smoke layer height and reduce tenability conditions at human level.

9:45 AM - 10:45 AM

Conference Paper Session 7 (Intermediate)

Increasing System Performance

Track: Fundamentals and Applications
Room: State
Chair: Roger Lautz, P.E., Member, Affiliated Engineers, Inc., Madison, WI
Optimizing the energy used to move water and air and ventilate buildings is a key requirement for an energy efficient building. The first presentation provides a comprehensive look at ways to most effectively minimize the pump energy used in a building. The second shows how the use of CFD can improve the design of mid-level mixing systems for better comfort and energy efficiency in large, tall, multi-zone spaces. The final presentation presents a case study showing how ASHRAE Standard 62.1 was used in the design of a high efficiency geothermal event center.

1. Pump Systems Optimization for Commercial Buildings (CH-18-C026)
***Greg Pimento, P.Eng.**[1] and Mark Sullivan[2], (1) Armstrong Fluid Technology, Toronto, ON, Canada, (2) Hydraulic Institute, Parsippany, NJ*

Commercial buildings fluid transfer processes include pumps as part of heating, cooling, water heating pressure boosting, wastewater and refrigeration systems. These pump-based systems consume more than 35 percent of a building's energy. Intelligent pumping solutions can improve energy performance and reliability while lowering operational costs for commercial buildings. The Hydraulic Institute discusses the primary factors in improving the energy performance of a pump system covering; System and operational requirements, installing the right-sized pump for the system requirements and Proper control methods for service. Utilizing the best building industry practices for maintaining and repairing the components of a building pumping system.

2. Zone Specific Airflow Rate Optimization by Incorporating PI Controller in a General Purpose Commercial CFD Code (CH-18-C027)
***Andrew N. Page, Affiliate** and Deepak Kandra, P.E., Arup, New York, NY*

Flow rate requirements for conditioning large tall multi-zone spaces utilizing mid-level mixing ventilation scheme are typically optimized using Computational Fluid Dynamics (CFD). Traditional CFD modelling techniques for airflow rate optimization involve simulating several design iterations, analyzing results from individual analysis and eventually making an analytically

driven design decision. A case study is presented where a Proportional-Integral controller is incorporated within a general purpose commercial CFD code to optimize flow rates and achieve uniform temperature distribution objective in such a space. This presentation covers the methodology employed and compares the performance of baseline and optimized designs.

3. Case Study: Prestigious Event Center Achieves Sustainability Goals Using the Indoor Air Quality Procedure of ASHRAE Standard 62.1 (CH-18-C028)

***Marwa Zaatari, Associate Member**, enVerid Systems, Needham, MA*

Balancing energy efficiency and ventilation needs of a high occupancy project or a project with contaminated outdoor air is one of the most challenging aspects a design team faces. This session covers a comparison of ventilation technologies and the ASHRAE ventilation procedures that best suits them, the LEED alternative compliance pathway for documenting with the IAQ Procedure, the developing industry of sorbent-based air cleaning technology, design considerations for high occupancy spaces, and a real world case study - how Shelby Farms Park Event Center (LEED Registered) in Tennessee designed a high-efficiency geothermal event center, overcoming cooling capacity limitations.

9:45 AM - 10:45 AM

Seminar 24 (Intermediate)

Building Automation Solutions to Code Compliance Challenges in Hospitals

Track: Standards, Guidelines and Codes

Room: Red Lacquer (4th Floor)

Sponsor: 1.4 Control Theory and Application, 9.6 Healthcare Facilities, 7.5 Smart Building Systems

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

Progressive hospitals are leveraging their building automation systems to document compliance with the codes and standards required by various regulatory agencies for medical service accreditation. The quantity and penetration of smart devices used in every facet of health care spaces is increasing at remarkable rates. The first speaker describes the recent advances in available tools and methods used to automate the collection and presentation of smart device data for compliance reporting. The second speaker presents strategies for retrocommissioning building automation systems in hospitals while meeting their enhanced code requirements.

1. Harvesting Data in Smart Hospitals for Code Compliance Reporting

***Daniel Farrow**, Palomar Health, San Diego, CA*

The quantity and penetration of smart devices used in every facet of health care spaces is increasing at remarkable rates. Applied to healthcare, IoT includes intelligent convergence and integration of sensor data collected via medical devices and mobile technologies. With the ultimate goal of a single user interface to control and monitor all hospital smart systems, this seminar introduces the concept of a “building automation dashboard.” The presentation describes how building automation dashboards are revolutionizing the healthcare industry by assisting in compliance reporting.

2. Retrocommissioning Strategies to Save Energy in Existing Hospitals

***Joseph Kilcoyne, P.E., Member**, SC Engineers, Inc., San Diego, CA*

California’s code requirements for hospital facilities are among the most restrictive in the nation. Requirements for pressurization, temperature and humidity control, air change rates and filtration prevent most designers from attempting to implement energy saving control strategies common to commercial spaces. This seminar presents proven strategies to implement RCx measures while meeting and exceeding the requirements of the California Mechanical Code. Typical savings and payback periods, case studies and lessons learned will be presented.

9:45 AM - 10:45 AM

Seminar 25 (Intermediate)

Modeling and Metrics for Data Center Performance

Track: Modeling Throughout the Building Life Cycle

Room: Empire

Sponsor: 9.9 Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment

Chair: Nick Gangemi, Life Member, Northern Air Systems, Rochester, NY

The only metric in common use for measuring data center performance is PUE. Yet, PUE is criticized because other than power delivery, PUE does not measure data center performance. This seminar describes a first step by The Green Grid to measure, predict and display cooling performance using the Performance Indicator so that business and technical stakeholders can understand cooling performance. A case study uses modeling to help save energy and dollars even environment to protect the IT is the top priority. The seminar concludes using case study data to look at what is needed to measure and model successfully.

1. The Performance Indicator: A Data Center Cooling Performance View

***Mark Seymour, CEng, Member**, Future Facilities Ltd, London, United Kingdom*

Following the development of PUE by The Green Grid (TGG) more than 10 years ago, it has been adopted as a common standard of performance measurement of data center energy efficiency. Although in common use it is criticized because of the possibility of ‘gaming’ the calculation, but importantly because it is an incomplete metric. As a step towards a more complete view, TGG

developed The Performance Indicator, a view showing efficiency alongside effectiveness. The view can be used by technical and business stakeholders alike. This seminar presents the basis of PI and why you should use it.

2. Using Modeling and Metrics to Improve the Citigroup Flextech Upgrade

***Christian Pastrana, P.E., Associate Member**, Citigroup, New York, NY*

When Citigroup wanted to improve their NYC data center's efficiency without compromising its performance, they built a detailed CFD model of their data center, and used the simulation results to pinpoint thermal issues. Citigroup then used the model to design and simulate solutions to these issues, resulting in the potential for over $400,000 of annual energy cost savings and a 4-month ROI after implementation. This presentation explains the use of modeling and metrics in the context of a case study and culminates showing that the performance metrics have been improved satisfying the business targets.

3. Quantifying Data Center Cooling Performance

***Kourosh Nemati, Ph.D.**, Future Facilities Incorporated, New York, NY*

The only metric in common use measuring data center performance is PUE. Yet, PUE only indicates power delivery effectiveness and doesn't represent data center cooling performance. The latter has considerable impact on PUE. There is a need for more complete metrics. This presentation looks at The Green Grid's Performance Indicator (PI) and, with a view to a possible LBNL future project to establish a more complete data set and guidance, it considers what data is readily available, Performance Indicator view for data centers already assessed and how your target PI score might depend on your data center type.

9:45 AM - 10:45 AM

Seminar 26 (Basic) NY PDH G

Steam System Fundamentals and Applications

Track: Fundamentals and Applications

Room: Monroe

Sponsor: 6.1 Hydronic and Steam Equipment and Systems, Student Activities Committee

Chair: Rex Scare, P.E., Member, Armstrong International Inc, Three Rivers, MI

This seminar covers the physical properties of steam and their relationship to pressure as well as an overview of basic steam system design and measures to increase efficiency. Additional topics include flash steam, steam dryness and superheated steam. This seminar presents a better understanding of how, when and where to use steam systems. System schematics and components are discussed as well as the difference in system and component efficiencies.

1. Steam System Fundamentals

***Robert Feeman**, Armstrong International Inc, Three Rivers, MI*

This seminar covers the physical properties of steam and their relationship to pressure as well as an overview of basic steam system design and measures to increase efficiency. Additional topics include flash steam, steam dryness and super-heated steam.

2. Steam System Applications

***Justin Westmoreland, P.E., Member**, aesc - Alternative Energy Systems Consulting, Fresno, CA*

This seminar gives a better understanding of how, when and where to use steam systems. System schematics and components are discussed as well as the difference in system and component efficiencies.

9:45 AM - 10:45 AM

Seminar 27 (Basic) NY PDH G

Urban-Scale Energy Modeling, Part 7

Track: Tall Buildings

Room: Adams

Sponsor: 1.5 Computer Applications, 9.12 Tall Buildings, 4.7 Energy Calculations

Chair: Joshua New, Ph.D., Member, Oak Ridge National Lab, Oak Ridge, TN

Development of urban-scale building energy models is becoming increasingly tractable for many applications including city-wide energy supply/demand strategies, urban development planning, electrical grid stability and urban resilience. This seminar has assembled several researchers with capabilities in the field of urban-scale energy models to discuss an overview of the field as well as the data, algorithms, workflow and practical challenges addressed in their applications involving creation of useful models of individual and tall buildings at the scale of a city, urban or metropolitan area.

1. Micro Environment in City of Chicago and Impacts to UBEM

***Luke Leung, P.E., Member**, Skidmore, Owings, & Merrill LPP, Chicago, IL*

Urban environment has city canyons and tall buildings that create microclimates. Current weather files are typically 10 meters above grade, at the airport and do not address tall buildings very well. Some suggested using weather files nearby with a regular temperature lapse rate is good enough. This discussion focuses on actual environmental data (climatic and contaminants) measured in Chicago and the effort of Argonne National Lab through the "Array of Things" to collect city data (including

climatic factors, contaminants, cloud coverage), and how that can impact natural ventilation, energy modeling, wellness of occupants and energy consumption.

2. Sources of Errors in the Physical and Computational Modeling of Wind in the Urban Realm

***Duncan Phillips, Ph.D., P.E., Associate Member**, RWDI, Guelph, ON, Canada*

CFD vs. Wind Tunnel: there are many sides to the debate about which is better for modeling airflow around buildings and developments. In some cities, there are examples of problematic wind conditions around the base of buildings where CFD and windtunnel testing were done during design: but problems still exist. In 2016, the City of London (UK) commissioned a study to evaluate how wind tunnel and CFD can result in incorrect answers. This seminar summarizes this work providing answers to how both techniques can contribute to a solution, but also identify how they can fail.

11:00 AM - 12:00 PM

AHR Expo Session 1 (Intermediate)

Senses and Cents: Reducing Sound, Improving Comfort and Enabling Energy Efficiency in Residential Buildings

*Track: Residential Mini Track @ Expo**

Room: S101A

Sponsor: 6.1 Hydronic and Steam Equipment and Systems, 5.2 Duct Design, Residential Building Committee

Chair: Lew Harriman, Fellow ASHRAE, Mason-Grant Consulting, Portsmouth, NH

People complain about a lot of stuff, but when it comes to residential heating and cooling systems it's all about the noise, discomfort and forking out money to an unfriendly utility. Learn to apply the fundamentals in duct and pipe design for the benefit of your client's senses and cents.

1. Goldie Locks Was a Wethead: Fluid Flow, Not Too Fast and Not Too Slow…Just Right for Quiet, Comfortable and Efficient Systems

***Robert Bean,P.L.(Eng.), Member**, Indoor Climate Consultants Inc., Calgary, AB, Canada*

Noise, discomfort and inefficiencies in residential hydronic systems are attributable in part to poor selections in pipe and control valves. Solving the challenges begins with an understanding of the hydraulics in hydronics.

2. The Big Bad Wolf Was an Airhead: Huffing and Puffing and Blowing the House Down Is Not a Prerequisite for Duct Design

***Allison Bailes, Ph.D., Member**, Energy Vanguard LLC, Decatur, GA*

When residential air distribution systems result in noise, comfort problems and high energy bills, the causes often can be traced back to poor selections in ducts, fittings and registers. Solving the challenges begins with an understanding of the pressures and velocities in air systems.

11:00 AM - 12:00 PM

AHR Expo Session 2 (Intermediate)

Lubricant Changes for Low GWP Next Generation Equipment

*Track: Refrigerant Mini Track @ Expo**

Room: S101B

Sponsor: 3.4 Lubrication, MTG.LowGWP Lower Global Warming Potential Alternative Refrigerants

Chair: Edward Hessell, Ph.D., Associate Member, Chemtura Corporation, Middlebury, CT

This seminar focuses on the lubricant changes and challenges needed for next generation refrigerants and replacement for R123, R134a, R404A and R410A.

1. Lubrication Considerations for Lower GWP R-410A Alternatives

***Julie Majurin, Associate Member**, CPI Fluid Engineering, Midland, MI*

The industry has made significant progress in developing, evaluating and beginning to implement lower GWP refrigerant alternatives as interim or long-term HCFC and HFC replacements. These efforts are enabled through empirical assessments of existing or optimized lubricants with the new fluids, and in some cases development of new lubricant formulations to meet the reliability and efficiency requirements of the application. This presentation covers lubrication considerations for multiple R-410A alternatives as they relate to factors such as oil return (miscibility), bearing life (working viscosity and solubility) and compressor discharge temperature (chemical stability) relative to baseline R-410A performance.

2. Understanding Lubricant Requirements for Next Generation Low Global Warming Potential Refrigerants

***Ed Hessell, Ph.D., Associate Member**[1] and Roberto Urrego, Associate Member[2], (1)Chemtura Corp., Fords, NJ, (2)Chemtura Corporation, Middlebury, CT*

This presentation covers some fundamental data on the solution properties of polyolester lubricants in combination with select low global warming potential refrigerants such as R-32, R-1234ze, R-290 as well as HFC/HFO mixtures. The data provides

insight into potential lubrication issues associated with the commercialization of next generation refrigerants but also suggests opportunities where the proper optimization of the refrigerant/lubricant pair can improve system performance.

3. Lubricant Changes for Low GWP Next Generation Equipment

***Joe Karnaz, DSc, Member**, Shrieve Chemical, Houston, TX*

Transition is upon us again in regards to moving to low GWP next generation refrigerants. As in the past, refrigerant changes require investigation into how this effects the current lubricants that are used or alternate lubricants to be used. Sometimes certain changes bring about opportunity to explore what's next for the market and industry. This presentation reviews lubricant development for refrigerant changes; what was needed then when considering an effective lubricant and refrigerant combination. The presentation also looks forward at market focused low GWP next generation refrigerants that are being considered and how this will impact lubricant selection.

11:00 AM - 12:00 PM

Conference Paper Session 8 (Intermediate)

HVAC in Critical Environments

Track: Fundamentals and Applications

Room: Honore

Chair: John Dunlap, Fellow Life Member, Dunlap & Partners, Richmond, VA

The proper design and operation of HVAC systems serving critical environments such as health care facilities and laboratories is vital to maintaining safe environments for patients and occupants. A case study of an operating room system designed to meet specified microbial contamination requirements is presented. An analysis of energy saving options for a hospital facility is also shared. Finally, a study of laminar airflow diffusers using computational fluid dynamics for spaces such as laboratories and operating rooms is presented.

1. Constructing Operating Room HVAC with Performance Assurances; An Alternate Approach (CH-18-C029)

***Travis English, P.E., Member**, Jessica Grey and Nabil Mikhail, P.E., Member, Kaiser Permanente, Anaheim, CA*

Performance tests of operating rooms are common in Euorpe. This presentation details a performance-based approach, in the US. The operating room is designed, built and then tested for sterile performance. The final test assures the space achieves sterility prior to acceptance by the owner. Several vendors offer integrated OR ceilings, adapting technology from the clean room industry. One owner solicited proposals, interviewed vendors and selected a vendor for an agreement to provide operating room ceilings on future projects. The agreements between the two parties is shared. It includes testing to meet ISO 14644 Class 6 and 10 CFU/m3.

2. Modeling a Healthcare Facility in South Louisiana for Evaluating Potential Energy Savings (CH-18-C030)

***Zahra Sardoueinasab**[1], Sally Anne McInerny, Ph.D., P.E., Member[1], Peng Yin, Ph.D., Associate Member[1] and Chris Morgan[2], (1)University of Louisiana at Lafayette, Lafayette, LA, (2)CD Morgan and Associates, Lafayette, LA*

A hospital model was developed in EnergyPlus and validated with the utility data to evaluate potential opportunities for saving energy in healthcare facilities. Three energy efficient measures were implemented in the developed model, including reducing lighting power density, installing high efficiency windows and the combination of both approaches. Simulation results showed 12% and 1% annual energy savings by reducing the lighting power density and using high efficient windows, respectively. The combination of both approaches reduces the annual energy consumption by 13% based on the simulation results.

3. Dynamics of Semi Unidirectional Air Flow (CH-18-C031)

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

Perfectly unidirectional (laminar) flows are rare. In most cases the flows are "semi unidirectional" – unidirectional only in the core of the supply air stream and recirculating/mixing in the other locations. This CFD study analyzes behavior of such semi unidirectional flows under isothermal and non-isothermal conditions. Under isothermal conditions the discharge velocity has little impact on the flow behavior of the supply air jet. Under non-isothermal conditions the discharge velocity can significantly affect the directionality of the flow. The entrainment of hot air into the downward moving jet cause acceleration in the centerline velocity.

11:00 AM - 12:00 PM

Conference Paper Session 9 (Intermediate)

Optimizing Heat Exchanger Performance

Track: Heat Exchange Equipment

Room: Chicago

Chair: Michael Sherber, P.Eng., Member, The Firma Group, Inc., Rocky Hill, CT

Analysis of different heat exchanger applications, including review of performance and heat exchanger configuration is presented. The potential for a bare tube heat exchanger (coil) along with configuration and operational issues is considered. Fouling effects on the air side of a refrigerant to air condenser coil is reviewed. Finally, an analysis of challenges and benefits of incorporating condensing gas-fired heat exchangers in packaged rooftop units is also shared.

1. Airside Thermal and Hydraulic Performance of a Bare Tube Heat Exchanger with Diameter of 0.8 Mm under Dehumidifying Conditions (CH-18-C032)

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

Recently it was found that finless bare tube heat exchangers can deliver two times higher air-side heat transfer performance than ones with fins under dry conditions. In current study, the thermal and hydraulic performance of a novel bare tube heat exchanger prototype, manufactured by using stainless steel tubing with outer diameter of 0.8 mm, was experimentally investigated under dehumidifying condition using air and water. New correlations for air-side heat transfer coefficient and friction factor were developed based on new experimental data and the mean deviations of proposed correlations are all within ±10%.

2. Development of a Method for Testing Air-Side Fouling Effects on Outdoor Heat Exchangers (RP-1705) (CH-18-C033)

***Mehdi Mehrabi, Student Member** and David P. Yuill, Ph.D., P.E., Member, University of Nebraska, Omaha, NE*

This paper describes an ongoing project that focuses on the effects and characteristics of condenser airside fouling and a method to realistically mimic fouling deposition in a laboratory. A test apparatus was designed and built to study the heat transfer and air-side pressure drop through different coils before and after cleaning the condenser. A test method is proposed to characterize air-side fouling effects for any given heat exchanger design, independent of the condenser fan's performance. One potential outcome of this work is that it will facilitate design of heat exchangers that are less sensitive to air-side fouling.

3. Field Evaluation of Condensing Heating Rooftop Units (RTUs) in 100% Outside Air Applications (CH-18-C034)

***Patricia Rowley, Associate Member**[1], Douglas Kosar, Member[1], Paul Glanville, P.E., Associate Member[1], Shawn Scott[1], Sam Halasa[2] and Wayne Fang[3], (1)Gas Technology Institute, Des Plaines, IL, (2)Beckett Gas Inc., North Ridgeville, OH, (3)Munters Corporation, Selma, TX*

Although widely offered in furnaces, boilers and water heaters applied indoors, the introduction of condensing gas-fired heating in packaged rooftop units (RTUs) has been slowed by both economic and technical challenges. Larger ventilation or make-up air applications have been identified as the most cost effective early market entry point for >90% efficient condensing heating RTUs. This paper summarizes findings from multiple field demonstrations of dedicated outdoor air systems (DOAS) with condensing heating technology, including gas savings and cost effectiveness based on net energy and maintenance costs. Technical challenges will be addressed through a review of condensate management practices.

11:00 AM - 12:00 PM

Seminar 28 (Advanced) NY PDH G

Development of a Unified Tool for Analysis of Room Loads and Conditions

Track: Fundamentals and Applications

Room: Monroe

Sponsor: 6.5 Radiant Heating and Cooling

Chair: Peter Simmonds, Ph.D., Fellow ASHRAE, Buildings and Systems Analytics, Marina Del Rey, CA

This research creates a single tool that includes all of the necessary algorithms to complete the tasks of calculating heat balance and radiant energy exchange in a space. This is particularly important for predicting the performance of spaces that incorporate radiant components, but is equally important to evaluating any space's passive performance during intermediate seasons. To properly assess the radiant exchange in a space the dynamic interactions of a space involving conduction, mass storage, radiant exchange between surfaces and convection heat transfer must be predicted.

1. The Theory and Background behind Radiant Performance Explorer/Heat Balance

***Chip Barnaby, BEMP, Fellow ASHRAE**, Retired, Lexington, MA*

The primary tangible result of the project is the Radiant Performance Explorer/Heat Balance (RPEHB), a PC-based Windows application that calculates and displays comfort results for multiple positions within an arbitrarily shaped room. The technical heart of the work is development of a method that calculates view factors from an arbitrarily-positioned occupant to all surfaces of an arbitrarily-shaped space. The method supports any number of room surfaces, each with any number of child surfaces (e.g. windows or radiant panels). The space and its surfaces can be non-convex, so troublesome cases such as L- or U-shaped rooms can be analyzed.

2. Practical Applications of a Radiant Performance Explorer/Heat Balance Module

***Peter Simmonds, Ph.D., Fellow ASHRAE**, Buildings and Systems Analytics, Marina Del Rey, CA*

The objective of this work was to produce a unified space analysis application that calculates and displays room conditions, heating and cooling loads (delivered by air-based and/or radiant systems) and mean radiant temperature (MRT). The inputs for RPEHB calculations will be room shape, construction, operational requirements (e.g. control set points) and design-day weather conditions. Preparation of geometric input data will be supported by import from 3D tools such as SketchUp. This presentation illustrates the practical applications of the RPEHB module.

11:00 AM - 12:00 PM

Seminar 29 (Intermediate)

Fan Energy Savings and System Efficiency Increase by Using the Fan Energy Index

Track: Systems and Equipment

Room: Empire

Sponsor: 5.1 Fans, 5.9 Enclosed Vehicular Facilities

Chair: Joe Brooks, P.E., Member, AMCA International, Arlington Heights, IL

This seminar introduces the FEI. It was first developed by AMCA, refined with input from industry at large, and is awaiting adoption as part 6 of ISO standard 12759. The FEI is the ratio of the electric power consumption of a selected fan to a baseline fan power, both at a given airflow and pressure point. The FEI provides a tool for effective fan selection and application and will help to improve energy savings through energy codes and utility programs.

1. Fan Energy Index Defined

***Tim Mathson, Member**, Greenheck Fan Corporation, Schofield, WI*

The FEI metric was developed in order to properly evaluate fan suitability for a given performance requirement. This metric is defined and explained in detail, including how it can be used to establish maximum power allowed for a given application.

2. Fan Selection Using FEI

***Armin Hauer, Member**, ebm-papst, Farmington, CT*

This new fan efficiency metric was developed for use in fan regulation, but has additional benefits for engineers. Armed with a simple understanding of FEI, design engineers can easily specify and effectively hold their design intentions. This presentation covers weaknesses of some other fan efficiency metrics and shows with examples how the FEI will quickly become a favorite of HVACR engineers.

11:00 AM - 12:00 PM

Seminar 30 (Intermediate)

From Concept to Commissioning: How to Get a 1,000 Ton Chiller Plant in a +60 Story Condominium Building

Track: Tall Buildings

Room: Red Lacquer (4th Floor)

Sponsor: 7.9 Building Commissioning, 9.12 Tall Buildings

Chair: Francis Kohout, P.E., Member, Cyclone Energy Group, Chicago, IL

A 64-story high-rise condominium building in Chicago (340 on the Park) commissioned a study which led to the installation of a chilled water plant built at the top of the building to disconnect them from a district chilled water source. This session reviews the project feasibility, economics, design methodology, project delivery, construction challenges and ongoing operations of the new system.

1. Proposing, Managing and Commissioning the New Chiller Plant

***Francis Kohout, P.E., CPMP, Member**, Cyclone Energy Group, Chicago, IL*

This presentation presents the process required to install a new chiller plant on top of a high rise condominium, from inception through commissioning and final ownership.

2. The Owners Perspective on Installing a New Chiller Plant in an Existing Condominium Building

***Amy Eickhoff**, Lieberman Property Management, Chicago, IL*

This presentation provides insight into the considerations and decisions made by the building's owners as part of the cooling plant's installations process.

3. Designing and Installing a New Chiller Plant on Top of an Existing Tall Building

***Owen Putman, P.E.**, Hill Mechanical Corp, Chicago, IL*

This presentation features the unique challenges associated with installing a new chiller plant in an existing building, 64 stories above the ground.

11:00 AM - 12:00 PM

Workshop 3 (Intermediate)

ASHRAE Building Energy Quotient: A Building Rating System and More

Track: Fundamentals and Applications

Room: Adams
Sponsor: 1.5 Computer Applications, Building EQ Committee
Chair: Bill Klock, P.E., Member, EEA Consulting Engineers, Austin, TX
ASHRAE is in the process of introducing an updated version of Building Energy Quotient (Building EQ). A web portal for data entry and building energy evaluation is coming online in Fall 2017. This workshop gives an overview of the Building EQ rating system, explains the web portal a bit, and talks about some of the marketing initiatives being taken to promote this rating system to building owners and other interested parties.
1. The Methodology of Building EQ
***Charles Eley, P.E., BEMP, Member**, Eley Consulting, San Francisco, CA*
ASHRAE's Building EQ is a rating program, but more. It produces both In Operation and As Designed ratings, but also interfaces with building auditing procedures to help building owners and managers improve the energy efficiency of their buildings. This presentation reviews the methodology and procedures underlying Building EQ and lay the groundwork for the new web portal which makes it easier to submit and review rating applications.
2. A Discussion of the New Building EQ Web Portal
***Stephen Roth, P.E., Member**, Carmel Software Corp., San Rafael, CA*
This workshop discusses the new Building EQ web portal including advantages over the current Building EQ spreadsheets that are used. The discussion covers how the web portal will help increase adoption of the Building EQ rating system and also how it will help ASHRAE personnel better be able to validate information and approve submissions much more quickly and easily.

11:00 AM - 12:00 PM
Workshop 4 (Intermediate)
Code Red: Is your Facility Prepared?
Track: Earth, Wind & Fire
Room: State
Sponsor: 9.6 Healthcare Facilities
Chair: Robert Cox, P.E., Member, Jacobs Carter Burgess, Cary, NC and Mark Tome, Member, CESI
Defend in place is a key element of disaster planning for hospitals and nursing homes. Inpatient and residential health facilities rely on carefully developed plans for isolating fire and smoke and limiting its spread to maintain the delivery of patient care and keep patients and staff safe so that evacuation of patients and cessation of operations is avoided to the fullest extent possible. This workshop discusses fundamentals of defend in place strategy and typical field observations for open discussion.
1. What, Why, and How to Defend-in-Place in Hospitals
***Michael Meteyer, P.E., Member**, Erdman Companies, Madison, WI*
A fire in a hospital is a horrifying situation to imagine. Having a well-planned defend-in-place firefighting strategy is critical to minimize its impact. This presentation provides a review of the code requirements and discusses the various elements related to HVAC systems such as fire/smoke damper operation and control, smoke isolation zones, air-handler sequences and functional testing requirements and best practices.
2. Code Red: Is Your Facility Prepared?
***Ronald Westbrook, P.E., Member**, State University of New York Upstate Medical University, Syracuse, NY*
Large hospitals with continually changing service lines can create havoc with the maintenance of fire and smoke detection and protection systems. Even small changes can have large impacts when departmental boundaries change without consideration of how those changes can affect disaster planning. Incorrect air balancing can cause fire doors to not secure properly. Fans needed for delivery of patient care service may shutdown inadvertently by fire command or not at all. Care must be taken during planning and design to ensure coordination between equipment operation, fire and life safety systems, and departmental disaster plans to ensure continuation of operations and prevent having to evacuate patients.

1:00 PM - 2:30 PM
AHR Expo Session 3 (Intermediate)
Real-World Experience Providing Residential Energy Excellence
*Track: Residential Mini Track @ Expo**
Room: S101A
Sponsor: 2.8 Building Environmental Impacts and Sustainability, Residential Buildings Committee
Chair: Carrie Anne Crawford, Associate Member, Not Applicable, Austin, TX
High performance residential buildings combine modeling skills, designs for sustainable performance, installation practices that implement the integrated designs and strategies that satisfy a diverse set of occupant needs without penalizing energy performance or indoor environmental quality over the life of the building. This seminar highlights the importance of a trained workforce in meeting expected design and performance targets, shows the benefits of modeling to achieve exceptional

performance affordably, compares model predictions with monitored performance in multifamily applications and demonstrates the positive impact of awareness and actionable energy data on occupant behavior when the landlord is paying the energy bill.

1. Five New Multifamily Residential Buildings: Measured Vs. Modeled Energy Consumption
***Katrin Klingenberg**, Passive House Institute US | PHIUS, Urbana, IL*

Passive multifamily buildings' certifications have been increasing exponentially recently. Housing finance agencies recognize the energy, comfort and resiliency benefits of passive buildings, offering target-based incentives to affordable multifamily project developers. The first such projects, ranging from 12-60 units, have been occupied long enough to permit comparison of measured performance data with modeled designs. This presentation highlights modeled passive multifamily building designs compared to ASHRAE Standard 90.1 requirements, establishing by how much passive buildings were expected to exceed code. Modeled results are compared to monitored performance data in five projects. Potential reasons for variances between modeled and actual performance are discussed.

2. Prescriptive Doesn't Work for Buildings so Why Would It Work for a Project Team?
***Kimberly LLewellyn**, Mitsubishi Electric Cooling & Heating, Suwanee, GA*

Acknowledging that prescriptive based building codes and programs are reaching their limit, performance codes are emerging as the preferred approach to meet high performance building objectives. Integrated project teams are also key to achieving these goals, especially on complex projects. However, when it comes to assembling a project team, we undertake this crucial task prescriptively. This presentation provides lessons learned by reverse engineering some failures from roof, to brick, to HVAC starting with the remediation professionals and chasing the process back to the beginning when teams and budgets were being determined prescriptively and without integration with other teams.

3. The U.S. Army Experience: Reducing Energy When Occupants Don't Pay for Utilities
***Katherine Hammack, Fellow Member**, Ernst & Young, McLean, VA*

The US Army is an active residential stakeholder by virtue of its role as both owner and lessee in many housing markets. Over 400,000 barracks spaces for Single Soldiers are under Army control around the world. Army bases also include over 86,000 homes and 5,000 direct lease authorizations. This presentation describes an Army program to enhance resident awareness and education with visible "actionable energy data" that has been able to be achieved improved energy efficiency behavior by these occupants, even though the Army pays the energy bill. Measured performance data shows a 12% reduction in energy consumption through these efforts.

1:00 PM - 2:30 PM

AHR Expo Session 4 (Intermediate)

Some Low GWP Next Generation Refrigerant will be Flammable: What does it mean to be Flammable?

*Track: Refrigerant Mini Track @ Expo**
Room: S101B
Sponsor: 3.1 Refrigerants and Secondary Coolants, MTG.LowGWP Lower Global Warming Potential Alternative Refrigerants
Chair: Steven Eckels, Ph.D., Member, Kansas State University Institute for Environmental Research, Manhattan, KS
This seminar focuses on the fundamentals of flammability, issue in handling flammable refrigerants and ASHRAE and industry funded research into flammable refrigerants. Product and standard changes needed to handle flammable refrigerants are also discussed.

1. Flammable Refrigerant Basics
***Stephen Kujak, Member**, Trane, Ingersoll Rand, La Crosse, WI*

Increasing concerns about the impact of refrigerants on the environment and on climate change are driving new regulatory policies to restrict and lower the global warming potential (GWP) impact of fluorocarbon refrigerants used in the HVAC&R industry. In response, the industry is developing and examining a new class of lower GWP refrigerants. As this transition moves forward, many questions exist about changing refrigerants options and requirements to use them safely. This presentation highlights some important considerations, particularly flammability, that engineers, designers and building owners should keep in mind regarding next-generation refrigerants.

2. Flammability: A Continuum Vs. Discrete Boundary
***Gregory Linteris, Ph.D., Associate Member**, National Institute of Standards and Technology, Gaithersburg, MD*

The concept of gas-phase flammability was developed largely in the context of the use of hydrocarbons for energy. For these compounds, the flammable behavior for the most flammable mixture is unambiguous. For other compounds, however, such as some fluorinated hydrocarbons, the concept of flammability is less well defined. The measurement of flammability is device-dependent and the consequences of an ignition are highly dependent upon the flow-field and configuration. This presentation discusses some examples to illustrate the relevant concepts.

3. AHRI Flammable Refrigerant Research
***Xudong Wang, Ph.D., Member**, Air-Conditioning, Heating and Refrigeration Technology Institute, Arlington, VA*

The presentation provides an overview of the recent AHRI research activities on flammable refrigerants. The activities cover A2L refrigerants leak and ignition testing, A2Ls hot surface ignition temperature testing, examining the potential ignition sources and a summary of the current sensor technologies for A2L refrigerants.

4. Developing Guidelines for Flammable Refrigerant Use
William Goetzler *and Matt Guernsey, Associate Member, Navigant, Burlington, MA*

Several countries outside the U.S. are adopting flammable refrigerants as low-global warming potential (GWP) alternatives to hydrofluorocarbons (HFCs); however, their specific requirements for safe handling and use are generally unknown to the US HVAC&R industry. ASHRAE 1807-TP sought to provide industry with insights on the best, consistent handling practices that can be used in the US to enable the safe use of flammable refrigerants. The presentation covers available requirements and best practices in other countries related to the safe handling, storing and transporting of flammable refrigerants and HVAC&R equipment containing flammable refrigerants from cradle to grave.

2:15 PM - 3:45 PM

Seminar 31 (Intermediate) G

Disrupting the Status Quo with Natural Refrigerants

Track: Systems and Equipment
Room: Chicago
Sponsor: 10.7 Commercial Food and Beverage Refrigeration Equipment, 10.3 Refrigerant Piping, Controls and Accessories
Chair: Shitong Zha, Member, Heatcraft, Stone Mountain, GA

Transitioning away from high global warming potential refrigerants has significantly affected system construction, arrangement and operation when traditional refrigerants are abandoned. This seminar explores how natural refrigerants like ammonia, propane and carbon dioxide are disrupting the status quo and what it means for designers, manufacturers and end users. Low-charge packaged ammonia systems have been used in commercial retail and HVAC applications. Propane is feasible as the sole refrigerant for supermarkets and carbon dioxide is spreading into hotter climates. Design considerations are also reviewed with respect to material compatibility and system architecture, as well as system operation and efficiency.

1. Micro-Distributed: A Simple Solution to Our Refrigerant Challenges
Tom Wolgamot, P.E., CPMP, Member*, DC Engineering, Missoula, MT*

There is significant pressure on the current refrigerant choices in the commercial sector due to their environmental impacts. There are several natural refrigerants which are environmentally benign and also have higher refrigerating capacities. These natural refrigerants each have challenges associated with them in the way of operating pressures, toxicity or flammability. Micro-Distributed systems manage these risks very effectively and while still providing a robust, simple to operate system. This presentation outlines the system architecture, efficiencies and benefits over currently applied systems and other natural refrigerant choices.

2. Low Charge Ammonia Chillers for Broad Applications
Caleb Nelson, P.E., Associate Member*, Azane, Inc., Missoula, MT*

There are several forces acting to shape ammonia into a more widely used refrigerant. Industrially, there is a need to increase safety and avoid regulation. Commercially, there's a need for natural refrigerant solutions that can operate efficiently in hot climates without consuming water. Air-cooled, low-charge, packaged ammonia chillers developed over a decade ago have allowed ammonia to be used in much broader applications around the world. This presentation reviews the unique characteristics of an ammonia system that is fit for broad application. Consideration will be given to charge optimization, system reliability, efficiency sustainability, running costs and maintenance.

3. Piping Solutions for Natural Refrigerants
Chris Mueller, Associate Member*, Mueller Industries, Memphis, TN*

As refrigerant solutions have evolved, so have the demands on the piping systems. Industry standards are slow to change and often don't address current system requirements. Copper piping are proven capable of supporting higher operating pressures than historically assumed. High-strength copper alloy piping has also been proven to support transcritical CO2 systems with UL ratings up to 1860 PSI - previously limited to steel piping. This presentation provides insight to the available solutions with a focus on compatibility, ratings, joints and transitions between various piping materials.

2:15 PM - 3:45 PM

Seminar 32 (Intermediate) NY PDH G

The Art and Science of Delivering Healthy, Productive and Effective Buildings

Track: Fundamentals and Applications
Room: Adams
Sponsor: 2.8 Building Environmental Impacts and Sustainability, CIBSE ASHRAE Liaison Committee (co-sponsored by TC2.8 & TC7.1 & TC7.6)
Chair: Tim Dwyer, CEng, Fellow ASHRAE, UCL Institute for Environmental Design and Engineering (IEDE), London, United Kingdom

This seminar draws on the experience of senior industry practitioners who will show how robust, but not extreme, engineering practice that is accessible to all building professionals delivers buildings that are not just 'fit for purpose,' but can excel in performance and be delivered in time. The speakers present both the high level picture as well as essential details that deliver success. The seminar identifies the essential characteristics required to deliver high performance buildings and then explores real-world examples of project techniques that have a proven record in new-build, retrofit and the critical commissioning process.

1. The Art of High Performance Buildings
***Peter Wong, CEng, Member**, Yook Tong Electric Co Ltd, Hong Kong, Hong Kong*

Efficient and cost effective high performance buildings that deliver comfortable, healthy and productive environments do not necessarily cost more than 'ordinary' buildings.
This presentation explores the art of creating high performance buildings and the essential characteristics of projects that deliver them. It looks at the role of collaborative working, commissioning a building and facilities management in designing, creating and delivering high performance buildings. The presentation also highlights the importance of whole team working at construction, commissioning and operational phases to ensure systems operate as intended and that information and expertise transfers from the construction team to the operational team.

2. Creating Healthy Emergency Rooms for Staff and Patients
***David Clark, CEng, Member**, Stantec, Toronto, ON, Canada*

The project involved a new Emergency and Psychiatric Emergency Services departments and a 6-bed Psychiatric Intensive Care unit for Nanaimo Regional General Hospital - a building project of 6,000m^2 (64,500 ft^2). Significant emphasis was placed on patient and occupant comfort and experience. Using 'Evidence Based Design', several innovative mechanical systems were used including displacement ventilation, radiant heating and cooling and heat recovery. One of the standout features being the geothermal exchange labyrinth. Completed in 2012, this seminar focuses on design features and results of a 2016 post occupancy survey.

3. Retrofitting to Net Zero Energy
***Kevin Hydes, P.E.**, Integral Group, Oakland, CA*

This presentation describes the transformation of a two-story 24,000 sf building from an industrial warehouse to the first zero net energy office in San Francisco. Located in a dense urban environment the team focused on innovation, social responsibility and sustainability. Taking just 10 months from design to completion and with a typical market rate budget was possible by applying “off the shelf” technologies to reduce energy demand, total carbon emissions and improved indoor environmental quality, which has led to 94% occupant satisfaction. The 100% electric building has zero onsite combustion and generates more renewable energy than it consumes.

4. High Performance Buildings Require High Performance Commissioning
***David Green, CEng, CPMP, Member**, CDML, Edmonton, AB, Canada*

Operating and maintaining a building over its life-cycle represents the greatest expense in building ownership. This presentation explains that a key requirement for delivering high-performance buildings that operate efficiently is high performance technical commissioning (HPTC). HPTC is an integrated multi discipline process bridging between the project design and delivery. The primary focus of HPTC is results and not just reports, with emphasis on hands-on inspections, functional testing and verification of building systems performance. Today's successful construction team needs to integrate commissioning and recognize that high-performance buildings are likely to require a higher level of commissioning.

2:15 PM - 3:45 PM
Forum 2

The Future of Standards
Track: Standards, Guidelines and Codes
Room: Monroe
Sponsor: ASHRAE BOD ExCom
Chair: Ginger Scoggins, P.E., Member, Engineering Designs, Cary, NC
The purpose of this forum is to have an open discussion on the future of standards in the world today, focusing on ASHRAE standards and the need for globalization of our standards, as well as how to maximize the impact of our standards for the built environment.

2:45 PM - 3:45 PM
AHR Expo Session 5 (Intermediate)

Keeping Occupants Happy and Healthy Through Affordable and Flexible Air and Water Control Strategies
*Track: Residential Mini Track @ Expo**
Room: S101A
Sponsor: 6.6 Service Water Heating Systems, Residential Building Committee
Chair: Kevin Brown, P.E., Member, ABM Technical Solutions, Atlanta, GA

Hidden opportunities for improving home energy and environmental performance include inexpensive filtration approaches that clear the air we breathe, and simple and reliable water system design strategies that reduce the amount of hot water needed for bathing, washing clothes and washing dishes. This seminar highlights challenges and opportunities to better understand and control exposure to ultrafine particulate matter in homes. Domestic hot water design and control strategies to minimize the amount of water in the distribution system along with optimizing consumption requirements will also be provided.

1. Airborne Particulate Matter in Residences: Challenges and Opportunities for Control
***Brent Stephens, Associate Member**, Illinois Institute of Technology, Chicago, IL*

Human exposure to airborne fine and ultrafine particulate matter (PM) is consistently associated with a variety of adverse health effects in large epidemiology studies using outdoor concentrations as surrogates for exposure. However, much of human exposure to PM of both indoor outdoor origin actually occurs indoors, particularly in residences where people spend nearly 70% of their time, on average. This presentation summarizes the current state of understanding of indoor exposures to PM and highlight several challenges and opportunities to better understanding and controlling PM exposures and associated health effects, with special focus on portable filtration options.

2. Best Practices in Residential Hot Water System Design
***Gary Klein, Associate Member**, Gary Klein and Associates, Inc., Rancho Cordova, CA*

Given the number of choices in flow rates and fill volumes for plumbing fixtures and appliances and the uncertainty of occupancy schedules, how do you select equipment that works well as a system? What can you do in your projects that will give you assurance that the system will satisfy your customers' needs and expectations as efficiently as possible? Using existing data and research results that answer the question "How Low Can We Go; How Close Can We Get?" this presentation discusses best practices to implement the principle of hot-water-as-a-system.

2:45 PM - 3:45 PM

AHR Expo Session 6 (Basic)

Next Generation of Lower or Low GWP Next Generation HVAC&R Equipment

*Track: Refrigerant Mini Track @ Expo**
Room: S101B
Sponsor: 3.1 Refrigerants and Secondary Coolants, 8.2 Centrifugal Machines
Chair: Christopher Seeton, Ph.D., Member, Shrieve, The Woodlands, TX

New lower and low GWP next generation refrigerants are being offered in equipment today in the market place. This seminar focuses on the type of new equipment being offered with lower GWP refrigerants and also includes retrofitting of equipment with high GWP HFC's with lower GWP refrigerants. Seminar topics include discussions on new equipment in the area of chillers, unitary, commercial refrigeration, portable HVAC&R equipment and retrofitting of existing R404A commercial refrigeration with lower GWP refrigerants.

1. Low GWP Refrigerant Alternatives for Chillers
***Barbara Minor, Member**, Chemours Fluorochemicals, Wilmington, DE*

Regulatory actions are leading to the development and investigation of a new class of refrigerants, unsaturated fluorinated and chlorinated hydrocarbons, with dramatically lower GWPs. This presentation provides an overview of the low GWP alternatives for low and medium pressure chillers. This includes the state of understanding and development of these alternatives and their environmental, safety, compatibility and performance. Tradeoffs between GWP, flammability, and specific capacity have been made to utilize these new refrigerants. Some lower GWP refrigerants are beginning to be introduced in many market segments.

2. Low GWP Systems for Commercial Refrigeration
***K.C. Kolstad**, Target, Minneapolis, MN*

The commercial refrigeration sector has been one of the most active looking at new lower GWP refrigerants, both retrofit and new systems designs, because of mounting regulatory pressure on R404A and many older systems still using R-22. This seminar discusses the process, equipment changes and other issues involved in R404A or R22 systems conversions, i.e. retrofits, to R449A. In addition, the retailer discusses their experiences with new lower GWP systems, like CO_2 cascade, CO_2 transcritical and R290 equipment.

3. Key Learnings from Conversions of Commercial Refrigeration Systems to Low GWP Alternatives
***Charles Allgood, Ph.D.**, Chemours, Wilmington, DE*

The search for replacements for HCFC and HFC based refrigerants such as R-22 and R-404A, being phased out globally due to stratospheric ozone depletion and global warming potential issues, has led to the development of low GWP HFO blend alternatives, such as R-449A. This presentation includes the retrofit procedure for HFO refrigerants in low and medium temperature commercial refrigeration systems that were originally designed for HCFC and HFC refrigerants. Also, data obtained

during actual system conversions, including compatibility with seals/lubricants as well as operational and energy performance is reported.

4:00 PM - 5:00 PM

AHR Expo Session 7 (Basic)

ASHRAE's Duct Size Calculator Tool for Easy, Reliable Residential Duct Sizing

*Track: Residential Mini Track @ Expo**

Room: S101A

Sponsor: Residential Building Committee

Chair: Neil P. Leslie, P.E., Member, Gas Technology Institute, Des Plaines, IL

ASHRAE has developed a new duct calculator tool that uses the results of ASHRAE Research to provide practitioners with better and quicker ways to size/design duct systems - particularly for flexible ducts. This seminar discusses the research and methodology underlying the calculator tool and provides demonstrations and examples of how to use it in various residential applications and duct designs.

1. What's Inside ASHRAE's Duct Calculator Tool: How It Works, and Why It Helps

***Charles Culp, Ph.D., Fellow Life Member**, Texas A&M University, College Station, TX*

This presentation summarizes the ASHRAE sponsored research used to develop the new duct calculator tool. This includes a brief description of the experiments that were carried out and the results of those experiments.

2. How You Can Use ASHRAE's Duct Design Tool for Your Job?

***Chris Van Rite, Associate Member**, M&M Manufacturing Co, Fort Worth, TX*

This presentation covers a brief history of flex duct research, options and findings. Data is presented illustrating flex duct performance measurements at various compression levels followed by the averaged data that was used for the duct design tool. Use of the duct calculator tool in residential flex duct applications are highlighted. Illustrations from ducts installed in residential attics are also presented.

4:00 PM - 5:00 PM

AHR Expo Session 8 (Intermediate)

Contaminant Control: What is the Same and What is New When Using Low GWP Refrigerants?

*Track: Refrigerant Mini Track @ Expo**

Room: S101B

Sponsor: 3.3 Refrigerant Contaminant Control, MTG.LowGWP Lower Global Warming Potential Alternative Refrigerants

Chair: William Bradford Boggess, Associate Member, Emerson, Syndey, OH

This seminar focuses on the contaminant control needs, differences and experiences when using next generation low GWP refrigerant containing products.

1. Chemistry Considerations and Contaminant Control for Low GWP Refrigerants

***Joe Karnaz, DSc, Member**, Shrieve Chemical, Houston, TX*

Transitioning to different refrigerants involves a great deal of consideration and effort particularly for new product implementation. OEM's tests their units to make sure their system performance is at least maintained when compared to the incumbent unit. Details that need to be investigated are, will the refrigerant work effectively with the other chemistries and possible contaminants that are used in the unit. This presentation focuses on the transition of both synthetic and natural low GWP refrigerants with the potential of using these refrigerants in OEM and retrofit applications.

2. Impact of Contamination on the Stability of Low GWP Refrigerants

***Sarah Kim, Ph.D., Associate Member**, Arkema, Inc., King of Prussia, PA*

Servicing with low GWP refrigerants is becoming common in the HVAC&R industry due to the phase out of conventional refrigerants. It is important to follow best practices such as refraining from mixing refrigerants and using the recommended lubricants while considering that HFOs will exhibit a different nature than HFC or HCFC refrigerants. This session covers the impact of common contaminants that may influence the system performance and reliability of some very low GWP refrigerants containing unsaturated molecules such as R-1234yf and R-1233zd(E). In addition, stabilizers which can prevent the deterioration of performance due to contaminants is discussed.

3. Effect of Contaminants on the Stability of HFO Refrigerant Systems

***Ngoc Dung (Rosine) Rohatgi, Ph.D., Member**, Spauschus Associates Inc., Sylva, NC*

This presentation summarizes the results of two research projects that focused on the effects of contaminants on the thermal and chemical stability of the HFO refrigerants and their corresponding lubricants. AHRI research project 00904-RP refrigerants R1234yf, R1234ze and R1234yf blended with R32 (50/50 by weight) were tested with two POE oils and one PVE oil. ASHRAE research project 1641-TRP, three refrigerant/lubricant mixtures, including R134a/POE, R1234yf/POE and R123/mineral oil were

tested in the presence of unsaturated halogenated contaminants. The results from these research projects were implemented in AHRI Standard 700.

Tuesday, January 23

8:00 AM - 9:30 AM

Conference Paper Session 10 (Intermediate)

Building Envelope Effect on Other Systems

Track: Fundamentals and Applications

Room: Chicago

Chair: William Murphy, Ph.D., P.E., Fellow Member, University of Kentucky, Paducah, KY

Building envelope components and building mounted systems can have significant impacts on energy efficiency and occupant comfort. This session covers shading options and analysis of these options, as well as an analysis of solar-combined cooling, heating and power systems. A review of performance and comfort of different system types for residential applications are also presented. Finally, an analysis of retrofitting buildings using advanced analysis methods to identify optimal thermal insulation values is shared.

1. Learning from the Vernacular: The Impacts of Massive Perforated Screen Shades on Building Energy Savings and Thermal Comfort in Three Different Hot Climate Zones (CH-18-C035)

Ihab Elzeyadi, Ph.D., BEMP and HBDP *and Ayesha Batool, University of Oregon, Eugene, OR*

Solar-Screen shading systems applied to building facades present an opportunity to manage solar heat gains, daylight penetration, and glare impacts in multi-story commercial buildings resulting in substantial reduction in operational energy. Despite the increased interest in adopting these strategies in buildings, there is a knowledge gap of their impacts on energy savings and indoor environmental quality of perimeter office spaces. This investigation combined a field assessment and experimental simulation of different screen geometries in two hot climate zones. Results show that solar screens of one form do not fit all buildings in all hot climates at all times.

2. The Influence of Lighting Conditions, Shading Patterns and Weather on Occupant Visual Preferences in Perimeter Building Zones (CH-18-C036)

Jie Xiong*, Seungjae Lee, Student Member, Panagiota Karava, Ph.D., Associate Member and Athanasios (Thanos) Tzempelikos, Ph.D., Member, Purdue University, West Lafayette, IN*

In this study, the influence of lighting and daylighting conditions on occupant visual preferences is investigated. Experiments with human subjects were conducted in perimeter offices with large windows, motorized shades and dimmable electric lights. The subjects were asked for their relative preferences under designed controlled patterns of lighting and shading operation with variable weather (outside) conditions. The monitored physical variables and preference data were analyzed to infer the satisfaction probability distribution under compared sets of conditions. The personalized satisfaction models can be used to better control indoor environments according to realistic occupant visual preferences, with quantified implications on energy use.

3. Economic Feasibility of Hybrid Solar-Combined Cooling, Heating and Power (CCHP) Systems for a Large Office in California (CH-18-C037)

Hyeunguk Ahn, Student Member[1]*, Donghyun Rim, Ph.D., Associate Member*[2] *and James Freihaut, Ph.D., Member*[2]*, (1)Pennsylvania State University, State College, PA, (2)Pennsylvania State University, University Park, PA*

This study evaluates economic and environmental performances of a hybrid solar photovoltaic (PV) and combined cooling, heating and power (CCHP) system for a large office in San Francisco, CA. The results are compared to a reference system that purchases electricity from the grid and produces heat from a boiler. The hybrid system utilizes both electric and absorption chillers while the conventional CCHP system uses only an absorption chiller. The study introduces Modified Following Electrical Load (MFEL) strategy to determine the power output that dynamically varies according to electrical load for the electric chiller.

4. Experimental Study on Heating Emitters in an Environmental Chamber (CH-18-C038)

Duan Wu, Ph.D., Member*, Mitsubishi Electric R&D Center Europe-UK, Livingston, United Kingdom*

Hydronic heat emitters are commonly used in domestic heating in EU houses and their performance has a strong influence on energy consumption and human comfort. In this study, an in-house environmental chamber was built for evaluating the performance of emitters from different perspectives such as heating up speed, temperature uniformity, air velocity distribution and human comfort. This paper gives important figures for comparing emitter performance from the indoor environmental comfort point of view and it indicates the optimization possibilities for future product design.

5. Life-Cycle Assessment of Apartment Building Renovation in Latvia (CH-18-C039)

Anatolijs Borodinecs, Dr.Ing., Member*, Jurgis Zemitis, Ph.D. and Aleksandrs Geikins, Riga Technical University, Riga, Latvia*

This paper is prepared in scope of work done within the EUH2020 MORE-CONNECT project and continued by ERDF project “Nearly Zero Energy Solutions for Unclassified Buildings”. The main aim of this study is to develop retrofitting process based on 3D laser scanning and BIM to ensure correct energy simulations as well as evaluation of LCA and LCC. The paper presents

results of Latvian case buildings 3D scanning results, BIM application and selection of the optimal thermal insulation layout to ensure both end-user energy efficiency and minimization of overall negative environmental impact.

8:00 AM - 9:30 AM

Conference Paper Session 11 (Intermediate)

System Optimization Using Controls and Heat Transfer

Track: Systems and Equipment

Room: Honore

Chair: Bass Abushakra, Ph.D., Member, United States Military Academy, West Point, NY

In today's connected world, HVAC&R is being driven by the digital environment. From big data to IOT we are seeing tremendous advances. This session lookS at four cases where connected environment is impacting the HVAC&R industry. Data driven decisions, cyber security, IOT and optimization being used to impact four different aspects of the industry.

1. Data-Driven Framework to Find the Physical Association between AHU and VAV Terminal Unit: Pilot Study (CH-18-C040)

June Young Park, Student Member[1]*, Bertrand Lasternas*[2] *and Azizan Aziz*[2]*, (1)The University of Texas at Austin, Austin, TX, (2)Carnegie Mellon University, Pittsburgh, PA*

With improvements in information and communication technology (ICT), building automation now incorporates a large number of data points into every element of a building. Varying naming conventions and schemas assigned to these elements by different companies and field engineers pose a challenge to identifying relationships between building systems. To solve this problem, a framework is developed using machine learning and signal processing techniques. As a pilot study, the proposed framework associates the relationship between air handling units (AHU) and variable air volume (VAV) terminal units in the university building.

2. Cyber Security for Internet Connected HVAC/R Components (CH-18-C041)

Christian Ellwein, Ph.D., Member *and Heinrich Steinhart, Dr.Ing., KRIWAN Industrie-Elektronik GmbH, Forchtenberg, Germany*

Today HVAC/R components like compressors are often connected to the internet. Next to significant advantages there are also new threats: cyber security became an important topic. Security against internet threats in an office IT-environment is typically based on secure connections, analysis of data and algorithms to encrypt data. There are additional ways to protect against cyber threats if industrial components are connected to the internet. These methods are not based on IT but on electro technical principles. Due to this they are more independent of short term development cycles in IT and are independent of frequent updates and patches.

3. Business Cases for Improved Control and Internet of Things in HVAC/R (CH-18-C042)

Christian Ellwein, Ph.D., Member*, KRIWAN Industrie-Elektronik GmbH, Forchtenberg, Germany*

Compressors, pumps or fans connected the Internet of Things need business plans how to earn money with data generated by those machines. Operation of the machine with reduced energy consumption, reduced machine downtime, added sales revenue with cross-selling and services or saving money by adapting to fluctuating energy prices can be opportunities to generate value with data out of the machine. Technical proposals how to implement these opportunities are made in the paper additional to a basic calculation of the ROI (return on invest).

4. Relationship Between Sensitivity and Calibration Accuracy on Virtual in-Situ Calibration in Building Systems (CH-18-C043)

Sungmin Yoon *and Yuebin Yu, Ph.D., Associate Member, University of Nebraska-Lincoln, Omaha, NE*

This paper focuses on the relationship between a sensitivity and a calibration accuracy for working sensors in building systems using a Bayesian sensor calibration. The relative importance of input variables varies from the used system equations for this calibration. Such an importance can be represented by the sensitivity index calculated from a sensitivity analysis. If variables having a lower sensitivity have a lower calibration accuracy and vice versa, the sensitivity analysis is needed before a calibration. Then, their sensitivity should be enhanced to improve the overall accuracy. This study suggests how to improve the calibration accuracy with a sensitivity analysis.

5. Optimization of Microchannel Condenser with Phase Separation in the Header (CH-18-C044)

Jun Li, Student Member[1] *and Pega Hrnjak, Ph.D., Fellow ASHRAE*[2]*, (1)University of Illinois, ACRC, Urbana, IL, (2)University of Illinois, ACRC and CTS, Urbana, IL*

This presentation covers both modeling and experiment results that proves phase separation in an intermediate header is beneficial to microchannel condenser performance. Heat exchanger-level improvement is shown in terms of higher condensate flow rate and lower outlet temperature. System-wise results are shown in terms of higher COP. The main benefits come from high local heat transfer coefficient in the vapor path during condensation. To maximize the performance, a steady-state finite-volume model has been built for the theoretical study of optimization of condenser geometry and refrigerant used for separation.

8:00 AM - 9:30 AM

Seminar 33 (Intermediate)

Advances in Understanding Corrosion in Heat Exchangers

Track: Heat Exchange Equipment

Room: Empire

Sponsor: 8.4 Air-to-Refrigerant Heat Transfer Equipment

Chair: Chad Bowers, Ph.D., Associate Member, Ingersoll Rand, Clarksville, TN

Air-side corrosion continues to be a topic of much interest in the industry. Specifically understanding how to standardize on accelerated testing and combat corrosion with appropriate designs. Updates of ongoing ASHRAE research and advances in the understanding of the nature and causes of corrosion in air to refrigerant corrosion are presented by industry experts and those conducting the research.

1. Cyclic Polarization of AA 3102 in Various Corrosive Electrolytes

***Seifollah Nasrazadani, Member**, University of North Texas, Denton, TX*

This presentation evaluates whether cyclic polarization can be used to assess corrosion resistance of AA 3102 in corrosive environments and if corrosion potential can be used as a measure of AA3102 performance in corrosive environments.

2. Field Test Data and Comparison to Accelerated Corrosion Lab Tests for Different Mchx Solutions.

***Claudi Martín Callizo, Ph.D., Associate Member**, Granges Aluminium (Shanghai) Co. Ltd, Shanghai, China*

This presentation shows corrosion performance data of different MCHX system solutions from several field test sites with distinct atmospheric environments; compares these results with data from accelerated cabinet tests from the lab; and explains the corrosion mechanisms and corrosion sequence of different MCHX systems.

3. Aluminum Round Tube: Application Requirements and Corrosion Performance

***Vikas Somani**, Brazeway, Adrian, MI*

This presentation discusses aluminum round tube applications and requirements as well as corrosion rate and behavior of 3xxx series alloy under different corrosion tests.

8:00 AM - 9:30 AM

Seminar 34 (Intermediate)

Net Zero Energy Buildings

Track: Fundamentals and Applications

Room: Red Lacquer (4th Floor)

Sponsor: Publishing and Education Council

Chair: Van Baxter, Ph.D., Fellow Life Member, ORNL, Oak Ridge, TN

Heating, cooling and ventilation of buildings is one of the dominant shares of our world's energy use. Building codes and incentive programs in many countries require reduced energy use in current and future buildings. With their high energy performance, nearly zero-energy buildings (NZEB) set new standards for building design and operation. NZEB buildings have efficient thermal envelopes resulting in low energy requirements for space heating and cooling. Their energy needs are offset by renewable energy resources. This session presents material on the subject from recently published papers from ASHRAE's archival journal, Science and Technology for the Built Environment.

1. Beyond NZEB: Experimental Investigation of the Thermal Indoor Environment and Energy Performance of a Single-Family House Designed for Plus-Energy Targets

***Ongun Kazanci, Ph.D., Associate Member** and Bjarne Olesen, Ph.D., Fellow ASHRAE, Danish Technical University, Lyngby, Denmark*

This presentation outlines the main findings from an experimental investigation of the thermal indoor environment and energy performance of a single-family house designed for plus-energy targets. The energy use, energy production and thermal indoor environment of the house were measured for one year. Although the house was designed to be a plus-energy house, the results show that it did not perform as one. The lessons learned and suggestions for achieving plus-energy targets in future housing will be outlined in this presentation, together with the results from further parametric studies.

2. Analysis on a Net-Zero Energy Renovation of a 1920s Vintage Home

***Stephen Caskey, Student Member**[1], Eric Bowler[2] and Eckhard Groll, Dr.Ing., Fellow ASHRAE[1], (1)Purdue University, West Lafayette, IN, (2)Whirlpool Corporation, Benton Harbor, MI*

A 1920s vintage home was renovated with the goal of becoming net-zero energy over a 12-month period. The project was performed over two years. The first phase quantified the energy profile of the house in the original state. The second phase included a deep energy retrofit to improve the thermal insulation of the building envelope and an installation of a PV-T solar system. The annual heating demand was reduced by almost 50 percent from 38,000 kWh to 19,000 kWh. Adjustments made to the annual demand considered missing occupancy during the first phase, gaps in monitoring and the heating system used.

3. Daytime Space Cooling with Phase Change Material (PCM) Ceiling Panels Discharged Using Rooftop PV/T Panels and Night-Time Ventilation

Eleftherios Bourdakis, Student Member[1], *Thibault Q. Péan*[1], *Luca Gennari*[1] *and Bjarne Olesen, Ph.D., Fellow ASHRAE*[2], *(1)Technical University of Denmark, Kongens Lyngby, Denmark, (2)Danish Technical University, Lyngby, Denmark*

This seminar examines the possibility of using photovoltaic/thermal panels for producing cold water through the process of night-time radiative cooling. Cold water to discharged phase change material (PCM) in ceiling panels in a climatic chamber. The operative temperature remained within the range of Category III of standard DS/EN 15251 for 50% to 99% of the occupancy period. The percentage of electrical energy usage covered from the photovoltaic/thermal varied from 56% to 122%. The PCM ceiling panels were capable of providing an acceptable thermal environment and the photovoltaic/thermal panels provided most of the required electricity and cold water needed for cooling.

8:00 AM - 9:30 AM

Seminar 35 (Intermediate)

Low GWP Refrigerants in Heat Exchange Equipment: Part 1, Introduction and Case Studies

Track: Heat Exchange Equipment

Room: Monroe

Sponsor: MTG.LowGWP Lower Global Warming Potential Alternative Refrigerants, 1.3 Heat Transfer and Fluid Flow, TCs 1.3, 3.1, 8.4, 8.5, 8.11, The American Society of Thermal and Fluids Engineers (ASTFE) and the U.S. National Committee of the International Institute of Refrigeration (IIR).

Chair: Lorenzo Cremaschi, Ph.D., Member, Auburn University, Auburn, AL

This session introduces the audience to heat transfer characteristics, energy performance, safety and trade-off aspects of the low GWP refrigerants used in heat exchange equipment of air conditioning and refrigeration systems. The speakers provide an overview of several case-studies with low GWP refrigerants and with natural refrigerants, and they discuss modeling, simulation and laboratory performance testing. Real world applications and performance under field type conditions are presented. This session provides the background information for the follow up forum panel discussion of Part 2 of this session.

1. Simulated Thermal Performance of Flooded Evaporators with R1234ze (and others) Vs. R134a with Oil Effects

John Thome, Ph.D., *Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland*

This presentation describes a new simulation code for flooded evaporators, which is a fully-incremental code along the length of the bundle and also tube row by tube row from bottom to top. This code handles enhanced boiling tubes, new and existing refrigerants, adverse oil effects locally within the bundle and the onset of dryout and dry tube rows along the top of the bundle. Presently, the code is used to make and present some case studies on thermal performance between new and existing refrigerants, focusing on local and total performance of the bundle with and without oil effects.

2. Low Environmental Impact Refrigerants for Air-Conditioning, Chiller and Refrigeration Applications

Ankit Sethi, Associate Member, *Honeywell International, Buffalo, NY*

R410A refrigerant is used widely for residential and commercial air-conditioning, heat pump applications and air-cooled direct expansion chillers and R404A refrigerant is widely used for various refrigeration applications. The first part of this presentation discusses an evaluation of low GWP replacements for R410A in air-conditioning and chiller applications. The second part presents an evaluation of low GWP replacements for R404A in refrigeration applications. Thermal properties as well as experimental results in representative systems and components are presented, showing the benefits of using these new working fluids.

3. Recent Developments in Low GWP Refrigerants for Refrigeration and Air Conditioning

Joshua Hughes, Member, *Chemours, Wilmington, DE*

Blended HFO-based refrigerant compositions have been developed and optimized to provide improved overall safety and performance, while retaining significant environmental sustainability properties versus the legacy refrigerants. The trade-offs that exist between refrigeration capacity, energy efficiency, temperature glide, GWP value and flammability in optimized HFO-based refrigerant blends have been explored and assessed. Data presented will include thermodynamic properties and modeling results, heat transfer results and system performance results. These new refrigerant blends should provide useful options to help maintain quality of life and health benefits from air conditioning and refrigeration, but in an energy efficient, cost effective and environmentally sustainable manner.

4. Comparative Analysis of Conventional Shell Side Ammonia Flooded Evaporator versus New Concept Direct Expansion Evaporator

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

Extensive experimental study was conducted on direct expansion of ammonia on a plain tube bundle at saturation temperature range of -1.7 to -20C and heat flux range of 5 – 45 kW/m2. Heat transfer coefficient showed a classic behavior of increase with both saturation temperature and heat flux. The effect of exit superheat and inlet quality on the overall performance and pass to pass bundle effect was also investigated. The results are compared with such type chillers currently installed world-wide and conventional flooded evaporator operating at the same operating conditions. This concept has advantages over the flooded systems.

5. Heat Exchanger Performance of Low GWP Refrigerants in Chillers
***Kenneth Schultz, Ph.D., Member**, Ingersoll Rand, La Crosse, WI*

This presentation provides an overview of the thermodynamic and heat transfer properties of the new low GWP refrigerants being considered for replacing R123, R134a and R410A in chillers. Fortunately, the thermodynamic and heat transfer properties of fluids to replace R123 in low pressure chillers are quite good. On the other hand, the characteristics of the medium and high pressure fluids present some challenges to maintaining the efficiencies of chillers using R134a and R410A today.

8:00 AM - 9:30 AM
Seminar 36 (Basic) NY PDH G

Resiliency: Building a Safer Future

Track: Earth, Wind & Fire
Room: Adams
Sponsor: 2.5 Global Climate Change
Chair: Elizabeth Tomlinson, P.E., Member, TKDA, St. Paul, MN
ASHRAE members need to understand how to design our built environment for future climates. Along with climate change mitigation, planning for and adapting to tomorrow's climate is a hot topic for public and private owners, consultants and citizens. This panel of resiliency experts presents various viewpoints on needed building design changes to address increased weather extremes. Panelists include city, state and federal level resiliency viewpoints.

1. Safeguarding Assets for a Robust Relevant Practice
***Ann Kosmal, F.A.I.A., LEED AP BD +C, CPHC, PDC**, U.S. General Services Administration, Washington, DC*

Uncertainty and climate science are specifically addressed in the session as it pertains to the professional ethics and liabilities of licensed design professionals working to incorporate plausible climate futures. The presenting practitioner uses examples of statistical downscaling and discusses the limitations and opportunities for action.

2. Making Buildings Resilient
***Daniel Nall, P.E., HBDP, CPMP and BEMP, Fellow Life Member**, Syska Hennessy, New York, NY*

This presentation focuses on how to prepare buildings for natural disasters and acts of terror. It identifies the elements of a building risk assessment, stressing realistic threats and realistic desired outcomes. It shows strategies for making building life safety systems more resistant to catastrophic events. The presentation presents the approach and some of the recommendations of the New York City Building Resilience Task Force, a group of professionals convened by the Mayor of New York to develop recommendations for the city and for building owners in the aftermath of Tropical Storm Sandy.

3. State-Level Resiliency Planning
***Matthew Lieuallen, J.D.**, Ecology and Environment, Inc., Portland, OR*

This presentation explores a range of strategies that states across the nation have implemented for resiliency guidelines. In Oregon, communities live under the threat of a Cascadia Subduction Zone earthquake and resultant tsunami. The state has developed the Oregon Resilience Plan and the 2016 Cascadia Rising exercise. In Colorado, the state developed an innovative and programmatic approach to resilience that resulted in its first Colorado Resiliency Framework and capability building efforts statewide. In New York, the aftermaths of Superstorm Sandy, Hurricane Irene, and Tropical Storm Lee created opportunity for community-driven planning through the New York Rising Communities program.

8:00 AM - 9:30 AM
Seminar 37 (Intermediate) NY PDH G

Use of Energy Modeling Tools to Support Building Asset Ratings: Screening Analysis, Simplified Modeling and Retrofit Analysis

Track: Modeling Throughout the Building Life Cycle
Room: State
Sponsor: 4.7 Energy Calculations
Chair: Chris Balbach, P.E., Associate Member, Performance Systems Development, Ithaca, NY
With more cities employing energy-related mandates as a vehicle to improve energy utilization in commercial and residential buildings, publicly available tools utilizing energy simulations, in the form of Asset Rating Systems, are being creatively used to triage and prioritize investment in infrastructure. A streamlined process that integrates benchmarking, energy audit, retro-commissioning and deep retrofits is critical to minimize implementation costs, facilitate adoption and move the market to scale.

1. Integration of Screening, Modeling, and Energy Audit
***Nora Wang, Dr.Eng**, PNNL, Richland, WA*

This presentation demonstrates how the Asset Score provides a streamlined process for quick analyses of building portfolios, easy-to-use simplified energy modeling and in-depth energy audit through a single, integrated platform. The Asset Score allows users to quickly run batch analyses of a large number of buildings with seven easy-to-collect data points (aka Preview) or perform a full scale ASHRAE standard level 2 audit (aka Audit Template). Both Preview and Audit Template can be converted

to simplified Energy Plus models for evaluation of the as-built physical characteristics of a building, independent of its occupancy and operational choices.

2. Driving Efficiency through Home Energy Ratings

***Madeline Salzman**, USDOE, Washington, DC*

Commercial buildings are a likely first target of cities, but many jurisdictions have come to realize that single family homes offer substantial, and in some cases even greater, potential for energy and cost savings. That said, the single family market has its own set of challenges. Most homes are owned by single families, not corporations. Little data is available on existing homes. Housing stock varies considerably.

3. Energy Services Triage for Buildings

***Greg Thomas**, Performance Systems Development, Ithaca, NY*

This seminar demonstrates how information extracted from Commercial Asset Ratings can be visually presented to help building owners set performance targets and engage service providers for further developing targeted workscopes aimed at likely areas of energy utilization improvement. When combined with Operational information such as that available from a Portfolio Manager score, the potential for a) retuning/retro commissioning services, b) capital equipment replacement and c) occupant/behavioral interventions can also be qualitatively assessed. A case study is used to demonstrate the principles in action.

9:45 AM - 10:45 AM

Debate 2 (Basic)

Low GWP Refrigerants in Heat Exchange Equipment

Track: Heat Exchange Equipment

Room: Adams

Sponsor: MTG.LowGWP Lower Global Warming Potential Alternative Refrigerants, 1.3 Heat Transfer and Fluid Flow, TCs: 3.1, 8.4, 8.5, 8.11, The American Society of Thermal and Fluids Engineers (ASTFE), and the U.S. National Committee of the International Institute of Refrigeration (IIR).

Chair: Omar Abdelaziz, Ph.D., Member, ORNL, Oak Ridge, TN, John Thome, Ph.D., Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, Zahid Ayub, Ph.D., P.E., Fellow ASHRAE, Isotherm, Inc., Arlington, TX, Kenneth Schultz, Ph.D., Member, Ingersoll Rand, La Crosse, WI, Ankit Sethi, Associate Member, Honeywell International, Buffalo, NY and Joshua Hughes, Member, Chemours, Wilmington, DE

From the previous session, this panel forum is a roundtable panel on lower GWP refrigerants within the context of the Kyoto Protocol. The audience has the opportunity to ask questions, offer case studies, propose ideas and discuss solutions on low GWP refrigerants for heat transfer equipment, air conditioning and heat pump systems.

9:45 AM - 10:45 AM

Technical Paper Session 3 (Intermediate) NY PDH G

System Enhancement through Commissioning and Metering

Track: Systems and Equipment

Room: Chicago

Chair: Marija S. Todorovic, Fellow Member, University Of Belgrade, Belgrade, Serbia

This session presents several commissioning measures for a heat recovery chiller application at a large district plant. A look at how on-site measured data from the building automation system is used to develop a regression model to evaluate the savings potential for each measure is presented. Additionally, presenters will show how methodology and control strategies can also be applied to optimize other heat recovery chiller applications.

1. Commissioning an Existing Heat Recovery Chiller System at a Large District Plant (CH-18-006)

***Lei Wang, Ph.D., P.E., Member**[1], Yasuko Sakurai[2], Steven Bowman[2] and David Claridge, Ph.D., P.E., Fellow ASHRAE[1], (1)Texas A&M University, College Station, TX, (2)Utilities & Energy Services, Texas A&M University, college station, TX*

This paper presents several commissioning measures for a heat recovery chiller application at a large district plant in central Texas. The on-site measured data from the building automation system is used to develop a regression model to evaluate the savings potential for each measure. The current operating strategy saves $270,375/year compared to a baseline chiller without heat recovery but the proposed control strategies would improve the savings to $389,182/year at current utility prices, or 43.9% more savings than the current control strategy. Although these savings are based on a case study project, the methodology and control strategies can also be applied to optimize other heat recovery chiller applications.

2. Valve Flow Meter Enhancement through Computing Valve Dynamic Behaviors (CH-18-007)

***Shima Shahahmadi, Student Member**[1] and Li Song, Ph.D., P.E., Member[2], (1)University of Oklahoma, Norman, OH, (2)University of Oklahoma, Norman, OK*

A virtual water flow meter was developed that uses the chilled water control valve on an air-handling unit as a measurement device. The flow rate of water through the valve was calculated using the differential pressure across the valve and its associated coil, the valve command and an empirically-determined steady-state valve characteristic curve. In order to compensate for the

loss in accuracy by using the valve command to indicate the valve open position, in this paper, valve dynamic behavior was empirically described using valve stiction and deadband (S) and slip-jump (J) to convert valve commands to actual valve positions.

9:45 AM - 10:45 AM

Conference Paper Session 12 (Intermediate)

Residential and Urban Developments

Track: Fundamentals and Applications

Room: Honore

Chair: Hyojin Kim, Ph.D., Member, The Catholic University of America, Washington, DC

The potential of a low-cost indoor vertical plant production module for residential applications is investigated in this session. Future R&D needs are discussed, as well as new heat transfer techniques and material selection for the development of a low cost HVAC product that can compete in today's marketplace. Papers in this session summarize the results of a transient one-dimensional, finite difference based thermal analysis of a planter build-up composed of concrete, insulation, soil and mulch layers.

1. Indirect Evaporative Cooling with Thermally Reactivated Desiccant Dehumidification for a Net Zero Energy, Hybrid Residential Dwelling (CH-18-C045)

James Leidel, Member[1]*, Pouyan Pourmovahed, Student Member*[1] *and Valeriy Maisotsenko, Ph.D., Member*[2]*, (1)Oakland University, Rochester, MI, (2)IDALEX Technologies, Denver, CO*

For high solar fraction residential dwellings located in hot, humid climates, the cooling load is typically a significant portion of energy consumption. This paper discusses the need for a commercially available indirect evaporative cooling unit with thermally reactivated desiccant to allow for an extremely low electrical demand cooling system without use of HFC refrigerants. Thermal reactivation from solar or gas driven CHP provides cooling with minimal electricity. The utilization of this type of system in an appropriately designed and sized hybrid residential application for a typical dwelling located in a hot, humid climate is presented. Future R&D needs are discussed.

2. Dynamic Thermal Analysis of Soil Temperature Distribution in an Urban Park Landscape Above an Enclosed Rail Yard for Optimizing in-Slab Cooling System Sizing, Design and Controls (CH-18-C046)

Kirsten Salmins, Associate Member[1]*, Deepak Kandra, P.E.*[2] *and Raymond Quinn, P.E., Member*[2]*, (1)Arup, New York City, NY, (2)Arup, New York, NY*

Earth typically serves as a heat sink for vegetation planted directly in the ground; however, trees and plants located in the shallow soil depths of planter build-up above a rail yard can be overheated by ambient conditions and heat sources within the rail yard. This session examines a case where an overbuild development incorporating mixed-use buildings and a large park above an enclosed rail yard has been proposed. The results of a transient one-dimensional, finite difference based thermal analysis of a planter build-up will be presented. The optimization of a cooling system and cooling control strategy will also be discussed.

3. Analysis and Performance of a Residential Indoor Vertical Plant Production Module (CH-18-C047)

Jonathan Maisonneuve, Ph.D., Associate Member[1]*, Pouyan Pourmovahed, Student Member*[1]*, Lianqing Zhu*[2] *and Mingli Dong*[2]*, (1)Oakland University, Rochester, MI, (2)Beijing Information Science and Technology University, Beijing, China*

This paper investigates the potential of a low-cost indoor vertical plant production module for residential applications and examines its relationship to the indoor environment. An experimental unit is built and tested. Energy consumption of lighting, irrigation, ventilation, humidity control and other loads are presented, along with other necessary inputs to the system. Effect on room temperature as well as indoor humidity is presented and strategies for temperature and humidity control are discussed. Preliminary results demonstrate cost-effective yields capable of supplying year round salad greens for a typical residential household. Future research and development needs are discussed.

9:45 AM - 10:45 AM

Seminar 38 (Advanced)

Climate Effects on Tall, Supertall and Megatall Buildings

Track: Tall Buildings

Room: State

Sponsor: 9.12 Tall Buildings

Chair: Peter Simmonds, Ph.D., Fellow ASHRAE, Buildings and Systems Analytics, Marina Del Rey, CA

The design of tall buildings has historically relied on ground measurements for climate data. However, as buildings have become taller the need for elevation specific meteorological data is becoming more important. The climate conditions at 100 m above grade is not the same as 600m. Over the height of the building, the pressure between the buildings and environment will become huge enough to cause a large impact on the functionality of these buildings, even on the building façade directly. Therefore, architects and engineers should pay sufficient attention to this phenomenon and ensure the function and operation of the building.

1. An Engineers Solution to the Problems

Peter Simmonds, Ph.D., Fellow ASHRAE*, Buildings and Systems Analytics, Marina Del Rey, CA*

Architects and engineers should pay sufficient attention to the vertical climate effect and ensure the function and operation of the building. Rarely does the design of upper level of the building capitalize on the vertical climate effect. Furthermore, wind, temperature and pressure conditions at the top of a tall building are considerably different, therefore façade leakage rates and the buildings stack effect must be carefully assessed. If sufficient data is known about this difference, it can be incorporated to optimize the overall building design.

2. An Architect's Perspective of the Problem

***Russell Gilchrist, AIA**, Gensler, Chicago, IL*

As buildings have become taller the need for elevation specific meteorological data is becoming more important. The climate conditions at 100 m above grade is not the same as 600m. Over the height of the building, the pressure between the buildings and environment will become huge enough to cause a large impact on the functionality of these buildings, even on the building façade directly. Therefore façade leakage rates and the buildings stack effect must be carefully assessed.

9:45 AM - 10:45 AM

Seminar 39 (Intermediate)

Humidity Control in the Built Environment

Track: Fundamentals and Applications

Room: Red Lacquer (4th Floor)

Sponsor: Publishing and Education Council

Chair: Fu Linda Xiao, Ph.D., Member, Hong Kong Polytechnic University, Hong Kong, Hong Kong

Humidity in the built environment is usually passively controlled due to coupled heat and moisture transfer in conventional air conditioning processes. Research and development for achieving energy-efficient active humidity control, or independent temperature and humidity control in the built environment, mainly adopts two approaches. The first is to modify conventional air conditioning systems, the second to develop new energy-efficient air humidification and dehumidification technologies. This session features material on recent experimental and theoretical work on humidity control using liquid and solid desiccants and novel vapor permeable membranes, recently published in ASHRAE's journal, "Science and Technology for the Built Environment".

1. Experimental Study of the Flow Characteristics in a Falling Film Liquid Desiccant Dehumidifier

***Hong-xing Yang, Ph.D.**[1], Yimo Luo, Ph.D.[2], Yi Chen, Ph.D.[1], Tammy Zhong Dan, Ph.D.[2] and Yuanhao Wang, Ph.D.[2], (1)Hong Kong Polytechnic University, Hong Kong, Hong Kong, (2)Technological and Higher Education Institute of Hong Kong, Hong Kong, Hong Kong*

A detailed study on the flow characteristics in a falling film liquid desiccant dehumidifier is presented from simulation and experiments. The study was to determine the heat and mass transfer performance of the dehumidifier. A simple single-channel test rig was established for observing and describing the flow characteristics in the dehumidifier. The impacts of various variables on the flow morphology, coverage ratio, and minimum wetting rate have been analyzed. A correlation was developed to predict the minimum wetting rate of the solution flow. Besides, our new progress of this research project is also reported in this presentation.

2. Heat and Mass Transfer Performance Comparison between a Direct-Contact Liquid Desiccant Packed Bed and a Liquid-to-Air Membrane Energy Exchanger for Air Dehumidification

***Carey Simonson, Ph.D., Fellow Member**, Gaoming M. Ge, Ph.D., Ahmed Abdel Salam, Ph.D. and Mohamed R.H. Abdel-Salam, Student Member, University of Saskatchewan, Saskatoon, SK, Canada*

Liquid-to-air membrane energy exchangers (LAMEEs) are novel liquid desiccant exchangers by using semi-permeable membranes to separate the air and liquid flows. LAMEEs are able to eliminate the liquid droplets carryover and reduce flow maldistribution. In this study, the heat/mass transfer performance of a LAMEE and a direct-contact packed bed with the same volume and operating condition are compared: (1) with the same air pressure drop and (2) with the same heat/mass transfer area. The LAMEE shows 13-20% higher effectiveness at the former condition. Additionally, the impact of membrane on the heat mass transfer in the LAMEE is quantitatively evaluated.

9:45 AM - 10:45 AM

Seminar 40 (Intermediate)

Introduction to the New ASHRAE Dedicated Outdoor Air System Design Guide

Track: Systems and Equipment

Room: Empire

Sponsor: 8.10 Mechanical Dehumidification Equipment and Heat Pipes

Chair: Kevin Muldoon, KCC International, Louisville, KY

The ASHRAE Dedicated Outdoor Air System Design Guide was published in mid-2017. The goal was to gather existing knowledge into a single guide, focused on providing the working-level HVAC designer with the information needed to understand the design considerations that are specifically relevant to DOAS, and then to design a DOAS which best balances installed cost, building energy use and indoor environmental quality. This seminar overviews the purpose, structure and content

of the guide, describes how it is intended to be used, shares some key learnings from the process and presents content from several of its key sections.

1. Overview of the New ASHRAE DOAS Design Guide

***Svein Morner, Ph.D., P.E., Member**, Sustainable Engineering Group, Madison, WI*

The ASHRAE Dedicated Outdoor Air System Design Guide was published in mid-2017. The goal was to gather existing knowledge into a single guide, focused on providing the working-level HVAC designer with the information needed to understand the design considerations that are specifically relevant to DOAS, and then to design a DOAS which best balances installed cost, building energy use and indoor environmental quality. This seminar reviews the purpose, structure and content of the guide, describes how it is intended to be used, shares some key learnings from the process and presents content from several of its key sections.

2. Common Pitfalls in the Design and Operation of DOAS

***John Murphy, Fellow ASHRAE**, Trane, La Crosse, WI*

The ASHRAE Dedicated Outdoor Air System Design Guide was published in mid-2017. The goal was to gather existing knowledge into a single guide, focused on providing the working-level HVAC designer with the information needed to understand the design considerations that are specifically relevant to DOAS, and then to design a DOAS which best balances installed cost, building energy use and indoor environmental quality. This seminar reviews the purpose, structure and content of the guide, describes how it is intended to be used, share some key learnings from the process, and present content from several of its key sections.

9:45 AM - 10:45 AM

Workshop 5 (Advanced) NY PDH G

Status of Standards in Europe and the Relation to IEC, ISO in View of the Application of Low GWP Refrigerants

Track: Standards, Guidelines and Codes

Room: Monroe

Sponsor: Refrigeration Committee

Chair: Martin Dieryckx, Member, Daikin Europe NV, oostende, Belgium

In view of the F-gas regulation there is a strong need in Europe to update the safety standards for use of Lower GWP substances. This workshop aims to give a view of the changes that already happened in Europe, the link with IEC and ISO as well as the work ongoing in IEC.

1. Changes and Work in Progress in IEC 61D and IEC 61C Related to Implementation of Low GWP Substances

***Brian Rodgers**, Underwriters Laboratories, Northbrook, IL*

This presentation contains the latest developments IEC SC61D WG 9 developing requirements for A2L refrigerants and IEC SC 61D WG 16 developing requirements for increased charge limits for A2 and A3 refrigerants. The requirements once voted through the FDIS stage will be published in IEC 60335-2-40 for air conditioners. IEC SC 61C WG4 is developing requirements to increase the charge limits of A2L, A2 and A3 refrigerants. The requirements once voted through the FDIS stage will be published in IEC 60335-2-89 for commercial refrigeration.

2. Changes and Work in Progress in European Standards for Low GWP Substances and Relation to ISO and IEC

***Els Baert, Member**, Daikin Europe NV, oostende, Belgium*

This presentation aims to give a view of the changes that already happened in Europe, the link with IEC and ISO as well as the work ongoing in IEC.

11:00 AM - 12:30 PM

Technical Paper Session 4 (Intermediate) NY PDH G

Energy Cost Analysis of HVAC Systems

Track: Fundamentals and Applications

Room: Chicago

Chair: Daniel Pettway, Life Member, Hobbs & Associates, Norfolk, VA

This session begins with presentation of a new comprehensive method for evaluating the energy and cost efficiency of complete HVAC systems to better enable comparison of different systems such as roof-tops and chilled water systems. It also covers the impact of reflective roof membranes on combined heating and cooling cost as well as the cost of recovering heat from a power plant for other uses. The final paper in this session examines cost tradeoffs for constant speed and variable speed pumps in a university power plant.

1. Analysis of Whole-Building HVAC System Energy Efficiency (CH-18-008)

***Jiajun Liao, Student Member**[1], Linyan Wang[2] and David E. Claridge, Ph.D., P.E., Fellow ASHRAE[1], (1)Texas A&M University, College Station, TX, (2)Bractlet, Inc., Austin, TX*

This paper defines a whole building heating/cooling efficiency measure, called the Building Systems Load/Energy Ratio (LER), as a comprehensive HVAC system efficiency measure. The LER is the ratio of the total heating/cooling loads on the building heating and cooling systems to the total energy input provided by all the heating and cooling system components to meet the loads – hence it is basically a system "COP" or "efficiency" that includes all of the heating and cooling system energy consumed instead of just the boiler or chiller energy.

2. Cool Roof Use in Commercial Buildings in the United States – An Energy Cost Analysis (CH-18-009)
Thomas Taylor *and Christian Hartwig, GAF, Parsippany, NJ*

Solar radiation absorption and reflection on roof surfaces affects heating and cooling energy demand. Prior studies of energy costs associated with the long term trend towards using highly reflective roof membranes, i.e. so called "cool roofs" have shown conflicting results in terms of the impact on heating costs. Also, the guidance for membrane reflectivity selection for building designers in terms of climate zone and/or heating and cooling degree days has not been clear. In this presentation, both 2015 energy costs and insulation codes by state have been used to model the impact of cool roofs on building energy demand.

Improving the Energy Efficiency of a Mid-Size Power Plant by Increased Recovery and Reuse of Waste Heat (CH-18-010)
James Mathias, Member *and Jeffery Green, Southern Illinois University Carbondale, Carbondale, IL*

An older, mid-sized coal fired power plant was studied to improve overall plant efficiency. The power plant consists of a Circulating Fluidized Bed (CFB) boiler and three turbines that produce up to 120 MW. Lake water provides cooling to the cycle through the condenser. The study examined increasing the heat recovery from the exhaust gases to increase the overall efficiency. Flue gas from the CFB is regularly near 160°C (320°F) allowing for a large amount of potential heat recovery. The study examines possible uses for the heat.

3. Comprehensive Analyses of Variable, Constant Speed Pumps and Heat Exchanger and Energy Cost Savings Potential in KU Power Plant (CH-18-011)
Ronald L. Dougherty, Ph.D., P.E.[1] *and Raoof Alabdullah*[2]*, (1)Department of Mechanical Engineering, University of Kansas, Lawrence, KS, (2)Republic of Iraq' Ministry of Oil, Basra, Iraq*

Minimizing the waste energy of pumping systems is one of the primary foci in facilities operations nowadays. Thus, investigating optimal approaches for running such a facility has been studied and analyzed in this paper. Specifically, a comparative study between using variable speed pumps versus constant speed pumps has been conducted in the steam power plant at the University of Kansas. This study considers energy costs/savings of the pumps themselves; but because the pumps affect other systems in the power plant, overall plant costs/savings are also considered. In the University of Kansas power plant, both types of pumps are employed.

11:00 AM - 12:30 PM
Conference Paper Session 13 (Intermediate) NY PDH G

Application of Modern Modeling Techniques

Track: Modeling Throughout the Building Life Cycle
Room: Honore
Chair: Wade H. Conlan, P.E., Member, Hanson Professional Services, Orlando, FL

Modelling systems is used in our industry for systems and equipment to identify best approaches to utilize systems effectively and efficiently. CFD analysis of cooling tower reentrainment provides guidance on placing towers in relation to differing enclosures and wind to minimize efficiency impact. CFD results will show designers the proper placement of IAQ sensors for different air delivery systems. Modelling of Electric Thermal Storage, specifically the BAS control of systems, provides the designer correct sizing and control strategies. Inverse modeling shows how outliers in residential building energy use patterns can be addressed to better predict residential building energy use.

1. On the Modelling of Flow Regimes Around Cooling Towers (CH-18-C048)
Essam E. Khalil, Fellow ASHRAE*, Waleed Abdelmaksoud, Ph.D. and Mohamed Omar, P.E., Cairo University, Cairo, Egypt*

Cooling Towers are one of the main components utilized in numerous major processes applications; any decrease in the cooling tower performance highly affects the main process. The present work aimed to study the aspects leading to cooling tower recirculation using Computational Fluid Dynamics CFD to determine recommendations and considerations for cooling towers layout to minimize recirculation and ensure stable and efficient operation. The current work represents a parametric study on recirculation at different winds speeds, direction, fans exit velocities, architectural enclosure louvers location, and parapet wall height.

2. CFD Analysis of Dispersion of Particles and Gases in Buildings for Optimal IAQ Sensor Positioning (CH-18-C049)
Gen Pei, Student Member[1]*, Donghyun Rim, Ph.D., Associate Member*[1] *and Matthew Vannucci*[2]*, (1)Pennsylvania State University, University Park, PA, (2)University of California, Berkeley, CA*

This paper presents a numerical modeling study that examines optimal sensor positioning in indoor spaces served by a demand-controlled ventilation (DCV) system. Computational Fluid Dynamic (CFD) simulation is employed to examine dispersion of particles, CO_2, and ozone with different source locations in three representative ventilation rooms. Results show that a sensor

reading of pollutant concentration can vary significantly with diffuser arrangement, source location and pollutant characteristics. The results suggest that sensor positioning at the room exhaust can work in only for particular ventilation scenarios.

3. Characteristics and Causes of Outliers in Inverse Modeling of Residential Building Energy Use Data (CH-18-C050)

***Huyen Do, Student Member**, Kristen Cetin, Ph.D., P.E., Associate Member and Trevor Andersen, Iowa State University, Ames, IA*

Inverse modeling is a commonly-used method for prediction of building energy use. However, for some residential buildings, energy use patterns are not consistent, limiting the model's accuracy due to the presence of outliers lie outside model predictions. This research studied a detailed dataset of residential homes' energy use, providing identification and quantification of why households use more or less energy than predicted. The result of this research work towards improving on accuracy of inverse modeling techniques and their treatment of outliers, enabling better prediction of residential building energy use.

4. Control-Oriented Modeling of an Air-Based Electric Thermal Energy Storage Device (CH-18-C051)

***Jennifer A. Date, Student Member**[1], José A. Candanedo, Ph.D.[2], Andreas Athienitis, Ph.D., P.E., Fellow ASHRAE[1] and Karine Lavigne[3], (1)Concordia University, Montreal, QC, Canada, (2)Natural Resources Canada, CanmetENERGY, Varennes, QC, Canada, (3)Laboratoire des technologies de l'énergie, Shawinigan, QC, Canada*

This study investigates a simplified modeling strategy for an air-based thermal energy storage device used for peak-load shedding. The device is an Electric Thermal Storage (ETS) system, which is designed to "store" electric energy as heat during hours when energy costs are lower. Although ETS devices have proven their usefulness, there are still some issues regarding their operation and control logic. This particular work aims to develop and compare simple and robust control-oriented models for the ETS. These models are intended to be used, along with knowledge of future conditions, to plan ahead control actions to better regulate electrical loads.

11:00 AM - 12:30 PM

Seminar 41 (Intermediate)

Going Large in Air-to-Air Energy Recovery

Track: Systems and Equipment

Room: State

Sponsor: 5.5 Air-to-Air Energy Recovery

Chair: Adam Fecteau, Member, Aldes, Saint-Léonard-d'Aston, QC, Canada

With the continuous improvement to building envelopes, the desire to improve IAQ and the necessity to minimize energy consumption, air-to-air energy recovery plays an important role. From small projects with a few hundred of CFM up to very large applications with ventilation rates in the tens of thousands, ERVs have their rightful place. This seminar focuses on the large applications. It addresses the design considerations for buildings with very large ventilation rates, considers the impact on the HVAC system and give guidelines on how to specify large ventilation equipment in order to maximize its efficiency.

1. Going Big in Energy Recovery

***Ronnie Moffitt, P.E., Member**, Trane, Lexington, KY*

Exhaust air energy recovery is often utilized in buildings to reduce peak loads and operating expenses associated with heating and cooling ventilation air. There are many off the shelf solutions for smaller applications, however the adoption of energy recovery technologies to large commercial applications will require different design considerations. A system with a ventilation air requirement in the tens of thousands CFM may end up looking quite different than a system with far less. There are many reasons for this, some related to the building others to the technologies themselves. Overall, going big with energy recovery can have big benefits.

2. Enthalpy Plate Exchangers for Large Airflow Application

***Mo Afshin, P.Eng., Member**, dpoint technologies, Vancouver, BC, Canada*

With the increasing ventilation requirements and advancements in envelopes, the role of exhaust air energy recovery has become more significant than ever. With different energy recovery components available for large air flow applications, developers can still benefit from energy recovery for applications where a single unit provides the ventilation air. This presentation reviews the trends in energy recovery technology and standards for high flow rate applications and challenges facing enthalpy plate exchangers. These challenges include; pressure drop and foot print. This study reviews each challenge and offers solutions with calculations and case studies.

3. Integrating Large Energy Recovery Units in Cold Climate Designs

***Julien Allard, P.Eng., Member**, BPA, Montréal, QC, Canada*

With the increase in outdoor air needs in buildings and the necessity of reducing our energy consumption, the use of high efficiency energy recovery units is a great tool especially in cold climates where the heating demand is very high. This presentation addresses the main design considerations, different types of units as well as all related impacts to other disciplines. It also takes a look at installation methods and addresses the cross-contamination issue.

11:00 AM - 12:30 PM

Seminar 42 (Intermediate)

Don’t Blow Your Top! Designing Rooftop Systems for Wind and Seismic Compliance

Track: Earth, Wind & Fire

Room: Adams

Sponsor: 2.7 Seismic and Wind Resistant Design, 5.2 Duct Design

Chair: Patrick Marks, P.E., Fellow ASHRAE, Johnson Controls, New Freedom, PA

Rooftop equipment is subjected to both seismic and wind loads. This seminar presents the results of RP-1692, which shows the effects of rooftop architectural elements on wind load calculations. The seminar also discusses the specific design criteria for roof mounted HVACR units as well as piping, duct work and solar panels.

1. Designing Rooftop Systems for Wind and Seismic Compliance

***Robert Simmons, P.E., Member**, Petra Seismic Design, Houston, TX*

Design of HVAC&R systems for wind/seismic compliance is required by code. Recent code changes have significantly increased required wind design loads. Roof top systems such as duct, pipe, and solar panels must be restrained to prevent wind or seismic load failure. Loss of the systems can shut down a building or damage the roofing, causing major economic loss. But rooftop support systems are difficult to restrain without affecting the roof membrane. This presentation discusses practical methods.

2. Wind Loads on Architectural Screens and Impact on Wind Loads for Roof Mounted Equipment They Surround

***Murray Morrison, Ph.D.**, Insurance Institute for Business and Home Safety, Richburg, SC*

The use of architectural screens on buildings is required in many urban planning/zoning requirements to hide roof-mounted equipment (RME) from view. They may also serve as wind screens to reduce loads on RME. Currently, there is a lack of guidance for designers and engineers on how to appropriately calculate wind loads on these structures. IBHS and others have shown that loads on RME can be reduced when RME is surrounded by other RME units. However, the reduction in wind loads due to surrounding RME or architectural screens has not been quantified in a systematic way to allow for codification.

3. Secure Roof Top Equipment

***Matthew Hooti, P.E., Member**, ISOTECH Industries, Vaughan, ON, Canada*

Design of HVAC&R systems for wind/seismic compliance is required by code. Recent code changes have significantly increased required wind design loads. Roof top equipment such as air handling systems and cooling towers must be restrained to prevent wind or seismic load failure. Loss of the systems can shut down a building or damage the roofing, causing major economic loss. This presentation discusses practical methods for restraining most common roof top equipment.

11:00 AM - 12:30 PM

Seminar 43 (Advanced)

New Advances in Ground-Source Borehole Thermal Response Testing and Storage Applications

Track: Fundamentals and Applications

Room: Monroe

Sponsor: 6.8 Geothermal Heat Pump and Energy Recovery Applications

Chair: Cary Smith, Member, Sound Geothermal Corp., Sandy, UT

Borehole thermal resistance is the most important field measured component in the loopfield design. Advancements in measurement and heat storage/recovery enable more detailed information to the design engineer and adds forensic tools. The advanced analytical tool extracts more information from the thermal conductivity test in a shorter amount of time. Thermal regimes, such as grout conductivity, can be identified, and stability of the power source is less important. Advances in borehole thermal storage (BTS) management permit more precise use of the heat stored and being stored. This seminar presents the latest advancement in storage management and measurement.

1. Dynamic Determination of Ground Thermal Conductivity and Minimum Thermal Response Test Duration Using the Line Source Model

***Xiaobing Liu, Ph.D., Member**, ORNL, Oak Ridge, TN*

The effective ground thermal conductivity (GTC) is a critical design parameter for sizing ground heat exchangers (GHXs) of ground source heat pump (GSHP) systems. GTC is usually determined with a thermal response test (TRT) and inverse modeling. The current practice requires extremely stable power supply for 36-48 hours during a TRT. A new method is developed to dynamically analyze the TRT data during the test. With this method, the TRT duration could be shortened by 20 to 40% while retaining similar accuracy in the determined GTC value as the current practice.

2. Simulation Correlation Analysis Method Capabilities and Continuous Line-Slope Method Findings

***Rick Clemenzi**, Geothermal Design Center Inc., Ashville, NC*

Current TRT is limited to only determining approximate Ground Thermal Conductivity. Other ground parameters are assumed to be "as reported by the requester, driller, and grouter". Correct Grout TC is critical to an efficiently operating GHP system, yet poor grouting quality is common. The new Simulation Correlation Analysis Method for the first time also determines Grout TC and confirms loop type and length for test wells or for installation Quality Assurance. The new method also removes the necessity of steady power/heat input -- a requirement of the current Line-Slope TRT method, opening new doors for Commissioning and System Validation Testing.

3. Advanced Thermal Response Applications
***Garen N. Ewbank, Member**, Ewbank Geo Testing, LLC, Fairview, OK*

Ground Heat Exchangers (GHEX) are a system component of a convective circulation circuit (or C_t^3). The GHEX is a renewable resource of heat and a storage device for wasted heat. To quantify the performance, capacity, and duration of the resource and storage one should be capable of forecasting the thermal response within the C_t^3 to insure performance and operation. The use of the Dynamic Determination of Ground Thermal Conductivity and Minimum Thermal Response Test Duration Using the Line Source Model allows the designer to model hourly responses within the heat flux of the C_t^3.

4. Utilizing DTS for DTRS and Ghx/Btes Temperature Instrumentation
***Chuck Hammock, P.E., Associate Member**, Andrews, Hammock & Powel, Inc., Macon, GA*

Traditional Thermal Response Tests (TRT), aka Thermal Conductivity Tests (TCT), are limited to determining only an average ground thermal conductivity "k" factor of the formation. By deploying fiber optic based Distributed Temperature Sensing (DTS) cable inside the U-bend, "distributed" thermal conductivity values can be resolved at much more granular levels (typically every two meters) via this "Distributed TRT" or DTRT methodology. DTS systems can also be utilized to instrument traditional/non-traditional Groundloop Heat Exchangers (GHX) for temperature monitoring/control of these systems. This session provides a brief introduction/overview of the technology and real world examples of their use.

11:00 AM - 12:30 PM

Seminar 44 (Intermediate) NY PDH G

The Best of "Engineer's Notebook" 2nd Edition

Track: Fundamentals and Applications
Room: Empire
Sponsor: 9.1 Large Building Air-Conditioning Systems, 9.10 Laboratory Systems
Chair: John Kuempel Jr., P.E., Member, DeBra-Kuempel, Cincinnati, OH

The "Engineer's Notebook" series in ASHRAE Journal was established in its current form in 2013, with four authors contributing monthly articles on a rotating basis. All four authors are ASHRAE Fellows and senior consulting engineers with more than 100 years of collective practical experience, and the concept of the recurring column is to share with peers what they have learned in the course of their careers, along with helpful design tips and tools. In this seminar, each of the four has chosen one of their favorite columns to date and has adapted it for presentation.

1. Building Automation System Control of Variable Air Volume Labs
***Steven T. Taylor, P.E., Fellow ASHRAE**, Taylor Engineering LLC, Alameda, CA*

Controls for variable air volume (VAV) laboratory supply and exhaust systems have traditionally been separate from the primary Building Automation System (BAS). This typically results in two separate control systems, the lab controls for labs and the BAS for everything else, including non-lab zones, air handlers, heating and cooling plant, etc. This seminar shows attendees how to use the BAS to do all lab controls, allowing dedicated lab controls to be eliminated.

2. Chillers and Boilers in the Same Room: A Cautionary Tale
***Stephen W. Duda, P.E., BEAP, HBDP and HFDP, Fellow ASHRAE**, Ross & Baruzzini, Saint Louis, MO*

A recent real-life investigation highlights the complications that can arise when installing both chillers and boilers in a common equipment room. This case study describes an incident that left boiler breechings acutely corroded and failed. This seminar highlights that investigation and reviews a number of problems uncovered, reviews applicable codes and Standard 15's provisions in this regard, and concludes with recommendations to avoid those problems on your projects.

3. Energy Efficient Ventilation Systems for Labs
***Daniel H. Nall, P.E., BEMP, CPMP and HBDP, Fellow Life Member**, Syska Hennessy Group, New York, NY*

For laboratories, the greatest energy challenge is meeting ventilation air flow requirements while maintaining a comfortable and functional interior environment. When exhaust driven ventilation requirements exceed the airflow required for sensible cooling, and supply temperature reset for the air supply is limited by humidity control or the presence of load-driven labs on the same air system, reheat is often the only alternative. Reheat energy and the wasted energy of the offset sensible cooling are opportunities for energy savings in these buildings. This presentation demonstrates some strategies for reducing reheat and the energy required for make-up air conditioning.

4. Underground Piping Distribution Systems
***Kent W. Peterson, P.E., BEAP, Presidential Fellow ASHRAE**, P2S Engineering, Inc., Long Beach, CA*

One of the main components of heating and cooling systems serving multiple buildings is the distribution or piping network that conveys the energy. The piping is often the most expensive portion of these types of systems. The piping usually consists of a combination of pre-insulated and field-insulated pipe with isolation valves in both direct burial and concrete tunnel applications. It is important to understand available pipe materials and means of isolation when designing these systems.

11:00 AM - 12:30 PM

Seminar 45 (Basic)

What In The World? Global Refrigerant Regulations Explained By Experts from Around the Globe

Track: Standards, Guidelines and Codes

Room: Red Lacquer (4th Floor)

Sponsor: MTG.LowGWP Lower Global Warming Potential Alternative Refrigerants, Refrigeration Committee, UNEP

Chair: Jason Robbins, P.E., Member, McDonald's, Romeoville, IL

Regulations around refrigerants have been changing faster in the last few years than in the past few decades. This seminar combines the knowledge of experts in the field from around the globe to provide an in-depth but concise update on U.S. and global refrigerant regulations and safety standards. Updates are given on phase out schedules, current and pending environmental regulations and impacts on HVAC&R industries globally. In addition, an update on current status of global safety regulations as it pertains to lower GWP refrigerants especially A2L's and how they will impact design and equipment.

1. The Kigali Amendment: What Does It Actually Do and Why Should I Care?

***Andrea Voigt, Member**, The European Partnership for Energy and the Environment, Brussels, Belgium*

What actually is in the Kigali amendment? How will it impact how equipment is built, sold and operates? This presentation answers those questions.

2. US Refrigerant Regulatory Updates, ASHRAE Standard 15 and UL Safety Standards

***Bill Hansen, P.E., Member**[1] and Jason Robbins, P.E., Member[2], (1)Ingersoll Rand, La Crosse, WI, (2)McDonald's, Romeoville, IL*

Are HFO and A2L refrigerants safe? Are they approved for use where I do business? This presentation answers those questions.

3. Refrigerant Regulations in Asia

***Tetsuji Okada**, Japanese Refrigeration and Air Conditioning Industry Association (JRAIA), Tokyo, Japan*

What is going on in Asia with refrigerant regulations? How will what is happening there impact markets around the globe? This presentation answers those questions.

4. Refrigerant Regulations in Developing Countries

***Ayman Eltalouny, Member**, OzonAction Programme at UN Environment, Manama, Bahrain*

Have a new project in a developing country? How will refrigerants be regulated and implemented? What refrigerants are allowed? This presentation answers those questions.

5. Refrigerant Regulatory Updates in Europe

***Martin Dieryckx, Member**, Daikin Europe NV, Oostende, Belgium*

How are F-Gas regulations being implemented across Europe? How are industries reacting? What has happened already, and what is coming? How does it impact equipment around the globe? This presentation answers those questions.

1:00 PM - 1:30 PM

Seminar TC

Building Automation, Social Media and Millennials! What Do They Have in Common?

Track: Fundamentals and Applications

Room: Salon 4/5

Sponsor: 1.4 Control Theory and Application

Chair: Marcelo Acosta, P.Eng., Member, Armstrong Fluid Technologies, Toronto, ON, Canada

OPEN SESSION: No badge required; no PDHs awarded; the expectations of Smart Buildings have been transformed over the past decade alongside technological innovation and the entrance of new generations into the workforce. The role of the HVAC controls designer has grown into that of a master systems integrator, expanding the required knowledgebase of controls engineers. This special TC-1.4 seminar discusses how to communicate the exciting developments within the building industry through social media to increase industry retention of millennial engineers. This seminar introduces trends that all ASHRAE members need to know to stay relevant to young engineers.

1:30 PM - 3:00 PM

Debate 3 (Intermediate)

Environmental Health Is of Little Concern to the Designer

Track: Fundamentals and Applications

Room: Adams

Sponsor: College of Fellows, Environmental Health Committee

Chair: Larry Spielvogel, P.E., Fellow Life Member, Consulting Engineer, Bala Cynwyd, PA, Katherine Hammack, Fellow Member, Ernst & Young, McLean, VA, Lawrence Schoen, P.E., Fellow ASHRAE, Schoen Engineering Inc, Columbia, MD, William Bahnfleth, Ph.D., P.E., Presidential Fellow ASHRAE, Pennsylvania State University, University Park, PA, Don Beaty, P.E., Fellow Life ASHRAE, DLB Associates, Eatontown, NJ, Peter Wong, CEng, Member, Yook Tong Electric Co Ltd, Hong Kong, Hong Kong and E. Mitchell Swann, P.E., Member, MDCSystems, Paoli, PA

It can be argued that as long as the designer gets the temperature, humidity and noise correct then the customer should be happy. Alternatively, the occupant needs a healthy and productive workspace. Does cost inhibit a healthy result? Does tick box design suffice?

1:30 PM - 3:00 PM

Technical Paper Session 5 (Intermediate)

Investigations of Energy Efficient Airflow Design

Track: Systems and Equipment
Room: Honore
Chair: Ratnesh Tiwari, Ph.D., Member, University of Maryland, College Park, MD

This session explores various approaches to airside system design, including variations in air handler configurations and terminal unit applications ranging from fixed to variable airflow and series to parallel layouts. The papers discussed in this session also focus on the energy consumption/impact of each of the variations investigated.

1. A Comparison of Fixed and Variable Airflow Series Fan Powered Terminal Units (CH-18-012)
***Dennis O'Neal, Ph.D., P.E., Fellow ASHRAE**, Baylor University, Waco, TX*

The annual energy use of fixed and variable airflow series fan-powered terminal units in a small office building were evaluated and compared using the hourly weather data from five cities: Houston, Phoenix, New York, Chicago, and San Francisco. A fixed airflow series fan powered terminal unit with a permanent split capacitor motor was used as the baseline. Three different sized fixed and variable airflow fan powered units with electronically commutated motors with evaluated. The results demonstrated the energy savings potential of fixed and variable airflow fan powered terminal units with electronically commutated motors when applied to this small office building.

2. Energy and Control Performance Investigation of Dual-Branch Air Handling Units with Return Air Bypass (CH-18-013)
***Koosha Kiamehr, Student Member**, University of Miami, Coral gables, FL*

Since single-duct air handling units (SDAHUs) supply the cooling air to all zones with the same temperature, the cooling air normally is reheated to satisfy the heating demand in exterior zones in cold seasons. Supply air temperature reset reduces the reheat load but on the down side, it increases the supply airflow rate to the interior zones which increases the fan power. Dual-branch air handling units are proposed to mix the return air with the cooling air to simultaneously distribute the warm air to exterior zones and the cold air to interior zones in cold seasons to reduce the reheat load. This study investigates the energy performance and control of the proposed DBAHUs through simulations.

3. Annual Energy Performance Evaluation of Series and Parallel Fixed Airflow Fan Powered Terminal Units (CH-18-014)
***Peng Yin, Ph.D., Associate Member**[1], Dennis O'Neal, Ph.D., P.E., Fellow ASHRAE[2] and Di Lu[2], (1)University of Louisiana at Lafayette, Lafayette, LA, (2)Baylor University, Waco, TX*

Given the limited capacity of modeling fan-powered terminal units (FPTUs) in EnergyPlus, an alternate model following the mass and energy balance approach was developed and implemented in Engineering Equation Solver (EES) to capture the terminal unit performance over a range of design options and operating characteristics. In order to evaluate the ability of the alternate model for energy calculation and investigate the energy impact of FPTU design options, the annual energy consumption of a single-story, five-zone office building with a single duct variable air volume (VAV) system was determined in EnergyPlus and EES.

1:30 PM - 3:00 PM

Conference Paper Session 14 (Intermediate)

Cooling Mission Critical Facilities

Track: Fundamentals and Applications
Room: Chicago
Chair: Nick Gangemi, Life Member, Northern Air Systems, Rochester, NY

Data Center energy use continues to rise and different techniques are discussed to show alternatives to the air and water systems commonly utilized. Initially the metrics for data center energy and sustainability are discussed. Then four different methods of using refrigerant, water, or variable refrigerant to cool the data center with less energy are discussed. Each of these studies included real proof of concept projects to prove the theories and analysis. Combined theory and practical application results in the discussion of four different techniques to improve the efficiency of the data center.

1. Effective Cooling of Server Boards in Data Centers by Liquid Immersion Based on Natural Convection Demonstrating PUE below 1.04 (CH-18-C052)
***M. Matsuoka, Ph.D., BEAP, Member**[1], Kazuhiro Matsuda, M.D., BEAP, Member[1] and Hideo Kubo[2], (1)Osaka University, Osaka, Japan, (2)Fujitsu Limited, Tokyo, Japan*

This paper proposes an immersion cooling with natural convention for high power server board used in data centers. The cooling performance was evaluated by CFD simulation and actual experiment. As the refrigerant, several non-conductive, thermally and

chemically stable fluids, including Silicon oil, Soybean oil, and Perfluorocarbon structured Fluorinert are applied. The CPU temperature in the refrigerant monotonically decreases with the Rayleigh numbers of the refrigerant. The smoother refrigerant is better for cooling the high power CPU. As a result, this proposed technology with natural convention exhibits high potential for low energy and space-saving board cooling which demonstrates PUE below 1.04.

2. Proposal of Cooling System for High Performance Computing by Drip-Feeding Cooling (CH-18-C053)

Kazuhiro Matsuda, M.D., BEAP, Member[1]*, Morito Matsuoka, Member*[1] *and Yuichiro Miyake*[2]*, (1)Osaka University, Osaka, Japan, (2)NTT Group, Tokyo, Japan*

In recent years, the widespread use of high performance computing (HPC) has caused difficult cooling problems due to high thermal density. This paper proposes an innovative drip feed cooling system. This cooling method cools the server by directly dripping the non-conductive coolant to high heat generating parts such as CPU and GPGPU, realizing a more efficient and lightweight cooling system than conventional refrigerant immersion method. Simulation by Computational Fluid Dynamics (CFD) and experiment using prototype system show that efficient cooling can be achieved. PUE achieved less than 1.04, including power consumption of cold water production.

3. Cooling System with Nearly Zero Cooling Power for Server Rooms (CH-18-C054)

Naoki Aizawa, BEAP*, Takasago Thermal Engineering Co.,Ltd., Kanagawa, Japan*

This paper proposes a server room managed each zone with heat density. A cooling system was built, using general-purpose element equipment and measured power consumption and PUE of the cooling system operated under some energy saving methods. It was confirmed about the cooling system that stable driving is possible as the experiment and obtaining a result of the energy simulation is possible. The PUE of an annual average confirmed the feasibility of less than 1.04 by using general-purpose element equipment and some general energy saving methods.

4. Data Center Sustainability Index (CH-18-C055)

Sophia Flucker, CEng[1]*, Robert Tozer, Ph.D., Life Member*[1]*, Beth Whitehead, Ph.D.*[1]*, Deborah Andrews, Ph.D.*[2] *and Jon Summers*[3]*, (1)Operational Intelligence Ltd., Kingston upon Thames, United Kingdom, (2)London South Bank University, London, United Kingdom, (3)University of LEEDS, Leeds, United Kingdom*

Data center life cycle assessment identifies energy efficiency, source energy mix and embodied impacts of the mechanical, electrical and IT equipment as a facility's main environmental impacts. Facility energy efficiency metrics are well used but other areas often go unmonitored. Without a holistic view of impact, burden shift may occur, where action is taken to reduce the impact of one area which moves or increases the impact to another area. This paper describes indices and key variables for each main area of impact, allowing their influence to be understood and informing decision making, and includes application case studies.

5. Efficient Cooling and Heat Recovery with VRF Systems in Embedded Data Centers (CH-18-C056)

Micah Sweeney[1]*, Mukesh Khattar, Ph.D., Fellow ASHRAE*[2] *and Ron Domitrovic, Ph.D., Member*[3]*, (1)EPRI (Electric Power Research Institute), Knoxville, TN, (2)EPRI (Electric Power Research Institute), Palo Alto, CA, (3)Electric Power Research Institute, Knoxville, TN*

This paper presents results of a demonstration study of VRF technology vis-a-vis conventional rooftop heat pumps for conditioning a server room within a building. A 22-ton VRF system was installed in a laboratory space where it provides conditioning to both occupied space as well as a 1,000 sq.ft. server room. The VRF technology was evaluated and its performance was compared with the packaged rooftop heat pumps in several modes of operation, including heating, cooling, and heat recovery. This paper presents the technical approach for evaluating VRF technology in embedded data center applications and the results from evaluation in the laboratory.

1:30 PM - 3:00 PM

Seminar 46 (Intermediate) NY PDH G

CFD Modeling throughout the Building Lifecycle

Track: Modeling Throughout the Building Life Cycle

Room: Monroe

Sponsor: 4.10 Indoor Environmental Modeling

Chair: Jinchao Yuan, Ph.D., P.E., Member, University of Idaho, Boise, ID

CFD simulations have long been used in many built environmental designs. However, over the life cycle of the facilities, time-evolving changes can occur in occupied schedules, functionality and the surrounding environment. How CFD simulations cope with these changes becomes critical. In this session, three representative CFD simulation studies throughout the facilities life cycle are presented: 1) commercial data center energy usage and thermal resilience optimization as operation needs evolve over time 2) industrial airplane manufacturing facility ventilation effective code compliance with re-purposed functionality and 3) urban train station infrastructure ventilation revaluation brought by continuously surrounding urban development over the years.

1. Is a Reactive Approach to Data Center Overheating Sufficient?

Mark Seymour, CEng, Member*, Future Facilities Ltd, London, United Kingdom*

CFD modelling is commonly used for data center design and trouble-shooting. However, the common approach to management is to install IT within conceptual design guidelines until there are thermal alarms. These alarms often arrive before reaching capacity. A common consequence is that alarms result in caution, and further equipment is not installed. Before that, some installation requests may be denied because they are above the design power density. This seminar illustrates how an immediate

'No' becomes 'May-be' which, when analyzed using CFD becomes 'Yes', 'No' or 'How about…'. The potential result - a high capacity resilient and efficient design.

2. Design Considerations for Occupational Health When Large Maintenance Facilities Are Repurposed for Aircraft Painting

***James Bennett, Ph.D., Member**, CDC/NIOSH, Cincinnati, OH*

Reducing exposures of aircraft painters to hazardous metals and organics motivates design and operation of hangar ventilation systems in purpose-built facilities. Field studies have shown that facilities are often repurposed for aircraft painting, even when the ventilation system has been designed for thermal comfort or general dilution. Contaminant exposures under cross-flow, ceiling diffuser, and hybrid ventilation configurations were evaluated. Occupational Safety and Health Administration (OSHA) regulations require 100 fpm (0.508 m/s) through spray booths/rooms, and this condition is difficult to achieve with most ceiling diffuser installations. Cross-flow designs provided lower contaminant exposures, with decreased residence times and efficient flow paths.

3. CFD Modeling to Support City Building Re-Development

***Duncan Phyfe, Associate Member**, ARL, Alden, MA*

The Boston skyline has changed over the years since its first settling. The changes continue today. This seminar looks specifically at the Boston South Station overbuild project, in which a high rise will be placed over a large portion of the presently open train station. This effort has been in development since the 1990's, long enough to see the evolution of CFD tools. The original physical models have been replaced with more flexible CFD models to ensure the pollutant levels in the overbuild remain within limits. Today, CFD is being used to finalize the design of the station.

1:30 PM - 3:00 PM

Seminar 47 (Intermediate) NY PDH G

Requirements for Extreme Weather Operation of HVAC Systems

Track: Earth, Wind & Fire

Room: State

Sponsor: 7.3 Operation and Maintenance Management

Chair: Robyn Ellis, Associate Member, City of Hamilton - Public Works, Hamilton, ON, Canada

Extreme cold, heat, wind, snow and other weather can affect HVAC system performance. Despite a designer's best efforts, time and use can allow deterioration to the point where a system can be overwhelmed. This session examines how designers, owners and operators can configure new and existing HVAC systems to weather the storms.

1. Extreme Cold Weather HVAC System Configuration and Operation

***Orvil Dillenbeck, P.Eng. Member**, Canadian Nuclear Laboratories, Chalk River, ON, Canada*

Extreme cold weather can affect HVAC system performance. Despite a designer's best efforts, time and use can allow deterioration to the point where a system can be overwhelmed. With a focus on operational preparedness, this session is about how designers, owners and operators can configure new and existing HVAC systems to handle extreme cold conditions.

1:30 PM - 3:00 PM

Seminar 48 (Basic) NY PDH G

Cost Effective Measurement and Verification for Large Systems

Track: Systems and Equipment

Room: Empire

Sponsor: 7.6 Building Energy Performance

Chair: Annie Smith, P.E., Associate Member, Ross & Baruzzini, St. Louis, MO

The industrial sector's energy use is rising faster than energy reductions achieved in the residential and commercial sectors. Concurrently, more complex energy efficiency projects are implemented to save energy in industrial-scale and other large systems. Therefore, measurement and verification for industrial and other large systems is incredibly important to verify estimated energy and cost savings. However, this process can be very resource-intensive depending on the measurement and verification methodology. This seminar covers the methodologies available, how to properly measure energy savings in an industrial application and will touch on how valuable information can be obtained to identify additional savings opportunities.

1. Measurement and Verification of Efficiency Upgrades in Chilled Water Systems

***Abdul Qayyum "Q" Mohammed, Associate Member**, Go Sustainable Energy, Columbus, OH*

As the energy efficiency industry evolves, more complex efficiency projects like chilled water system upgrades, are being implemented which can get complicated and be resource-intensive. Two case studies are discussed in this presentation. A chilled water plant serving space-cooling loads and a chilled water system serving industrial process loads. The methodology being discussed allows the evaluator to meter the system for a reduced amount of time, observe an improvement in system efficiency

and quantify the annual energy savings of the system, resulting in a streamlined process, reduced costs, better annual energy savings estimates and cost effective utility efficiency programs.

2. Adventures in Industrial Process Improvements

***Dennis Landsberg, Ph.D., P.E., BEAP, Fellow Life Member**, L&S Energy Services, Inc., Clifton Park, NY*

Industrial energy use is growing faster than energy efficiency improvements being achieved in the residential and commercial sectors. Studies of industrial plants should include process as well as building improvements to find significant energy savings. Unlike other building types, industrial energy use is a function of production. To calculate savings and track performance, industrial energy consumption is divided into baseline usage and Btu/widget produced. This permits adjustment against variations in production over time and is required to apply for utility rebate programs to receive custom measure incentives. This presentation provides an overview of energy savings in some common industrial processes.

3. Measurement and Verification: Added Expense or Cheapest Energy Savings Available?

***Chris Smith, P.E., Member**, Energy 350, Portland, OR*

The performance improvements of measurement and verification far exceed the cost, making it the most cost-effective portion of the project. M&V ensures the project is performing as expected, but also allows the implementer to gain more savings than originally anticipated or recovers savings that would have otherwise been lost. These incremental savings through combined commissioning and M&V can be harvested for a fraction of the cost of the initial savings. Using case studies and multiple real-world examples, this presentation quantifies and compares the cost of conducting combined commissioning and M&V to increase energy savings, producing the cheapest energy savings available.

1:30 PM - 3:00 PM

Seminar 49 (Intermediate) NY PDH G

The Process for Zero Energy K-12 Schools: The Next Series of ASHRAE Advanced Energy Design Guides

Track: Fundamentals and Applications

Room: Red Lacquer (4th Floor)

Sponsor: 2.8 Building Environmental Impacts and Sustainability

Chair: Charles Eley, P.E., Member, Eley Consulting, San Francisco, CA

K-12 schools are leading the way for zero energy. As the next in the series of the popular Advanced Energy Design Guides, this zero energy guide focuses on what is needed to achieve zero energy in K-12 schools. The session focuses on the simulation models; EUI targets; lighting and HVAC design, on-site renewable energy needs; as well as looking at processes to ensure success in meeting the zero target. How-to tips and practical advice are presented as well as successful zero energy case studies.

1. The Process of Creating Zero Energy Design Guidance: The Next in the Series

***Paul Torcellini, Ph.D., P.E., Member**, NREL, Golden, CO*

ASHRAE in conjunction with AIA, IES, USGBC and USDOE have created the next series of Advanced Energy Design Guides. The first in this series is the zero energy design guidance for K-12 schools. This presentation focuses on the process to create the guide, energy use intensity targets and the analysis to achieve them, plug loads and on-site renewable energy.

2. The Owners Perspective: Making Zero Energy Happen

***John Chadwick, AIA**, Arlington Public Schools, Arlington, VA*

Arlington County Public Schools set out to build a new elementary school with a passion to be a leader. They hired an effective design team and set out on a path to create a zero energy school within the existing budget. This presentation focuses on the effective goal setting, the communications required and the coordination needed to achieve zero energy. This building's owner's perspective provides important insights to the future of buildings.

3. Lighting Design Parameters for Successful Zero Energy Schools

***Shanna Olson**, IMEG Corp., Chicago, IL*

Lighting is a critical piece of designing zero energy buildings. In addition, lighting technologies are changing dramatically with almost 100 percent of new efficient lighting being LED. This presentation examines the interactions with daylighting, effective lighting layout and control strategies. In addition, lighting power targets are provided to help appropriately design HVAC systems.

4. Making It All Work: Important Aspects of HVAC Zero Energy Design

***Daniel Nall, P.E., HBDP, CPMP and BEMP, Fellow Life Member**, Syska Hennessy, New York, NY*

HVAC systems bring all the pieces together in creating a zero energy school. The results of effective envelope, lighting and plug loads all come together in the selection of HVAC system type and its configuration. Proper sizing, as well as sequence of operations, are critical for success in delivering a school that meets its EUI target which on-site renewable energy can meet. This presentation also covers thermal mass and the benefits of load diversity on the HVAC system. It also provides some unique insights on working with HVAC systems in zero energy schools.

2:00 PM - 3:00 PM

Seminar TC

CFD Study of Hydraulic Shock in Two-Phase Anhydrous Ammonia

Track: Systems and Equipment
Room: Clark 3
Sponsor: 10.3 Refrigerant Piping, Controls and Accessories
Chair: Chidambaram Narayanan, ASCOMP USA Inc., Surich, Switzerland
OPEN SESSION: No badge required; no PDHs awarded; the condensation induced hydraulic shock (CIHS) problem in ammonia refrigeration systems utilizing hot gas defrost is a safety issue which requires the accurate prediction of the risk of pipe rupture due to formation of a hydraulic shock. This study is an attempt to model all the fluid dynamics of this problem using three-dimensional CFD software using a compressible multiphase model.

3:15 PM - 4:45 PM

Seminar 50 (Basic) G

Low Energy Design Impacts on Peak Heating and Cooling Load Calculations

Track: Fundamentals and Applications
Room: Monroe
Sponsor: 4.1 Load Calculation Data and Procedures
Chair: Glenn Friedman, P.E., Fellow ASHRAE, Taylor Engineering, Alameda, CA
Energy codes like Standard 90.1 and technological change have reduced peak loads significantly. This trend continues in RP 1742, Update to Measurements of Office Heat Gain Data, used in the latest ASHRAE Handbook, Fundamentals volume. This significantly impacts design of HVAC and other building systems and can create a new set of pitfalls. Engineers should recognize these trends and the impact they have on old "rules of thumb." Likewise these trends can have a significant impact on energy modeling and built environment energy use. Tuning existing buildings and systems to take advantage of these trends is a major industry opportunity.

1. Heating and Cooling Load Trends: Down, Down, Down
***Steven Bruning, P.E., Fellow ASHRAE**, Newcomb & Boyd, Atlanta, GA*

As energy codes have evolved over the years since ASHRAE 90-75, their requirements have steadily improved building envelopes and reduced allowable lighting loads. While technology exploded with the advent of personal computers in the early 80's, plug loads resulting from that technology at first significantly increased cooling loads. More recently that trend has reversed with improved technology, thin clients and cloud technology. What impact have these trends had on HVAC design, the old one cfm/sf rule of thumb is literally out the window.

2. Decreasing Internal Loads: Could This Lead to Problems?
***Christopher K. Wilkins, P.E., Member**, CBR USA, Cambridge, MA*

This presentation reviews the downward trend for internal loads over time, with an emphasis on lighting loads and plug loads. The presentation also discusses the most recent research by TC 4.1 on low energy lighting (LED) and plug load measurements. The presentation also introduces the question of determining the point where lower loads can present system or indoor air quality issues.

3. Low Loads: Reap the Benefits but Read the Fine Print
***Manalee Nabar, P.E., Associate Member**, Bright Power Inc., New York, NY*

Low loads, both overall and internal plug/lighting are pivotal factors when achieving energy efficient (Passive House, Net Zero, etc.) building design. This presentation first delves into the basic components of heating and cooling loads and examines how different load calculation methods handle the interdependency and time lag between them. Next, strategies to minimize internal loads is discussed. Lastly, common pitfalls in HVAC system sizing due to low loads is discussed and what factors should be kept in mind when specifying equipment.

3:15 PM - 4:45 PM

Seminar 51 (Intermediate) G

Control System Best Practices: How to Make the Control System a Success, Part 2

Track: Systems and Equipment
Room: Adams
Sponsor: 1.4 Control Theory and Application
Chair: Israa Ajam, Associate Member, Ecosystem, New York, NY
Building automation systems (BAS) can substantially improve: building comfort, occupant wellness and building systems efficiency, with reduced energy costs and promoting proactive facilities maintenance measures for better customer service. Getting a BAS project to provide palatable results is achievable with the right recipe and balance of ingredients. Realize how the BAS standard, commissioning agent, CSI Division 25 and being involved in the BAS design development process from the start

can generate great results. The discussion establishes how these ingredients can provide an owner with a BAS deliverable that controls building systems effectively, efficiently with the aroma of success.

1. Control System Best Practices: How to Make the Control System a Success Part 2A
Barry Bridges, P.E., CPMP, Life Member*, NV5, Saint Paul, MN*

The commissioning agent should be involved in the project from the development of the Owners Project Requirements (OPR) document through the Functional Testing and Owner Training. The commissioner has a significant role in the successful outcome of the project. Addressing the control system requirements in the OPR, seeing that the OPR requirements are implemented in the bid documents and submittals are an important step towards success. The best practices for developing the functional tests and their execution to demonstrate the control system operation for all likely operating modes and conditions are highlighted.

2. Control System Best Practices: How to Make the Control System a Success Part 2B
Chariti Young, Member, *Automated Logic Corp., Kennesaw, GA*

Building Automation Systems (BAS) can substantially improve: building comfort, occupant wellness, and building systems efficiency, with reduced energy costs and promoting proactive facilities maintenance measures for better customer service. Getting a BAS project to provide palatable results is achievable with the right recipe and balance of ingredients. Realize how the BAS Standard, Commissioning Agent, CSI Division 25 and being involved in the BAS design development process from the start can generate great results. The discussion establishes how these ingredients can provide an owner with a BAS deliverable that controls building systems effectively, efficiently with the aroma of success.

3. Control System Best Practices: How to Make the Control System a Success Part 2C
Israa Ajam, Associate Member*, Ecosystem, New York, NY*

How can it be ensured that a new HVAC design is operated properly? Information must be properly transferred throughout the project from the design team to build team to the O&M team. The design team should stay with the project for a 1 full year (all seasons) to fine tune the project and provide continuous O&M team training. Systems must remain automated to prevent inefficient operation and monitoring is used to optimize building operation. Ideally, a building fault detection system is installed to indicate alarms in addition to troubleshooting to help the O&M team maintain proper operation of the building.

3:30 PM - 4:30 PM

Seminar TC (Basic)

TC Seminar How Accurate is Your Air Flow Capture Hood Measurement?

Track: Systems and Equipment
Room:Honore
Sponsor: 1.2 Instruments and Measurements
Chair: Stephen Idem, Ph.D., Member, Tennessee Technological University, Cookeville, TN
OPEN SESSION: No badge required; no PDHs awarded; presented during the TC's meeting. The accuracy of a capture hood depends on factors such as mode of operation, the hood placement relative to each outlet or inlet, the diffuser/grille cross section and/or the particular design of the diffuser/grille, as well as the effects of back-pressure. This seminar describes how capture hoods are calibrated and will provide guidance regarding best practices when capture hoods are utilized for either residential or commercial systems.

Accuracy of Residential Capture Hoods
Steve Rogers*, The Energy Conservatory, Minneapolis, MN*

Research was conducted using a laboratory duct system comprised of a supply fan, a main plenum and four branches to supply registers, similar to a residential home. Data is presented for measurements with 5 different capture hoods and multiple styles of residential supply registers. Flow accuracy and insertion loss is discussed along with how they each affect air flow measurements at supply registers.

Capture Hood Errors Associated with Commercial Diffuser Types
Robert Moss*, Dwyer, Michigan City, IN*

This presentation reviews test data revealing significant errors associated with many commercial diffuser types on capture hoods as measured using a precision calibration station. Information on the effect of entrance size and elbow direction is presented on several specific diffuser types. Computational Fluid Dynamic models are presented for some of the diffuser types to help in understanding the origin of these errors. This study also includes a composite graph that depicts errors, in percent, by diffuser type, over the normal velocity range. This information can be used to correct capture hood readings on the job site.

Wednesday, January 24

8:00 AM - 9:30 AM

Technical Paper Session 6 (Intermediate) NY PDH G

Unique Methods of Improving Building Operation

Track: Fundamentals and Applications
Room: Chicago
Chair: Luke Leung, P.E., Member, Skidmore, Owings, & Merrill LPP, Chicago, IL
Fault detection is increasingly being used to locate and correct operating problems in buildings. This technical paper session examines techniques for using power meter data to identify faults in lighting circuits and work-order data and operator logbooks to develop an HVAC work-order frequency model. The session also discusses an energy modelling methodology which helps energy master planners determine trade-offs between buildings energy saving measures and district systems.

1. Software-Based Fault Detection for Multi-Circuit Building Lighting Systems (CH-18-015)
***Jayson Bursill, Student Member**, William O'Brien, Ph.D., Member and Ian Beausoleil-Morrison, Carleton University, Ottawa, ON, Canada*

This paper uses floor level building automation system data to characterize the lighting system, develop active and passive fault detection approaches and present the data in a manner that is easy to assimilate. The active approach was based on systemic manipulation and monitoring of the lighting circuits, while the passive approach was based on deductive observations during run-time. It was found that both active and passive fault detection could identify faults within one hour or slightly over one state change respectively and that even with only one power meter inferences could be made for multiple circuits.

2. A Preliminary Study on Text-Mining Operator Logbooks to Develop a Fault-Frequency Model (CH-18-016)
***H. Burak Gunay**[1], Weiming Shen[2], Brent Huchuk[3] and Zixiao Shi[2], (1)Usable Buildings, Ottawa, ON, Canada, (2)Carleton University, Ottawa, ON, Canada, (3)ecobee, Toronto, ON, Canada*

Textual data inside operator logbooks represent an untapped opportunity to retrieve information about the maintenance routines of heating, ventilation, and air-conditioning (HVAC) equipment and control infrastructure. This paper presents a case study in which seven years' worth of work-order logs from 44 buildings in a university campus were analyzed. After extracting HVAC-related keywords such as fan, AHU, VAV, stuck, leak from custom operator descriptions, the presenters employed the apriori algorithm to derive association rules that define the co-existence tendencies of the keywords in a work-order (e.g., co-existence of the words radiator and leak).

3. Energy Modelling Methodology for Community Masterplanning (CH-18-017)
***Scott Bucking, Ph.D., Associate Member**, Carleton University, Ottawa, ON, Canada*

Net-zero energy is an influential idea in guiding the building stock towards renewable energy resources. Increasingly, this target is scaled to entire communities which include dozens of buildings. Although building energy modelling processes and codes have been well developed to guide decision making, there is a lack of solutions for community integrated models which quantify energy saving opportunities. The problem is further complicated by the availability of district systems which better harvest and store on-site renewable energy. In response to these challenges, this paper contributes an energy modelling methodology which helps energy masterplanners determine trade-offs between buildings energy saving measures and district systems.

4. Simulation of Radiant Cooling Systems in Clean Room Applications Using Computational Fluid Dynamics (CH-18-018)
***Mohamed Al Beltagy**[1], Ahmed El Baz[2], Mohamed Elmorsi[3] and Ahmed El Assy[2], (1)Howeedy Consultant, Cairo, Egypt, (2)Ain Shams University, Cairo, Egypt, (3)American University, Cairo, Egypt*

The current study investigates a proposed convective and/or radiant cooling system, for a mass measurement laboratory, utilizing CFD. The laboratory is in the National Institute of Standards located in the Mariutia District, Cairo-Egypt. It is required to have a uniform temperature distribution with draft free conditions in order to avoid affecting the sensitivity and integrity of the measurement devices. The CFD work is conducted by a commercial software, PHOENICS, utilizing the HVAC module called FLAIR. The results show that radiant cooling techniques are capable of producing more stable and comfortable conditions compared to convection HVAC techniques.

8:00 AM - 9:30 AM

Conference Paper Session 15 (Intermediate)

Contemporary Heat Pump Methods

Track: Heat Exchange Equipment
Room: Honore
Chair: Philip Agee, Student Member, Virginia Polytechnic Institute and State University, Blacksburg, VA
Contemporary Heat Pumps have various applications in commercial and residential buildings and can differ greatly based on the fuel source (electric, gas, and geothermal) and cooling/heating loads. The overall effectiveness of these systems can be applied to traditional space loads as well as water heating needs. The analytical data shared in this session covers the potential of using underground railway adjacent soil as an energy source, the impact of gas fired units on system efficiency for a northern climate library, application of inverter-driven units for low load residences, and application of space and domestic water heating for residential applications.

1. Performance Enhancement of Urban Ground Source Heat Pumps through Interactions with Underground Railway Tunnels (CH-18-C057)
***Akos Revesz, Student Member**, Mari Mavroulidou, Issa Chaer, Ph.D., Mike Gunn, Jolyn Thompson and Graeme Maidment, Ph.D., P.E., London South Bank University, London, United Kingdom*

This presentation highlights key results from a numerical investigation which aimed to investigate the interactions of urban underground railways with localized ground source heat pumps (GSHPs). The investigation used London as a case study because GSHP installations are becoming increasingly common in the city and thus will get closer in proximity to the running tunnels. The presentation also highlights the key parameters impacting on railway-GSHP interactions and the potential heating related benefits.

2. Preliminary Analysis of the Impact of Gas-Fired Heat Pump on Heating and Cooling Energy Consumption of a Library Building (CH-18-C058)

Altamash Baig, Student Member *and Alan Fung, Ryerson University, Toronto, ON, Canada*

Analysis of energy consumptions of a gas-fired absorption heat pump (GAHP) installed in a library building in Ontario, Canada in heating and cooling modes is presented. Linear regression analysis was conducted using outdoor dry bulb temperature and energy consumption data from 2012–2014 to determine the annual heating and cooling energy consumptions and demands. Preliminary analysis shows an average annual reduction of 10.3% in energy consumption, 22.3% reduction in energy cost and 9.0% reduction in greenhouse gas (GHG) emissions compared with conventional heating and cooling equipment.

3. Longitudinal Evidence of Inverter-Driven Heat Pump Performance in Low-Load Residential Buildings (CH-18-C059)

Philip Agee, Student Member*, Georg Reichard, Ph.D., Member and Andrew McCoy, Ph.D., Virginia Polytechnic Institute and State University, Blacksburg, VA*

Buildings are complex systems, yet architecture, engineering and construction professionals often perform their work lacking a formal post-occupancy feedback process that informs the efficacy of goals for building performance. This study aims to contribute to closing the post-occupancy performance gap hindering professionals today. This study utilizes two case studies located in a mixed-humid climate to evaluate 1) simulated versus measured performance of inverter-driven heat pumps in low-load residential buildings; 2) the impact of actual weather versus simulated standard climate on year to year energy. Data are collected from two, all electric, low-load, affordable senior housing developments.

4. Laboratory and Field Evaluation of a Gas Heat Pump-Driven Residential Combination Space and Water Heating System (CH-18-C060)

Paul Glanville, P.E., Associate Member[1]*, Daniel Suchorabski*[1]*, Chris Keinath, Ph.D.*[2] *and Michael Garrabrant*[2]*, (1)Gas Technology Institute, Des Plaines, IL, (2)Stone Mountain Technologies, Inc., Erwin, TN*

Combination space and water heating systems have historically offered end users and installation contractors numerous benefits over conventional, standalone equipment – typically a gas furnace or electric heat pump paired with a standard gas or electric storage water heater. These systems, typically driven by a gas-fired potable (tankless water heater) or non-potable (boiler) water heating system, offer benefits including reduced equipment costs with one “thermal engine”, reduced installation costs through requiring only one vent/gas line/condensate drain, and when deployed effectively, they can yield consistent high operating efficiency and reduced cost.

8:00 AM - 9:30 AM

Seminar 52 (Intermediate)

Are You Ready for the Next Disaster?

Track: Earth, Wind & Fire

Room: Monroe

Sponsor: TG2 Heating Ventilation and Air-Conditioning Security (HVAC)

Chair: Carol Lomonaco, Member, Johnson Controls, Inc., Milwaukee, WI

Extreme events that lead to disruptions in the lives of building occupants tend to trigger immediate responses. In the aftermath, the public is made more aware of a risk while governments often respond by funding research into the event to understand the event and to mitigate the impact of similar events. In particular, the resilience of building systems will come under scrutiny. After time passes, awareness of hazards naturally tends to fade and the risks are forgotten until the next event. This seminar explores several facets of readiness for events that compromise the health and safety of building occupants.

1. Past Disasters: What Can We Learn?

Anthony York, P.E., Member*, Syska Hennessy Group, New York, NY*

Disastrous events in the past inevitably shape how future events should be planned for and hopefully allow for better responses in the future. While there is often great emphasis on criminal acts (e.g. the 2001 anthrax attacks), it is important to recognize that unintentional incidents (e.g. superstorm Sandy) can have just as much impact on the occupants of buildings than intentional acts. This presentation reviews a number of recent incidents and some of the lessons learned.

2. Current State: How Do We Assess Security?

Jason DeGraw, Ph.D., Member*, NREL, Golden, CO*

An important component in preparation for extreme events is the assessment of the vulnerability of buildings and building systems to extreme events. A wide variety of assessment techniques are available, from high-level checklists that more prescriptively approach the problem of assessment to simulation models that attempt to measure building performance during an extreme event. This presentation gives an overview of the landscape, with particular attention paid to performance-based assessments.

3. Moving Forward: What Guidance on Security and Risk Assessment Is Available?

***Scott Campbell, Ph.D., Member**, Portland Cement Association, Milwaukee, WI*

ASHRAE and other bodies have published a number of guidance documents that, when used with a proper domain expertise, allow for the proper preparation for and mitigation of extreme events. These documents include Guideline 29, Guideline for the Risk Management of Public Health and Safety in Buildings, which has recently been revised. With growing interest in the resiliency and with an ASHRAE position document potentially under development, it is increasingly important that guidance in this area be consistent, helpful and comprehensive. This presentation reviews the current state of guidance and discusses what is needed for a more secure future.

8:00 AM - 9:30 AM

Seminar 53 (Intermediate)

Biomass Hydronic Heating: Achieving High Performance Systems in Residential and Commercial Applications

Track: Systems and Equipment

Room: Empire

Sponsor: 6.10 Fuels and Combustion, 6.1 Hydronic and Steam Equipment and Systems

Chair: Paul Sohler, Crown Boiler Company, Philadelphia, PA

Biomass use for heating offers many advantages and is important in large regions of the U.S. The technology is different from rapid-response fossil-fuel systems and there is a strong need for integrated designs where the boilers work in conjunction with a properly designed and controlled balance-of-plant. This seminar assembles leaders in the field of efficient, clean, integrated biomass heating systems and includes: a discussion of technologies and test methods for boilers; the valuable role that properly designed thermal energy storage systems play in enhancing performance and delivered efficiency of biomass heating installations; and sharing extensive experience from numerous field installations.

1. Efficiency and Emissions of Modern Hydronic Biomass-Fired Heating Systems

***Thomas Butcher, Ph.D., Fellow ASHRAE**, Brookhaven National Laboratory, Upton, NY*

Use of renewable biomass for heating applications has been growing, driven by economics and benefits including use of local fuel resources and renewable aspects. Technologies are evolving rapidly and newer aspects include expanded use of sensor and control systems, two-stage and gasification combustion, integrated emission control and condensing heat recovery. The increased interest and new technologies create challenges for test methods which can accurately reflect the way these systems are installed and used in residential and commercial buildings. In this presentation, technologies, field use, tests methods and testing results are discussed.

2. Staging Biomass and Conventional Boilers for Optimal Energy Management

***John Siegenthaler, P.E., Member**, Appropriate Designs, Holland Patent, NY*

Staging of multiple fossil-fuel boilers is a routine control requirement. When tasked with controlling the combination of a biomass boiler and fossil fuel boiler, control system designers will typically treat the biomass boiler as a “fixed lead” first stage, to be supplemented with the fossil-fuel boiler as a “lag” stage. This can work, but there are differences that must be respected to avoid issues that can cause increased energy consumption and lowered efficiency. This presentation describes those issues and shows simple control concepts to eliminate them and allow optimal management of thermal energy storage.

3. Numerous Lessons Learned from Biomass Heating System Commercial Installations in New York State

***Khaled Yousef, P.E., Member**, Pyramid Energy Engineering Services, Albany, NY*

This presentation shares numerous lessons from several biomass heating systems installed at commercial sites. It covers varying sizes and a wide range of installations and layouts. Topics include sizing, controls, systems integration, Commissioning (Cx), Testing, Adjusting and Balancing (TAB), Thermal Energy Storage (TES), hydronics, venting, layouts, differences between stick-built vs. containerized plant options, and project roles and responsibilities. Also included is a list of valuable conclusions, recommendations, suggested next steps and valuable take home messages. Well-integrated and holistic project development approaches can support successful biomass installations. Attendees will acquire benefits and skills that are useful beyond biomass heating.

8:00 AM - 9:30 AM

Seminar 54 (Intermediate)

Ventilation Equipment and Systems for Underground Railway Facilities

Track: Systems and Equipment

Room: Adams

Sponsor: 5.9 Enclosed Vehicular Facilities, 5.1 Fans, 5.6 Control of Fire and Smoke

Chair: Igor Maevski, Ph.D., P.E., Member, Jacobs Engineering, New York, NY

Chicago is the main transportation hub which houses lots of underground transportation systems, including subways, road tunnels, railway tunnels. Chicago Union station is one of the busiest stations in the country. Its ventilation, especially in the platform and track areas, poses lots of challenges for mechanical designers. Those challenges include both system design and

equipment selection. This session demonstrates some system engineering solutions for Chicago Union Station and discusses ventilation fans and dampers equipment selection, testing, commissioning and design for underground railway and transit facilities.

1. Chicago Union Station: Ventilation System Design Innovations
***Jonathan Ko, P.E., Member**, Jacobs Engineering, New York, NY*

A new ventilation system for Chicago Union Station and the connecting tunnel complex has been proposed to ventilate smoke during a fire emergency and ventilate noxious gases during normal operation in compliance with ASHRAE Handbook, NFPA 130 and Amtrak standard. The proposed ventilation system utilizes the hybrid longitudinal and semi-transverse ventilation scheme, due to limited ventilation access to the street level. The effectiveness of the system was validated in CFD analysis of airflow and sound level analysis within the station. It can significantly improve air quality at the platforms during normal operation and control smoke under fire emergency conditions.

2. Emergency Tunnel Ventilation Fans: A Guide to Selections and the Ramifications of the Choices
***Michael Feuser, Member**, Twin City Clarage, Inc., Pulaski, TN*

How do engineers choose which ventilation fans to specify for underground railway facilities and why? Many factors must be considered when specifying equipment, and many of the questions are fundamental. This presentation discusses 1. Volume and Pressure: efficiency, stall region and sound concerns 2. Space limitations and reversal requirements, overall size envelopes for fan room and 3. Additional requirements imposed by standards and the customer.

3. Tunnel Ventilation Dampers: A Guide to Selections for Underground Passenger Rail Facilities
***Bill Lampkin, Member**, Greenheck, Schofield, WI*

Dampers are the key devices in ventilation systems for underground passenger rail facilities. Damper selection, design and construction vary among the underground facilities. Reliability, longevity and maintainability are the key factors that drive the damper selection and damper design. Special attention shall be given to the underground environment where the dampers will operate. It is typically heavily corrosive. Pressure pulses from the trains pose specific requirements to the blades selection and torque for the actuators. Special considerations shall be given to testing dampers in compliance with ASHRAE, AMCA and UL testing requirements.

4. Subway Fires
***Yoon Ko, Ph.D., Member**, National Research Council Canada, Ottawa, ON, Canada*

A subway fire could be started from garbage on the track or friction caused by mechanical faults fueled by track lubricants or wood ties. The consequences of the fire or smoke could be dangerous and fatal. This presentation discusses the risks of subway facility fires, previous subway fire accidents and methods to protect the facility and people.

8:00 AM - 9:30 AM

Seminar 55 (Intermediate)

Unique Refrigeration Applications

Track: Systems and Equipment
Room: Red Lacquer (4th Floor)
Sponsor: 10.1 Custom Engineered Refrigeration Systems
Chair: Tom Wolgamot, P.E., Member, DC Engineering, Missoula, MT

This seminar explores unique refrigeration applications that have helped advance the industry. Case studies presented include refrigeration aboard the International Space Station, global food storage techniques, design of micro-breweries and the first transcritical CO2 system for an NHL-sized ice rink. Specific hurdles of the applications are discussed and how the systems addressed those challenges.

1. Refrigeration Aboard the ISS
***Daniel Dettmers**, Member, IRC, U.W. Madison, Madison, WI*

There is a tremendous interest in natural refrigerants as the effects of man-made fluids become better understood. It is perceived there are technical hurdles to deploy natural refrigerants in a broader setting, but these hurdles can be easily overcome. The International Space Station faces some of the harshest and stringent conditions imaginable for a refrigeration system. This seminar describes how ammonia was utilized in a safe and effective manner aboard this challenging environment.

2. Design of Micro-Breweries
***Daniel Dettmers, Member**, IRC, U.W. Madison, Madison, WI*

If non-comfort cooling refrigeration is considered the “unconstrained” section of the HVAC&R world, then the systems being cobbled together for the world of brewpubs, nanobreweries and microbreweries has to be classified as the wild-west of refrigeration. With over 5,000 small breweries in the U.S. today, it not hard to imagine that many of these start-ups had little cash on hand. This presentation discusses a proper microbrewery refrigeration system and how it differs from a traditional large brewery. It also delves into some of the more “interesting and creative” refrigeration set ups the presenter has seen in the field.

3. Use of Transcritical Co2 in a Pumped Direct Floor Ice Rink
***James Blahey, P.Eng. Member**, Cimco, Winnipeg, MB, Canada*

CO2 is making its way back as a viable ice rink refrigerant solution. This seminar presents an application in which CO2 is used as a primary “brine” refrigerant pumped directly into the refrigerated concrete slab. Significant pumping horsepower savings are

realized along with much higher system COP's when return gas temperatures are depressed in cooler ambient conditions and overall on a seasonally adjusted basis. This ice plant utilizes semi-hermetic compressors, an adiabatic gas cooler and ½" stainless tubes embedded in 5" concrete slab and is a new option in both the retrofit and new construction markets.

8:00 AM - 9:30 AM

Seminar 56 (Intermediate)

Using Optimization for Airflow Management in Data Centers and Operating Rooms

Track: Modeling Throughout the Building Life Cycle
Room: State
Sponsor: 4.10 Indoor Environmental Modeling, 9.9 Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment
Chair: James W. VanGilder, P.E., Member, Schneider Electric, Andover, MA

The value of CFD modeling for indoor environment applications is well established. This seminar uniquely focuses on minimizing energy while ensuring the health of electronic and human occupants – in data center and operating-room applications. "Optimization" is the primary unifying theme with two presentations focusing on the familiar manual "design-stage" optimization carried out by the CFD modeler, one including a formal optimization study, and another proposing a formal optimization engine for ongoing operational control and energy savings in data centers.

1. Optimization Study of Stanchion Layout and Flow Partitioning to Achieve Uniform Airflow through Perforated Tiles in Data Centers
***Cheng-Xian (Charlie) Lin, Ph.D., Member**, Florida International University, Miami, FL*

Airflow non-uniformity normally causes uneven cooling for computing servers in data centers. To tackle the airflow variation from perforated tiles, we perform an optimization study, which considers these two most important parameters, i.e., stanchion layout and flow partitioning (flow resistance). The response surface methodology based on a radial basis function is used to reduce the run time for producing a large set of genetic generations during an optimization process in which the tile airflow variation is minimized. As a result, guidance on the design of stanchions and perforated tile type selection is provided.

2. Optimizing Supply Airflow Location in Data Centers Using CFD
***Ramin Rezaei, Associate Member**, Southland Industries, Dulles, VA*

Optimizing airflow management in data centers saves money by reducing the energy usage and avoiding hot spots. One of the main design criteria for data centers is the location of supply airflow. The three widely used data center cooling architectures are "underfloor", "overhead" and "sidewall" supply. In this presentation, the difference between the flow and temperature distributions amongst these 3 scenarios is investigated using CFD . Detailed three-dimensional analysis helps find optimum airflow temperature and flowrate.

3. Improving Data Center Efficiency with Active Airflow Control
***James W. VanGilder, P.E., Member**[1] and Christopher Healey, Ph.D.[2], (1)Schneider Electric, Andover, MA, (2)Schneider-Electric, Andover, MA*

The efficient control of cooling for data centers is an issue of broad economic importance due to the significant energy consumption of data centers. Many solutions attempt to optimize the control of the cooling equipment with temperature, pressure, or airflow sensors. This presentation shows how simulation-based approaches combined with power-consumption models can reduce cooling energy consumption in data centers. It also provides a real-life case study to demonstrate how energy-saving cooling set points can be found using calibrated simulations and smooth metamodels of the system.

4. Optimizing Air Change Rates in an Operating Room Using CFD
***Mehran Salehi, Ph.D., Associate Member**, Southland Industries, Dulles, VA*

Indoor air quality in hospital operating rooms is of a great concern for both patients and medical personnel, thus mandating the use of efficient HVAC systems and active gas scavenging systems. In this study, the velocity, temperature and particle distribution of an actual operating room is studied at different ACH values. Using CFD it is possible to determine the optimized ACH value and regions with high pollution concentration and ensure that the sterile zone is supplied with sufficient air to remove particles.

9:45 AM - 10:45 AM

Conference Paper Session 16 (Intermediate)

Low GWP Refrigerants

Track: Fundamentals and Applications
Room: Honore
Chair: Bo Shen, Ph.D., ORNL, Oak Ridge, TN

Research continues on low GWP refrigerants in efforts to reduce refrigerant effects on the environment. This session looks at performance studies as well as safety studies on new low GWP refrigerants.

1. Comparing Atmospheric Stability Versus HVACR Equipment Chemical Stability of New Low GWP Olefin Based Refrigerants (CH-18-C061)

Stephen Kujak, Member *and Elyse Sorenson, Associate Member, Trane, Ingersoll Rand, La Crosse, WI*

A whole new class of refrigerant chemistry has been developed which can react quickly in the atmosphere in days while remaining stable in HVAC&R equipment for years. It is confusing to many that a refrigerant with high atmospheric reactivity can have low reactivity in HVACR equipment. These new refrigerants have been evaluated in laboratory testing under accelerated temperature HVACR equipment conditions and have shown a variety of chemical reactions, but in general have shown acceptable stability. This paper provides an overview of the fast atmospheric chemistry reactions and compare and contrast them to very slow chemical reactions in HVACR equipment.

2. Investigation of Low GWP Flammable Refrigerant Leak from Rooftop Units (CH-18-C062)

Ahmed Elatar, Ph.D.[1]*, Ahmad Abu-Heiba, Member*[2]*, Viral Patel, Ph.D., Member*[2]*, Omar Abdelaziz, Ph.D., Member*[1]*, K Dean Edwards*[2]*, Mingkan Zhang*[2] *and Van Baxter, Ph.D., Fellow Life Member*[2]*, (1)ORNL, Oak Ridge, TN, (2)Oak Ridge National Laboratory, Oak Ridge, TN*

This paper presents a numerical investigation to study R32 (ASHRAE A2L) leak scenario from a rooftop unit into a large room. A catastrophic leak scenario was simulated where mixture of air and refrigerant is diffused from air grills mounted on the ceiling. The leak rate was assumed to be constant and the total simulation time was 5 minutes to study the refrigerant diffusion and dispersion of the flammable refrigerant in the room after the inception of the leakage. The total volume of where the molar concentration exceeds LFL is quantified and presented as an indication of the risk of ignition.

3. Performance of Low GWP Refrigerant R-516A in an Air-Cooled Chiller (CH-18-C063)

Kenneth Schultz, Ph.D., Member *and Marcos Perez-Blanco, Ph.D., Ingersoll Rand, La Crosse, WI*

R-516A, aka ARM-42, has been proposed as a lower GWP (<150) alternative to R-134a. It is an azeotropic blend with thermodynamic properties very similar to R-134a and has an ASHRAE classification of A2L. This paper reports the results of tests that were performed on an air cooled screw chiller, comparing R-516A to R-134a. The results indicate that R-516A can be considered a design-compatible alternative to R-134a in water chiller products.

9:45 AM - 10:45 AM

Seminar 57 (Advanced) NY PDH G

Air Barriers and HVAC Systems: A Better Marriage

Track: Tall Buildings

Room: Monroe

Sponsor: 4.4 Building Materials and Building Envelope Performance

Chair: Chris Schumacher, Member, RDH Building Science Laboratories, Waterloo, ON, Canada

Building air leakage compromises the performance of ventilation systems and air-based heating/cooling systems, preventing air from being delivered in the right amount, to the right space, at the right time. However, there are ways to ensure the air barrier system works as intended, reducing loss of conditioned air, while improving the HVAC system delivery efficiency. This session reviews the principles and requirements for air barrier systems; design, construction and commissioning processes are addressed; building envelope – HVAC interactions are considered; and field measurements of air leakage and ventilation airflow distribution for a 13-story residential building are presented.

1. Air Barrier in the Building Envelope: Basics

Laverne Dalgleish, Associate Member*, Air Barrier Association of America, Boston, MA*

People tend to look to the thermostat when they are uncomfortable in a building. The HVAC system will only work properly if the building envelope has been properly designed and constructed. The industry is starting to understand that an air barrier system is critical for the performance of the HVAC system in a building. This presentation covers the basics of an air barrier system in a building.

2. Airflow Breakdown: Mapping Ventilation Airflow in a 13 Storey Residential Tower

Lorne Ricketts, P.Eng., Associate Member*, RDH Building Science Inc., Vancouver, BC, Canada*

This presentation covers a case study of air leakage and airflow in a 13-storey residential building. For this study a combination of techniques including fan doors, perfluorocarbon tracer gas testing and long term monitoring to assess pressure differences and in-service air flow rates. Overall, this study aims to improve the general understanding of factors affecting airflows in buildings and how these factors combine to influence the performance of building mechanical ventilation systems. The results of the study allow for general recommendations with regards to the design of ventilation systems, building enclosure airtightness and compartmentalization strategies for high-rise residential buildings.

9:45 AM - 10:45 AM

Seminar 58 (Intermediate)

ASHRAE Standard 100-2015, Energy Efficiency in Existing Buildings: Applications, Updates and Plans

Track: Standards, Guidelines and Codes
Room: Empire
Sponsor: 7.6 Building Energy Performance, SSPC 100 Energy Efficiency in Existing Buildings
Chair: Joseph Firrantello, Ph.D., P.E., Member, Envinity, Inc., State College, PA
ASHRAE Standard 100 has undergone significant updates compared to the 2007 version of the standard, including new target tables in the 2015 version and additional compliance options in addendum b. This session summarizes new compliance requirements and options as well as approaches to facilitate international application of the standard, including climate zone information and target table development methods. Progress on possible enhancements to the underlying energy use index methodology in the next version of standard is highlighted.

1. Targets and Climates for International Application of Standard 100
***Glenn Friedman, P.E., Fellow ASHRAE**, Taylor Engineering, Alameda, CA*

Most of the energy audit and provisions of Standard 100 can be applied around the world. However, the new target tables and climate zones are based on US information that may not be as useful for application in other countries. This presentation describes efforts to develop a methodology for determining targets for different countries, starting with Canada and broadening to Europe and the Middle East as well as Asia. Options for addressing climate zone variations as well as building categories will be reviewed.

2. New Compliance Options for Individual Users of ASHRAE Standard 100
***Neil P. Leslie, P.E., Member**, Gas Technology Institute, Des Plaines, IL*

ASHRAE Standard 100-2015 Addendum b adds an alternative compliance path for users by providing normative primary energy EUI target tables in Sections 7 and 10 and Normative Appendix A of the standard. Along with these primary energy EUI target tables, site electricity and fossil fuel use target tables are also included for authorities having jurisdiction that prefer to use locally derived primary energy conversion factors for their primary energy EUI target calculation. This presentation provides details on derivation of these new primary energy EUI tables. Various options available to individual users for compliance with the standard are also illustrated.

3. Alternative Expressions of Performance for ASHRAE Standard 100: Is EUI Enough or Does It Need Help?
***Dennis Landsberg, Ph.D., P.E., BEAP, Fellow Life Member**, L&S Energy Services, Inc., Clifton Park, NY*

Energy Utilization Index (EUI), typically measured in Btu per square foot per year, is the metric often used to characterize building energy efficiency, even though it is an energy performance metric. Among other issues with EUI, the energy use of some building types may not be strongly correlated with floor area, and high rise buildings may have different EUIs than low rise buildings with the same energy efficient construction characteristics. This presentation highlights ongoing activities within SSPC 100 to explore options that may provide better correlation with the energy efficiency of building systems than the current EUI metric.

9:45 AM - 10:45 AM

Seminar 59 (Intermediate)

Dehumidification Designs for Surgical Suites

Track: Fundamentals and Applications
Room: State
Sponsor: 8.12 Desiccant Dehumidification Equipment and Components, 5.5 Air-to-Air Energy Recovery
Chair: Mark Piegay, Associate Member, Alfa Laval - Kathabar, Tonawanda, NY
Studies indicate that over 40% of energy consumption in a hospital is due to reheating of supply air that has been over cooled in order to satisfy prescribed humidity requirements and minimum air change rates. This session explains the basics of solid rotor desiccant systems and liquid desiccant systems and how they can be used to reduce the amount of cooling and subsequent reheating required to maintain environmental conditions in hospital operating rooms. Benefits to infrastructure required to support the operating room HVAC system are discussed.

1. Applying Dry Rotor Desiccant Systems in Temperature and Humidity Control for Hospital Operating Rooms
***James Piscopo, P.E., Member**, Jacobs Engineering, Philadelphia, PA*

Studies indicate that over 40% of energy consumption in a hospital is due to reheating of supply air that has been over cooled in order to satisfy prescribed humidity requirements and minimum air change rates. This session explains the basics of solid rotor desiccant systems and how they can be used to reduce the amount of cooling and subsequent reheating required to maintain environmental conditions in hospital operating rooms. Benefits to infrastructure required to support the operating room HVAC system are also discussed.

2. Applying Liquid Desiccant Systems in Temperature and Humidity Control for Hospital Operating Rooms
***Mark Piegay, Associate Member**, Alfa Laval - Kathabar, Tonawanda, NY*

This session explains the basics of liquid desiccant systems and how they can be applied to surgical suites HVAC designs to save energy compared to conventional methods of over cooling and reheat. Benefits of the system include maintaining tight control of

the required temperature and humidity specified by ASHRAE Standard 170 for surgical suite designs as well as cleaning the air of bacteria and viruses.

9:45 AM - 10:45 AM

Seminar 60 (Intermediate)

Energy Optimization and Loads for Indoor Plant and Animal Growth

Track: Fundamentals and Applications

Room: Adams

Sponsor: 2.2 Plant and Animal Environment, 8.10 Mechanical Dehumidification Equipment and Heat Pipes, 9.8 Large Building Air Conditioning Systems

Chair: Carol Donovan, Member, Alares LLC, Quincy, MA

This session presents approaches to energy efficient plant and livestock environments. Latent and sensible heat load calculation methodologies for both environments are a focus. Plant environments tend to use closed loop systems with minimal or no makeup air. Livestock environments tend to use open loop systems with minimal or no recirculation air. Presenting the calculations for both plant and livestock thermal environmental modification and control shows the two extremes of HVAC system design – fully closed loop versus fully open loop.

1. Latent and Sensible Calculations for Indoor Plant Growth

***Craig Burg, Member**, Desert Aire Corp, Germantown, WI*

A limited amount of data exist for the prediction of latent energy generated by the growth of plants indoors. Although methods exist for outdoor crops, there are differences in indoor environments. Plant transpiration and evaporation is effected by light in specific spectrums, vapor pressure deficit at the leaf surfaces, and leaf temperature. Crop and watering techniques also have an impact. In a closed system, the watering rate is the same as evapotranspiration, but the rate of transpiration changes throughout the growth cycle. This presentation shows calculations and correlation to real rooms by comparing the predicted data and measurements.

2. Calculation Methodology for Preconditioning Inlet Air for Livestock Facilities

***Joe Zulovich, Ph.D., P.E., Affiliate**, University of Missouri, Columbia, MO*

Traditional heat abatement systems for livestock facilities are not able to provide sufficient heat stress relief for high performance livestock operations located in hot and humid climates. In climates where traditional heat abatement systems are fully effective, the amount of water required to provide the heat stress relief is becoming a major concern. This presentation provides an overview of livestock ventilation system design methodologies and current heat abatement systems. A new livestock ventilation design calculation method is presented that can assess dehumidification by DOAS as a potential option for less water intensive heat abatement systems for livestock facilities.

9:45 AM - 10:45 AM

Seminar 61 (Intermediate)

Cutting-Edge Japanese Technologies SHASE Annual Award for Systems and Equipment in 2017: Retrofit Project

Track: Systems and Equipment

Room: Red Lacquer (4th Floor)

Sponsor: SHASE

Chair: Ryozo Ooka, Ph.D., Member, University of Tokyo Institute of Industrial Science, Tokyo, Japan

Retrofitting is crucial, not only to save energy but also to rehabilitate systems, particularly old district heating and cooling systems. A retrofit project for a 20-year-old DHC system, which was honored with a SHASE Award, boosted overall plant efficiency by 29% by downsizing, reduction in pumping energy and replacement of centrifugal refrigerators. Another SHASE-awarded retrofit project was completed at a public natural history museum in Japan. Here, energy consumption was reduced by 43% using additional insulation, LED lighting and electrification of cooling and heating devices.

1. Energy-Saving Retrofit of Facilities in the Museum, Slashing Energy Consumption By 40%

***Taro Nomura**, Japan Facility Solutions, Inc., Tokyo, Japan*

This museum is a large facility that handles natural history and plays a key role in boosting natural learning in Gunma Prefecture. Meanwhile, given the urgent need to reduce greenhouse gas emissions in Gunma Prefecture, significant reductions were also expected within this facility. Leveraging the ESCO project, we planned comprehensive energy-saving measures such as using a heat-storage air-conditioning system, LED lighting and additional insulations; aiming to drastically reduce CO_2 emissions and energy consumption. Once this project got underway in 2014, energy consumption at this facility was reduced by more than 40% compared to the 2008 to 2010 average.

2. Energy-Saving Retrofitting of Heat Source in DHC

***Satoshi Yamakawa**, TEPCO Energy Partner, Incorporated, Tokyo, Japan*

This DHC (District Heating and Cooling) established in 1989 is the first in Japan to utilize river water as a heat source and some unexpected issues have emerged through its operation. While it was renewed over the 2012-2014 period, with deliberate examination, a 20% improvement in energy efficiency was achieved, earning the Energy Conservation Grand Prize. This article outlines the system and the improvements made. Technologies introduced include a high-efficiency heat pump using renewable river water energy, control technology utilizing river water and preserving the river ecosystem and Cloud BEMS technology for high-efficiency.

9:45 AM - 10:45 AM

Seminar 62 (Intermediate)

Thermodynamic Limits for Buildings

Track: Fundamentals and Applications

Room: Chicago

Sponsor: 7.4 Exergy Analysis for Sustainable Buildings (EXER)

Chair: David Vernon, Associate Member, UC Berkeley Center for the Built Environment, Berkeley, CA

This seminar addresses the issues mechanical system design engineers encounter in daily situations, but cannot appropriately address with energy analysis only. Since exergy analysis enables the comparison of different forms of energy and different energy qualities, it makes it possible to optimize the performance of an HVAC system holistically, including fan and pump powers. This seminar includes presentations from practitioners and from researchers, and covers the applicability of exergy analysis in optimizing the HVAC system performance, and how we can use exergy analysis to reach net zero energy or exergy building targets.

1. Thermodynamic Limits for Air-Conditioned Buildings

***William Kopko, Member**, Johnson Controls, Chiller Solutions, Technology and Innovation Group, New Freedom, PA*

For commercial buildings built to modern energy codes, fan and pump energy usage frequently exceeds that of compressors. For large chillers, codes require a design efficiency of approximately 60% of the Carnot limit, but fluid flow in a building does not face similar thermodynamic limitations. For example, duct pressure drop is roughly proportional to duct length over diameter to the fourth power, which means that duct pressure drop and corresponding fan energy can approach zero with appropriate duct design. In addition, reducing the indoor fan power reduces the cooling load, an effect that is generally ignored in building energy analysis.

2. Exergy in Air Conditioning

***Mike Trantham, Member**, IMI Flow Design, Dallas, TX*

A few simple calculations based on the Carnot cycle show that thermal control of buildings, even given the same heat loads, could happen with less energy input than current systems consume. Exergy analysis is used to numerically calculate losses in a cooling system. Every time heat is transferred across a temperature differential, work that could have been done is lost. Similarly, every time work becomes heat, that work cannot practically be retrieved. By identifying and numerically comparing various losses, one can identify primary targets for improvement in the effort to achieve net zero energy or exergy buildings.

3. Holistic Analysis of HVAC Systems Using Exergy

***Ongun Berk Kazanci, Ph.D., Associate Member**, Technical University of Denmark, Kgs. Lyngby, Denmark*

Exergy analysis enables the comparison of the effects of operating temperatures on system performance and different forms of energy flows (e.g. heat and electricity), allowing for a holistic system analysis. This presentation outlines the main principles of exergy analysis and presents the results from the comparison of different heating and cooling systems using exergy.

11:00 AM - 12:30 PM

Panel 1 (Intermediate)

Integrated Design and Delivery: Spirit of a New World or a Fantasy?

Track: Modeling Throughout the Building Life Cycle

Room: Adams

Sponsor: 7.1 Integrated Building Design, 1.7 Business, Management & General Legal Education, 7.2 HVAC Design-Build Contractors

Chair: E. Mitchell Swann, P.E., Member, MDCSystems, Paoli, PA, Martin Weiland, P.E., Member, US General Services Administration, Washington, DC, Charles Gulledge, P.E., Member, AC Corporation, Greensboro,, NC and Elyse Malherek, Associate Member, The Weidt Group, Minnetonka, MN

The AEC industry needs to 'do better'. Key to success is working together more effectively. Improved cooperation can make a project a shining star and keep your head to the sky. IPD and BIM are touted as the holy grails of technique and technology. But is that just imagination? Or is the adversarial attitude the way of the world? This panel focuses on the integrated process pros and cons and the future of the industry. You decide if it is the right time to get away from old methodologies and work side-by-side to deliver mighty, mighty projects.

1. The Contractor's Perspective

***Charles Gulledge, P.E., HBDP, Member**, AC Corporation, Greensboro,, NC*

The project delivery process is inherently a team sport. Contractors have traditionally been the "last guy on the match" in terms of the delivery process. Too often seen, but not heard. However as buildings, systems and delivery methodologies have gotten more complex and speed to market has gotten more important, there can be great value in getting input from the 'boots on the ground' that actually build the project. Many hands make light(er) work. How do Integrated Processes change the contractor's role in delivering the project? How does that new role change the traditional focus on primarily first cost and over a short time horizon?

2. The Owner's Perspective

***Martin Weiland, P.E., Member**, US General Services Administration, Washington, DC*

The project delivery process is inherently a team sport. And on this team the owner is the owner. However as buildings, systems and delivery methodologies have gotten more complex and speed to market has gotten more important, today's owner may find themselves a bit more involved in the granular decisions that they may have left to others in the past. Along with the need to be more intimately involved, there is the expectation of heightened performance and its impact on operations and maintenance. No matter how great your car is built, your mileage may still vary. How do Integrated Processes change impact the role of the owner in project during design and construction and the owner's relationship to the team?

3. The Engineer\Modeler Perspective

***Elyse Malherek, Associate Member**, The Weidt Group, Minnetonka, MN*

The project delivery process is inherently a team sport. Engineers are often perceived of as strictly 'role players' on the team. However as buildings, systems and delivery methodologies have gotten more complex and speed to market and overall performance has become more important - and more measurable, there can be some tension between near term speed and long term performance. Also, with enhanced technology, the impacts of modeling on design (and cost) decisions have grown. Many hands make light(er) work. How do Integrated Processes change the role and practice of engineering and how does modeling interface with the standard of care?

11:00 AM - 12:30 PM

Conference Paper Session 17 (Intermediate)

Radiant Panels and Phase Change Materials

Track: Systems and Equipment

Room: Honore

Chair: Paul Torcellini, Ph.D., P.E., Member, NREL, Golden, CO

Several simulation studies using recently developed plug-ins to examine the performance of phase change materials are presented.

1. A Simulation Study on the Performance of Radiant Ceilings Combined with Free-Hanging Horizontal Sound Absorbers (CH-18-C064)

***Ongun Berk Kazanci, Ph.D., Associate Member**, L. Marcos Dominguez, Student Member, Nils Rage and Bjarne W. Olesen, Ph.D., Fellow ASHRAE, Technical University of Denmark, Kgs. Lyngby, Denmark*

When simulating radiant ceiling systems, most building simulation models assume an uncovered ceiling; however, this might not be the case in practice, due to the use of free-hanging sound absorbers. The use of sound absorbers will affect the performance of radiant ceiling systems. The quantification of the effects during the design phase is crucial. A two-person office room equipped with Thermally Active Building Systems (TABS) was simulated using a commercial simulation software with a recently developed plug-in. The simulation model was able to predict closely the cooling performance reduction of TABS, the ceiling surface temperature, and the thermal indoor environment.

2. Simulation Study of Active Ceilings with Phase Change Material in Office Buildings for Different National Building Regulations (CH-18-C065)

***Hajan Farhan, Student Member**[1], Casper Stefansen, Student Member[2], Eleftherios Bourdakis, Student Member[3], Ongun Berk Kazanci, Ph.D., Associate Member[4] and Bjarne W. Olesen, Ph.D., Fellow ASHRAE[1], (1)Technical University of Denmark, Lyngby, Denmark, (2)Technical University of Denmark, Copenhagen, Denmark, (3)Technical University of Denmark, Kongens Lyngby, Denmark, (4)Technical University of Denmark, Kgs. Lyngby, Denmark*

The aim of this study was to examine the performance of PCM in active ceilings for an office room under different Danish building regulations for both heating and cooling purposes. A simulation model of a two-person office room with an area of 23 m^2 (246 ft^2) was created in a commercially available dynamic building simulation software. The only heating and cooling source was radiant ceiling panels, including a layer of PCM. The target was to reduce energy use for the simulation models and still manage to meet the recommended criteria of Class II for the European Standard EN 15251:2007.

3. Simulation Study of Performance of Active Ceilings with Phase Change Material in Office Buildings Under Extreme Climate Conditions (CH-18-C066)

***Casper Stefansen, Student Member**[1], Hajan Farhan, Student Member[2], Eleftherios Bourdakis, Student Member[3], Ongun Berk Kazanci, Ph.D., Associate Member[4] and Bjarne W. Olesen, Ph.D., Fellow ASHRAE[2], (1)Technical University of Denmark, Copenhagen, Denmark, (2)Technical University of Denmark, Lyngby, Denmark, (3)Technical University of Denmark, Kongens Lyngby, Denmark, (4)Technical University of Denmark, Kgs. Lyngby, Denmark*

This study examines the performance of PCM in active ceiling panels under extreme climate conditions, in order to reduce the annual energy use while maintaining an acceptable indoor climate. Dynamic yearly simulations were run with a building simulation software for eight different climates, were two different building models of a two person office were simulated, a model with PCM and a model without. The implementation of PCM panels showed to have a positive effect on both the energy use and the indoor climate. The largest difference on energy use between the two models were found in the cold climates.

4. The Influence of a Radiant Panel System with Integrated Phase Change Material on Energy Use and Thermal Indoor Environment (CH-18-C067)

Lin Flemming Nielsen, Student Member[1], *Eleftherios Bourdakis, Student Member*[2], *Ongun Berk Kazanci, Ph.D., Associate Member*[3] *and Bjarne W. Olesen, Ph.D., Fellow ASHRAE*[1], *(1)Technical University of Denmark, Lyngby, Denmark, (2)Technical University of Denmark, Kongens Lyngby, Denmark, (3)Technical University of Denmark, Kgs. Lyngby, Denmark*

Thermal energy storage is an important factor when striving for decrease of the peak load for a system. Implementation of phase change materials (PCM) in building structures enables high thermal storage capacity at nearly constant temperatures in otherwise light-weight buildings. This paper examines the effect on the energy use and thermal comfort when combining microencapsulated PCM with radiant ceiling panels in a two-person office. The behaviour of the systems was studied during the cooling season in the climates of Copenhagen, Denmark, and Rome, Italy, using a basic cooling strategy and a night cooling strategy.

11:00 AM - 12:30 PM

Seminar 63 (Advanced) NY PDH G

Challenges in Heat and Mass Exchange for Absorption Systems

Track: Heat Exchange Equipment

Room: Red Lacquer (4th Floor)

Sponsor: 8.3 Absorption and Heat Operated Machines, 1.10 Cogeneration Systems

Chair: William Ryan, Ph.D., P.E., Member, Univ. of Illinois at Chicago, Chicago, IL

This seminar covers any heat and mass transfer issue in absorption cycles, whether chillers, air conditioners, heat pumps or heat transformers using any solution pair. Topics can include research into new absorption-oriented heat and mass transfer processes, new heat or mass exchanger concepts in commercial development or new heat or mass exchange in commercial production that are sufficiently new or different and will be of interest to the ASHRAE membership.

1. Enhancing Heat and Mass Transfer in Absorbers Using Membrane-Constrained Flow and Laminar Mixers

Saeed Moghaddam, Member*, University of Florida, Gainesville, FL*

The slow diffusion of an absorbate molecule into an absorbent in conjunction with significant heat release makes the absorption process a rate-limiting step in many applications. Here, different strategies for enhancing the absorption rate are discussed and experimental data on increasing the absorption rates by 3-4 times compared to traditional absorbers are discussed. It is shown that transport in a laminar solution flow constrained by a porous membrane can be changed from diffusive to advective using surface structures. Surface structures are also utilized to produce a uniform solution film and minimize its thickness and to continuously interrupt the boundary layer.

2. Absorbers for Industrial Ammonia Absorption Units

G Anand, Member*, Energy Concepts Co, Annapolis, MD*

Heat exchangers used as absorbers in ammonia refrigeration encounter demanding requirements. They must be mass exchangers as well as heat exchangers, with mass flux approaching zero at the absorber exit. Liquid distribution is highly important, as is the distinction between co-, cross-, and counter-currency, both in regards to heat and to mass exchange. Past research has focused on absorption processes in bubble, falling-film, or spray absorbers. This presentation focuses on absorber heat exchanger designs used in industrial units. Factors affecting exchanger type and configuration are presented. Operating data is presented that summarizes absorber performance in one of these applications.

3. Titanium Tubes the "New Normal of Modern Absorption Units"

Doug Davis, Member*, Broad USA, Hackensack, NJ*

A review of the evolution of tube material choices from 1960 to 2010 from a variety of absorption manufacturers and how these decisions affected projects and customer experiences as well as life cycle costs. This presentation addresses the current status of titanium for use in the vast majority tube bundles in modern absorbers and the benefits that this material brings from a life cycle cost standpoint. Specifics cover tensile strength, weight, longevity and improved heat transfer characteristics of modern titanium tubes when compared to the traditional copper or CuNi tube.

11:00 AM - 12:30 PM

Seminar 64 (Intermediate) NY PDH G

Combo Filters for IAQ and Energy Savings

Track: Systems and Equipment

Room: State

Sponsor: 2.3 Gaseous Air Contaminants and Gas Contaminant Removal Equipment, 5.4 Industrial Process Air Cleaning (Air Pollution Control), 2.4 Particulate Air Contamination and Particulate Contaminant Removal Equipment
Chair: Kyung-Ju Choi, Ph.D., Member, Clean & Science, Louisville, KY
A combination particulate/gas phase filter is capable of controlling primary air pollutants to below levels specified by national air quality standards, as well as removing bacteria, mold and fungi. Since indoor contaminants consist both of particulates and airborne chemicals such as odors, VOCs and SVOCs, both types of filters are needed to treat the air. When dealing with HVAC and air pollution control systems, the pressure drop of a filter should be low while maintaining good airflow, as well as energy savings, throughout the life of the filter.

1. Developments in the Application and Use of Combination Particulate/Chemical Filters for IAQ and Energy Savings
***Christopher Muller, Member**, Purafil, Filtration Group, Doraville, GA*

No single air cleaning technology exists that can solve all IAQ problems. Advances in filtration manufacturing technology have developed a new filter medium that incorporate silver nanoparticles to both standard nonwoven and HEPA media that can control PM_{10} and $PM_{2.5}$ along with viable particles. Adding this to a filter element employing granular sorbent media results in a pleatable air filtration medium that can now address essentially all the primary chemical pollutants of concern as well. Products incorporating this combination of filtration technologies can be used in commercial and residential applications, cabin air filtration and masks for personal protection.

2. Development of a Combinatorial Filter for Removing Both Particle and Organic Vapor in Residential Homes: Approach and Challenges
***Jianshun Zhang, Ph.D., Fellow ASHRAE**, Syracuse University, Syracuse, NY*

Particles and gaseous compounds are two major types of indoor air pollutions. This study aimed at developing a low-cost combinatorial filter that could remove both types of pollutants simultaneously. Three type of particle filters were selected and loaded with Fe_2O_3-MnO_2 particles (0.6 to 0.8 μm in particle diameter). The performance test showed that the techniques developed could be used to create combinatorial filters, but none of the tested sorbent media could provide a sufficient removal efficiency or capacity for gaseous pollutants. Further research should be focused on developing more effective catalysts for targeted pollutants for use with combinatorial filters

3. A Combination-Filter for Residential HVAC Filtration
***Dennis Glass**, 3M, St. Paul, MN*

Although some filtration solutions were developed to address the airborne chemical contaminates and household odors, those solutions were either not very effective at removing VOCs or too restrictive to the airflow. We have recently developed a new combination filter which has been proven to be effective at removing both airborne particulates and gaseous pollutants in the residential houses. The new filter is based on the state-of-the-art carbon-loaded-web (CLW) technology which incorporates sorbent particles in the web with polymeric fibers. The new combination filter has excellent particulate and VOC removal performance, very low pressure drop and superior adsorption capacity

4. A Combination Filter Used in Pollution Control Device: Kitchen Ventilation
***Derek Schrock, Member**, Halton Company, Scottsville, KY*

This presentation reviews typical pollution control devices which are utilized for cleaning exhaust air from commercial kitchen ventilation systems. It discusses particulate and vapor phase challenges from commercial cooking processes and then address the equipment that can be selected to help mitigate them, as well as the efficiencies of some of these filtering methods. Emphasis is on removing the components from the airstream, including controlling odor before discharge.

5. Particulate and Gas-Phase Residential Filtration
***Thad Ptak, Ph.D., Member**, A. O. Smith Corporation, Milwaukee, WI*

In order to reduce the health impact and improve IAQ, air cleaning devices must be able to remove particulate matter and gas-phase pollutants. Typical particle removal methods in residential applications are based on various filter media, electrostatic precipitation and combination of both. Gas-phase filtration methods can include sorption, chemical reaction and oxidation. This presentation provides analysis of the current filtration technologies in terms of reducing concentration of the critical air pollutants responsible for DALY losses. Impact of particulate filtration on the performance of selected gas- phases filtration systems will be discussed.

11:00 AM - 12:30 PM

Seminar 65 (Intermediate) NY PDH G

It's Not Just the Water Heater Anymore

Track: Fundamentals and Applications
Room: Chicago
Sponsor: 6.6 Service Water Heating Systems, 6.1 Hydronic and Steam Equipment and Systems
Chair: James D. Lutz, P.E., Member, Hot Water Research, Oakland, CA
Current developments in residential domestic hot water systems are covered. This seminar presents four issues to be considered in the design of system that impact the efficiency and safety of domestic hot water. The first speaker discusses two topics: modeling hot water draw profiles and drain water heat recovery. The third presentation discusses the system implications and limitations due to water conservation efforts. The final presentation is about balancing scald risk and legionella prevention.

1. Title 24 Draw Profiles: What They Are and How You Can Use Them
***Peter Grant**, Frontier Energy, Davis, CA*

California has recently added detailed hot water draw profiles to the Title 24 code compliance calculator. These draw profiles are based on field study data, both monitoring how people use hot water in homes, and how many people typically live in homes of different sizes. In addition to improving the level of rigor in code compliance simulation in California, they represent an extremely valuable research tool for both simulators and experimentalists.

2. Modeling Drainwater Heat Recovery
***Peter Grant**, Frontier Energy, Davis, CA*

California has recently added an algorithm for savings from vertical drain water heat recovery (V-DWHR) devices to the Title 24 code compliance program. Additional projects are underway to develop algorithms for horizontal and sloped DWHR devices, and they will soon be added to the compliance program as well. This presentation discusses the testing and data analysis efforts behind the algorithm development, as well as anticipated savings in the state.

3. How Low Can You Go? How Close Can You Get?
***Gary Klein, Associate Member**, Gary Klein and Associates, Inc., Rancho Cordova, CA*

Given the number of choices in flow rates and fill volumes for plumbing fixtures and appliances and the uncertainty of occupancy schedules, how do you select equipment that works well as a system? What can you do in your projects that will give you assurance that the system will satisfy your customers' needs and expectations as efficiently as possible, particularly for water efficient fixtures and appliances? Using existing data including results from a current research project funded by the California Energy Commission, this session discusses best practices to implement the principle of hot-water-as-a-system

4. Service Hot Water Systems: A Balancing Act between Legionella Prevention and Scald Prevention
***Ronald L. George, CPD, Associate Member**, Plumb-Tech Design & Consulting Services, LLC, Newport, MI*

This session covers the design of domestic hot water systems and myths and common misunderstandings associated with water heaters and domestic hot water systems. Attendees learn how to design a plumbing system to simultaneously control scalding and Legionella bacteria hazards. The session also covers plumbing code and standards language related to hot water systems and discusses design, installation, maintenance, water conservation, water quality, water velocities and water temperature issues.

11:00 AM - 12:30 PM

Seminar 66 (Intermediate) NY PDH G

High Performance Envelopes: From Cold to Net Zero

Track: Fundamentals and Applications
Room: Monroe
Sponsor: 4.4 Building Materials and Building Envelope Performance, Residential Building Committee
Chair: Marcus Bianchi, Ph.D., P.E., Member, Owens Corning, Granville, OH

Many ASHRAE members have an interest in the building envelope as it has a direct and often significant impact on building energy use. However, building envelopes do more than control heat flow and air leakage; they also must control rain water and vapor movement. This seminar introduces the idea of the "perfect wall," extends that to the perfect envelope. The presentations discuss how these concepts can be applied to actual wall/roof/foundation assemblies, and considers how they may be incorporated in standards and codes.

1. The Perfect Wall
***Joseph Lstiburek, P.Eng., Fellow ASHRAE**, Building Science Corp, Westford, MA*

This presentation introduces the "Perfect Wall" concept. Dr. Lstiburek reviews the building science principles (including control of heat, air and moisture) as they relate to envelope design. Dr. Lstiburek also discusses how these principles apply to different building materials and arrangements and through example and discussion, guides the audience to the perfect assembly arrangement.

2. Why Is the Building Envelope so Complicated?
***Simon Pallin, Ph.D., Associate Member**, ORNL, Oak Ridge, TN*

This presentation discusses why building envelope design is complicated. Dr. Pallin reviews what influences the building envelope performance; what we know, and what is still uncertain. Dr. Pallin also discusses how industry professionals should make use of field tests, laboratory measurements and simulations combined, to better understand and anticipate the energy and moisture durability performances of existing and future buildings.

3. DOE Perspective of the Perfect Envelope: Building Science Advisor
***Eric Werling, Member**, U.S. Department of Energy, Washington, DC*

This presentation discusses risks and challenges that make it difficult for builders to specify "perfect walls". Mr. Werling introduces a new DOE funded "expert system" to help builders and designers understand the moisture durability risks of wall designs in their specific climate. The "Building Science Advisor" was developed by ORNL with Building America program funding, and input from some of the best experts in the field.

11:00 AM - 12:30 PM

Seminar 67 (Intermediate)

Why ASHRAE Standard 160 Is Critical to Designing High Performance Buildings

Track: Standards, Guidelines and Codes

Room: Empire

Sponsor: 4.4 Building Materials and Building Envelope Performance, 1.12 Moisture Management in Buildings, SPC 160 and Residential Building Committee

Chair: Diana Fisler, Ph.D., Associate Member, Johns Manville, Littleton, CO

To assess moisture risks and prevent problems, design analysis needs to consider moisture sources, moisture migration through building assemblies and the resulting moisture and temperature conditions over time. ASHRAE Standard 160, Criteria for Moisture-Control Design Analysis in Buildings, specifies performance-based design criteria for predicting, mitigating or reducing moisture damage to all components of the building, depending on climate, construction type and HVAC system operation. This seminar provides an overview of Standard 160, an update on changes between 160-2009 and 160-2016, and example applications of the standard to high performance residential and commercial buildings across different climates.

1. Introduction to ASHRAE Standard 160

***Stanley Gatland II, Member**, Certainteed, Philadelphia, PA*

ASHRAE Standard 160 provides standardized criteria for conducting, evaluating and reporting the results of hygrothermal analysis on new and existing building envelope systems. Hygrothermal analysis predicts the impact of transient heat and moisture transfer on building envelopes over time. Several computer modeling programs are available to designers. This presentation gives an overview of Standard 160, covering design input parameters, such as initial moisture conditions of building materials, indoor temperatures, indoor relative humidity, building air pressure differentials, air flow and weather data; minimum requirements for analytical tools that perform transient heat and moisture transfer calculations; and criteria for evaluating performance.

2. Update on ASHRAE Standard 160-2016: Changes Since 160-2009

***Samuel Glass, Ph.D., Member**, USDA Forest Products Laboratory, Madison, WI*

ASHRAE Standard 160 was first published in 2009 and was republished in 2016. This presentation highlights the major changes to the standard, with attention to (1) the default values for residential moisture generation used in calculating indoor humidity levels and (2) the evaluation criteria for conditions necessary to minimize mold growth. The simplified criteria for minimizing mold growth in 160-2009 were replaced with an empirical model that predicts risk of mold growth and is more consistent with performance observed in the field. In addition to these updates, several potential future changes to Standard 160 are discussed.

3. Applications of ASHRAE Standard 160 to Various Climate Zones

***Manfred Kehrer, P.Eng., Member**, WJE, Chicago, IL*

ASHRAE Standard 160 has changed the evaluation criteria in its 2016 edition. Previously focused only on threshold levels for relative humidities in the 2009 edition, the standard has now introduced a mold-growth model which takes into account temperature, time and different mold growth sensitivities of building materials. This presentation shows the application of this mold-growth model on three different projects with wall, roof and floor systems in residential and commercial enclosures. Furthermore, attendees are shown the whole decision process when applying ASHRA Standard 160 to make the hygrothermal performance assessment a success.

4. Applications of ASHRAE Standard 160 to Commercial Buildings in both Hot and Humid and Cold Climates

***Achilles Karagiozis, Ph.D., Member**, Owens Corning, Granville, OH*

ASHRAE 160 was developed to allow designers a systematic method to design for moisture control. This presentation shows the design application of a number air permeable and impermeable insulations deployed in commercial builders. The results show how the proper application of the SPC 160 standard is applied to a number of commercial wall systems in a number of climate zones. The presentation concludes with a number of new activities and possible future direction of SPC 160 and how to better address the needs of our ASHRAE stakeholders.