



2024

HERRICK CONFERENCES

COMPRESSORS | REFRIGERATION | BUILDINGS

WEST LAFAYETTE, IN, USA
JULY 15-18, 2024

HOSTED BY:

**PURDUE CENTER FOR HIGH PERFORMANCE BUILDINGS
RAY W. HERRICK LABORATORIES**

2024 FINAL CONFERENCE PROGRAM

SHORT COURSES AND INTELLIGENT BUILDING OPERATIONS (IBO) WORKSHOP • JULY 14, 2024
HERRICK CONFERENCES • JULY 15-18, 2024

THANK YOU TO OUR 2024 CONFERENCE SPONSORS:



FOREWORD

Dear Attendees,

On behalf of the Organizing Committee, the Ray W. Herrick Laboratories, the Center for High Performance Buildings, Purdue University, the Co-Sponsoring Organizations, and the Endorsing Organizations, it is a great pleasure to present to you the Final Program of the 27th International Compressor Engineering Conference, the 20th International Refrigeration and Air Conditioning Conference, and the 8th International High Performance Buildings Conference at Purdue, known as the Herrick Conferences.

Two years ago, we celebrated the 50-year anniversary of hosting the compressor conference. Ray Cohen, Werner Soedel, and Jim Hamilton hosted the very first compressor conference in 1972. We are honored to continue the tradition of bringing innovation to the HVAC&R and building industries.

As all of us have experienced, the last several years have been difficult. The challenges of the COVID pandemic have certainly created a strain on our industries, communities, and families. Therefore, we are extremely excited to welcome our friends and colleagues back to campus for an in-person experience. In addition, societal awareness of global warming and related environmental challenges have created widespread opportunities in our field, sparking creative ways to pursue new technologies. This week we are excited to read and hear about research born from these initiatives.

The Organizing Committee received 505 abstracts and accepted 354 papers for publication. Every effort was made to include papers of current engineering and scientific interest. Furthermore, an internal review was conducted of each paper. Nevertheless, the Organizing Committee takes no responsibility for the correctness or completeness of the papers published. I would like to thank the authors for having chosen our conferences to present their work and for all their efforts in preparing and submitting papers. Thanks to them we present a conference program that is exciting and informative.

I would like to thank the session chairs and session co-chairs for their help in supporting the technical program. I would also like to thank the members of the advisory committee, the Co-Sponsoring and Endorsing Organizations and their representatives for their support and helpful suggestions. In particular, I would like to thank the members of the Organizing Committee and the many graduate students who are helping us to host these conferences and are integral in making our conferences a success.

We hope that you enjoy our conferences and return home with new ideas and professional contacts. The next Herrick Conferences are planned for July 2026, and we are excited to continue to build upon the successes of previous years. We are honored to bring you 52 years of innovation in the HVAC&R and building industries.

Sincerely,



Dr.-Ing. Eckhard A. Groll

William E. and Florence E. Perry Head of Mechanical Engineering
Reilly Professor of Mechanical Engineering
School of Mechanical Engineering, Purdue University

ORGANIZING COMMITTEE

General Conference Chair

Eckhard A. Groll

International Compressor Engineering Conference

Chair W. Travis Horton

Co-Chair Riley Barta

Student-Chair Xin Ding

International Refrigeration & Air Conditioning Conference

Chair Davide Ziviani

Co-Chair Haotian Liu

Student-Chair Abd Bani Issa

International High Performance Buildings Conference

Chair James E. Braun

Co-Chair Thanos Tzempelikos

Student-Chair Sichen Lu

Director, Ray W. Herrick Laboratories

Gregory Shaver

Conference Coordinator

Brian T. Barrett

ConfTool Management

Chair: Steven Liang Co-Chair: Mingjie Zhu

System Modeling Short Course Organizer

Davide Ziviani

Haotian Liu

Jinwoo Oh

Refrigeration Short Courses Organizer

William E. Murphy

IBO Workshop Organizers

Kevin Kircher

Gregor Henze

James E. Braun

ADVISORY COMMITTEE

AD-HOC MEMBERS

Dr. Stefan Bertsch

Professor and Head, Institute for Energy Systems
OST Eastern Switzerland University of
Applied Sciences
Buchs, Switzerland

Mr. Sergio Bobbo

CNR
Istituto per le Tecnologie della Costruzione,
Sezione di Padova, Italy

Dr. Roy Crawford

Johnson Controls, USA

Dr. Ashvin Dhunput

Senior Development Engineer
ADC (a member of Daikin group), UK

Dr. Ir. Carlos Infante Ferreira

Faculty of Mechanical,
Maritime & Materials Engineering
Delft University of Technology, The Netherlands

Dr. Mitsuhiro Fukuta

Professor, Department of Mechanical Engineering
Shizuoka University, Japan

Dr. Andrea Gasparella

Faculty of Science & Technology
Libera Università di Bolzano, Italy

Dr. Christian Hermes

Professor
Federal University of Santa Catarina, Brazil

Mr. Joseph Karnaz

Technical Director, Specialty Products Division
Shrieve Chemical Products, Inc., USA

Dr. Christopher Laughman

Senior Principal Research Scientist
Team Leader, Thermodynamics
Multiphysical Systems & Devices
Mitsubishi Electric Research Labs (MERL), USA

Dr. Vincent Lemort

Professor, Thermodynamics Laboratory
University of Liege, Belgium

Dr. Stephen B. Memory

A.O. Smith Corporate Technology Center, USA

Mr. Kevin Mercer

Sr. Principal Engineer, Development Engineering
Rheem Manufacturing Company, USA

Dr. William E. Murphy

Professor of Mechanical Engineering and Director of
Engineering Extended Campus Programs
University of Kentucky - Paducah, USA

Dr. Andrew Pearson

Managing Director
Star Refrigeration Ltd., Scotland

Dr. Michael Perevozchikov

Chief Scientist
Copeland, USA

Mr. Gordon Powell

Compressor Center of Excellence
Ingersoll Rand - Trane, USA

Dr. Joaquim Rigola

Professor, Heat and Mass Transfer
Technological Center, Technical University
of Catalonia, Spain

Dr. Chris Seeton

Applications Director
Koura Global, USA

ADVISORY COMMITTEE

Dr. Zachary Siefker

Lead Heat Pump Design Engineer
Cleaver-Brooks, USA

Dr. Ruzhu Wang

Professor and Director, Engineering
Research Center for Solar Energy
Shanghai Jiaotong University, P.R. of China

Mr. John Withouse

RAC Refrigerants - Sr. Principal Engineer
Sporlan Division of Parker Hannifin, USA

Mr. Jia Xu

Director Assistant of Compressor and Motor Institute
Gree Electric Appliances, Inc., P.R. of China

Mr. Jin Yan

Aero-Thermal Manager
Danfoss Turbocor Compressor Inc., USA

MEMBERS OF COOPERATING ORGANIZATIONS

Dr. Yosr Allouche

Director
IIR (International Institute of Refrigeration)

Dr. Andreas Athienitis

Scientific Director of NSERC, Professor and
Concordia Research Chair Tier I
NSERC Solar Buildings Research Network
(SBRN-SNEBRN), Canada

Dr. Lorenzo Cremaschi

Chair of USNC/IIR
Professor, Auburn University, USA

Dr. Brian Fricke

Representative IEA Heat Pump Center
Distinguished Research Staff Member
Oak Ridge National Laboratory, USA

Mr. Jeff Littleton

Executive Vice President
ASHRAE, USA

Dr. Ji-Hwan Jeong

Representative SAREK
Professor, Pusan National University, South Korea

Dr. Akio Miyara

Representative JSRAE (Japan Society of Refrigerating
& Air Conditioning Engineers)
Professor, Saga University, Japan

Mr. Brendan Owens

US Green Building Council USA

Dr. Christiane Thomas

Representative DKV (Deutscher Kalte-und Klimat-
echnischer Verein e. V.)
Professor, TU Dresden, Germany

Mr. Xudong Wang

Vice President, Research
AHRI, USA

CONFERENCE KEYNOTE SPEAKER



MONDAY, JULY 15 9:30 AM LOEB THEATRE

John Sipple

Tech Lead and Staff Software Engineer of Google's Core Enterprise Machine Learning Team

Title of talk: AI for Sustainability. Deploying Intelligent Diagnostics and Optimal Control to Reduce the Climate Burden of Google Office Buildings

As Tech Lead and Staff Software Engineer of Google's Core Enterprise Machine Learning team, John Sipple is on a mission to deploy novel fault detection and diagnostics and practical smart control to large-scale industrial problems. John leads multiple development efforts that combine multidimensional anomaly detection with model explainability. He also leads a research effort to deploy reinforcement learning to make commercial office buildings more efficient and environmentally sustainable. John has also worked on dialog summarization models for Google chat. Before joining Google, John developed and applied algorithms, statistical analysis, and machine learning solutions to cybersecurity, precision agriculture, counterfeit detection, and missile defense. As an adjunct professor at the George Washington University, John teaches graduate and undergraduate courses in Machine Learning.

Google's goal is to lead the transition to a more sustainable future through information and innovation, and we're pursuing net-zero emissions across our operations and value chain by 2030. This is supported by our ambitious clean energy goal to operate our data centers and office campuses on 24/7 carbon-free energy, such as solar and wind. With the increase in sensors and controllable parameters on physical devices, we also believe next-generation monitoring and control are key supporting technologies to achieving our sustainability goals in the near term with minimal impact to existing building infrastructure. Intelligent Diagnostics detects changes in the telemetry stream, extracts symptoms, and proposes root-cause analysis and treatments by combining Anomaly Detection, Explainable AI, and causal reasoning from language models, such as Gemini. Our novel combination of AI technologies assists the technician in rapid detection, informed evaluation, prioritization, and treatment selection, and reduce inefficiencies and emission. Optimal Control can be used to adapt building climate controls to the occupants' patterns and preferences while achieving significant energy efficiency gains and greenhouse gas emission reductions. However, there are a number of challenges we encountered and we've developed a number of solutions associated with training an agent in a virtual environment and deploying a trained control policy to physical office buildings. At Google, we are working to build a "living" office building environment that adapts to its occupants and allows them to shape the building's environmental load and energy curve. Intelligent Diagnostics and Optimal Control are just two directions for applying AI to intelligent building operations, but they should inspire other moonshot ideas of leveraging new technologies to achieve a significant positive climate impact.

HIGH PERFORMANCE BUILDINGS PLENARY

TUESDAY, JULY 16 8:30 AM LOEB THEATRE



Dr. Jeffrey Siegel

*Professor, Department of Civil & Mineral Engineering
University of Toronto*

Title of talk: Advances in Indoor Air Quality and Filtration Research for Healthy and Sustainable Buildings

Jeffrey Siegel, Ph.D., is Professor of Civil and Mineral Engineering at the University of Toronto and is a Bahen/Tanenbaum Chair in Civil Engineering and a member of the Hub for Advancing Buildings. He holds joint appointments at the Dalla Lana School of Public Health and the Department of Physical & Environmental Sciences. He has an M.S. and Ph.D. in Mechanical Engineering from the University of California, Berkeley as well as a B.Sc. from Swarthmore College. He is internationally recognized for his work on indoor air quality generally and air cleaning specifically and is a fellow of ASHRAE and a member of the Academy of Fellows of the International Society for Indoor Air and Climate (ISIAQ). His research interests include healthy and sustainable buildings, filtration and air cleaning, ventilation and indoor air quality in residential and commercial buildings, control of indoor particulate matter, and the impact of building systems on indoor microbiology and chemistry. He has published over 100 peer-reviewed journal articles on indoor air quality and related subjects and has been active in disseminating information about filtration and ventilation solutions for COVID-19.

LUNCHEON PLENARY SPEAKER



TUESDAY, JULY 16 12:00 PM
PURDUE MEMORIAL UNION

MICHAEL SEALY

Associate Professor, Mechanical Engineering, Purdue University

Title of talk: Feeding the Future through Convergent Manufacturing

Dr. Michael Sealy joined Purdue University in West Lafayette, IN as an Associate Professor in Fall 2021. Prior to Purdue, Sealy spent the six years at the University of Nebraska-Lincoln focused on hybrid additive manufacturing for health – including everything from metals to meat. More specifically, he specializes in coupling additive manufacturing with surface treatment technology on metals and polymers to print functionality in biodegradable magnesium implants and tissue engineered constructs for cultured meat.

He co-founded the Nebraska Engineering Additive Technologies (NEAT) Lab at UNL. He has received national and international recognitions from ASME, SME, ASM, and MRS, including the prestigious SME David Dornfeld Manufacturing Vision Award in 2022, the SME Outstanding Young Manufacturing Engineer award in 2020, and NSF CAREER award in 2019.

He is passionate about building engineering entrepreneurship ecosystems in academia, and he has received numerous commercialization awards, including 2nd Place at the first MRS International iMatSci Competition in 2014.

He is a current NSF I-Corps recipient with his startup, Digital Mayham, focused on commercializing hybrid additive manufacturing technology. He is a member of SME, ASME, CIRP, ASM, TMS, and Pi Tau Sigma.

REFRIGERATION CONFERENCES PLENARY PANEL

WEDNESDAY, JULY 17 8:30 AM LOEB THEATRE

TOPIC: State of the Art and Global Outlook of Refrigeration, AC and HP Compressors



DR. BRIAN FRICKE Panel Moderator
Group Leader, Building Equipment Research, Oak Ridge National Laboratory

Dr. Brian Fricke is the Group Leader for Building Equipment Research at Oak Ridge National Laboratory (ORNL). He oversees research and development initiatives aimed at advancing building equipment technologies, enhancing energy efficiency, and promoting sustainability. With a distinguished career dedicated to innovation in HVAC systems, refrigeration, and building energy performance, Dr. Fricke's contributions significantly impact the development of cutting-edge HVAC&R solutions for energy conservation and environmental stewardship. Dr. Fricke is an ASHRAE Fellow and served as the USNT chair and U.S. delegate to IIR Management Committee.



DR. MIN SOO KIM
Professor, Department of Mechanical Engineering, Seoul National University.

Dr. Min Soo KIM received his Ph.D. in mechanical engineering from Seoul National University in 1991, and he joined the faculty in 1994. His expertise is in thermal engineering including performance enhancement of refrigeration and heat pump systems, thermal management of next generation vehicles, and balance of plant of fuel cell systems. He has more than 270 journal papers and more than 510 conference papers together with about 50 patents. He is a member of ASME, ASHRAE, IIR, KSME, and SAREK. He got the Outstanding Academic Award from the Society of Air-conditioning and Refrigerating Engineers of Korea (SAREK) and from the Korean Society of Mechanical Engineers (KSME). He received Presidential Citation by the Ministry of Public Administration and Security. Recently, he received the Peter Ritter von Ritinger International Heat Pump Award from the International Energy Agency in 2023.



DR. ANDY PEARSON
Group Managing Director at Star Refrigeration Ltd.

Dr. Pearson is a Chartered Engineer and has worked in the industrial refrigeration sector since 1986. He is particularly interested in improving safety, efficiency and reliability of refrigerating systems and he also enjoys researching the history of engineering development.



DR. JASON WOODS
Senior Research Engineer, National Renewable Energy Laboratory's
Building Energy Science Group

Dr. Jason Woods is a senior researcher in NREL's Advanced Building Equipment Research Group. His expertise is in heat and mass transfer and phase change processes, with applications to heat pumps, thermal energy storage, dehumidification, and membrane-based HVAC processes. He leads many projects at NREL that connect system and building modeling with HVAC technology development and deployment. His research has led to 45 peer-reviewed publications and 11 issued patents. His current focus is on decarbonizing buildings through electric heat pumps that align electricity use with renewable generation using energy storage. He received his BS from Purdue University and his PhD from the University of Colorado, both in mechanical engineering.

COMPRESSORS CONFERENCE PLENARY



THURSDAY, JULY 18 8:30 AM LOEB THEATRE

DR. BACHIR BELLA

Director Sustainability and Product Safety

Copeland Europe (based in Germany)

Title of talk: Safe Use of Hydrocarbons in HVAC&R Applications

Dr. Bachir Bella holds a master's degree in mechanical engineering and a doctorate in energy from the University of Padua, Italy.

He is author of several papers on heat transfer and compressors.

Since 1993, he has been working in HVAC&R sector, on design of reciprocating, screw and scroll compressors, for household and commercial applications.

Currently, his focus is on refrigerants and safety of the refrigerating systems, he is member in technical committees of International IEC and ISO standards.

BREAKFAST FOR PRESENTERS, CHAIRPERSONS, AND VICE CHAIRPERSONS

A complimentary lunch (on Monday) and breakfast (Tuesday – Thursday) are scheduled in the Purdue Memorial Union, East & West Faculty Lounges for presenting authors, session chairs & vice-chairs scheduled for each day. You can find your presentation time in the Conference Overview. It is important to attend the speakers' lunch or breakfasts if you are presenting a paper to meet your session chair and address any presentation questions you might have. Updated presentations can also be loaded at this time. Instructions concerning audio/visual/projection systems and technical session organization will be addressed. Please only attend the lunch or breakfast on the day in which you present. If you have presentations scheduled for different days, you should attend the lunch or breakfasts each day so that you can meet your Session Chairperson and the other Presenters. If you are the Presenter in more than one session on the same day, please meet both Session Chairpersons. If you are a Presenter but not an author of a technical paper, you should be the person who attends this breakfast so that you may alert the Chairpersons that you are the Presenter.

PROGRAM FORMAT

Presentations are on a strict time schedule this year. Each presenter receives ONLY 20 minutes total, for both presentation and question/answers. Should there be a speaker who does not show up, or there is a gap for whatever reason, we will NOT move the speaker up, as has been done in the past, but instead ask each presenter to speak at their scheduled time as listed in the program.

PICTURES AND VIDEOTAPING DURING THE CONFERENCES

Conference attendees may NOT take pictures or videos at any presentation without the consent of the author or presenter. An official photographer will be taking pictures during the conferences. Attendees may NOT take pictures during the tours because the research is often highly sensitive.

PRESENTATIONS

If you have last minute changes to your presentation (different from what was uploaded into Conftool), please see your session co-chair during the daily breakfast Tuesday to Thursday or during the luncheon (Monday) to make arrangements to upload your new file.

FUTURE CONFERENCE DATE

2026 Herrick Conferences: July 13 - 16, 2026

28TH Compressor Engineering Conference

21ST Refrigeration and Air Conditioning Conference

9TH High Performance Buildings Conference

SHORT COURSES AND IBO WORKSHOP

Short Courses and the IBO Workshop are organized and presented by the faculty of Herrick Laboratories, in cooperation with our sponsoring organizations. Often, speakers from outside organizations and universities serve as presenters for these courses. One CEU credit can be earned through attendance to any of the offered short courses. The courses will meet from 8:00 a.m. until 5:00 p.m. on Sunday, July 14, 2024 in Rawls Hall, and will meet concurrently.

2024 SHORT COURSES

System Modeling Short Course – Steady-state, Dynamic and Reduced-Order Models of Heat Pump Systems and their Components

Coordinated by: Davide Ziviani (Purdue University), Haotian Liu (Purdue University), Jinwoo Oh (Purdue University)

The HVAC&R industry is facing numerous challenges including transition to low-GWP refrigerants, upcoming energy standards, decarbonization targets and electrification of heating. Model-based engineering design is an essential tool to evaluate design trade-offs, investigate new technologies and optimize year-round operation of equipment. In this Short Course, steady-state and dynamic modeling techniques will be covered to predict the performance of HVAC&R systems. Digital-twin and reduced order models (ROMs) will also be discussed to enable control development and fast computational models. Case studies will include residential, commercial, transport, and industrial applications as well as integration of thermal storage. The Short Course will be based on common modeling platforms such as Python and Dymola/Modelica.

SPONSORED BY



Refrigeration Short Course – Heat Pumps - Technology and Policies Update

Coordinated by: Prof. William Murphy (retired University of Kentucky) and the U.S. National Committee of the IIR in collaboration with Herrick Laboratories Faculty

Heat pumps are being promoted worldwide as an environmentally conscious alternative to combustion heating in buildings and in industrial applications while also satisfying the rapidly growing demand for comfort cooling. This short course will have recognized speakers who will address current and future advances in heat pump technologies as well as policy decisions that will encourage heat pump use around the world.

INTELLIGENT BUILDING OPERATION (IBO) WORKSHOP

Coordinated by: Kevin Kircher (Purdue University), Jim Braun (Purdue University), Gregor Henze (University of Colorado)

SPONSORED BY



The IBO workshop began in 2011 and typically alternates between the University of Colorado Boulder and Purdue University. In 2024, Purdue will host the IBO workshop in combination with the International Conferences on Compressor Engineering, Refrigeration and Air Conditioning, and High Performance Buildings (HPB). IBO-Purdue will focus on enabling scalable and cost-effective intelligent building operations (such as controls, fault detection and diagnostics, analytics, and data-driven business services) through theoretical developments, algorithmic advances, technology innovations, case studies, and field demonstrations. IBO-Purdue will combine a one-day workshop, featuring invited presentations, with several technical sessions held during the subsequent HPB conference. The technical session presentations will accompany peer-reviewed papers published in the HPB conference proceedings. IBO-Purdue and HPB conference participants can also attend any of the technical sessions associated with the compressor and refrigeration conferences.

CHPB: RESEARCH OVERVIEW & OUTLOOK SESSION

Session Co-Chairs: Jim Braun & Davide Ziviani

Session Vice-Chair: Jie Ma

Wednesday, July 17, 2023, from 1:00 to 3:00 p.m.

The Center for High Performance Buildings (CHPB) was launched in 2016 through a construction grant from the National Institute of Standards and Technology (NIST). The CHPB is housed at the Ray W. Herrick Laboratories and has the mission of partnering with industry in the development, demonstration, evaluation, and deployment of new technologies and analysis tools for high performance buildings. Since 2016, the Center has sponsored more than 70 projects spanning a broad range of topics, including indoor environmental quality (IEQ), human comfort and productivity, building envelopes, advanced space and water heating equipment, controls, smart grids, and equipment ratings. This session will cover a selection of projects that have led to the development of novel components, systems, control algorithms, and testing / rating methods.

CARNOT COMMEMORATIVE SESSION

Session Chair: Eckhard A. Groll

Session Vice-Chair: Andreas Hoess

SPONSORED BY



Wednesday, July 17, 2023, from 3:30 to 5:30 p.m.

As we commemorate the 200th Anniversary of the foundational work of the 2nd Law of Thermodynamics by Sadi Carnot in 1824, we invited several leading experts in the field of Thermodynamics to honor his seminal contributions and explore the latest advancements in Thermodynamics research. Each speaker will deliver a 15-minute overview of the cutting-edge research activities undertaken at their respective research institutes. These presentations will not be in-depth technical presentations but general overviews of the latest research topics. No papers will be published as part of this session, but all presentation slides will be electronically distributed to all conference attendees.

MONDAY, JULY 15

Reception at the Lafayette Brewing Company, 622 Main St, Lafayette, IN 47901

The reception is hosted by Carrier Corporation and will be held from 6:00 to 8:00 p.m. Shuttle buses will depart from the State Street bus stop in front of Stewart Center between 5:30 and 6:00 p.m. transporting attendees and guests to the reception. Attendees may also use CityBus or walk to the Reception. There will be transportation available after the Reception to take attendees back to the Stewart Center. Additional local restaurants and bars are open on Monday evenings in downtown Lafayette and the Purdue campus for attendees who may be interested after the reception.



TUESDAY, JULY 16

Luncheon – Purdue Memorial Union, North & South Ballrooms

The luncheon will be held from 11:50 a.m. to 1:20 p.m. It is hosted by Trane Technologies.



WEDNESDAY, JULY 17

Steak Barbecue – The Stables Event Center, 7071 S 100 E, Lafayette, IN 47909

The all conference dinner will be held from 6 p.m. to dusk and is hosted by Copeland.

Buses will begin departing from the State Street bus stop in front of Stewart Center at 5:45 p.m. The last bus will leave at approximately 6:15 p.m. for the dinner. There will be games, a beer wagon, awards, music, and a chance to visit outside. The buses will begin to return attendees and guests to campus starting at 9:00 p.m. Shuttles will continue through 10:00 p.m.. You may also drive your own vehicle to this venue, but given limited parking, you are encouraged to use the provided transportation.



STUDENT EVENTS

Student Paper Competition: Winners of the Student Paper Competition from each conference will be announced and awarded at the Steak Barbecue at The Stables Event Center. Plan to join us and congratulate these students on a job well done.

ASHRAE Student Meeting with the ASHRAE President – Monday, July 15 from 3:30-5:30 pm, Stewart 313

The ASHRAE Student Branch at Purdue University will host a meeting with the ASHRAE President. This meeting is open to ALL ASHRAE student members, not just ASHRAE student members at Purdue.

Student Mixer – Tuesday, July 16 from 8-10 pm, Baked By Brittany

Gather with other students from around the world at the newly opened Baked By Brittany. Baked By Brittany is a full service restaurant, bar & bakery located at **516 Northwestern Ave** on Purdue's Campus! This event is hosted by Rheem and is limited to students only.



PRACTICAL GUIDE

CONFERENCE OFFICE / HOSPITALITY ROOM

The Conference Office is located in Stewart Center, Room 204. Conference Hospitality is located in Stewart Center, Room 302/306

Monday 8:00 a.m. to 4:00 p.m.

Tuesday 8:00 a.m. to 4:00 p.m.

Wednesday 8:00 a.m. to 4:00 p.m.

Thursday 8:00 a.m. to 12:00 p.m.

INTERNET ACCESS

Wireless internet is available to all attendees via the ATT WIFI hotspot. Please choose ATT Wifi as your internet connection. When you open a browser, you will be automatically connected. You will need to provide your email address and accept terms & conditions. If you have difficulties, please visit the Conference Office, Stewart Center, 204.

CONFERENCE MOBILE APP

Registered attendees will be sent instructions on downloading the conference event app, sponsored this year by PDM Analysis. Attendees can customize their agenda, view plenary speaker bios, visit sponsor virtual booths, view technical session papers, and network with other conference attendees.



SMOKING POLICIES ON CAMPUS

Smoking is prohibited on the West Lafayette Campus, except in designated smoking areas. All smoking material shall be extinguished and disposed of in an appropriate receptacle at the perimeter of the campus. Designated smoking areas are published in maps around the Purdue campus. The closest smoking area to Stewart Center is located across Sate Street, north of the Agricultural Administration Building.

TEMPERATURES INSIDE & OUTSIDE DURING THE CONFERENCES

Outside summer temperatures in Indiana are usually between 75-95°F and very humid. Room temperatures in technical session rooms are often cool for our International visitors; come prepared!

TIME DURING CONFERENCES

The time zone in Indiana is Eastern Daylight Time. This is the same time as New York City in the summer.

TRANSPORTATION DURING THE CONFERENCE

There will be organized transportation available for the Conference Social Events or you may choose to use your own vehicles. This year's conference transportation is sponsored by Wabash National. The Conference Hotels may provide shuttle service between the hotels and the Purdue Memorial Union. They do not operate on a regular schedule so you may call for pick-up service. Please make sure that you obtain a contact number for your hotel shuttle. The Greater Lafayette Transit System will also be available.



LIMO SERVICE TO AND FROM INDIANAPOLIS AND CHICAGO AIRPORTS

LAFAYETTE LIMO SERVICE

Provides service to and from the Indianapolis International Airport
(765) 497-3828 or lafayettelimo.com

REINDEER

Shuttle service to and from the Indianapolis International Airport
(765) 637-5124 or reindeershuttle.com

EXPRESS AIR COACH

Provides shuttle service to and from the Chicago O'Hare Airport
expressaircoach.com/purdue/

Check their websites. Attendees must contact the companies themselves.

TRANSPORTATION SERVICES

AMTRAK - TRAIN

Riehle Plaza
Big Four Depot, 200 North 2nd Street
(800) 872-7245

GREYHOUND BUS

Riehle Plaza
Big Four Depot, 200 North 2nd Street
(765) 742-8836 or (800) 231-2222

PARKING ON CAMPUS




Parking is available in garages on the Purdue campus. Guests at the Union Club Hotel can park for free at the Grant Street Parking Garage. Grant Street Parking Garage is currently under construction and is limited to hotel guests only. Attendees are encouraged to park in either the Wood Street Garage or University Street Garage.

Visitors can purchase "A" garage permits or multiple day passes at the Parking facilities office (494-9494) Monday-Friday 7:30-4:30. The price is \$5.00/day and allows parking in any garage **EXCEPT** Grant Street and Harrison Street garages.







Do not park in marked parking spaces or you will be ticketed. We are not able to get your ticket dismissed. Attendees with Government issued plates are able to park in any A, B, or C parking spaces.

For detailed information visit https://purdue.t2hosted.com/cmn/auth_ext.aspx






MONDAY, JULY 15

7:00am - 10:00am	Conference Registration - <i>Ground Floor, Stewart Center Rooms 109 AB&C</i>							
8:00am - 4:00pm	Hospitality Room - STEW 302/306 Hosted by Saginomiya 							
8:00am - 1:00pm	Sponsor Expo - Purdue Memorial Union West Main Lounge							
9:30am - 11:30am	Opening Session, Welcome, and Keynote Address - Loeb Playhouse, Stewart Center							
11:30am - 1:00pm	Complimentary Lunch for Chairpersons & Presenting Authors for Monday's Sessions - <i>West Faculty Lounge, Second Floor, Purdue Memorial Union</i>							
11:30am - 1:00pm	Lunch Break							
	STEW 214 A&B	STEW 214 C&D	STEW 218 A&B	STEW 218 C&D	STEW 310	STEW 278	STEW 202	STEW 206
1:00 - 3:00pm	B-01: Human-centered building operation, smart sensing and data-driven control (IBO)	B-02: Sustainable building energy systems and building simulation	R-01: Heat & Mass Transfer and Pressure Drops	R-02: Alternative Refrigerants Modeling and Testing	R-03: Vapor Compression System Modeling I	R-04: Automotive and Transportation HVAC&R	C-01: Screw Compressors I	C-02: Novel Compressors
3:30 - 5:30pm	B-03: MPC (IBO)	B-04: Building design & retrofit tools/ models	R-05: CO2 Assessment	R-06: Energy Storage I	R-07: Environmental Aspects of Future Refrigerants	R-08: Fault Detection and Diagnostics and Sensing	C-03: Reciprocating Compressors I	C-04: Compressor Modeling I
3:30 - 5:30pm	ASHRAE Student Meeting with the ASHRAE President (open to all ASHRAE student members) - STEW 313							
5:30 - 6:00pm	Bus Transportation provided from Grant Street Garage to Lafayette Brewing Company sponsored by Wabash 							
6:00 - 8:00pm	Opening Night Reception - Lafayette Brewing Company (LBC) - Hosted by Carrier Corporation 							
8:00 - 8:30pm	Bus Transportation provided from Lafayette Brewing Company to Grant Street Garage							



TUESDAY, JULY 16

7:15 - 8:15am	Complimentary Breakfast for Chairpersons & Presenting Authors for Tuesday's Sessions <i>West Faculty Lounge, Second Floor, Purdue Memorial Union</i>							
8:00am - 4:00pm	Hospitality Room - STEW 302/306 Hosted by Parker  							
8:30am - 9:20am	High-Performance Buildings Plenary Session - Loeb Playhouse, Stewart Center							
9:20am - 9:40am	GT-SUITE Simulation Software Info Session - STEW 307 							
	STEW 214 A&B	STEW 214 C&D	STEW 218 A&B	STEW 218 C&D	STEW 310	STEW 278	STEW 202	STEW 206
9:40am - 11:40am	B-05: Reinforcement leaning & control (IBO)	B-06: Thermal Energy Storage & Heat Pumps	R-09: Frost and Defrost Characterization and Modeling I	R-10: Load-Based Testing	R-11: Air to Refrigerant Heat Exchangers	Student Paper Competition: Refrigeration	C-05: Screw Compressors II	C-06: Compressor Motors
11:50am - 1:20pm	Conference Luncheon (included in Registration) <i>North and South Ballrooms, Purdue Memorial Union</i> Hosted by Trane Technologies 							
1:30pm - 3:30pm	B-07: Thermal energy storage operation (IBO)	R-12: Flammable Refrigerants	R-13: Heat Exchanger Modeling	R-14: Heat Pump Water Heaters	C-07: Tribology	Student Paper Competition: Compressors	C-08: Compressor Modeling II	C-09: Lubricants I
3:30pm - 4:00pm	GT-SUITE Simulation Software Info Session - STEW 307 							
4:00pm - 6:00pm	B-08: IAQ, Air Cleaning & Filtration	R-15: Domestic Refrigeration	R-16: High Temperature Heat Pump	R-17: Heat Exchanger Design I	C-10: Compressor Testing and Evaluation I	Student Paper Competition: Buildings	C-11: Compressors for Alt. Refs.	C-12: Oil Management
4:00pm - 6:00pm	Combined IIR Commission B1, B2, E1, and E2 Meetings - STEW 313							
6:15pm - 7:45pm	Tours of Herrick Laboratories							
Evening	Free							
6:30pm - 8:00pm	Conference Advisory Committee Meeting (by invitation only) - <i>Spurgeon Club, Mackey Arena</i>							
8:00pm - 10:00pm	Student Mixer - Baked by Brittany Hosted by Rheem 							

WEDNESDAY, JULY 17

7:15 - 8:15am	Complimentary Breakfast for Chairpersons & Presenting Authors for Wednesday's Sessions <i>West Faculty Lounge, Second Floor, Purdue Memorial Union</i>							
8:00am - 4:00pm	Hospitality Room - STEW 302/306 Hosted by Simerics and Cleaver Brooks							
8:30am - 9:20am	Refrigeration Conference Plenary Session - Industry Panel: Electrification of the Heating Industry							
	STEW 214 A&B	STEW 214 C&D	STEW 218 A&B	STEW 218 C&D	STEW 310	STEW 278	STEW 202	STEW 206
9:40am - 12:00pm	B-09: Advances in heat pumps, smart controls and FDD (IBO)	R-18: Residential & Commercial HP & AC Systems I	R-19: Systems Integrated with PCM-TES	R-20: Membrane-Based Systems	R-21: Thermal Management of EVs	C-13: Scroll Compressors I	C-14: Compressor Modeling III	C-15: Lubrication II
12:00 - 1:00pm	Lunch Break							
12:00 - 1:00pm	Convergent Science Info Session - <i>Purdue Memorial Union Ballroom</i>							
1:00 - 3:00pm	B-10: Thermal energy storage & energy management (IBO)	R-22: Commercial & Industrial Refrigeration	R-23: Refrigerant Thermophysical Properties	R-24: Energy Storage II	R-25: Vapor Compression System Modeling II	General:: CHPB Session	C-16: Compressor Valves I	C-17: Compressor Testing and Evaluation II
3:30 - 5:30pm		R-26: Advances in heat pumps & controls (IBO)	R-27: Heat Exchanger Design II	R-28: Thermal Management of EVs		Carnot Commemorative Session	C-18: Scroll Compressors II	
5:30 - 6:00pm	Shuttle buses will transport attendees from the Grant Street Parking Garage to the Steak Barbeque (Sponsored by Wabash)							
6:00 - 10:00pm	Steak Barbeque - The Stables, West Lafayette, IN Hosted by Copeland							
9:30 - 10:30pm	Shuttle buses will transport attendees from Steak Barbeque to the Grant Street Parking Garage							

THURSDAY, JULY 18

7:15 - 8:15am	Complimentary Breakfast for Chairpersons & Presenting Authors for Thursday's Sessions <i>West Faculty Lounge, Second Floor, Purdue Memorial Union</i>							
8:00am - 4:00pm	Hospitality Room - STEW 302/306 Hosted by Shanghai-Highly and Belimo							
8:30am - 9:20am	Compressor Conference Plenary Session - Plenary Speaker: Bachir Bella <i>Loeb Playhouse, Stewart Center</i>							
	STEW 214 A&B	STEW 214 C&D	STEW 218 A&B	STEW 218 C&D	STEW 310	STEW 278	STEW 202	STEW 206
9:40am - 12:00pm	R-29: Frost and Defrost Characterization and Modeling II	R-30: Extreme Climate Heat Pumps	R-31: Heat Exchanger Design II	R-32: Residential & Commercial HP and AC II	R-33: Heat Driven Technologies	R-34: Drying & Dehumidification II	C-19: Compressor Valves II	C-20: Lubrication III
1:00 - 3:00pm	Advisory Committee Meeting (by invitation only) - STEW 307							
1:00 - 1:20pm	Optional Campus / Laboratory Tours							
3:00pm	End of Conference							

B-01: Human-centered Building Operation, Smart Sensing and Data-driven Control (IBO)

Session Chair: Huijeong Kim

1:00pm - 1:20pm ID: 3148

Tailoring the Heat Pump System Controller to the Building: Assessment of Adapted Heating Curves using Data-Driven Methods

Florian Will, Jonas Klingebiel, Christian Vering, Dirk Müller

RWTH Aachen University, Germany

1:20pm - 1:40pm ID: 3176

Development and Comparative Analysis of a Power-over-Ethernet (PoE) DC Lighting System for Residential Buildings

Lokesh Sriram, Aaron Farha, Andreas Hoess, Davide Ziviani, Eckhard Groll, Elias Pergantis, Kevin Kircher

Purdue University, United States of America

1:40pm - 2:00pm ID: 3518

Investigating Occupant Thermostat Adjustment Behavioral Patterns in Different Heat Pump Operation Modes: A Field Experiment

Feng Wu^{1,3}, Hemanth Devarapalli³, Hyeongseok Lee^{1,3}, Jaehyun Go^{1,3}, Huijeong Kim^{1,3}, Panagiota Karava^{1,3}, James E. Braun^{2,3}, Davide Ziviani^{2,3}, W. Travis Horton^{1,3}, Kevin Kircher^{2,3}

1 Lyles School of Civil Engineering, Purdue University, West Lafayette, IN, USA; 2 School of Mechanical Engineering, Purdue University West Lafayette, USA; 3 Center for High Performance Buildings, Ray W. Herrick Laboratories, Purdue University, West Lafayette, IN, USA

2:00pm - 2:20pm ID: 3575

Real-Time Estimation of Heat Gains for Demand-Driven Building Control Using Deep Learning

Dongjun Mah^{1,3}, Hubo Cai¹, Kevin J. Kircher^{2,3}, Athanasios Tzempelikos^{1,3}

1 Purdue University, Lyles School of Civil Engineering; 2 Purdue University, School of Mechanical Engineering; 3 Ray W. Herrick Laboratories, Center of High Performance Buildings

2:20pm - 2:40pm ID: 3581

Benchmarking Classification Algorithms for Data-Driven Fault Detection and Diagnostics for Building HVAC Systems

Mohammad Abdollah Fadel Abdollah, Rossano Scoccia, Marcello Aprile

Politecnico di Milano, Italy

2:40pm - 3:00pm ID: 3449

Development of Self-correction Algorithms for Thermostats Using OpenAPI Capabilities

Yimin Chen, Eliot Crowe, Jessica Granderson

LBNL, United States of America

B-02: Sustainable building energy systems and building simulation

Session Chair: Rebecca Ciez

1:00pm - 1:20pm ID: 3175

At-Home Vertical Farm and Automatic Irrigation System Implementation

Emma G. Balevic, Aaron H.P. Farha, Andreas J. Hoess, Eckhard A. Groll

Purdue University, United States of America

1:20pm - 1:40pm ID: 3420

A Hybrid Rf-Symbolic Regression Approach for Accurate Solar Irradiance Prediction in Mountain Regions

Aleksandr Gevorgian, Giovanni Pernigotto, Andrea Gasparella

Free University of Bozen-Bolzano, Italy

1:40pm - 2:00pm ID: 3437

Cost Reduction of Heat Pump Water Heating in Cold Climates for Low to Moderate Income Families

Mini Malhotra¹, Easwaran Krishnan¹, Joseph Rendall¹, Yanfei Li¹, William Worek², Kashif Nawaz¹, Jian Sun¹, Jamieson Brecht¹, Gary Klein³

1 Buildings and Transportation Science Division, Oak Ridge National Laboratory; 2 Argonne National Laboratory; 3 Gary Klein and Associates

2:00pm - 2:20pm ID: 3519

Thermal Modeling Of Industrial Environments Using Transient 0D And 1D Models

Jordi Vera^{1,2}, Octavi Pavon², Assensi Oliva^{1,2}, Deniz Kizildag¹, Oriol Sanmartí¹, Domingo Alcalá³

1 Heat and Mass Transfer Technological Center (CTTC) - Universitat Politècnica de Catalunya BARCELONA TECH (UPC), ESEIAAT, Colom 11, 08222 Terrassa, Spain; 2 Termo Fluids S.L., Carrer Magi Colet 8, Sabadell (Barcelona), Spain; 3 COCEDA, S.L., 08820 El Prat de Llobregat (Barcelona), Spain

2:20pm - 2:40pm ID: 3524

How to Develop Future Weather Data for Building Energy Modeling

Zhaoyun Zeng, Ji-Hyun {Jeannie} Kim, Ralph T. Muehleisen

Argonne National Laboratory, United States of America

R-01: Heat & Mass Transfer and Pressure Drops

Session Chair: Brian Fronk

1:00pm - 1:20pm ID:2158

Investigation Of Different Heat Transfer Correlations On Evaporation Within Fuel Cell Cooling Channels

Patrick Koschel¹, Markus Schönheit², Mario Raddatz², Yixia Xu¹, Christiane Thomas¹

1 TU Dresden, Schaufler chair of refrigeration, cryogenics and compressor technology, Germany; 2 TU Dresden, Thermal power machinery and plants, Germany

1:20pm - 1:40pm ID: 2224

Experimental Analysis of Local Condensation and Evaporation Heat Transfer of Zeotropic Mixture in a Plate Heat Exchanger

Afnan Hasan^{1,2}, Akio Miyara³

1 Graduate School of Science and Engineering, Saga University, Saga, 8408502, Japan; 2 Department of Mechanical Engineering, Chittagong University of Engineering & Technology, Chattogram, Bangladesh; 3 Department of Mechanical Engineering, Saga University, Saga, 8408502, Japan

1:40pm - 2:00pm ID: 2442

Experimental and Numerical Investigation of Droplet Evaporation on Heated Surfaces: Saltwater and the Role of Marangoni Effect

Tanveer Islam Joy, Anthony M. Jacobi

Department of Mechanical Science and Engineering, University of Illinois at Urbana-Champaign, 1206 W Green St, Urbana, IL 61801, USA

2:00pm - 2:20pm ID: 2497

Flow Boiling Heat Transfer Characteristics of R410A in Microchannel Exchangers: Development of Experimental Facility

Luyao Guo^{1,2}, Yi Chen¹, Xiaojie Lin^{3,4}, Long Huang¹

1 Xi'an Jiaotong-Liverpool University, Entrepreneur College (Taicang), School of Intelligent Manufacturing Ecosystem, Suzhou, 215123, China; 2 University of Liverpool, School of Engineering, Liverpool L69 3GJ, United Kingdom; 3 Shanghai Institute for Advanced Study, Zhejiang University, Shanghai, China; 4 College of Energy Engineering, Zhejiang University, Hangzhou, China

2:20pm - 2:40pm ID: 2539

Effect of Thermophysical Properties on Wall Superheat at Onset of Nucleate Boiling

Shota Akai, Kota Nakagawa, Katsumi Sugimoto, Hitoshi Asano

Department of Mechanical Engineering, Kobe University, Japan

2:40pm - 3:00pm ID: 2476

Boiling Heat Transfer and Flow Characteristics of Falling Film of HFO Refrigerant on Vertical Plate

Natsumi Numata, Daisuke Jige, Norihiro Inoue

Tokyo University of Marine Science and Technology, Japan

R-02: Alternative Refrigerants Modeling and Testing

Session Chair: Ian Bell

1:00pm - 1:20pm ID: 2191

Performance of R32/R1234yf Blends as Potential Lower GWP Replacements for R410A in a 3 RT Rooftop Heat Pump

Kenneth Schultz¹, Michael Petersen², Gurudath Nayak³

1 Trane Technologies, La Crosse; 2 Trane Technologies, Bloomington; 3 Trane Technologies, Bengaluru

1:20pm - 1:40pm ID: 2320

Evaluation of Lower GWP Refrigerant Blend for R23 And Blends Thereof in Ultra-low Temperature Refrigeration Applications

Michael Petersen¹, Gurudath Nayak Hebri², Steve Kujak³, Trace Lydick⁴

1 Trane Technologies, Bloomington, Minnesota 55420, USA; 2 Trane Technologies, Bengaluru, 560029, India; 3 Trane Technologies, La Crosse, Wisconsin, 54601 USA; 4 Trane Technologies, Marietta, Ohio, 45750 USA

1:40pm - 2:00pm ID: 2493

Validation Experiments on HFO-1123 Mixtures: Disproportionation Reaction and Its Suppression by the Internal Structure in Refrigerant Compressor

Zhihua Zhang¹, Hidekazu Okamoto¹, Makoto Ito², Eiji Hihara²

1 AGC Inc., Japan; 2 The University of Tokyo, Japan

2:00pm - 2:20pm ID: 2362

Refrigerants with GWP Below 300 for Air Conditioning and Heat Pumps

Joshua Hughes, Jethro Medina, Sunny Kalra

The Chemours Company, United States of America

2:20pm - 2:40pm ID: 2371

Dynamic Evaluation of Circulation Composition of Zeotropic Refrigerant in Heat Pump System with NIR Absorption Spectroscopy

Kosuke Miyawaki¹, Naoki Shikazono²

1 Mitsubishi Electric, Japan; 2 The university of Tokyo

2:40pm - 3:00pm ID: 2271

Experimental Study on Flow Condensation of Low Global Warming Potential Refrigerants in a Micro-fin Aluminum Tube

Yifeng Hu¹, Samuel F. Yana Motta¹, Saad A. Jajja², Cheng-Min Yang¹, Brian A. Fricke¹, Kashif Nawaz¹

1 Oak Ridge National Laboratory, United States of America; 2 National University of Sciences and Technology (NUST), H-12, Islamabad, Pakistan

R-03: Vapor Compression System Modeling I

Session Chair: Kashif Nawaz

1:00pm - 1:20pm ID: 2101

Dynamic Simulation of An Automatic Commercial Ice Maker

Daqing Li, Suresh Shivashankar

Copeland Company, United States of America

1:20pm - 1:40pm ID: 2109

A Power-Law Inductance Distribution Approach for Low-Pressure Axial Fan Blade Design

Gabriel Podgaietsky¹, Adriano Ronzoni², Christian Hermes¹

1 POLO Labs, Dept. of Mechanical Engineering, Federal University of Santa Catarina, Brazil; 2 Nidec Global Appliance, Joinville, SC, Brazil

1:40pm - 2:00pm ID: 2123

Integrating Steady State and Dynamic Simulations for The Design of Heat Pump Vapor Compression Cycle Systems

Joseph Araoz¹, Moritz Hubel²

1 Modelon Inc, United States of America; 2 Modelon AB, Germany

2:00pm - 2:20pm ID: 2284

Reduced Data Dependency in Heat Pump Performance Prediction Through Gray-box Modeling

Shahzad Yousaf¹, Craig Bradshaw¹, Rushikesh Kamalapurkar¹, Omer San²

1 Center for Integrated Buildings Systems, Oklahoma State University, Stillwater, OK; 2 Department of Mechanical, Aerospace and Biomedical Engineering, University of Tennessee, Knoxville, TN

2:20pm - 2:40pm ID: 2285

Quantification of Predictive Capabilities of an Empirical Model For A Variable Speed Heat Pump System Trained With Sparse Data

Shahzad Yousaf¹, Craig Bradshaw¹, Rushikesh Kamalapurkar¹, Omer San²

1 Center for Integrated Buildings Systems, Oklahoma State University, Stillwater, OK; 2 Department of Mechanical, Aerospace and Biomedical Engineering, University of Tennessee, Knoxville, TN

2:40pm - 3:00pm ID: 2415

Comparative Assessment of Operation Thermal Characteristics of Different Types of Refrigeration/Heat Pump Systems for Space Cooling/Heating

Maja Sharevska¹, Monika Sharevska¹, Yashar Hajimolana¹, Gerwin Hoogsteen², Johann Hurink², Gerrit Brem¹

1 Department of Thermal and Fluid Engineering, University of Twente, Enschede, The Netherlands; 2 Department of Electrical Engineering, Mathematics and Computer Science, University of Twente, Enschede, The Netherlands

R-04: Automotive and Transportation HVAC&R

Session Chair: Vincent Lemort

1:00pm - 1:20pm ID: 2116

A Generic Modeling Framework For Duty Cycle Simulations Of Transport Refrigeration Units

Rohit Dhumane¹, Matt Stinson²

1 Trane Technologies, Davidson, NC, USA; 2 Trane Technologies - Thermo King, Minneapolis, MN, USA

1:20pm - 1:40pm ID: 2122

Evaluating the Impact of Electrification on Emissions in Refrigerated Transport

Rohit Dhumane¹, Matt Stinson², Robert Srichai²

1 Trane Technologies, Davidson, USA; 2 Thermo King, Trane Technologies, Minnesota, USA

1:40pm - 2:00pm ID: 2253

Theoretical Investigation of Two-phase Cooling Cycles for Electronic Components in More-Electric Aircraft

Theresa Kramer¹, Marius Nozinski², Yixia Xu¹, Christiane Thomas¹, Stephan Kabelac²

1 Technical University Dresden, Schaufler Chair of Refrigeration, Cryogenics and Compressor Technology; 2 Leibniz University Hannover, Institute of Thermodynamics

2:00pm - 2:20pm ID: 2439

Thermal System Simulation Analysis of R452A Refrigeration System and Possible Refrigerant Alternatives

Nicolás Ablanque¹, Santiago Torras¹, Carles Oliet¹, Joaquim Rigola¹, Jesús Castro¹, Joan Vila², Santiago Martinez²

1 Universitat Politècnica de Catalunya, Spain; 2 Thermo King, Spain

2:20pm - 2:40pm ID: 2557

Holistic Thermal Modelling of Electrified Transport Refrigeration

Marie Shelly^{1,2}, Haotian Liu^{1,2,3}, Justin Weibel^{1,2}, Davide Ziviani^{1,3}

1 Purdue University School of Mechanical Engineering; 2 Cooling Technologies Research Center; 3 Center for High Performance Buildings

C-01: Screw Compressors I

Session Chair: Robin Langebach

1:00pm - 1:20pm ID: 1126

Geometric and Numerical Investigation of Twin-Screw Vacuum Pumps

Yang Lu, Sham Rane, Ahmed Kovacevic

City, University of London, United Kingdom

1:20pm - 1:40pm ID: 1190

Effect of Low Temperature on the Performance of BOG Twin-Screw Compressor

Yuhang Zhou¹, Yi Guo¹, Yuli Wang², Anna Diao², Xueyuan Peng¹

1 School of Energy and Power Engineering, Xi'an Jiaotong University, Xi'an 710049, China; 2 Shanghai Marine Diesel Engine Research Institute, Shanghai 201108, China

1:40pm - 2:00pm ID: 1321

Numerical Investigation of Pressure Pulsation in Oil-Free Twin Screw Compressor Discharge Systems Adopted to Oil and Gas Industry

Vitor Braga, Ernane Silva, Thiago Dutra, André Caetano, Olavo Silva, Arthur Andrezza

Federal University of Santa Catarina, Brazil

2:00pm - 2:20pm ID: 1593

Numerical Computation and Experimental Validation of the Thermodynamic and Mechanical Losses of an oil-injected and economized 4/6 twin-screw compressor

Abhignan Saravana, Haotian Liu, Eckhard A. Groll, Davide Ziviani

Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University West Lafayette, 47907-2099, USA

C-02: Novel Compressors

Session Chair: Ken Monnier

1:00pm - 1:20pm ID: 1120

Shape Optimization of a Roots Blower Rotor Profile Using CFD Model with a Coupled Adjoint-sculpting Method

Neeraj Bikramaditya¹, Sham Rane², Ahmed Kovacevic³

1 City, University of London, United Kingdom; 2 City, University of London, United Kingdom; 3 City, University of London, United Kingdom

1:20pm - 1:40pm ID: 1142

Vapor Injection Compressors: A Review of Opportunities, Testing and Sampling Techniques, and Methods of Characterization

Timothy Kim, Dennis Nasuta, Shankhinee Deshpande, Song Li, Cara Martin

OTS R&D, United States of America

1:40pm - 2:00pm ID: 1157

Performance Testing of a Liquid-injected Roots Compressor for R718

Thomas Werner Moesch^{1,2}, Moritz Enge², Veith Niklas Kaspar², Julian Hoffner¹, Justus Franzen¹, Yves Burgold³, Konrad Klotsche², Christiane Thomas²

1 Combitherm GmbH, Germany; 2 Technische Universität Dresden, Germany; 3 Kaeser Kompressoren SE, Gera, Germany

2:00pm - 2:20pm ID: 1350

Validation of Performance for a Novel Compressor-Expander Concept

Andy Pearson¹, Jon Fenton², Joe Subert², Cameron Carmichael²

1 Star Refrigeration Ltd, United Kingdom; 2 FeTu Ltd, United Kingdom

2:20pm - 2:40pm ID: 1417

Dynamic Modeling of Near Isothermal Compressor for Transcritical Carbon Dioxide Cycle

Haopeng Liu, Vikrant Aute, Yunho Hwang, Chengyi Lee, Jan Muehlbauer, Lei Gao

University of Maryland, United States of America

B-03: MPC (IBO)

Session Chair: Kevin Kircher

3:30pm - 3:50pm ID: 3216

Field Performance of Commercial Building Load Flexibility Using Model Predictive Control

Ettore Zanetti, David Blum, Marco Pritoni, Mary Ann Piette

Lawrence Berkeley National Laboratory, United States of America

3:50pm - 4:10pm ID: 3301

Results of the Implementation of Model Predictive Control in a Large Administrative Building for Energy Efficiency and Comfort Optimization

Svenne Freund, Gerhard Schmitz, Arne Speerforck

Hamburg University of Technology, Germany

4:10pm - 4:30pm ID: 3378

Multi-system Model Predictive Control For Multi-Zone Building Automation And Control

Pradeep Shakya¹, Krishnamoorthy Baskaran¹, Shiva Sreenivasan¹, Yagneshwar Dharmalingam¹, Swapnil Dubey¹, Shiyu Yang², Wan Man Pun³

1 Energy Research Institute @ Nanyang Technological University (ERI@N); 2 Department of Electrical Engineering and Renewable Energy, Oregon Institute of Technology, Klamath Falls, OR, USA, 97601; 3 School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore

4:30pm - 4:50pm ID: 3423

Carbon Responsive Control of Building Thermal Loads

Mingshi Yao¹, Zhimin Jiang², Jie Cai¹

1 University of Oklahoma, United States of America; 2 Trane Technologies, United States of America

4:50pm - 5:10pm ID: 3475

Demand Response Control for the Inverter Air Conditioners Based on Hierarchical Nonlinear Model Predictive Control for Plug-And-Play

Cuiling Wang, Baolong Wang

Tsinghua university, China

5:10pm - 5:30pm ID: 3511

Design and Experimental Performance of Practical MPC for Multi-zone VRF system for Small and Medium Commercial Buildings

Sang woo Ham, Donghun Kim, Lazlo Paul

Lawrence Berkeley National Laboratory, United States of America

B-04: Building design & retrofit tools/models

Session Chair: Nusrat Jung

3:30pm - 3:50pm ID: 3352

Impacts of Relaxing Humidity Constraints on Chilled Water Demand in a Commercial Building

Rebecca Grekin, Jacques de Chalendar, Sally Benson

Stanford University, United States of America

3:50pm - 4:10pm ID: 3533

Design and Commissioning of a Facility for Studying Next-Generation High Performance Building Technologies and their Interactions with Occupants

Feng Wu¹, Sourabh D. Yadav³, Sarah A. Alkandari², Jie Ma², Parveen Dhillon², Haotian Liu², James E. Braun², Panagiota Karava¹, Davide Ziviani², W. Travis Horton¹

1 Lyles School of Civil Engineering, Purdue University, West Lafayette, IN, USA; 2 Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University West Lafayette, USA; 3 Rheem Manufacturing Company, USA

4:10pm - 4:30pm ID: 3551

Field Evaluations in the Time of COVID-19: Overcoming Unexpected Challenges when Testing Occupied Buildings

Robert Hendron¹, Rebecca Simonson²

1 Frontier Energy; 2 Sonoma Clean Power

4:30pm - 4:50pm ID: 3556

The Benefits of Buried Ducts - Beyond What We Know Today.

Rebecca Evans, Simon Pallin, Keith Saechao

Frontier Energy, United States of America

4:50pm - 5:10pm ID: 3561

Comparative Energy Performance Evaluation of Data Centers using Economizer at Various Regions

Se Hyeon Ham¹, Soonbum Kwon¹, Yongchan Kim²

1 Graduate School of Mechanical Engineering, Korea University, Seongbuk-gu, Seoul, Korea; 2 Department of Mechanical Engineering, Korea University, Seongbuk-gu, Seoul, Korea

R-05: CO2 Assessment

Session Chair: Yunho Hwang

3:30pm - 3:50pm ID: 2100

Dynamic Simulation Of A CO2 Booster Rack Commercial Refrigeration System

Daqing Li, Don R Wiesmann, Suresh Shivashankar

Copeland Company, United States of America

3:50pm - 4:10pm ID: 2102

CIL Simulation of a CO2 Booster Rack Commercial Refrigeration System

Daqing Li, Don R Wiesmann, Suresh Shivashankar

Copeland Company, United States of America

4:10pm - 4:30pm ID: 2279

Numerical Investigation of High Delta-T Sensible Storage Integrated CO2 Heat Pump

Ransisi Huang, Nelson James, Eric Kozubal, Jason Woods

National Renewable Energy Lab, United States of America

4:50pm - 5:10pm ID: 2387

Experimental Study of a Vapor-liquid Ejector Performance for Compressor Oil Pumping

Md Muntasir Alam¹, Nenad Miljkovic^{1,2,3,4,5}, Stefan Elbel^{6,7}

1 Department of Mechanical Science and Engineering, University of Illinois at Urbana-Champaign, 1206 W Green St, Urbana, IL 61801, USA;

MONDAY • 3:30PM - 5:30PM

2 Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, 306 N Wright St, Urbana, IL 61801, USA; 3 Materials Research Laboratory, University of Illinois at Urbana-Champaign, 104 S Goodwin Ave, Urbana, IL 61801, USA; 4 Institute for Sustainability, Energy, and Environment (iSEE), University of Illinois at Urbana Champaign, 1101 W Peabody, Urbana, IL 61801, USA; 5 International Institute for Carbon Neutral Energy Research (WPI-I2CNER), Kyushu University, 744 Moto-oka, Nishi-ku, Fukuoka 819-0395, Japan; 6 Technische Universität Berlin, Institut für Energietechnik, FG Wärmeübertragung und -wandlung, Marchstr. 18, 10587 Berlin, Germany; 7 Creative Thermal Solutions, Inc., 2209 N Willow Rd, Urbana, IL 61802, USA

5:10pm - 5:30pm ID: 2612

Numerical Analysis and Optimization of a Bladeless Turbine for Refrigeration Cycles

Sai Kiran Chikatimarla¹, James Braun¹, Paul Lemke², Bernard Killingbeck³, Haotian Liu², Eckhard A. Groll²

1 North Carolina State University, Department of Mechanical and Aerospace Engineering, Raleigh, North Carolina, United States of America;

2 Purdue University, Department of Mechanical Engineering, West Lafayette, Indiana, United States of America; 3 Tree Associates, Norwich, United Kingdom

R-06: Energy Storage I

Session Chair: Min Soo Kim

3:30pm - 3:50pm ID: 2152

Investigation of Heat Pump Integrated Thermochemical Energy Storage for Cabin Heating of Electric Vehicles in Cold Climates

Luis Arturo Vargas-Ochoa¹, Ulises Gonzalez-Valle², Brian M. Fronk³

1 Monterrey Institute of Technology and Higher Education, Mexico; 2 University of Wisconsin-Green Bay, United States of America;

3 The Pennsylvania State University, United States of America

3:50pm - 4:10pm ID: 2153

Assessment of Centralized Domestic Hot Water Systems as An Electrification Option for Multi-Family Water Heating in Cold Climates

Zhenning Li¹, John Bush², Kyle Gluesenkamp¹

1 Oak Ridge National Laboratory, Oak Ridge, United States of America; 2 OTS Energy, Knoxville, United States of America

4:10pm - 4:30pm ID: 2160

Modeling and Analysis of a Heat Pump Clothes Dryer with Thermal Energy Storage

Xiaoli Liu¹, Cheng-Min Yang¹, Pengtao Wang¹, Kashif Nawaz¹, Christopher Hartnett², Troy Seay¹

1 Multifunctional Equipment Integration Group, Oak Ridge National Laboratory, United States of America; 2 Whirlpool Corporation, United States of America

4:30pm - 4:50pm ID: 2275

Development Of An Underground Stratified Thermal Energy Storage (TES) Tank Model
Development of an underground stratified thermal energy storage tank model and performance comparisons with an above-ground tank

Pouria Moghimi, Christian K. Bach, Jeffrey D. Spitler

Oklahoma State University, United States of America

4:50pm - 5:10pm ID: 2277

Development And Experimental Validation Of Simplified Numerical Models For Stratified Thermal Energy Storage (TES) Tanks Including Storage Mode And Adverse Feed Temperatures.

Pouria Moghimi, Khaled I. Alghamdi, Christian K. Bach, Jeffrey D. Spitler

Oklahoma State University, United States of America

R-07: Environmental Aspects of Future Refrigerants

Session Chair: Samuel Yana Motta

3:30pm - 3:50pm ID: 2131

OVERALL Environmental Impacts Comparison for Low GWP Options for Commercial Refrigeration Systems

Hongqing Jin, Kaimi Gao, Elizabet Vera Becerra, Ankit Sethi, Ryan Hulse, Ron Vogl

Honeywell, United States of America

3:50pm - 4:10pm ID: 2149

Mitigation of Safety and Environmental Challenges Posed by Low and Ultra-low GWP Refrigerants

Praveen Cheekatamarla, Vishaldeep Sharma, Brian Fricke, Samuel Yana Motta

Oak Ridge National Laboratory, United States of America

4:10pm - 4:30pm ID: 2402

LCCP Evaluation for Air-to-Air Heat Pumps Using Next-Generation Refrigerants

Shigeharu Taira, Tomoyuki Haikawa, Seishi Iitaka, Ryoichi Takafuji, Keisuke Mitoma, Kohei Maruko, Komei Nakajima

The Japan Refrigeration and Air Conditioning Industry Association, Kikai Shinko Bldg. 201, 5-8 Shibakoen 3-chome, Minato-ku, Tokyo 105-0011, JAPAN

4:30pm - 4:50pm ID: 2566

Atmospheric Chemistry and Fate of Selected Refrigerants

Mark L. Robin

The Chemours Company

4:50pm - 5:10pm ID: 2567

Atmospheric Transformation of Refrigerants: Current Research Developments and Knowledge Gaps

Christian Mark Salvador¹, Federico Sinche Chele¹, Louise Stevenson¹, Fred Dolislager¹, Anthony Armstrong¹, Teresa Mathews¹, Samuel Yana Motta²

¹ Environmental Science Division, Oak Ridge National Laboratory, 1 Bethel Valley Rd., Oak Ridge, TN 37830, USA; ² Buildings and Transportation Science Division, Oak Ridge National Laboratory, 1 Bethel Valley Rd., Oak Ridge, TN 37830, USA

5:10pm - 5:30pm ID: 2565

Environmental Aspects Of HFOs And HCFOs: Atmospheric Lifetimes, Relevant Policy Metrics And Degradation Products

Dimitrios K. Papanastasiou

Buffalo Research Laboratory, Honeywell International, 20 Peabody St. Buffalo, NY 14210, U.S.A.

R-08: Fault Detection and Diagnostics and Sensing

Session Chair: Donghun Kim

3:30pm - 3:50pm ID: 2531

Rigorous Feature Selection of the Virtual Refrigerant Charge Sensor for Variable-Speed Heat Pumps

Fangzhou Guo¹, Donghun Kim¹, Philani Hlanze², Jie Cai²

1 Building Technology & Urban Systems Division, Lawrence Berkeley National Lab, Berkeley, CA, USA; 2 School of Aerospace and Mechanical Engineering, University of Oklahoma, Norman, OK, USA

3:50pm - 4:10pm ID: 2137

Demonstration and Performance Evaluation of a Virtual Superheat Sensor

David Yuill, Seyed Ali Rooholghodos

University of Nebraska - Lincoln, United States of America

4:10pm - 4:30pm ID: 2178

Generalizability of A Machine-Learning Fault Classifier Utilizing A Practical Set of Features for Rooftop Units

Md Rasel Uddin^{1,2}, David P. Yuill¹, Robert E. Williams¹

1 Michaels Energy, United States of America; 2 University of Nebraska-Lincoln, United States of America

4:30pm - 4:50pm ID: 2193

Methods for Real-time Assessment of Refrigerant Charge in Residential Heat Pumps: Experimental Evaluation in Climatic Chambers

Maëlle Jouray^{1,2}, Odile Cauret¹, Cedric Teuillieres¹, Cong Toan Tran²

1 EDF Lab les Renardières, Ecuelles, France; 2 Centre for Energy, Environment & Processes (CEEP), Mines Paris, PSL University, Paris, France

4:50pm - 5:10pm ID: 2397

Rapid On-site Refrigerant Leak Detection Using Reflective Infrared Laser Technology

Tomoatsu Minamida¹, Tomoyuki Haikawa¹, Kazuyuki Satou¹, Takeshi Abe², Tsuyoshi Hara², Satoshi Wada³, Masaki Yumoto³, Takayo Ogawa³

1 DAIKIN INDUSTRIES, LTD.; 2 TOKYO GAS ENGINEERING SOLUTIONS CORPORATION; 3 Photonics Control Technology Team, RIKEN Center for Advanced Photonics, RIKEN

5:10pm - 5:30pm ID: 2436

Evaluation of Leak Detection Technologies for Low Global Warming Potential (GWP), Flammable Refrigerants

Viktor Reshniak, Hongbin Sun, Praveen Cheekatamarla, Vishaldeep Sharma, Samuel Yana Motta

Oak Ridge National Laboratory

C-03: Reciprocating Compressors I

Session Chair: Matt Cambio

3:30pm - 3:50pm ID: 1239

High-Pressure Liquid Injection for Reciprocating Compressors to Improve Efficiency and Operating Range

Jonas Schmitt, Robin Langebach

Karlsruhe University of Applied Sciences, Germany

3:50pm - 4:10pm ID: 1312

Disassembly of Off the Shelf Reciprocating Compressor After Employment in High-Temperature Heat Pump for More Than 1000 Operating Hours

Leon P. M. Brendel¹, Cordin Arpagaus¹, Julian Pfaffl², Florian Simon², Stefan S. Bertsch¹

1 Eastern Switzerland University of Applied Sciences, Switzerland; 2 BITZER Kuehlmaschinenbau GmbH, Germany

4:10pm - 4:30pm ID: 1313

Set of Performance Correlations for Reciprocating Compressor Covering Synthetic and Hydrocarbon Refrigerants

Owen Doughty¹, Cordin Arpagaus², Stefan S. Bertsch², Leon P. M. Brendel²

1 Purdue University, Mechanical Engineering; 2 Eastern Switzerland University of Applied Sciences, Switzerland

4:30pm - 4:50pm ID: 1332

Experimental Investigation of Liquid Slugging in Reciprocating Compressors

Teo B. Balconi¹, Tadeu T. Rodrigues², Cesar J. Deschamps¹

1 Federal University of Santa Catarina, Brazil; 2 NIDEC-GA, R&D

C-04: Compressor Modeling I

Session Chair: Michael Petersen

3:30pm - 3:50pm ID: 1132

Influence of Suction Muffler design on the Suction Effective Flow and Force Areas of a Reciprocating Compressor

Tadeu Tonheiro Rodrigues

Nidec GA, Brazil

3:50pm - 4:10pm ID: 1135

Numerical Analysis Scheme for Predicting the Oil Level Variation in Horizontal Rotary Compressor

Joonhyung Kim, Munseong Kwon, Jongwon Choi, Sedong Lee, Sunghyuk Park

Samsung Electronics, Korea, Republic of (South Korea)

4:10pm - 4:30pm ID: 1421

Predicting Vapor Injected Compressor Performance Using Artificial Neural Networks

Amjid Khan¹, Craig R. Bradshaw¹, Jonas Schmitt², Robin Langebach²

1 Center for Integrated Building Systems, Oklahoma State University, Stillwater, Oklahoma, US; 2 Karlsruhe University of Applied Science, Germany

4:30pm - 4:50pm ID: 1563

Research On Improving The Bearing Lubrication State Of Rotary Compressors

Mengli Xu¹, Chunhui Liu²

1 Shanghai Highly Electrical Appliances CO.,LTD, China, People's Republic of; 2 Shanghai Highly Electrical Appliances CO.,LTD, People's Republic of China

4:50pm - 5:10pm ID: 1289

Development of a Black-Box Compressor Model that Captures Vapor-Injection Compared Against Established Black-Box Models

Amjid Khan, Craig R. Bradshaw

Center for Integrated Building Systems, Oklahoma State University, Stillwater, Oklahoma, US

B-05: Reinforcement learning & advanced building control (IBO)

Session Chair: Neera Jain

9:40am - 10:00am ID: 3543

A Comparison Between Common And Reinforcement Learning-Based Supply Air Temperature Reset Strategies With Varying Occupant Temperature Preferences

Hussein Elehwany¹, Burak Gunay¹, Mohamed Ouf², Nunzio Cotrufo³, Jean-Simon Venne³, Junfeng Wen¹

1 Carleton University, Canada; 2 Concordia University, Canada; 3 Brainbox AI, Canada

10:00am - 10:20am ID: 3579

Optimizing Controls of IoT-based Manufacturing Buildings through Deep Reinforcement Learning

Dikai Xu¹, Jaewoo Shin², Lan Zhao², Ming Qu¹

1 Lyles School of Civil Engineering, Purdue University, West Lafayette, IN 47907, USA; 2 Rosen Center for Advanced Computing, Purdue University, West Lafayette, IN 47907, USA

10:20am - 10:40am ID: 3503

What Have We Learned From Field Demonstrations of Advanced Commercial HVAC Control?

Arash J. Khabbazi^{1,2}, Elias N. Pergantis^{1,2}, Levi D. Reyes Premer^{1,2}, Alex H. Lee^{1,2}, Jie Ma^{1,2}, Haotian Liu^{1,2}, Gregor P Henze^{3,4}, Kevin J. Kircher^{1,2}

1 School of Mechanical Engineering, Purdue University; 2 Center for High Performance Buildings, Ray W. Herrick Laboratories, Purdue University; 3 Department of Civil, Environmental and Architectural Engineering, University of Colorado; 4 National Renewable Energy Laboratory

10:40am - 11:00am ID: 3166

Advanced Predictive Rule-based Control for HVAC Cost Reduction Under Dynamic Electricity Pricing in Residential Buildings

Avik Ghosh^{1,2}, Xing Lu², Veronica Adetola²

1 University of California, San Diego, La Jolla, CA, USA; 2 Pacific Northwest National Laboratory, Richland, WA, USA

11:00am - 11:20am ID: 3180

Model-based Control Optimization of Air-conditioning for Proactive Building Demand Response

Mingkun Dai^{1,2}, Hangxin Li^{1,2}, Shengwei Wang^{1,2}

1 Department of Building Environment and Energy Engineering, The Hong Kong Polytechnic University, Hong Kong; 2 Research Institute for Smart Energy, The Hong Kong Polytechnic University, Hong Kong

11:20am - 11:40am ID: 3608

Detailed Analysis of Energy Demand and COVID-19 Impacts on Hotel Buildings

Hendrik Margraf, Fatih Meral, Federico Lonardi, Andrea Luke

University of Kassel, Department of Technical Thermodynamics, Kassel, Hesse, Germany

B-06: Thermal Energy Storage & Heat Pumps

Session Chair: Bill Hutzal

9:40am - 10:00am ID: 3252

Innovative Condenser - Storage Tank - Concept For Residential Heat Pumps

Kevin Diewald¹, Lena Schnabel¹, Hannes Fugmann¹, Christiane Thomas²

1 Fraunhofer-Institut for Solar Energy Systems, ISE, Germany; 2 TU Dresden, Schaufler Chair of Refrigeration, Cryogenics and Compressor Technology, Germany

10:00am - 10:20am ID: 3254

Performance Assessment of a Dual-Purpose HP-TES for a Typical Year Comparing Different Climate Zones

Alhussain Othman, Vikrant Aute, James Tancabel

University of Maryland, College Park, MD 27040 USA

10:20am - 10:40am ID: 3463

Design And Optimization Of The Conventional Heat Pump With Thermal Energy Storage For Grid-Interactive Efficient Buildings

Mingzhe Liu, Zhiyao Yang, Zheng O'Neill

Texas A&M University, United States of America

10:40am - 11:00am ID: 3562

An Analytical Method to Estimate the LCOE/S of Air Source Heat Pumps Integrated with Thermal Storage

Conrado Ermel¹, Marcus V.A. Bianchi², Paulo S. Schneider¹

1 Federal University of Rio Grande do Sul (UFRGS), Brazil; 2 National Renewable Energy Laboratory (NREL), USA

11:00am - 11:20am ID: 3582

Exploring the Power Demand and Efficiency Performance Limits of Heat Pumps with Thermal Storage

Kyle Gluesenkamp¹, Damilola Akamo¹, Zhenning Li¹, Yiyuan Qiao¹, Jason Hirschey², Xiaobing Liu¹, Bo Shen¹

1 Oak Ridge National Laboratory, United States of America; 2 National Renewable Energy Laboratory, United States of America

11:20am - 11:40am ID: 3212

Assessing Low-GWP Refrigerants in Ground Source Heat Pump Systems: Long-Term Thermal Performance under Varied Geological Conditions and Cold Climate

Zilong Zhao¹, Guoquan Lv^{2,3}

1Trane Technologies, United States of America; 2Zhejiang University, China; 3Center for Green Building and Low-Carbon City, China

R-09: Frost and Defrost Characterization and Modeling I

Session Chair: Stefan Elbel

9:40am - 10:00am ID: 2115

Two-Dimensional First-Principles Model for Uneven Frost Accretion in 'No-Frost' Evaporators

Dimitri Silva¹, Henrique Eberth¹, Carlos Richter², Diogo Da Silva³, Christian Hermes¹

1 POLO Labs, Dept. of Mechanical Engineering, Federal University of Santa Catarina, Brazil; 2 Electrolux do Brasil S/A; 3 Dept. of Mobility Engineering, Federal University of Santa Catarina, Brazil

10:00am - 10:20am ID: 2125

Experimental Study of Frost Formation and Various Defrosting Techniques on a Microchannel Evaporator in a Real Reversible Air Source Heat Pump System

Dalia Ghaddar¹, Kaushik Chettiar¹, Syed Angkan Haider¹, Jiazheng Liu¹, Kalyan Boyina¹, Nenad Miljkovic^{1,2,3,4}

1 Mechanical Science and Engineering, University of Illinois, Urbana, Illinois 61801, USA; 2 Department of Electrical and Computer Engineering, University of Illinois, Urbana, Illinois 61801, USA; 3 Materials Research Laboratory, University of Illinois, Urbana, Illinois 61801, USA; 4 International Institute for Carbon Neutral Energy Research (WPI-I2CNER), Kyushu University, 744 Moto-oka, Nishi-ku, Fukuoka 819-0395, Japan

10:20am - 10:40am ID: 2182

Thermo-Mechanical Defrosting using Multistable Heat Exchanger Fins

Aman Thakkar, Sean Peters, James E. Braun, W. Travis Horton, Andres F. Arrieta

Purdue University, United States of America

10:40am - 11:00am ID: 2197

A Review of Modeling Approaches for Predicting Frost Growth and Frost Melting on Tube-fin Heat Exchangers

Zechao Lu, Ransisi Huang, Jason Woods

National Renewable Energy Laboratory, United States of America

11:00am - 11:20am ID: 2242

Development of a Novel Dual Fan Outdoor Coil for Achieving Even Frosting Along the Airflow Direction in a Space Heating ASHP

Xiaoxia Bai¹, Shengnan Liu², Shiming Deng³, Long Zhang⁴

1 School of Architecture and Urban Planning, Yunnan University, Kunming, Yunnan, China; 2 School of Thermal Engineering, Shandong Jianzhu University, Jinan, Shandong, China; 3 Department of Mechanical and Industrial Engineering, Qatar University, P.O. Box 2713, Doha, Qatar; 4 Department of Energy and Power Engineering, School of Mechanical Engineering, Beijing Institute of Technology, Beijing, China

11:20am - 11:40am ID: 2272

Improving Heat Pump System Performance Using a Novel Frost/Defrost Model

Imran Alam, Nicholas Tobin, Andy Leonard, Mihail Spasov, Mayank Khichar

Gamma Technologies, Westmont, Illinois, United States of America

R-10: Load-Based Testing

Session Chair: David Yuill

9:40am - 10:00am ID: 2346

Field and Lab Testing of Residential Heat Pumps to Assess Representativeness of Fixed-speed and Load-based Test Methods

Bruce Harley¹, Christopher Dymond², David Yuill³, Gary Hamer⁴, Jennifer McWilliams⁵, Yuxuan Chen³

1 Bruce Harley Energy Consulting; 2 Northwest Energy Efficiency Alliance; 3 University of Nebraska; 4 BCHydro; 5DNV

10:00am - 10:20am ID: 2596

Uncertainty Quantification Approach for Dynamic Load-Based Testing

Parveen Dhillon¹, Dohyeon Kim², W. Travis Horton², James E. Braun²

1 National Renewable Energy Laboratory; 2 Ray W. Herrick Laboratories, Purdue University

10:20am - 10:40am ID: 2597

Closed-Loop Apparatus (CLA) Design and Assessment for Load-Based Testing

Dohyeon Kim¹, Parveen Dhillon², Ashwin Kidambi¹, Travis Horton¹, James E. Braun¹

1 Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University; 2 National Renewable Energy Laboratory, Golden, CO, USA

10:40am - 11:00am ID: 2599

An Improved Thermostat Environment Emulator (TEE) for Load-based Testing

Dohyeon Kim¹, Parveen Dhillon², W. Travis Horton², James E. Braun²

1 Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University; 2 National Renewable Energy Laboratory, Golden, CO, USA

R-11: Air to Refrigerant Heat Exchangers

Session Chair: Stefan Bertsch

9:40am - 10:00am ID: 2111

Investigation on Condensate Temperature from Cooling Coil

Tyler Stusynski, Jian Yu

Super Radiator Coils Ltd, United States of America

10:00am - 10:20am ID: 2112

Experimental Study on Air Friction in V-Shaped Coil Bank

Jian Yu

Super Radiator Coils Ltd, United States of America

10:20am - 10:40am ID: 2448

Study of Water Bridge Formation on Fin-and-tube Heat Exchangers

Haoyang Zou, Sophie Wang

Department of Mechanical Science and Engineering, University of Illinois at Urbana-Champaign, 105 S Mathews Ave, Urbana, IL 61801, United States

10:40am - 11:00am ID: 2477

Experimental Study of Air-Side Performance of a Flat Finned Tube Heat Exchanger under Dry and Wet Conditions

Oguz Kilic, Burhan Yoruk

FRITERM, Turkiye

11:00am - 11:20am ID: 2585

Test Stand For Characterization Of Microchannel Condensers Operating At Low-inlet-vapor Quality For Pumped Two-phase Cooling Loops Using Low-GWP Refrigerant

Jaewon Park¹, Tyler J. Schostek¹, Justin A. Weibel², Davide Ziviani¹

1 Ray W. Herrick Laboratories, Purdue University Mechanical Engineering West Lafayette, IN, 47906, USA; 2 Cooling Technologies Research Center, Purdue University Mechanical Engineering West Lafayette, IN, 47906, USA

11:20am - 11:40am ID: 2257

Performance Comparison of Different Circuitries for the TriCoil Three-fluid Heat Exchanger

Md Zayed Mostafa, Khaled Alghamdi, Jeffrey D. Spitler, Christian K. Bach

Oklahoma State University

R-Student Paper Competition

Session Chair: Davide Ziviani

9:40am - 10:00am ID: 2269

Machine Learning Based Prediction of Airflow Maldistribution in A-Type Heat Exchangers

Brian O'Malley, James Tancabel, Vikrant Aute

University of Maryland, College Park, United States of America

10:00am - 10:20am ID: 2390

Experimental Investigations Of Waste Heat Utilization Of High-Temperature Heat Pump Compressors

Jaromir Jeřberger^{1,2}, Florian Heberle^{1,2}, Dieter Brüggemann^{1,2}

1 Chair of Engineering Thermodynamics and Transport Processes (LTTT), University of Bayreuth; 2 Center of Energy Technology (ZET), University of Bayreuth

10:20am - 10:40am ID: 2419

Low-GWP Working Fluid Mixtures Screening for Industrial High Temperature Heat Pumps with Supply Temperature >200 °C

Jan Spale^{1,2}, Andreas J. Hoess¹, Ian H. Bell³, Davide Ziviani¹

1 Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University, West Lafayette, 47906 IN, USA; 2 Czech Technical University in Prague, Jugoslavských partyzanu 1580/3, 160 00 Prague, Czech Republic; 3 Applied Chemicals and Materials Division, National Institute of Standards and Technology, Boulder, CO 80305, USA

10:40am - 11:00am ID: 2329

Performance Evaluation Of A Water-to-Water Heat Pump Using the New Low Global Warming Potential Mixture R1234yf/R600a (0.85/0.15) As Drop-In Replacement For R134a Refrigerant

Giulia Lombardo^{1,2}, Yeonwoo Jeong³, Stefano Rossi¹, Davide Menegazzo^{1,2}, Michele De Carli², Laura Fedele¹, Sergio Bobbo¹, Min Soo Kim³

1 Construction Technologies Institute, National Research Council (CNR), Padova (Italy); 2 Department of Industrial Engineering, University of Padua (UNIPD), Padova (Italy); 3 Department of Mechanical Engineering, Seoul National University, Seoul (Republic of Korea)

11:00am - 11:20am ID: 2412

Simultaneous Deep Dehumidification and Sub-Dew Point Cooling by Combined Sorption Dehumidification and Evaporative Cooling (CoSDEC): The Effect of Inlet Air Condition

Marco Lao¹, Jie Lin², Frantisek Miksik³, Kyaw Thu^{1,4}, Takahiko Miyazaki^{1,4}

1 Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, Japan; 2 School of Mechanical and Aerospace Engineering, Queen's University Belfast, United Kingdom; 3 Future Society Creation Organization, Nagoya University, Japan; 4 International Institute of Carbon-Neutral Energy Research (I2CNER), Kyushu University, Japan

11:20am - 11:40am ID: 2214

Experimentation on Finned-Tube Microchannel Heat Exchanger Incorporating Phase Change Material and R-410A

Jangho Yang, Jan Muehlbauer, James Tancabel, Vikrant Aute, Yunho Hwang

University of Maryland, United States

C-05: Screw Compressors II

Session Chair: Gordon Powell

9:40am - 10:00am ID: 1607

Numerical Analysis of Air Inlet Pressure on Backflows and Isentropic Efficiency in an Oil - Injected Twin-Screw Compressor

Alp Büyükbayraktar, Deniz Arda Soylu, Buğrahan Bahadır, Sinan Pisirici

Dalgakıran Compressor, Research & Development, Istanbul, Turkey

10:00am - 10:20am ID: 1171

CFD Simulation and Improvement of High-speed Twin Screw Compressors for Chillers

Bingqi Wang¹, Xiaokun Wu², Chuang Wang¹, Zhiping Zhang^{2,3}, Kai Ma¹, Ziwen Xing¹

1 School of Energy and Power Engineering, Xi'an Jiaotong University, Xi'an, 710049, China; 2 State Key Laboratory of Air-Conditioning Equipment and System Energy Conservation, Gree Electric Appliances, INC., Zhuhai, 519070, China; 3 School of Electrical Engineering, Zhejiang University, Hangzhou, 310058, China

10:20am - 10:40am ID: 1118

Design Optimization for Efficiency and Mechanical Stress Management in High-Speed Screw Spindle Compressors

Sami Tuffaha^{1,2}, Thomas Werner Moesch^{1,2}, Konrad Klotsche¹, Christiane Thomas¹, Ralf Steffens²

1 Technische Universität Dresden, Germany; 2 Combitherm GmbH, Germany

10:40am - 11:00am ID: 1305

Development of the New Two-Stage Semi-Hermetic Single Screw Compressor for Heat Pump

Yoshiyuki Imamura, Takashi Inoue, Kazuhei Takahashi, Yoshiyuki Uemura, Harunori Miyamura

Daikin Industries, Ltd.

C-06: Compressor Motors

Session Chair: Rodolfo César Costa Flesch

9:40am - 10:00am ID: 1287

Temperature Prediction of Scroll Compressor Motor Coupling ANSYS Fluent and Maxwell

Liu Wang, Guangqiang Liu, Jiangbo Lin, Li Yao

Danfoss (Tianjin) Ltd., Tianjin, P. R. of China

10:00am - 10:20am ID: 1307

Torque Ripple Optimization of PMSM for Hermetic Reciprocating Compressors

Yakup Akyün, Burak Solak, Uğur Oğuz Ertuğrul

Arçelik A.Ş., Türkiye

10:20am - 10:40am ID: 1308

Design, Magnetic Analysis and Performance Optimization of PMSM for Hermetic Reciprocating Compressors

Yakup Akyün, Burak Solak, Uğur Oğuz Ertuğrul

Arçelik A.Ş., Türkiye

TUESDAY • 9:40AM - 11:40AM

10:40am - 11:00am ID: 1381

Motor Optimization Analysis for Hermetic Scroll Compressor

Li Yao, Wanzhen Liu, Guangqiang Liu, Zhenyu Wang, Yan Lin, Dandan Liu

Refrigeration and Air Conditioning Compressors Technology Key Lab, Danfoss (Tianjin) Ltd., People's Republic of China

11:00am - 11:20am ID: 1568

Single-Phase Induction Motor Design Optimization for Hermetic Rotary Compressor in Heat Pump Water Heating Applications

Osmar Pinheiro, Jônatas Lacerda, Lino Marco

Tecumseh do Brasil Ltda., Brazil

TUESDAY • 1:30PM - 3:50PM

B-07: Thermal energy storage operation (IBO)

Session Chair: Jason Woods

1:30pm - 1:50pm ID: 3255

Recharge Demand Mitigation for Latent Heat Thermal Energy Storage at Off-Peak Hours

Alhussain Othman, Vikrant Aute, James Tancabel

University of Maryland, College Park, MD 27040 USA

1:50pm - 2:10pm ID: 3348

Grid-interactive Efficient Buildings Using Thermal Energy Storage For Electric Heat Pumps

Prabhav Agrawala¹, Anurag Goyal²

1 Department of Mechanical Engineering, Malaviya National Institute of Technology, India; 2 Department of Mechanical Engineering, Indian Institute of Technology Delhi, New Delhi, India

2:10pm - 2:30pm ID: 3426

Electric Battery Energy Storage and Thermal Energy Storage

Jason Woods, Eric Kozubal

National Renewable Energy Laboratory

2:30pm - 2:50pm ID: 3530

Field Test and Evaluation of Model Predictive Control in a Grid-Interactive Thermal Energy Storage Integrated Heat Pump System

Yiyuan Qiao¹, Xiaobing Liu^{*1}, Liang Shi², Lingshi Wang¹, Jin Dong¹, Borui Cui¹, Ming Qu²

1 Oak Ridge National Laboratory, Oak Ridge, TN, USA; 2 Purdue University, Lyles School of Civil Engineering, West Lafayette, IN, USA

2:50pm - 3:10pm ID: 3532

MPC for a Hybrid RTU System integrated with Phase Change Material for Load Shifting and Peak Demand Reduction

Rohit Chintala, Huang Ransisi, Xin Jin

National Renewable Energy Lab, United States of America

R-12: Flammable Refrigerants

Session Chair: Steve Kujak

1:30pm - 1:50pm ID: 2188

Flammability Of 2L Refrigerants And Blends At Increasing Elevations.

David Grundy, Adam Newbould, Chris Seeton

Orbia, United Kingdom

1:50pm - 2:10pm ID: 2196

A Modeling Study on the R290 Leaking Assessment of Commercial Refrigeration Equipment

Mingkan Zhang, Vishaldeep Sharma, Praveen Cheekatamarla

Oak Ridge National Laboratory, United States of America

2:10pm - 2:30pm ID: 2200

Test Rig Hydrocarbon Mixtures For Multi-Source Commercial Heat Pumps

Michael Wördemann¹, Christiane Thomas¹, Valerius Venzik²

1 TU Dresden, Germany; 2 Viessmann Climate Solutions SE

2:30pm - 2:50pm ID: 2282

Low-Charge R290 Modular Heat Pump System Using Thermal Storage

Mathilde Wirtz, Jason Woods, Ransisi Huang, Juan Catano, Eric Kozubal

National Renewable Energy Laboratory, United States of America

2:50pm - 3:10pm ID: 2401

Propane as a Refrigerant in Residential Heat Pumps - Potential and Challenges

Diandra Maria Küçükkaya¹, Max Joswig¹, Sami Tuffaha¹, Konrad Klotsche¹, Ullrich Hesse¹, Christiane Thomas¹, Edgar Timm²

1 Technische Universität Dresden, Schaufler-Chair of Refrigeration, Cryogenics and Compressor Technology, Münchner Platz 3, 01069 Dresden, Germany; 2 ETSuS UG, Obere Stadt 13, 95326 Kulmbach, Germany

3:10pm - 3:30pm ID: 2494

Laminar Burning Velocity in R290/R32, R290/R1234yf, and R290/HFO-1123 Binary Mixtures: Comparing Experimental Results to Mixing Rule Calculations

Zhihua Zhang¹, Makoto Ito², Eiji Hihara²

1 AGC Inc., Japan; 2 The University of Tokyo, Japan

R-13: Heat Exchanger Modeling

Session Chair: Vikrant Aute

1:30pm - 1:50pm ID: 2173

A Modeling Based Design of Polymer Manifolds for Heat Exchangers with Reduced Maldistribution

Mingkan Zhang, Cheng-Min Yang, Kai Li, Kashif Nawaz

Oak Ridge National Laboratory, United States of America

TUESDAY • 1:30PM - 3:50PM

1:50pm - 2:10pm ID: 2195

Evaluation of Flow, Heat Transfer, and Phase Change Characteristics in Microchannel Condensers using Computational Fluid Dynamic (CFD) Simulations

Katherine J. Asztalos¹, Muhsin Ameen¹, Ameya Waikar², David Rowinski²

1 Argonne National Laboratory; 2 Convergent Science, LLC

2:10pm - 2:30pm ID: 2218

Effects of Splitter Placement on Fin-Tube Heat Exchanger Evaporator Performance

Matin Ghadiri, Christian K. Bach, Craig R. Bradshaw

Oklahoma State University, United States of America

2:30pm - 2:50pm ID: 2416

An Extensive Analytical DOE-Based Dimensionless Performance Comparison Of Plain, Wavy And Louvered Finned-Tube Heat Exchangers

Felipe Rivabem Gimenez^{1,2}, Sandro Tavares Conceição², Guilherme Borges Ribeiro¹

1 Aeronautics Institute of Technology (ITA), Brazil; 2 Embraer S.A., Brazil

2:50pm - 3:10pm ID: 2496

Data-Driven Modeling of Microchannel Heat Exchangers Utilizing Dimensionless Numbers for Enhanced Prediction

Junjia Zou^{1,2}, Yi Chen¹, Chen Zheng³, Long Huang¹

1 Xi'an Jiaotong-Liverpool University, School of Intelligent Manufacturing Ecosystem, Suzhou, China; 2 University of Liverpool, School of Engineering, Brownlow Hill, Liverpool, United Kingdom; 3GD Midea Heating & Ventilating Equipment Co., Ltd. P.R. China

3:10pm - 3:30pm ID: 2520

Transient Heat Exchanger Simulation Through 1D And 3D CFD Models

Jordi Vera^{1,2}, Eugenio Schillaci^{1,2}, Santiago Torras¹, Carles Oliet¹, Assensi Oliva^{1,2}

1 Heat and Mass Transfer Technological Center (CTTC) - Universitat Politècnica de Catalunya BARCELONA TECH (UPC), ESEIAAT, Colom 11, 08222 Terrassa, Spain; 2 Termo Fluids S.L., Carrer Magi Colet 8, Sabadell (Barcelona), Spain

R-14: Heat Pump Water Heaters

Session Chair: Kevin Mercer

1:30pm - 1:50pm ID: 2288

Model Based Control Development for Heat Pump Water Heater

Zhiqiang Li¹, Yonghua Zhu¹, Yueqian Jin¹, Yongli Yuan¹, Chao Ma², Xiaodong Yang²

1 Midea Group (Shanghai) Co., Ltd., China, China, People's Republic of; 2 Guangdong Midea Refrigeration Equipment Co., Ltd., China

1:50pm - 2:10pm ID: 2335

A Simulation Study of 120V Heat Pump Water Heaters

Bo Shen, Kyle Gluesenkamp, Melanie DeBusk, Zhenning Li, Brian Fricke

Oak Ridge National Lab, United States of America

2:10pm - 2:30pm ID: 2441

Low GWP Refrigerants for Heat Pump Water Heaters

Sarah Kim¹, Christopher Seeton¹, Robert Low²

1 Orbia Fluor & Energy Materials (Koura), United States of America; 2 Orbia Fluor & Energy Materials (Koura), United Kingdom

2:30pm - 2:50pm ID: 2452

Performance Evaluation of Drain Heat Recovery Heat Exchangers for Heat Pump Water Heaters

Easwaran Krishnan, Muneeshwaran Murugan, Joe Rendall, Kashif Nawaz, Jamieson Brechtl

Buildings and Transportation Science Division, Oak Ridge National Laboratory, 1 Bethel Valley Road, Oak Ridge, Tennessee, 37830

2:50pm - 3:10pm ID: 2466

Deployment Of R290 In Heat Pump Water Heaters And Implications for Decarbonization

Kashif Nawaz, Joseph Rendall, Ahmed Elatar, Jian Sun

Oak Ridge National Lab, United States of America

C-07: Tribology

Session Chair: Konrad Klotsche

1:30pm - 1:50pm ID: 1156

Tribometer for the Investigation of Self-Lubricating Sealing Materials under Realistic Compression Conditions

Max Joswig, Konrad Klotsche, Christiane Thomas

TU Dresden, Schaufler Chair for Refrigeration, Cryogenics and Compressor Technology, Germany

1:50pm - 2:10pm ID: 1155

Material Characterization and Material Model Development for Simulating Elastomeric Parts in Diaphragm Pumps

Andreas Swienty¹, Robert Eberlein², Raphaël Thierrin², Nuno Dias Vidal de Castro³

1 KNF Neuberger GmbH, 79112 Freiburg, Germany; 2 Zurich University of Applied Science, Institute of Mechanical Modelling, 8400 Winterthur, Switzerland; 3 Zurich University of Applied Science, Institute of Materials and Process Engineering, 8400 Winterthur, Switzerland

2:10pm - 2:30pm ID: 1167

Higher Oil Film Pressure between Scroll Wraps of Scroll Compressors Due to Rolling and Sliding

Keiko Anami¹, Ryosuke Okamoto¹, Masaru Tanaka², Kenichi Sata², Hideki Matsuura², Yukiko Maejima², Kosuke Nishimura², Kanetaka Miyazawa²

1 Osaka Electro-Communication University, Japan; 2 Daikin Industries, LTD., Japan

2:30pm - 2:50pm ID: 1184

Process Optimization to Improve Low Friction and Wear Resistance of Compressor Solid Lubricating Coatings

YoonHo Park¹, Youngmin Choi¹, SeongJun Park¹, Si-Geun Choi², Jong-Hyoung Kim², InKang Heo², Jaesang Yoo², Jin-Young Park²

1 Samsung Electronics Co., Ltd. / Digital Appliances / Compressor & Motor Business Team; 2 Korea Institute of Industrial Technology (KITECH), Korea, Republic of (South Korea)

2:50pm - 3:10pm ID: 1183

Wear and Lifespan Evaluation of solid lubricant in Rotary Compressors Operating in a Refrigerant Oil Environment

Jaesang Yoo¹, Si-Geun Choi¹, Jong-Hyoung Kim¹, InKang Heo¹, SooDol Park², Byunghyun Kim², JunPyo Lee², Jin-Young Park¹

*1 Korea Institute of Industrial Technology, Korea, Republic of (South Korea);
2 Samsung Electronics Co., Ltd. / Digital Appliances / Compressor & Motor Business Team*

C-Student Paper Competition

Session Chair: Leon Brendel

1:30pm - 1:50pm ID: 1276

Optimization of Internally Geared Screw Machine Geometry for Air Compression Application

Halil Lacevic, Ahmed Kovacevic, Matthew Read

City, University of London, United Kingdom

1:50pm - 2:10pm ID: 1290

Development of a Physics-Inspired Model for the Characterization of Vapor Injected Compressors

Amjid Khan, Craig R. Bradshaw

Center for Integrated Building Systems, Oklahoma State University, Stillwater, Oklahoma, US

2:10pm - 2:30pm ID: 1366

Online System Identification of a Compressor Test Stand With Echo State Networks

Guilherme Henrique Ludwig¹, Bernardo Barancelli Schwedersky², Rodolfo César Costa Flesch¹

1 Federal University of Santa Catarina, Brazil; 2 Federal University of Pelotas, Brazil

2:30pm - 2:50pm ID: 1488

Experimental Investigation of a Vapor-injected Reciprocating Compressor for the Use In a Multi-evaporator Domestic Refrigerator/Freezer

Changkuan Liang, Daniel A. Benadof, Haotian Liu, Eckhard A. Groll, Davide Ziviani, James E. Braun

Ray W. Herrick Laboratories, Purdue University Mechanical Engineering West Lafayette, IN, USA

2:50pm - 3:10pm ID: 1399

Consideration Of Oil Interaction On The Operating Behaviour Of Twin-Screw Compressors Using Chamber Model Simulations

Matthias Heselmann, Lasse Burchardt, Andreas Brümmer

TU Dortmund University, Germany

C-08: Compressor Modeling II

Session Chair: Ahmed Kovacevic

1:30pm - 1:50pm ID: 1400

Effect Of Vibrations Levels On The Reliability Of The Journal Bearings Of The Reciprocating Compressor

Umar Ul Haque¹, Mustafa Savaş², Atacan Oral³, Serhat Öztürk⁴

1 Arcelik A.S. Compressor Plant, Eskisehir; 2 Arcelik A.S. Central R&D, Istanbul; 3 Arcelik A.S. Compressor Plant, Eskisehir;

4 Arcelik A.S. Compressor Plant, Eskisehir

1:50pm - 2:10pm ID: 1302

Enhancing the Thermodynamic Efficiency of a Household Refrigerator's Hermetic Reciprocating Compressor by Using a Bypass Tube in the Suction Muffler

Aamir Shahzad, Pouya Pashak

Arcelik A.S, Turkiye

2:10pm - 2:30pm ID: 1605

CFD Optimization of the Relationship Between Blade Geometry and Separator Length for Improved Water and Air Separation Efficiency in Cyclone Separators

Alp Büyükbayraktar, Deniz Arda Soylu, Buğrahan Bahadır, Sinan Pisirici

Dalgakıran Compressor, Research & Development, Istanbul, Turkey

2:30pm - 2:50pm ID: 1105

Optimisation of Industrial Oil-Flooded Screw Compressors: A Comparative Analysis of Conventional and Soft Computing Approaches

Abhishek Kumar^{1,2}, Ahmed Kovacevic¹, Sathiskumar Anusuya Ponnusami¹

1 Centre for Compressor Technology, City, University of London, London, U.K.; 2 Kirloskar Pneumatic Company Limited, Pune, India

C-09: Lubricants I

Session Chair: Michael Petersen

1:30pm - 1:50pm ID: 1198

Verification of High-Performance Lubrication Due to Precession-Rolling in a Fully Loaded Thrust-Slide Bearing in a Large Capacity Scroll Compressor

Jin Takeda¹, Yoshinobu Yosuke¹, Hiroshi Kitaura¹, Keiko Anami², Noriaki Ishii²

1 Technology and Innovation Center, Daikin Industries, Ltd., Japan; 2 Dept. of Mechanical Engineering, Osaka Electro-Communication University, Japan

1:50pm - 2:10pm ID: 1365

An Investigation on the Dissociative Heat of Low-GWP Refrigerant/Lubricant Oil Mixtures for the Reliable Design of Refrigerant Compressors

Yemanebirhan Abirham¹, Yoshimi Ikeda¹, You Cheng², Takahiko Miyazaki^{2,3}

1 Mitsubishi Electric Co. Ltd., Japan; 2 Interdisciplinary Graduate School of Engineering, Sciences, Kyushu University; 3 International Institute of Carbon-Neutral Energy Research (I2CNER), Kyushu University

2:10pm - 2:30pm ID: 1369

SWOT Type Considerations Of Lubricants And Low GWP Refrigerant Options

Joseph Anthony Karnaz

Shrieve Chemical Products, LLC, United States of America

2:30pm - 2:50pm ID: 1370

Design and Commissioning of an Apparatus to Characterize Foamability and Solubility - Properties of Low-GWP Refrigerant and Lubricant Pairs (ASHRAE RP-1879)

Kyle A. Shepard, Craig R. Bradshaw

Center for Integrated Building Systems, Oklahoma State University

2:50pm - 3:10pm ID: 1408

Investigation of Thermal Properties of Lubricants Used In Refrigeration Systems

Aybüke Özkan^{1,3}, Ramazan Aydın², Sefa Yasin Uzen¹, Aysel Kantürk Figen³

1 Arçelik A.Ş., Central R&D, Istanbul, Turkey; 2 Arçelik A.Ş., Eskisehir Compressor Plant R&D Department, Eskisehir, Turkey;

3 Yıldız Technical University, Chemical Engineering Department, Istanbul, Turkey

B-08: IAQ, Air Cleaning & Filtration

Session Chair: Brandon Boor

4:00pm - 4:20pm ID: 3219

Indoor Atmospheric Nanocluster Aerosol Dynamics in Residential Buildings

Satya Patra¹, Gerhard Steiner², Nusrat Jung¹, Brandon Boor¹

1 Purdue University, United States of America; 2 GRIMM Aerosol Technik Ainring GmbH & Co. KG, Germany

4:20pm - 4:40pm ID: 3220

Development of a Chamber Platform for Evaluating Indoor Dust Contact Transfer and Resuspension in Infant Near-Floor Microenvironments

Brian Magnuson, Satya Patra, Nusrat Jung, Brandon Boor

Purdue University, United States of America

4:40pm - 5:00pm ID: 3221

Human Olfactory Assessment of Scented Volatile Chemical Product Emissions

Jordan Cross, Brian Magnuson, Zachary Limaye, Rashmika Manipati, Chunxu Huang, Jianghui Liu, Brandon Boor, Nusrat Jung

Purdue University, United States of America

5:00pm - 5:20pm ID: 3226

Indoor Nanoparticle Emissions and Exposures during Heat-Based Hair Styling Activities

Jianghui Liu, Jinglin Jiang, Satya Patra, Xiaosu Ding, Chunxu Huang, Jordan Cross, Brandon Boor, Nusrat Jung

Purdue University, United States of America

5:20pm - 5:40pm ID: 3227

Real-Time Energy and IEQ Monitoring of a Compact Living Space

Hongbo Lu¹, Emmanuel Aghimien², Xiaosu Ding¹, Ariane Rednour¹, Jordan Cross¹, Nusrat Jung¹

1 Purdue University, United States of America; 2 City University of Hong Kong, Hong Kong

5:40pm - 6:00pm ID: 3228

Development of a New Laboratory Test Methodology for Rapid Ageing of HVAC Filters

Chunxu Huang¹, Ta-Kuan Chuang¹, Iane Gomes², Laura Ajala³, Elliot Cram¹, Nusrat Jung¹, Brandon Boor¹

1 Purdue University, United States of America; 2 Universidade Federal do Rio de Janeiro, Brazil; 3 Universidade Estadual de Campinas, Brazil

R-15: Domestic Refrigeration

Session Chair: Christian Bach

4:00pm - 4:20pm ID: 2108

COP-Based Decision Tree for Fault Detection and Diagnosis in Single-Door Refrigerating Appliances

Guilherme Senger¹, Alessandro Silveira¹, Adriano Ronzoni², Christian Hermes¹

1 POLO Labs, Dept. of Mechanical Engineering, Federal University of Santa Catarina, Brazil; 2 Nidec Global Appliance, Joinville, SC, Brazil

4:20pm - 4:40pm ID: 2542

Automated Hot-Cycle Calorimeter for Household Refrigerating Compressors with Surrounding Air and Refrigerant Inlet Temperatures at 16 and 32°C

Alessandro Silveira, Jairo Vieira, Tiago Melo, Guilherme Senger, Christian Hermes

POLO Laboratories, Federal University of Santa Catarina, Brazil

4:40pm - 5:00pm ID: 2146

Benchmark testing of two Household refrigerators using R600a

Zhiming Gao, Philip Boudreaux, Mingkan Zhang, Yanfei Li, Pengtao Wang, Kashif Nawaz, Brian Fricke
Oak Ridge National Laboratory, United States of America

5:00pm - 5:20pm ID: 2487

Performance Investigation of a Flexible Multi-evaporator Domestic Refrigerator/Freezer System With Integrated Economization

Changkuan Liang, Haotian Liu, Eckhard A. Groll, Davide Ziviani, James E. Braun
Ray W. Herrick Laboratories, Purdue University Mechanical Engineering West Lafayette, IN, USA

5:20pm - 5:40pm ID: 2507

Performance Evaluation Of Various Configurations For Domestic Refrigerators With R-600a

Cheng-Min Yang¹, Bo Shen¹, M Muneeshwaran¹, Kashif Nawaz¹, Ernest Calvin Pickles², Christopher Hartnett²
1 Oak Ridge National Laboratory, United States of America; 2 Whirlpool Corporation, United States of America

5:40pm - 6:00pm ID: 2265

Experimental Investigation on Cooling performance of A Thermoelectric Freezer

Yifeng Hu, Bo Shen, Kyle R. Gluesenkamp, Samuel F. Yana Motta
Oak Ridge National Laboratory, United States of America

R-16: High Temperature Heat Pump

Session Chair: Andy Pearson

4:00pm - 4:20pm ID: 2339

How High Is High: What Temperatures Can We Achieve With High Temperature Heat Pumps?

Neil James Hewitt
Ulster University, United Kingdom

4:20pm - 4:40pm ID: 2462

High-Temperature Heat Pumps And Their Role In The Decarbonization Of Buildings And Industry

Kashif Nawaz, Pengtao Wang, Jian Sun, Steve Kowalski
Oak Ridge National Lab, United States of America

4:40pm - 5:00pm ID: 2314

Non-Condensable Gases at Low Concentrations in a High-Temperature Heat Pump Operating with R-1336mzz(Z)

Leon Philipp Martin Brendel, Noah Lüchinger, Cordin Arpagaus, Stefan S. Bertsch
Eastern Switzerland University of Applied Sciences, Switzerland

5:00pm - 5:20pm ID: 2206

Impact of Composition Adjustment on the performance of a Water-Ammonia High-Temperature Heat Pump

Shahzaib Abbasi¹, Elias Vieren², Kenny Couvreur², Steven Lecompte^{2,3}, Alessia Arteconi^{1,4,5}
1 KU Leuven, Department of Mechanical Engineering, Leuven, 3000, Belgium; 2 Ghent University, Department of Electromechanical, Systems and Metal Engineering, Ghent, 9000, Belgium; 3 FlandersMake @ UGENT - Core lab EEDT - MP, Leuven 3000, Belgium; 4 Dipartimento di Ingegneria Industriale e Scienze Matematiche, Università Politecnica delle Marche, 60131, Ancona, Italy; 5 EnergyVille, 3600, Genk, Belgium

5:20pm - 5:40pm ID: 2315

Experimental Results from a 70 kW Steam-generating Butane Heat Pump Using Off-the-shelf Components
Michael Uhlmann¹, Leon P. M. Brendel¹, Cordin Arpagaus¹, Luiseric E. Olmedo², Jürg Schiffmann²,
Stefan S. Bertsch¹

1 Eastern Switzerland University of Applied Sciences, Switzerland; 2 École Polytechnique Fédérale Lausanne, Laboratory for Applied Mechanical Design

5:40pm - 6:00pm ID: 2414

Performance of High Temperature Heat Pumps Integrated in Industrial Multi Energy Systems

Maja Sharevska¹, Monika Sharevska¹, Yashar Hajimolana¹, Gerwin Hoogsteen², Johann Hurink², Gerrit Brem¹

1 Department of Thermal and Fluid Engineering, University of Twente, Enschede, The Netherlands; 2 Department of Electrical Engineering, Mathematics and Computer Science, University of Twente, Enschede, The Netherlands

R-17: Heat Exchanger Design I

Session Chair: Roy Crawford

4:00pm - 4:20pm ID: 2211

Examination of Droplet Mobility and Critical Air Velocity on Slippery Liquid Infused Porous Surfaces with a Linear Wettability Gradient

Sarah Freeman, Andrew Sommers

Dept. of Mechanical and Manufacturing Engineering, Miami University, Oxford, OH 45056 USA

4:20pm - 4:40pm ID: 2440

Indirect Air-to-Liquid Heat Exchanger Design for Refrigeration Applications

Santiago Torras¹, Nicolás Ablanque¹, Joaquim Rigola¹, Carles Oliet¹, Jordi Vera¹, Joan Vila², Santiago Martinez²

1 Universitat Politècnica de Catalunya, Spain; 2 Thermo King, Spain

4:40pm - 5:00pm ID: 2117

On the Effectiveness of Brazed-Type Capillary Tube Suction Line Heat Exchangers Running with Isobutane

Pedro Bruggemann¹, Gabriel Podgajetsky¹, Kaitlyn Palermo², Elizabeth Wohlers², Joshua Julius²,
Anderson Bortoletto², Christian Hermes¹

1 POLO Labs, Dept. Mechanical Engineering, Federal University of Santa Catarina, Brazil; 2 Sub-Zero, Inc., WI, USA

5:00pm - 5:20pm ID: 2434

Microchannel Geometries for Improved Heat Transfer with Low-GWP refrigerants

Muneeshwaran Murugan, Cheng-Min Yang, Jamieson Brechtl, Kashif Nawaz

Oak Ridge National Laboratory, United States of America

5:20pm - 5:40pm ID: 2467

On the Corrosion Response of Novel Heat Exchangers Manufactured by Casting of Al-Ce-Mg Alloy

Kashif Nawaz, Jamieson Brechtl, Melanie DeBusk, Micheal Kesler

Oak Ridge National Lab, United States of America

5:40pm - 6:00pm ID: 2594

Calibration of Temperature-Dependent Resistance of 3D Printed Conductive Filaments for Embedded Sensing

Amanda Stone¹, Justin A. Weibel², Davide Ziviani¹

1 Ray W. Herrick Laboratories, School of Mechanical Engineering; 2 b) Cooling Technologies Research Center, School of Mechanical Engineering Purdue University, West Lafayette, IN, 47906, USA

C-10: Compressor Testing and Evaluation I

Session Chair: Travis Horton

4:00pm - 4:20pm ID: 1204

Evaluation of Positive Displacement Compressor Testing Techniques, Variation, and Uncertainty

Alexander Schmig, Lars Sjöholm

Trane Technologies / Thermo King, United States of America

4:20pm - 4:40pm ID: 1233

Isentropic-Isothermal Efficiency for Optimized Compressor Rating

Robin Langebach¹, Craig Bradshaw², Jonas Schmitt¹, Amjid Khan²

1 Karlsruhe University of Applied Science, Germany; 2 Oklahoma State University, Stillwater, OK

4:40pm - 5:00pm ID: 1443

Automatic Test Stand to Impose Operating Suction and Discharge Conditions on Compressors

Cassiano Montibeller, Gabriel Thaler, Rodolfo César Costa Flesch, João Paulo Zomer Machado,

Guilherme Henrique Ludwig

Federal University of Santa Catarina, Brazil

5:00pm - 5:20pm ID: 1554

Analysis of APF Standard of Japan and China and Research of R32 Inverter Compressor with High Efficiency

Rui Wu^{1,2,3}, Jiansheng Liao^{1,2,3}, Keke Tong^{1,2,3}, Hao Yang^{1,2,3}, Xingbiao Zhou^{1,2,3}, Hui Zhang^{1,2,3}

1 Guangdong Meizhi Refrigeration Co., Ltd; 2 Guangdong Provincial Key Laboratory of High Energy Efficiency Compressor Technology R&D; 3 Research Institute of Midea Industrial Technology Business Group, Midea Group Co., Ltd

5:20pm - 5:40pm ID: 1311

Noise Radiation and Control for Roots Pumps in Hydrogen Circulation Systems of FCVs

Shuangmei Zhou, Penghui You, Xiaohan Jia, Xueyuan Peng, Jianmei Feng

School of Energy and Power Engineering, Xi'an Jiaotong University, No. 28 West Xianning Road, Xi'an, 710049, P.R. China

5:40pm - 6:00pm ID: 1478

Research on Aerodynamic Noise Reduction of Rotary Compressor Discharge Port Slope

Yi Zhou^{1,2}, Weikang Jiang¹, Haijun Wang², Shujun Shan²

1 Shanghai Jiaotong University; 2 Shanghai Highly Electrical Appliances CO.,LTD

B-Student Paper Competition

Session Chair: Ming Qu

4:00pm - 4:20pm ID: 3577

Modeling Thermostat Adjustment Behavior in Residential Communities During Eco-feedback Energy Interventions

Jaehyun Go^{1,2}, Huijeong Kim^{1,2}, Ilias Billionis³, Panagiota Karava^{1,2}

1 School of Civil Engineering, Purdue University, West Lafayette, IN, USA; 2 Center for High Performance Buildings, Ray W. Herrick

Laboratories, Purdue University, West Lafayette, IN, USA; 3School of Mechanical Engineering, Purdue University, West Lafayette, IN, USA

TUESDAY • 4:00PM - 6:00PM

4:20pm - 4:40pm ID: 3572

Enabling Human-Centered Daylighting Operation Using Non-Intrusive Luminance Monitoring And Deep Learning

Sichen Lu, Dongjun Mah, Athanasios Tzempelikos

Purdue University, United States of America

4:40pm - 5:00pm ID: 3291

Data-Driven Probabilistic Causal Inference for Occupant Behavior Modeling

Jinyoung Ko, Seungjae Lee

Department of Civil and Mineral Engineering, University of Toronto, Toronto, ON M5S 1A4, Canada

5:00pm - 5:20pm ID: 3165

Beyond Average: Evaluating Indoor Average Temperature in Grey Box Modeling

Ozan Baris Mulayim, Mario Bergés

Carnegie Mellon University, United States of America

5:20pm - 5:40pm ID: 3138

Protecting Residential Electrical Infrastructure Through Advanced Control: The First Field Results

Elias Nikolaos Pergantis, Levi D. Reyes, Alex H. Lee, Haotian Liu, Eckahrd A. Groll, Davide Ziviani, Kevin J. Kircher

Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University West Lafayette, 47907-2099, USA

5:40pm - 6:00pm ID: 3201

Design And Validation Of A Heat Pump Digital Twin And Its Control Strategy Towards The Development Of Flexibility Focused Controllers

Nicolas Renté^{1,3}, Laure Meljac¹, Odile Cauret², Kévin Attonaty², Cong Toan Tran³, Pascal Stabat³

1 NIBE, Sweden; 2 EDF, France; 3 Mines Paris PSL, France

C-11: Compressors for Alt. Refs.

Session Chair: Andreas Brummer

4:00pm - 4:20pm ID: 1144

Advancing Sustainability: A Comprehensive Study on Energy-Efficient Screw Compressors for Biogas Applications

Abhishek Kumar^{1,2}, Neeraj Bikramaditya¹

1 Centre for Compressor Technology, City, University of London, London, U.K.; 2 Kirloskar Pneumatic Company Limited, Pune, India

4:20pm - 4:40pm ID: 1458

Investigation of the Impact of Reduced Density Low-GWP Refrigerants in a Commercial R-410A Scroll Compressor

Graham Alexander Tyra, Shahzad Yousaf, Craig Bradshaw

Center for Integrated Building Systems, Oklahoma State University, Stillwater, Oklahoma, US, United States of America

4:40pm - 5:00pm ID: 1491

Performance of a Scroll Compressor Working with Drop-in Refrigerant Replacements to R134a

Riccardo Conte¹, Marco Azzolin¹, Stefano Bernardinello², Davide Del Col¹

1 Department of Industrial Engineering - University of Padova, Italy; 2 Swegon Operations S.r.l., Italy

5:00pm - 5:20pm ID: 1546

An Empirical Model for a CO₂ Thermal Compressor Based on Experimental Data

Ali Salame¹, Vincent Lemort², Pascal Dufour³, Madiha Nadri³, Rabah Ibsaine¹

1 Boostheat Company, Lyon, France; 2 University of Liège, Energy Systems Research Unit, Liège, Belgium; 3 Univ Lyon, Université Claude Bernard Lyon 1, CNRS, LAGEPP UMR 5007, 43 boulevard du 11 novembre 1918, F-69100, VILLEURBANNE, France

5:20pm - 5:40pm ID: 1187

Development of a High Speed R290 Compressor for Room Air Conditioner

Li Zhang, La Da

Shanghai Highly Electrical Appliances Co., Ltd., China, People's Republic of

C-12: Oil Management

Session Chair: Christiane Thomas

4:00pm - 4:20pm ID: 1121

Two-phase Lubrication of Refrigerant-oil Mixture in High-pressure Compressor

Che Wang, Jianhua Wu, Zibo Zhao

Xi'an Jiaotong University, China, People's Republic of

4:20pm - 4:40pm ID: 1347

Transient Oil-refrigerant Mixture Flow Change after Compressor Shutdown at Suction and Discharge

Xin Wang¹, Nenad Miljkovic¹, Stefan Elbel²

1 Air Conditioning and Refrigeration Center, Department of Mechanical Science and Engineering, University of Illinois at Urbana-Champaign, 1206 West Green Street, Urbana, IL 61801, USA; 2 Technische Universität Berlin, Institut für Energietechnik, FG Wärmeübertragung und -wandlung, Marchstr. 18, 10587 Berlin, Germany

4:40pm - 5:00pm ID: 1379

Two-phase Simulations On Transient Flow In Scroll Compressor Using VOF Method

Jihyun Kim¹, Yanghee Cho², Jaesang Lee², Hyungmin Park¹

1 Seoul national university, Korea, Republic of (South Korea); 2 Energy Technology Lab., SAMSUNG ELECTRONICS Co., Korea, Republic of (South Korea)

5:00pm - 5:20pm ID: 1555

Research on Gas-Liquid Separation Characteristics of Integrated Compressor

Fengrong Zhao^{1,2,3}, Jiansheng Liao¹, Xingbiao Zhou¹, Hao Yang¹, Qingyang Huang¹, Jiating Zhang¹

1 Guangdong Meizhi Compressor Co.Ltd.; 2 Key Laboratory for R&D of High-Efficiency Compressor Technology Enterprises in Guangdong Province; 3 Midea Group

B-09: Advances in heat pumps, smart controls and FDD (IBO)

Session Chair: Todd Rossi

9:40am - 10:00am ID: 3536

A Predictive Heat Pump Water Heater Controller in a Residential Building: A Field Study

Levi D. Reyes Premer, Leo Semmelmann, Elias N. Pergantis, Eckhard A. Groll, Davide Ziviani, Kevin J. Kircher
Purdue University, United States of America

10:00am - 10:20am ID: 3150

Adaptive Model Control of Residential Solar-Air Source Hybrid Heat Pumps Water Heating System

Zihao Zhao, Baolong Wang

Beijing Key Laboratory of Indoor Air Quality Evaluation and Control, Department of Building Science, Tsinghua University, China

10:20am - 10:40am ID: 3273

A Dynamic Modeling Framework for High-Performance Heat Pumps and Controls Evaluations

Jiazhen Ling¹, Jermy Thomas¹, Kyle Benne¹, David Blum²

¹ National Renewable Energy Laboratory, United States of America; ² Lawrence Berkeley National Laboratory, United States of America

10:40am - 11:00am ID: 3274

Performance Evaluation of Ground-source Integrated Heat Pump for Residential Net-zero Energy Buildings

Dong Soo Jang, Harrison M. Skye

National Institute of Standards and Technology, United States of America

11:00am - 11:20am ID: 3130

A Data-driven AFDD Approach Using Acoustic Emission In Building HVAC Systems

Jiajing Huang¹, Zhiyao Yang², Guowen Li², Teresa Wu¹, Zheng O'Neill², Jin Wen³, K. Selcuk Candan¹

¹ School of Computing and Augmented Intelligence, Arizona State University, Tempe AZ, USA; ² J. Mike Walker '66 Department of Mechanical Engineering, Texas A&M University, College Station TX, USA; ³ Department of Civil, Architectural and Environmental Engineering, Drexel University Philadelphia, PA, USA

11:20am - 11:40am ID: 3139

Learning the Thermal Dynamics of a Residential Building from Limited Data

Elias N. Pergantis, Jaewon Park, Priyadarshan Priyadarshan, Trevor J. Bird, Davide Ziviani, Kevin J. Kircher

Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University West Lafayette, 47907-2099, USA

11:40am - 12:00pm ID: 3521

Physics-based Dynamic Bayesian Network For Fault Detection And Diagnostics In Building HVAC Systems

Dongyu Chen^{1,2}, Yiyuan Qiao^{2,3}, Qun Zhou Sun²

¹ School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai, China; ² Department of Electrical and Computer Engineering, University of Central Florida, Orlando, FL, USA; ³ Oak Ridge National Laboratory, Oak Ridge, TN, USA

R-18: Residential & Commercial HP & AC Systems I

Session Chair: Andy Hjortland

9:40am - 10:00am ID: 2324

Automatic Construction of an Efficient Air Conditioner Using GraPHsep Method

Mengdi Cui, Baolong Wang, Yuzheng Ying, Falin Wei

Department Building Science, Tsinghua University, Beijing, China

10:00am - 10:20am ID: 2213

Performance Comparison of a Residential Split-System Heat Pump Powered on AC versus DC Power

Aaron Harron Patrick Farha, Davide Ziviani, Kevin James Kircher, Eckhard A. Groll

Ray W. Herrick Laboratories

10:20am - 10:40am ID: 2304

Towards Efficient and Cost-Effective Heating and Cooling through Single-Split Air Conditioners as Hybrid Solutions in Existing Buildings

Katharina Theresa Breuer, Christian Vering, Dirk Müller

RWTH Aachen University, E.ON Energy Research Center, Institute for Energy Efficient Buildings and Indoor Climate, Germany

10:40am - 11:00am ID: 2451

Experimental Assessment of the Effect of Refrigerant Charge Levels on Variable-Speed Heat Pump Performances

Philani Gift Hlanze¹, Jie Cai¹, Donghun Kim²

1 School of Aerospace and Mechanical Engineering, University of Oklahoma, Norman, OK, United States of America; 2 Building Technology & Urban System Division, Lawrence Berkeley National Laboratory, Berkeley, CA, United States of America

11:00am - 11:20am ID: 2430

Development of Defrost Controller Platform for Commercial Rooftop Heat Pump Units

Julfikar Ali¹, Rana Siddharth², Aaron Alexander¹, Christian K. Bach¹

1 OKLAHOMA STATE UNIVERSITY, United States of America; 2 Birla Institute of Technology, Mesra, Ranchi, Jharkhand, India

11:20am - 11:40am ID: 2455

Insights Gained From The Experimental Testing Of A Rooftop Unit Under Frosting Conditions

Hamid Ikram, Tauseef Ismail, Rana Siddharth, Julfikar Ali, Aaron Alexander, Christian Bach

Oklahoma State University, United States of America

R-19: Systems Integrated with PCM-TES

Session Chair: Zhenning Li

9:40am - 10:00am ID: 2215

Optimization and Experimental Validation of Annular Finned PCM-HX for a Domestic Hot Water Heater Application

Tanjebul Alam, Jangho Yang, James Tancabel, Jan Muehlbauer, Yunho Hwang, Vikrant Aute

University of Maryland, United States

10:00am - 10:20am ID: 2243

Numerical Analysis Of An Off-Grid Cold Room With Latent Thermal Energy Storage For Food Preservation

Gianluca Slaviero^{1,2}, Dario Traverso², Franco Traverso², Marco Noro¹, Claudio Zilio¹, Simone Mancin¹

1 Department of Management and Engineering, University of Padova, Str.Ila S.Nicola 3, Vicenza, 36100, Italy; 2 Genius Cold Srl, Via Postumia 9/B, Carmignano di Brenta (PD), 35010, Italy

10:20am - 10:40am ID: 2549

Performance Evaluation of Trans-critical CO₂ Refrigeration System Based on CO₂ Hydrate Cold Energy Storage

Yumei Zhang, Guoyuan Ma, Lei Wang

Beijing University of Technology

10:40am - 11:00am ID: 2413

Reversible Heat Pump - Organic Rankine Cycle Systems With Zeotropic Fluid Mixtures For Enhanced Performance – Experimental And Simulative Results From A Pilot Plant

Maximilian Weitzer, Martina Moderegger, Lukas Metzner, Sebastian Kolb, Jürgen Karl

Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

11:00am - 11:20am ID: 2446

Slanted Stages Design: A Numerical Approach to Enhancing Multiple PCMs melting in a Shell and Tube Unit

Amr Kotb, Sophie Wang

University of Illinois at Urbana-Champaign, United States of America

11:20am - 11:40am ID: 2281

Development & Experimental Validation of a Generalized Resistance-Capacitance Model for Numerical Simulation of Phase-Change Material Embedded Heat Exchangers

Mylena Menezes, James Tancabel, Daniel Bacellar, Vikrant Aute

University of Maryland, United States of America

R-20: Membrane-Based Systems

Session Chair: Kyle Gluesenkamp

9:40am - 10:00am ID: 2298

Preliminary Test on Moisture Transfer of Flat Sheet Membrane-based Dehumidification System

Hye-Jin Cho, Seong-Yong Cheon, Soo-Jin Lee, Jae-Weon Jeong

Department of Architectural Engineering, College of Engineering, Hanyang University, Seoul, Republic of Korea

10:00am - 10:20am ID: 2303

Thermodynamic Analysis of Cascade Vacuum Pump Based Membrane Dehumidifier in Air Conditioning System

Seong-Yong Cheon, Hye-Jin Cho, Jae-Hee Lee, Sang-Hwan Park, Jae-Weon Jeong

Hanyang University, Korea, Republic of (South Korea)

10:20am - 10:40am ID: 2571

Energy-Saving Potential of a Dual-Module Humidity Pump for Residential and Commercial Air Conditioning

Songhao Wu, Anand Balaraman, Andrew Fix, Jinwoo Oh, James E. Braun, David M. Warsinger

Department of Mechanical Engineering, Purdue University, United States of America

10:40am - 11:00am ID: 2583

Development and Characterization of Nanocomposite Membranes for Next-Generation Air Dehumidification Technologies

Setareh Heidari¹, Ansh A. Mishra², Maria Augusta Correa Martins¹, Jinwoo Oh¹, Anand Balaraman¹, MD Ashiqur Rahman¹, Davide Ziviani¹, James E. Braun¹, David M. Warsinger^{1,2}

1 Purdue University, United States of America; 2 Georgia Institute of Technology, United States of America

11:00am - 11:20am ID: 2590

A Comprehensive Sizing Analysis Using an Effectiveness-NTU Framework for Vacuum Membrane Dehumidification Systems

Md Ashiqur Rahman, Andrew J. Fix, Jinwoo Oh, James E. Braun, David M. Warsinger

Department of Mechanical Engineering, Purdue University, United States of America

11:20am - 11:40am ID: 2611

Numerical Investigation of a Membrane-Integrated Heat Pump for Industrial Drying

Junyan Ren¹, Makena Thompson¹, David M. Warsinger², Davide Ziviani¹

1 Ray W. Herrick Laboratories, Purdue University West Lafayette, IN 47907-2099, USA; 2 Birck Nanotechnology Center, Purdue University West Lafayette, IN 47907-2099, USA

R-21: Thermal Management of EVs

Session Chair: Rohit Dhumane

9:40am - 10:00am ID: 2217

Review of Thermal Management Systems in Electric Vehicles

Mina Michel Kamel Mikhaeel, Wulfer de Bruijn

Lucid Motors Inc., United States of America

10:00am - 10:20am ID: 2240

Comparison and Evaluation of Injector structures for Air Conditioning systems in Electric Cars

Joerg Aurich, Rico Baumgart

IAV GmbH, Germany

10:20am - 10:40am ID: 2241

Investigation of Rotary Piston and Swing Compressor Concepts with Medium Pressure Injection for Electrified Vehicles

Rico Baumgart, Joerg Aurich, Frank Hohmann, Rico Resch

IAV GmbH, Germany

10:40am - 11:00am ID: 2299

Effects Of Metal Foam Heat Sink For The Immersion Battery Cooling System

Hongseok Choi, Hoseong Lee

Korea University, Korea, Republic of (South Korea)

11:00am - 11:20am ID: 2375

Experimental Study On Battery Cooling/Preheating Using Heat Pipe-assisted Hybrid Fin Under Extreme Conditions

Yongjoo Jun, Hoseong Lee

Korea University, Korea, Republic of (South Korea)

11:20am - 11:40am ID: 2380

Application of a Novel Three-Dimensional Structure Pulsating Heat Pipe to Relieve Internal Heat Bottlenecks in EV Batteries

Jongmin Jung¹, Yongseok Jeon²

1 Graduate school of Ajou University, Department of Mechanical Engineering; 2 Ajou University, Department of Mechanical Engineering

C-13: Scroll Compressors I

Session Chair: Michael Perevozchikov

9:40am - 10:00am ID: 1154

Automated Optimization of Variable Back-Pressure of Scroll Compressors Across the Entire Operation Envelope

Christian Busch, Markus Öttl

Obrist Engineering GmbH, Austria

10:00am - 10:20am ID: 1229

Numerical Study on the Performance Characteristics and Pressure Pulsation of the Electric Scroll Compressor
Kai Ma¹, Zhilong He¹, Dantong Li¹, Minglong Zhou², Wenqing Chen²

1 School of Energy and Power Engineering, Xi'an Jiaotong University, Xi'an 710049, China; 2 Suzhou Academy, Xi'an Jiaotong University, Suzhou 215123, China

10:20am - 10:40am ID: 1513

Investigation of Variable Wall-thickness Scroll Compressor Geometries for EV Heat Pump Applications
Xin Ding, Davide Ziviani, Eckhard Groll

Herrick Laboratories, Purdue University, United States of America

10:40am - 11:00am ID: 1238

Study on the Asymmetric Thermodynamic Process of an EV Scroll Compressor

Zibo Zhao¹, Jianhua Wu¹, Shuai Zhang^{1,2}, Che Wang¹, Jiajing Li¹

1 School of Energy and Power Engineering, Xi'an Jiaotong University, Xi'an, Shaanxi, China; 2 Jiangsu Nanfang Changsheng Amperex Technology Co., Ltd, Changzhou, Jiangsu, China

C-14: Compressor Modeling III

Session Chair: Joaquim Rigola

9:40am - 10:00am ID: 1103

Enhancing Efficiency and Reducing Carbon Footprint in Centrifugal Air Compressors with active magnetic bearings: High-Speed Operation for Specific Energy

Ramdane Lateb¹, Joaquim Da Silva¹, Juha Lammi², Mihail Lopatin², Olli Kuismanen², Igor Nagaev²

1 SKF Magnetic Mechatronics, France; 2 Tamturbo Oy, Finland

10:00am - 10:20am ID: 1106

Thermal Analysis of a Twin Screw Vacuum Pump using CFD Model

Sham Ramchandra Rane¹, Ahmed Kovacevic¹, Khurram Akhtar², Christopher White²

1 City, University of London, United Kingdom; 2 Fruitland Manufacturing - Vacuum Pumps, Canada

10:20am - 10:40am ID: 1225

Design of Axial Active Magnetic Bearing with High Load Capacity for Low Pressure Centrifugal Chiller
Shih-Ying Chiang, Chao-Yun Chen, Kuo-Shu Hung

Industrial Technology Research Institute, Taiwan

10:40am - 11:00am ID: 1323

Study The Effect Of Micro-Hardness On The Wear Behavior Of Crankshaft And Connecting Rod Pair Of A Hermetic Reciprocating Compressor

Mehmet Burak Yetim, Umar Ul Haque, Aamir Shahzad

Arcelik A.S, Turkiye

11:00am - 11:20am ID: 1445

Semi-Supervised Learning Algorithm for Running-in Analysis on Compressors

Jonatan Leandro Machado, Gabriel Thaler, Rodolfo César Costa Flesch, João Paulo Zomer Machado

Federal University of Santa Catarina, Brazil

C-15: Lubrication II

Session Chair: Sarah Kim

9:40am - 10:00am ID: 1199

Thermophysical Property Model of Lubricant Oils and Their Mixtures with Refrigerants

Xiaoxian Yang, Markus Richter

Technische Universität Chemnitz, Germany

10:00am - 10:20am ID: 1231

Modeling and Experimental Validation of the Thermophysical Properties of a POE+R1233zd(E) Mixture

Nicolas Leclercq¹, Katharina Stöckel², Christiane Thomas², Vincent Lemort¹

1 Thermodynamics Laboratory, University of Liège, Liège, Belgium; 2 Schaufler Chair of Refrigeration, Cryogenics and Compressor Technology, Technische Universität Dresden, Dresden, Germany

10:20am - 10:40am ID: 1259

Study of R-1336mzz(Z), R-1336mzz(E), and R-1233zd(E) Stereoisomerization at Elevated Temperatures

Stephen Kujak, Morgan Herried Leehey, Christopher Collins

Trane Technologies, La Crosse, WI, USA

10:40am - 11:00am ID: 1357

Development of Prognostic Machine Learning Models for Thermophysical Properties Predictions of Nanodiamond-Based Nanolubricants

Ammar Bahman¹, Emil Pradeep¹, Zafar Said², Prabhakar Sharma³

1 Mechanical Engineering Department, College of Engineering and Petroleum, Kuwait University; 2 Department of Sustainable and Renewable Energy Engineering, University of Sharjah; 3 Department of Mechanical Engineering, Delhi Skill and Entrepreneurship University

B-10: Thermal Energy Storage & Energy Management (IBO)

Session Chair: Jie Cai

1:00pm - 1:20pm ID: 3251

On the design of Latent Thermal Energy Storage Solutions for Buildings: from Materials to Applications

Dario Guarda, Giacomo Favero, Gianluca Slaviero, Giulia Righetti, Claudio Zilio, Luca Doretto, Simone Mancin

University of Padova, Italy

1:20pm - 1:40pm ID: 3424

Effect of Liquid Fraction Sensing Accuracy on the Performance of a Smart Energy Management System for Residential Heat-Pump Heating with Latent Thermal Energy Storage

Carolina Mira-Hernandez, Simone Mancin

University of Padova, Italy

1:40pm - 2:00pm ID: 3427

Pressure Sensor for State of Charge Measurements in Latent Thermal Energy Storage (P-SOC)

Joseph Rendall, Achutha Tamraparnia, Zhenglai Shen, Diana Hun, Som Shrestha

Buildings and Transportation Science Division, Oak Ridge National Laboratory, 1 Bethel Valley Road, Oak Ridge, Tennessee, 37830

2:00pm - 2:20pm ID: 3457

Experimental Investigation and Performance Characterization of PCM Integrated Finned Tube Heat Exchanger for Building Heating and Cooling Applications

Achutha Tamraparni, Joseph Rendall, Zhenglai Shen, Diana Hun, Som Shrestha

Buildings and Transportation Science Division, Oak Ridge National Laboratory, 1 Bethel Valley Road, Oak Ridge, Tennessee, 37830

2:20pm - 2:40pm ID: 3479

Feasibility of Gravity Batteries in Residential Homes: A Case Study

Caden L Jaraus, Thomas B Avery, Enrico Setiawan, Andreas J Hoess, Haotian Liu, Eckhard A Groll

Ray W. Herrick Laboratory, Purdue University, United States of America

2:40pm - 3:00pm ID: 3498

Modelling And Simulation Of A Carnot Battery Coupled To Seasonal Underground Stratified Thermal Energy Storage For Heating, Cooling And Electricity Generation

Aitor Cendoya¹, Frederic Ransy^{1,2}, Vincent Lemort¹, Andres Hernandez¹, Pierre Dewallef¹, Pierre-Henri Gresse³, Jacques Windeshausen²

1 University of Liege, Belgium; 2 Wingest Energy, Belgium; 3 Flexide Energy, Belgium

R-22: Commercial & Industrial Refrigeration

Session Chair: Brian Fricke

1:00pm - 1:20pm ID: 2129

Energy Efficiency Improvement Approaches in Ice Related Processes

Praveen Cheekatamarla, Hongbin Sun

Oak Ridge National Laboratory, United States of America

1:20pm - 1:40pm ID: 2360

Refrigeration System Performance Assessment for Food Processing and Storage

Andy Pearson

Star Refrigeration Ltd, United Kingdom

1:40pm - 2:00pm ID: 2185

Energy-saving Control Method of NH₃-CO₂ Cascade Refrigeration System Driven by a Hybrid Mechanism-based and Data-based Approach

Yiwei Feng¹, Chuang Wang¹, Shengli Qu¹, Yanpeng Li¹, Dawe Ren^{1,2}, Ziwen Xing¹

1 School of Energy and Power Engineering, Xi'an Jiaotong University, Xi'an, 710049; 2 Moon Environment Technology Co., Ltd, Yantai, 264002

2:00pm - 2:20pm ID: 2203

Performance Comparison of a Centrifugal Shipboard Chiller using R-134a and a Low-Global Warming Potential Replacement

Patrick Gresh-Sill¹, Florin Iancu², Brian M. Fronk¹

1 The Pennsylvania State University, United States of America; 2 Johnson Controls, United States of America

2:20pm - 2:40pm ID: 2310

Enhancing Freshwater Production in Humidification-Dehumidification Desalination by Regulating Seawater and Air Temperature

Kolanu Sai Sandeep, Prof. Sandip S. Deshmukh, Prof. Santanu Prasad Datta

Bits Pilani Hyderabad Campus, India

2:40pm - 3:00pm ID: 2374

Computational Study of Thermal Performance Enhancement in High-energy Density Data Center through Immersive Liquid Cooling

Jeebeom Kim, Hoseong Lee

Department of Mechanical Engineering, Korea University, Korea, Republic of (South Korea)

R-23: Refrigerant Thermophysical Properties

Session Chair: Chris Seeton

1:00pm - 1:20pm ID: 2114

SAFT-Based Refrigerant Property Models Accounting For Polarity

Ian Bell

NIST, United States of America

1:20pm - 1:40pm ID: 2189

Refining Equation Of State Models For Refrigerant Mixtures Around The Critical Temperature Of One Component

David Grundy, Clare Skae, Chris Seeton, Bob Low

Orbia, United Kingdom

1:40pm - 2:00pm ID: 2359

Enhancing Thermodynamic Data Quality for Refrigerant Mixtures: Domain-Informed Anomaly Detection and Removal

Christopher Laughman, Vedang Deshpande, Ankush Chakrabarty, Hongtao Qiao

Mitsubishi Electric Research Laboratories, United States of America

2:00pm - 2:20pm ID: 2482

Computationally Efficient Property Calculation for Mixed Refrigerants Using Weighted Piecewise Polynomial Regression

Abdulmumin Olamilekan Olaoke¹, Baojie Mu², Yaoyu Li¹

1 University of Texas at Dallas, 800 Campbell Rd., Richardson, TX 75080; 2 Rheem Manufacturing Company, 1875 Waters Ridge Dr. #300, Lewisville, TX 75057

2:20pm - 2:40pm ID: 2246

Chemical Stability of HFO and HCO Refrigerants

Morgan Herried Leehey, Stephen Kujak, Christopher Collins

Trane Technologies, La Crosse, WI, USA

R-24: Energy Storage II

Session Chair: Jason Woods

1:00pm - 1:20pm ID: 2294

A Simultaneous Approach for Heat and Cold Production Enabled by Heat Pump and Latent Thermal Energy Storage

Xiaoxue Kou, Ruzhu Wang

Shanghai Jiao Tong University, China, People's Republic of

1:20pm - 1:40pm ID: 2318

Studying The Solidification Process Of Salt Hydrates Via X-ray Computed Tomography

Dario Guarda^{1,2}, Jorge Martinez-Garcia², Benjamin Fenk², Damian Gwerder², Anastasia Stamatiou², Jörg Worlitschek², Simone Mancin¹, Philipp Schuetz²

1 University of Padova, Italy; 2 Hochschule Luzern, Italy

1:40pm - 2:00pm ID: 2444

A Dynamic Model of Refrigerator with Energy Storage for Demand Flexibility

Yanfei Li, Zhiming Gao, Philip Boudreaux, Kashif Nawaz

ORNL, United States of America

2:00pm - 2:20pm ID: 2514

Heat Pumps with Integrated Thermochemical Energy Storage for Electricity Load Levelling

Allannah Duffy, Alper Saygin, Srinivas Garimella

Georgia Institute of Technology, United States of America

2:20pm - 2:40pm ID: 2264

Grid Independent High Efficiency Heating System for Buildings

Sandeep Alavandi, Hamid Abbasi, David Cygan, John Wagner, Joseph Pondo, Vitaliy Gnatenko

GTI Energy, United States of America

R-25: Vapor Compression System Modeling II

Session Chair: Jason LeRoy

1:00pm - 1:20pm ID: 2322

Leveraging System Simulation to Support the Design of a Reversible Heat Pump

Adrien Réveillère¹, Zhequan Jin²

1 Siemens Digital Industries Software: Lyon, 69007 France; 2 H&A R&D Center, LG electronics: Seoul, 08592, Republic of Korea

1:20pm - 1:40pm ID: 2373

Toward Virtual Product Development of the Heat Recovery VRF Heat Pump System Using an Object-Oriented, Open Platform Language

Noma Park, Jin-Min Cho, Han-Won Park, Hoon-Bong Lee, Min-Jae Kwon, Man-Soo Park, Saikee Oh

LG Electronics, Korea, Republic of (South Korea)

1:40pm - 2:00pm ID: 2405

Heat Transfer Modeling in Server Refrigeration: A Transient Box Model Approach

Jordi Vera^{1,2}, Carles Oliet¹, Deniz Kizildag¹, Joaquim Rigola¹, Assensi Oliva^{1,2}, Oriol Sanmartí¹

1 Heat and Mass Transfer Technological Center (CTTC) - Universitat Politècnica de Catalunya BARCELONA TECH (UPC), ESEIAAT, Colom 11, 08222 Terrassa, Spain; 2 Termo Fluids S.L., Carrer Magi Colet 8, Sabadell (Barcelona), Spain

2:00pm - 2:20pm ID: 2480

A Physics-Constrained Data-Driven Modeling Approach for Vapor Compression Systems

Jiacheng Ma¹, Hongtao Qiao², Christopher Laughman²

1 Purdue University; 2 Mitsubishi Electric Research Laboratories, United States of America

2:20pm - 2:40pm ID: 2473

Compact Modeling of Compressed Air Distribution Network for Usage Forecasting and Energy Optimization

Kazuaki Yazawa, Greg Laorange, Mark Voorhis, Ali Shakouri

Purdue University, United States of America

2:40pm - 3:00pm ID: 2603

Reduced-dimension Bayesian Optimization for Calibrating Dynamic Models of Vapor Compression Cycles

Jiacheng Ma¹, Donghun Kim², James E. Braun¹

1 Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University West Lafayette, IN, USA; 2 Building Technology & Urban Systems Division, Lawrence Berkeley National Laboratory Berkeley, CA, U.S.

General:: CHPB Session

Session Chair: Davide Ziviani / Jim Braun

Membrane Technologies

Andrew Fix / Jinwoo Oh / David Warsinger

Electrochemical Heat Pumps

Nelson James / Davide Ziviani

Aeroacoustic Removal of Bioaerosols and Pollutants from Air

Ardekani / Wagner / Warsinger

Next Generation Equipment Rating: Load-Based Testing

Parveen Dhillon / Travis Horton / Jim Braun

Wall-Embedded Micro Heat Pump & HBIL

Feng Wu / Panagiota Karava

DC Nanogrid House & Whole-Building Control

Elias Pergantis / Kevin Kircher

C-16: Compressor Valves I

Session Chair: Craig Bradshaw

1:00pm - 1:20pm ID: 1334

Prediction of Reed Valve Velocity Impact

Igor L. L. P. Silva¹, Artur D. Favera¹, Claudio J. Santos², Cesar J. Deschamps¹

1 Federal University of Santa Catarina, Brazil; 2 NIDEC-GA, R&D

1:20pm - 1:40pm ID: 1504

Dynamic Reed Valve in Rolling Piston Compressor: A 3-Dimensional Transient CFD Simulation

Nirav Chaudhari¹, Chinmoy k Mohapatra², Hui Ding³, Haiyang Gao³

1 Simerics India Ltd., India; 2 Simerics Inc., MI, USA; 3 Simerics Inc., WA, USA

1:40pm - 2:00pm ID: 1510

Ultra-Thin Reed Valves For Higher Energy Efficiency And Noise Reduction In Compressors

Muhammad Waqas Tofique, Dipankar Sarkar, Alexander Löf, Chris Millward

voestalpine Precision Strip AB, Sweden

2:00pm - 2:20pm ID: 1517

Reed Valve Simulation Using 3D High-order Finite Volume and Finite Element Methods

Pablo Castrillo¹, Eugenio Schillaci², Joaquim Rigola²

1 Instituto de Estructuras y Transporte, Facultad de Ingeniería, Universidad de la República, Montevideo, Uruguay; 2 Heat and Mass Transfer Technological Center (CTTC) Universitat Politècnica de Catalunya - BARCELONA TECH (UPC), Spain

2:20pm - 2:40pm ID: 1553

Evaluation of Flapper Valves Using an Impact Testing Machine that Simulates Operating Condition

Tsutomu Nozaki¹, Ryota Iijima¹, Shuhei Nagata¹, Kazuhiro Yamamura², Hiroyoshi Fujihara²

1 Hitachi, Japan; 2 Proterial, Japan

C-17: Compressor Testing and Evaluation II

Session Chair: Jan Muehlbauer

1:00pm - 1:20pm ID: 1247

Material Compatibility of Seal Materials with Low GWP Refrigerants and Lubricant

Cameron Robaczewski, Morgan Herried Leehey, Zachary DeDeker

Trane Technologies, La Crosse, WI, USA

1:20pm - 1:40pm ID: 1248

Material Compatibility of Polymers with Low GWP Refrigerants and Lubricant

Cameron Robaczewski, Morgan Herried Leehey, Zachary DeDeker

Trane Technologies, La Crosse, WI, USA

1:40pm - 2:00pm ID: 1249

Material Compatibility of Motor Materials with Low GWP Refrigerants and Lubricant

Cameron Robaczewski, Morgan Herried Leehey, Zachary DeDeker

Trane Technologies, La Crosse, WI, USA

2:00pm - 2:20pm ID: 1500

Influence of Suction Conditions and Refrigerant Fluid on Scroll Compressor Mass Flow Rate and Extrapolation Strategies

Javier Marchante-Avellaneda¹, Rubén Ossorio¹, Emilio Navarro-Peris¹, Som S. Shrestha²

1 Univeristat Politècnica de València, Instituto Universitario de Investigación en Ingeniería Energética (IUIIE), Spain; 2 Buildings and Transportation Science Division, Oak Ridge National Laboratory, USA

2:20pm - 2:40pm ID: 1512

Oil Temperature Characterisation in a Direct Suction Scroll Compressor

Nicolás Gómez Parada, Francisco Barceló Ruescas, José González Maciá

Universitat Politècnica de València, Spain

2:40pm - 3:00pm ID: 1573

Flow Visualization Of Injection Process Of R134a Scroll Compressor

Inchan Hwang¹, Sangwook Lee², Giulia Lombardo^{3,4}, Stefano Rossi³, Davide Menegazzo^{3,4}, Laura Fedele³, Sergio Bobbo³, Min Soo Kim¹

1 Seoul National University, Korea, Republic of (South Korea); 2 School of Energy Systems Engineering, Chung-Ang University, Korea, Republic of (South Korea); 3 Construction Technologies Institute, National Research Council (CNR), Padova (Italy); 4 Department of Industrial Engineering, University of Padua (UNIPD), Padova (Italy)

R-26: Lubrication in HVAC&R Systems

Session Chair: Joe Karnaz

3:30pm - 3:50pm ID: 2208

Estimation of Oil Circulation Ratio in a Vapor Compression System using a Discharge Side Oil Separator

Syed Angkan Haider¹, Christopher Seeton², Nenad Miljkovic¹, Stefan Elbel^{3,4}

1 Air Conditioning and Refrigeration Center, Department of Mechanical Science and Engineering, University of Illinois Urbana-Champaign, 1206 West Green Street, Urbana, IL 61801, USA; 2 Koura Global, 950 Winter Street, South Entrance 1st Floor, Waltham, MA 02451, USA; 3 Technische Universität Berlin, Institut für Energietechnik, FG Wärmeübertragung und Wandlung, Marchstr. 18, 10587 Berlin, Germany; 4 Creative Thermal Solutions, Inc., 2209 North Willow Road, Urbana, IL 61802, USA

3:50pm - 4:10pm ID: 2382

The Compatibility studies of the Building Blocks of Refrigerant Blends with Lubricants and Components of the Automotive AC System Materials Applications

Rusul Alrubaay, Chris Seeton, Ira Saxena

Orbia F&EM, United Kingdom

4:10pm - 4:30pm ID: 2209

Modeling of Flashing Flows at Evacuated Sampling Cylinder Entrance during Oil Circulation Ratio Measurements for a Vapor Compression System

Syed Angkan Haider¹, Nenad Miljkovic¹, Stefan Elbel^{2,3}

1 Air Conditioning and Refrigeration Center, Department of Mechanical Science and Engineering, University of Illinois Urbana-Champaign, 1206 West Green Street, Urbana, IL 61801, USA; 2 Technische Universität Berlin, Institut für Energietechnik, FG Wärmeübertragung und Wandlung, Marchstr. 18, 10587 Berlin, Germany; 3 Creative Thermal Solutions, Inc., 2209 North Willow Road, Urbana, IL 61802, USA

4:30pm - 4:50pm ID: 2523

Experimental Investigation on Foaming Factors and Foaming Characteristics of Oil/Refrigerant Mixtures

Yuto Kato¹, Mitsuhiro Fukuta¹, Masaaki Motozawa¹, Satoshi Goto², Tomohiro Takaki²

1 Shizuoka University, Japan; 2 ENEOS Corporation, Japan

4:50pm - 5:10pm ID: 2522

Study on Oil Behavior at Branch of Suction Line in Automotive Refrigeration Cycle

Taiki Onishi, Mitsuhiro Fukuta, Masaaki Motozawa

Shizuoka-University, Japan

R-27: Drying & Dehumidification I

Session Chair: Kyle Gluesenkamp

3:30pm - 3:50pm ID: 2286

An Empirical Data-Driven Model for Energy Consumption Prediction of a Heat-Pump-driven Liquid-Desiccant Air-Conditioning system

Jae-Hee Lee, Minseong Kim, Ha-Youn Cho, Jae-Weon Jeong

Hanyang University, Seoul, South Korea

3:50pm - 4:10pm ID: 2388

Feasibility of a Mist-atomization Liquid Desiccant Dehumidifier

Soo-Jin Lee, Seheon Kim, Su-Yeon Hong, Yingdao Nan, Jae-Weon Jeong

Hanyang University, Korea, Republic of (South Korea)

4:10pm - 4:30pm ID: 2429

Comparison of Electrically-driven Dehumidification Technologies for Separate Sensible and Latent Cooling Systems

Ananthkrishnan K, Anurag Goyal

Department of Mechanical Engineering, Indian Institute of Technology Delhi Hauz Khas, New Delhi-110016, India

4:30pm - 4:50pm ID: 2453

Performance Analysis of a Dual-Module Humidity Pump for Efficient Drying and Dehumidification

Jinwoo Oh, Andrew J Fix, Davide Ziviani, James E Braun, David M Warsinger

Purdue University, United States of America

R-28: HVAC System Enhancements

Session Chair: Kyle Gluesenkamp

3:30pm - 3:50pm ID: 2222

Applicability Evaluation of Active Anti-Condensation Materials Using Thermoelectric Technology in Building Systems

Minseong Kim¹, Yong-Kwon Kang¹, Beom-Jun Kim¹, Taeyeon Kim¹, Jae-Weon Jeong²

1 Graduate School, Department of Architectural Engineering, Hanyang University, Republic of Korea; 2 Department of Architectural Engineering, Hanyang University, Republic of Korea

4:10pm - 4:30pm ID: 2262

Investigation On The Effective Use Of Glide And A Suction-line Liquid-line Heat Exchanger To Improve Performance In Air Conditioning And Heat Pump

Bruno Yuji Kimura de Carvalho, Ankit Sethi, Wissam Rached

Honeywell, United States of America

4:30pm - 4:50pm ID: 2170

The Mother & Father Hybrid Compression Technology, A Possible Solution For Future Clean Energy Production

Mihail-Dan Staicovici

Retired, Romania

4:50pm - 5:10pm ID: 2179

Synergic Coupling Of Mother & Father Hybrid Compression Sub-Ambient Power (SAP) Cycles With Existing Ambient Power (AP) Cycles For Electrical Efficiency Increase

Mihail-Dan Staicovici

Retired, Romania

Carnot Commemorative Session

Session Chair: Eckhard A. Groll

03:30 - 03:50 pm

Research Activities at the Ray W. Herrick Labs, Purdue University

Dr. James E. Braun

03:50 - 04:10 am

Research Activities at the Refrigeration System & Control Laboratory / Fuel Cell System Laboratory, Seoul National University

Dr. Min Soo Kim

04:10 - 04:30 pm

Research Activities at the Air Conditioning and Refrigeration Center (ACRC), University of Illinois at Urbana-Champaign
Dr. Craig R. Bradshaw

04:30 - 04:50 pm

Research Activities at the Schaufler Chair of Refrigeration, Cryogenics and Compressor Technology, Technical University Dresden
Dr. Christiane S. Thomas

04:50 - 05:10 pm

Research Activities at POLO, Research Laboratories for Emerging Technologies in Cooling and Thermophysics, Federal University of Santa Catarina
Dr. Jader Barbosa Jr.

05:10 - 05:30 am

Research Activities at the Thermodynamics Laboratory, University of Liege, Belgium
Dr. Vincent Lemort

C-18: Scroll Compressors II

Session Chair: Thomas Moesch

3:30pm - 3:50pm ID: 1145

Modeling Scroll Compressor Performance with Different Refrigerants
Andrew L. Hjortland, Roy R. Crawford
Johnson Controls Internatinoal plc, United States of America

3:50pm - 4:10pm ID: 1169

New Understanding of Precession-Rolling-induced Oil Film Pressure in Thrust-Slide Bearings in Scroll Compressors
Keiko Anami¹, Masaru Tanaka², Kenichi Sata², Hideki Matsuura², Yukiko Maejima², Kosuke Nishimura², Kanetaka Miyazawa²
1 Osaka Electro-Communication University, Japan; 2 Daikin Industries, LTD., Japan

4:10pm - 4:30pm ID: 1526

An Integrated Workflow for Addressing Performance, Dynamics, Tribological and NVH Issues in Scroll Compressors
Rodrigo Aihara, Sibi Kandasamy, Rifat Keribar, Ali Afshari, Zhiqiang Wang, Chao Ma, Dejun Song
Gamma Technologies LLC, United States of America

4:30pm - 4:50pm ID: 1499

Floating Scroll Pump For Oil-Free Multi-Phase Flow Application
Dave Cai, Oliver Ni
Scroll Laboratories, Inc., United States of America

R-29: Frost and Defrost Characterization and Modeling II

Session Chair: Bo Shen

9:40am - 10:00am ID: 2340

Modeling and Experimental Analysis of Interlaced Hot Glycol Defrost System

Harun Denizli, Burhan Yoruk, Mustafa Zabun

Friterm Thermal Devices Inc., Turkiye

10:00am - 10:20am ID: 2361

Modeling the Effect of Non-uniform Frost Accumulation on the Performance of Heat Pump with Refrigerant side Flow Maldistribution

Tauseef Ismail, Hamid Ikram, Aaron Alexander, Christian Bach

Oklahoma state university, United States of America

10:20am - 10:40am ID: 2432

A Novel Frost Growth Model Incorporated with Ice Propagation Using CFD Method

Jiong Chen, Young Joon Park, Sophie Wang

University of Illinois at Urbana-Champaign, United States of America

10:40am - 11:00am ID: 2433

Defrost Model with Frost Distribution on Surface Considered

Jiong Chen, Ke Tang, Sophie Wang

University of Illinois at Urbana-Champaign, United States of America

11:00am - 11:20am ID: 2486

System Modeling of Frost/Defrost Cycles in Heat Pumps

Bo Shen, Yifeng Hu, Brian Fricke

Oak Ridge National Lab, United States of America

11:20am - 11:40am ID: 2552

Enhancing Defrost Efficiency in Refrigeration Systems through Adaptive Defrosting Indicators

Jaruwat Arunwon, Nutsanun Jeenpetch

Siam Compressor Industry, Thailand

R-30: Extreme Climate Heat Pumps

Session Chair: Jinwoo Oh

9:40am - 10:00am ID: 2266

Experimental Investigation on Heating Performance of A Cold Climate Thermoelectric-Assisted Heat Pump

Yifeng Hu¹, Bo Shen¹, Kyle R. Gluesenkamp¹, Samuel F. Yana Motta¹, Sreenidhi Krishnamoorthy², Don Shirey²

1 Oak Ridge National Laboratory, United States of America; 2 Electric Power Research Institute, United States of America

10:00am - 10:20am ID: 2344

Design and Analysis of a Residential Cold Climate Heat Pump Using a Vapor Injection Variable Speed Compressor and Economizer

Yisarai Valbuena Sanchez¹, Davide Ziviani²

1 Trane Technologies, United States of America; 2 Purdue West Lafayette

10:20am - 10:40am ID: 2353

Exergy, Environmental, and Economic Analyses of Solar-Powered Dedicated Mechanical Subcooling Refrigeration in Hot Climates

Anes Guedour, Ammar Bahman, Osama Ibrahim

Mechanical Engineering Department, College of Engineering and Petroleum, Kuwait University

R-31: Heat Exchanger Design II

Session Chair: Harshad Inamdar

9:40am - 10:00am ID: 2172

Development and Evaluation of a Loop Thermosiphon Heat Exchanger as Passive Replacement to Secondary Loop for Low GWP Heat Pumps

Matthew Nicholas Robinson¹, Scott Goedeke¹, Taylor Maxwell², Devin Pellicone², Morton Blatt¹, Sara Beaini¹

1 Electric Power Research Institute, United States of America; 2 Advanced Cooling Technologies

10:00am - 10:20am ID: 2356

A Study of Correlation Between Fin-Tube Braze Joint Integrity and the Thermal Performance of Aluminum Microchannel Heat Exchangers

Yupeng Wang¹, Hui Zhao^{1,2}

1 University of Illinois Urbana-Champaign; 2 Creative Thermal Solutions, Inc.

10:20am - 10:40am ID: 2506

Thermal-hydraulic Performance Of Emerging Low GWP Refrigerant Mixture Under Flow Boiling In Brazed Plate Heat Exchangers

Cheng-Min Yang, M Muneeshwaran, Troy Seay, Vishaldeep Sharma, Praveen Cheekatamarla, Kashif Nawaz

Oak Ridge National Laboratory, United States of America

10:40am - 11:00am ID: 2164

Impact of Temperature Glide on Heat Exchanger Sizing for Low Global Warming Potential Refrigerant Blends

Bobby Dean, Charles Allgood, Andrew Pansulla

The Chemours Company, United States of America

11:00am - 11:20am ID: 2595

Coupled System and Heat Exchanger Optimizations for low-GWP Refrigerant Blends

Weigang Hou, John Huby, Haotian Liu, Jinwoo Oh, Eckhard A. Groll, Riley Barta, Davide Ziviani, James E. Braun

Ray W. Herrick Laboratories, Purdue University 177 S Russell Street, West Lafayette, IN, 47907-2099, USA

11:20am - 11:40am ID: 2325

Experimental Analysis and Simulation of Coils in an Air-to-Water Heat Pump Operating at Full and Part Load Conditions

Suraj Krishnamurti², Ignacio Ortega¹, Jaime Sieres¹, Vikrant Aute²

1 University of Vigo, Spain; 2 University of Maryland, United States of America

R-32: Residential & Commercial HP and AC II

Session Chair: Haotian Liu

9:40am - 10:00am ID: 2342

Performance Investigation of A Residential Air Source Heat Pump With Partial Variable Speed Electronics Driving a PSC Rotary Compressor As Single Stage, Two Stage And Variable Speed Compressor

Bin Yang, Ludovic Chretien

Regal Rexnord Corporation, United States of America

10:00am - 10:20am ID: 2386

Monitoring Of Two Ground-Source Heat Pumps Working with R454B and R600a in a Pilot Facility

Davide Menegazzo^{1,2}, Giulia Lombardo^{1,2}, Sergio Bobbo¹, Laura Fedele¹, Michele De Carli², Sara Bordignon², Fabio Poletto³, Dimitris Mendrinou⁴, Alessandro Bortolin⁵, Adriana Bernardi⁵

1 National Research Council, Construction Technologies Institute (ITC-CNR), Padova, Italy; 2 University of Padova, Department of Industrial Engineering, Padova, Italy; 3 Hi-Ref S.p.a. Padova, Italy; 4 Geothermal Energy Department, Centre for Renewable Energy Sources and Saving, Pikermi, Greece; 5 National Research Council, Atmosphere and Climate Sciences Institute (ISAC-CNR), Padova, Italy

10:20am - 10:40am ID: 2431

Effects of Refrigerant Drop-In (R32/R410) on the Performance of a Heat Pump System

Mohammad Arafat Zaman, Sophie Wang

University of Illinois at Urbana Champaign, United States of America

10:40am - 11:00am ID: 2428

Experimental Study of Compressor Modulation Method Effects on Heat Pump Performance

Mohammad Arafat Zaman, Sophie Wang

University of Illinois at Urbana Champaign, United States of America

11:00am - 11:20am ID: 2435

Parametric Study of a Variable Refrigerant Flow Air Conditioner with Two Evaporators

Thiago Dutra^{1,2}, Jonathan Maceda Silveira¹, Rogerio Gomes de Oliveira¹, Ernane Silva²

1 LABCITEA/UFSC, Brazil; 2 TEG/UFSC, Brazil

R-33: Heat Driven Technologies

Session Chair: Parveen Dhillon

9:40am - 10:00am ID: 2485

Sizing and Control Design of Solar Thermal Absorption Refrigeration for Horticultural Cold Storage in Hot-Humid Climates

Prabir Barooah¹, Jie Cai², Tapan Gogoi³

1 Indian Institute of Technology Guwahati, India; 2 The University of Oklahoma, USA; 3 Tezpur University, India

10:00am - 10:20am ID: 2501

Comparison of Air- and Water- Coupling for Adsorption Chillers for Off-Grid Food Storage

Kristian Lockyear¹, Roland Crystal¹, Anurag Agarwal², Srinivas Garimella¹

1 Georgia Institute of Technology, United States of America; 2 New Leaf Dynamic Technologies (P) Ltd, New Delhi, India

10:20am - 10:40am ID: 2535

Adaption of Sorption-Based Systems to Environmental Thermal Energy Harvesting

S. Kazadi¹, R. T. Muehleisen², C. O. Iloeje², J. Overcash¹, N. Stukel¹, R. C. Ekyalongo¹

1 Kazadi Enterprises Ltd., United States of America; 2 Argonne National Laboratory

10:40am - 11:00am ID: 2564

Assessment And Comparison Of The Ternary NH₃-H₂O-LiBr Mixture, Regarding the Binary NH₃-H₂O Mixture, when Used as the Working Fluid of a Small-scale Absorption Cooling System

José Camilo Jiménez¹, Vianey Ximena Martínez², Victor Hugo Gómez¹, Wilfrido Rivera¹

1 Instituto de Energías Renovables, Mexico; 2 Licenciatura de Ingeniería en Energías Renovables, Instituto de Energías Renovables, México

11:00am - 11:20am ID: 2140

Advances Concerning Hybrid Compression Refrigeration Research

Mihail-Dan Staicovici

Retired, Romania

R-34: Drying & Dehumidification II

Session Chair: Andrew Fix

9:40am - 10:00am ID: 2119

Simulation Study on Performance of Closed Air Source Heat Pump Drying System

Qingqing Wu

Shanghai Highly Electrical Application Co., Ltd, Shanghai, China, China, People's Republic of

10:00am - 10:20am ID: 2177

Techno-Economic Analysis of High-Temperature Heat Pumps for Industrial Drying Process in the US

Pengtao Wang, Steve Kowalski, Kashif Nawaz, Jian Sun, Zhiming Gao, Cheng-Min Yang

Oak Ridge National Laboratory, United States of America

10:20am - 10:40am ID: 2613

Estimating Carryover Parameters of a Non-wicking Random Weave Fabric with Applications to Liquid Desiccant Systems

Dylan Fallows, Michael Muller, Todd Rossi

Rutgers University, Mechanical and Aerospace Engineering Department, New Brunswick, NJ, USA, United States of America

10:40am - 11:00am ID: 2538

Dynamic Simulation Modeling and Control of a Desiccant Assisted Direct-expansion Air Handling Unit

Chao Pan¹, Jian Sun², Kashif Nawaz², Kai Li², Yaoyu Li¹

1 University of Texas at Dallas, United States of America; 2 Oak Ridge National Laboratory, United States of America

C-19: Compressor Valves II

Session Chair: Yangfan Liu

9:40am - 10:00am ID: 1202

How To Achieve the Reliability of the Valve System In the Compressors

David Liang, Bing QIN, Nan JIA, Weifeng DU, Yizhen CAO, Le Xu

Zhejiang Hummingbird Novel Materials Co., Ltd, the People's Republic of China

10:00am - 10:20am ID: 1330

Performance of Cylinder Head and Piston Head Suction Valve Configurations in Small Variable-Speed Reciprocating Compressors

Willian T. F. D. Silva¹, Sérgio K. Lohn², Igor L. L. P. Silva¹, Cesar J. Deschamps¹

1 Federal University of Santa Catarina, Brazil; 2 NIDEC-GA, R&D

10:20am - 10:40am ID: 1574

Advancements In Compressor Valve Steel For Enhanced Performance In Refrigeration And Freezer Applications

Anders Hoel, Stefan Jonsson, Guofan Zhang

Alleima, Strip Division, Sweden

C-20: Lubrication III

Session Chair: Riley Barta

9:40am - 10:00am ID: 1143

Air Conditioning Compressor Oil Enhancement using Carbon-based Nanolubricants

Hessah Althalab¹, Naser Ali², Shikha Ebrahim¹, Ammar Bahman¹

1 Mechanical Engineering Department, College of Engineering and Petroleum, Kuwait University; 2 Nanotechnology and Advanced Materials Program, Energy and Building Research Center, Kuwait Institute for Scientific Research

10:00am - 10:20am ID: 1363

Development of POE with Improved Low-temperature Fluidity

Satoshi Goto, Tomohiro Takaki, Tsukasa Sakuraba

ENEOS Corporation, Japan

10:20am - 10:40am ID: 1384

Refrigeration lubricant Structure Effect on the Foaming Phenomenon in the POE-Refrigerant Mixture

Yu-Kai Chen, Yu-Hsiang Wang, Jung-Tsung Hung

Patech Fine Chemicals Co.,Ltd, Taiwan

10:40am - 11:00am ID: 1474

Evaluation of Refrigeration Lubricants for Low GWP refrigerants

Kohei Yoshida, Tomoya Matsumoto, Shota Kita, Hiroki Maezono

Idemitsu Kosan Co., Ltd., Japan

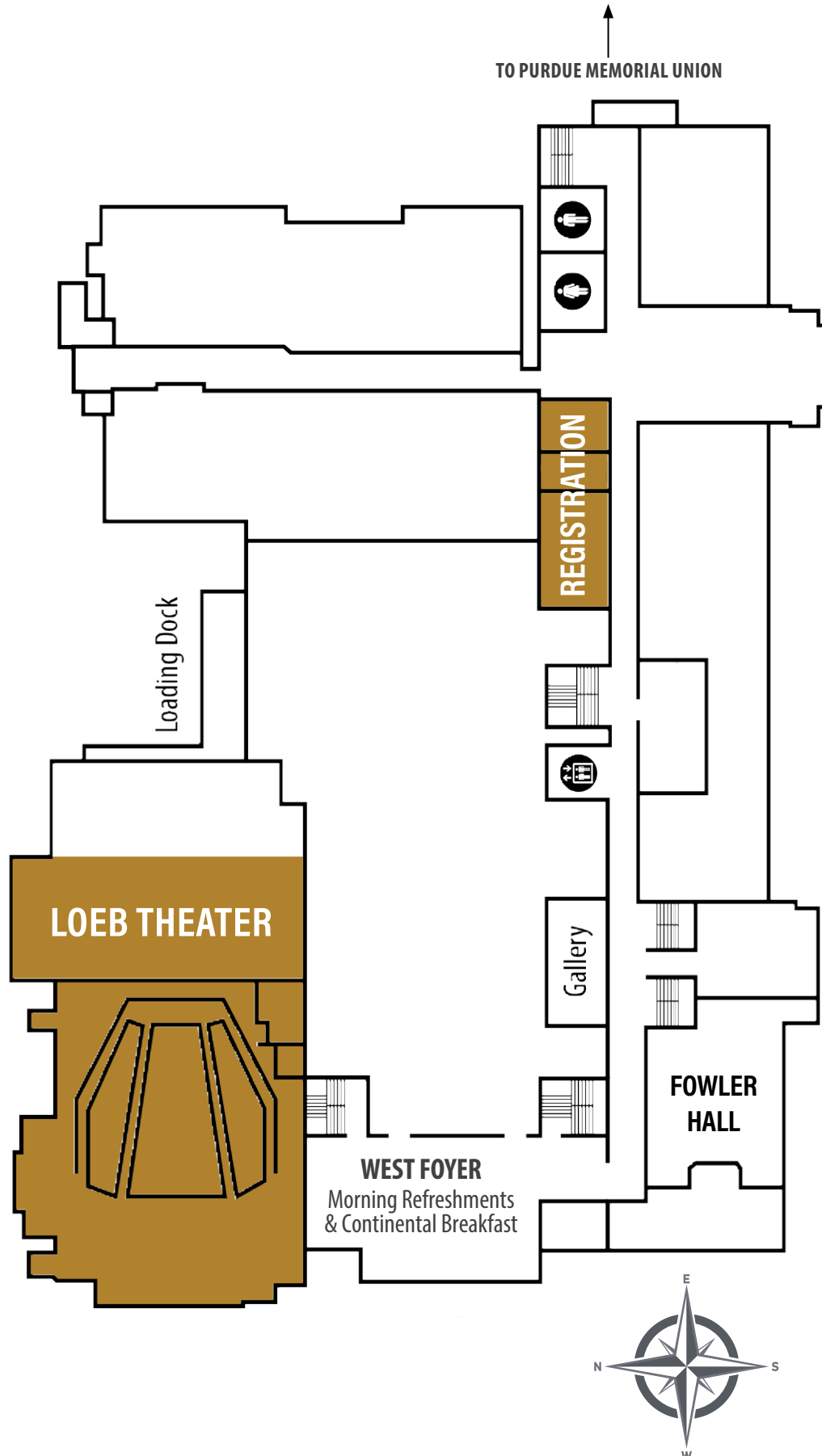
11:00am - 11:20am ID: 1516

Investigation of Refrigerant Dissolution into Thin Oil Film During Compression Process

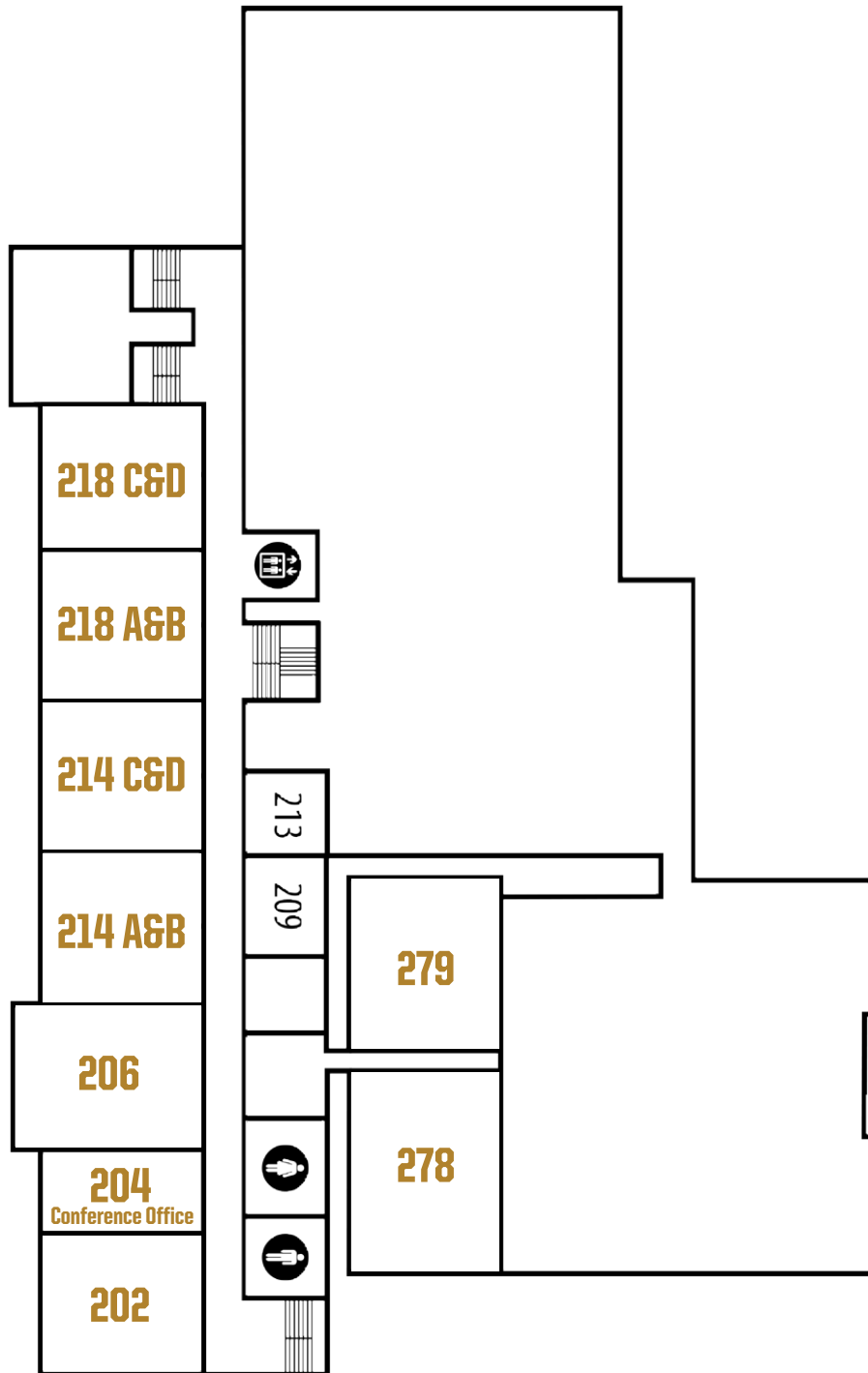
Wannarat Rakpakdee¹, Kei Watanabe², Yunong Lei², Mitsuhiro Fukuta¹, Masaaki Motozawa¹, Shohei Atobe³

1 Department of Mechanical Engineering, Shizuoka University, Hamamatsu, 432-8561, Japan; 2 Graduate School of Integrated Science and Technology, Shizuoka University, Hamamatsu, 432-8561, Japan; 3 Carrier Japan Corporation, Tadehara, Fuji, Shizuoka, 416-8521, Japan.

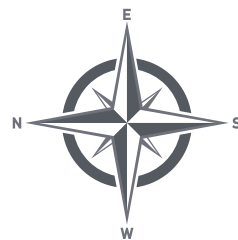
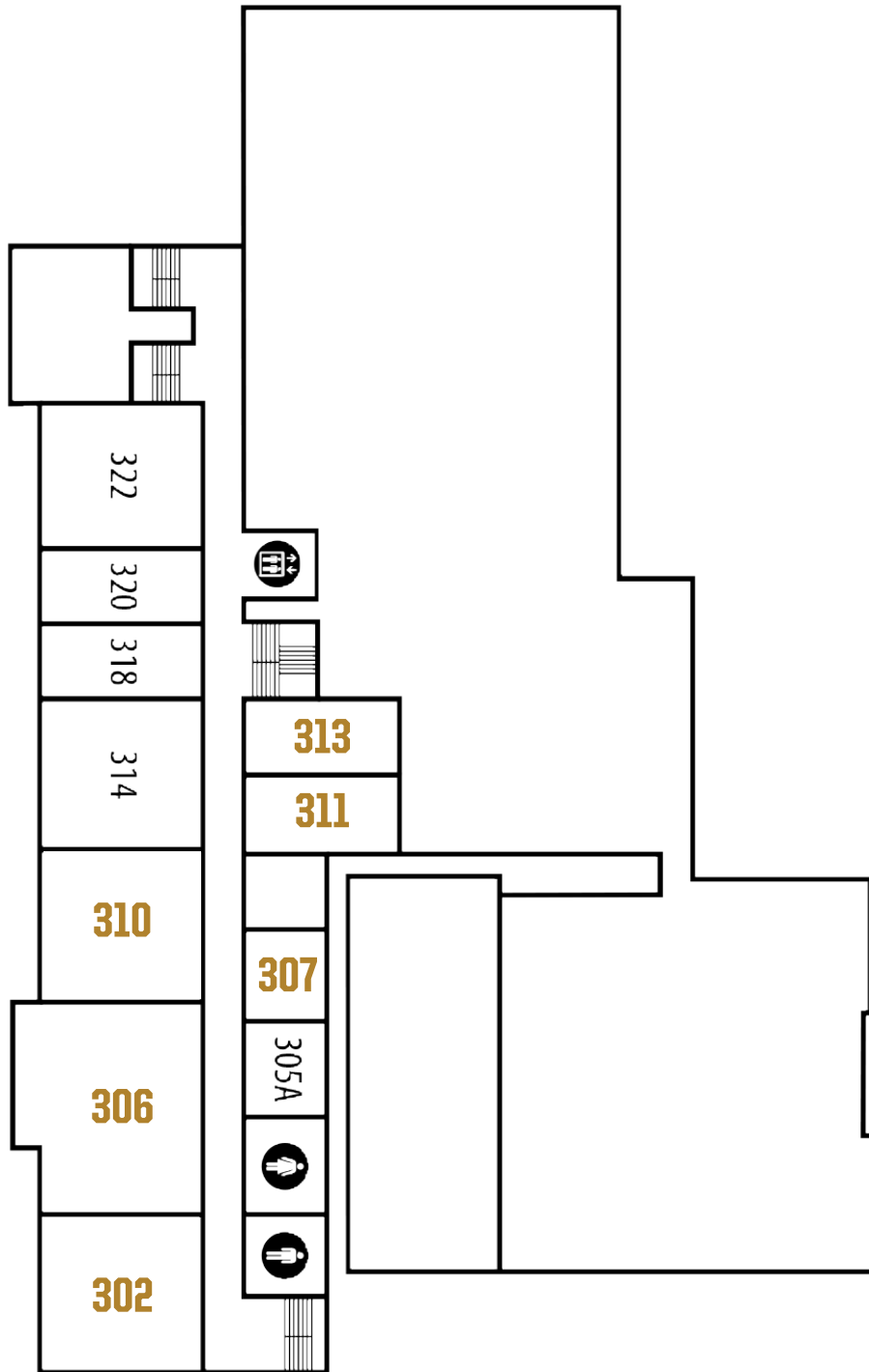
STEWART CENTER MAP: MAIN LEVEL



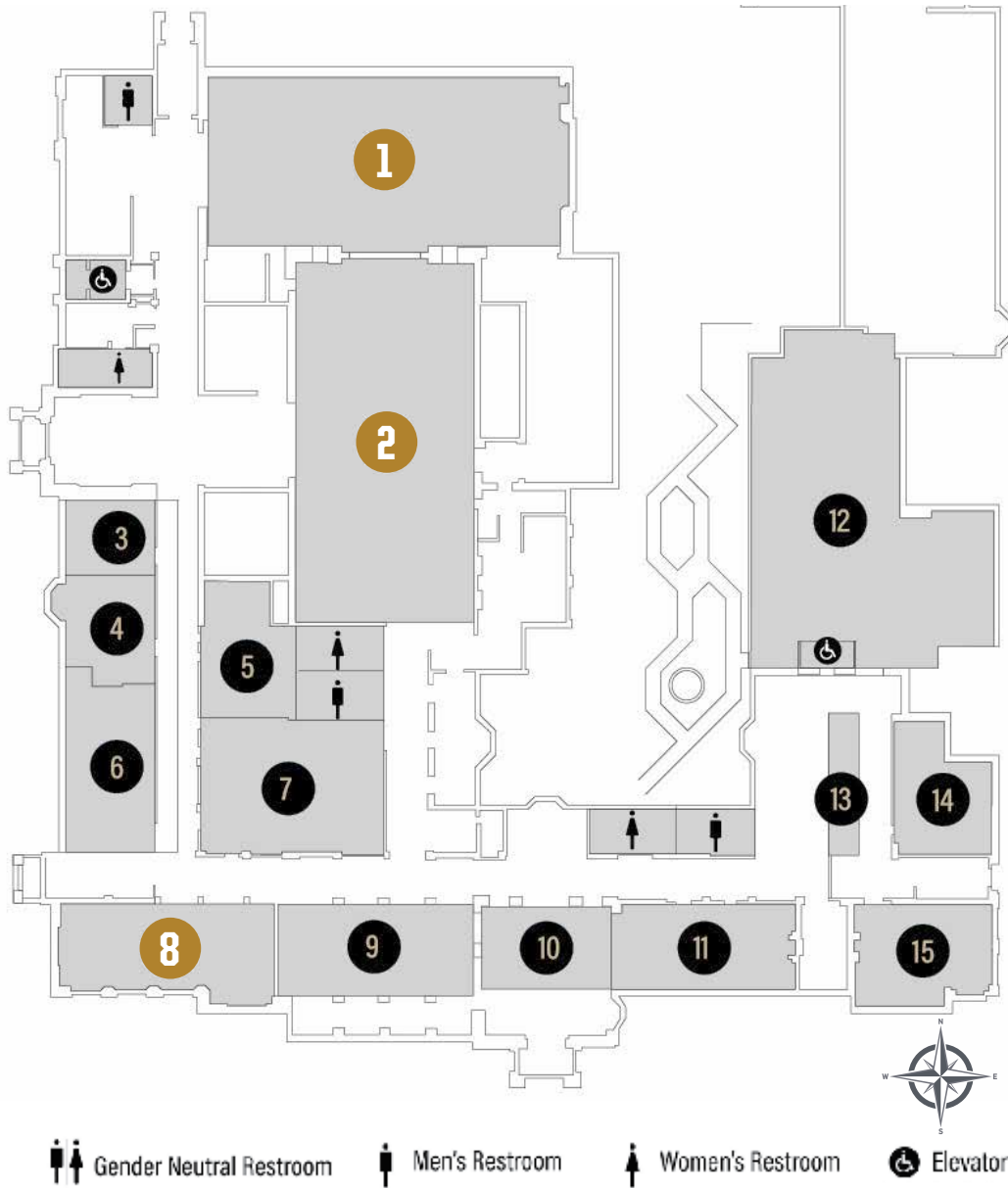
STEWART CENTER MAP: SECOND FLOOR



STEWART CENTER MAP: THIRD FLOOR



PURDUE MEMORIAL UNION MAP: FIRST FLOOR



EVENT VENUES

- 1** North Ballroom
- 2** South Ballroom
- 8** West Main Lounge
- 9** East Main Lounge
- 10** Great Hall (Info Desk)
- 11** 118 Lounge
- 12** Union Club Hotel Lobby

FOOD VENUES

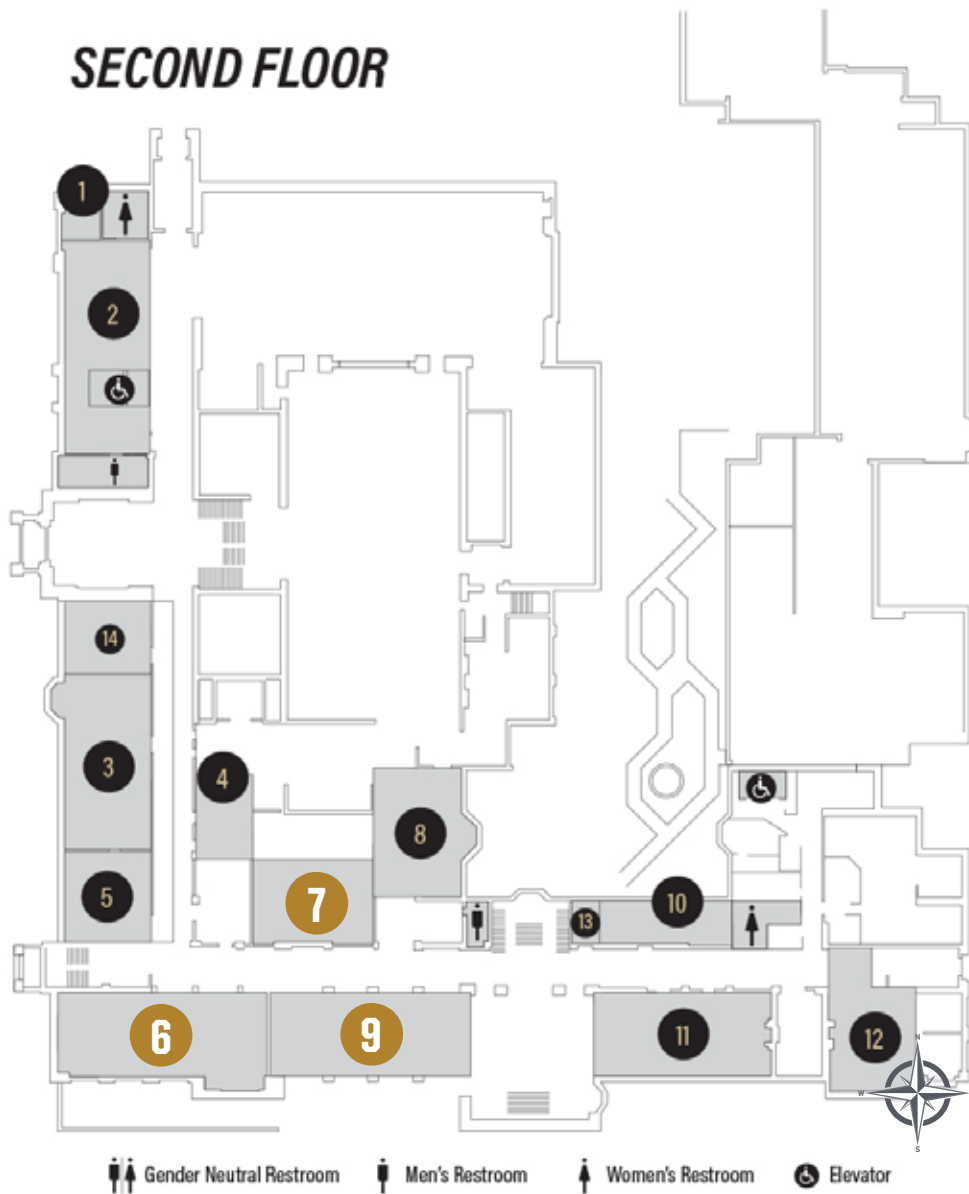
- 13** Leaps Coffee
- 14** Boiler Up Bar
- 15** 8Eleven Modern Bistro

RETAIL TENANTS

- 3** UPS Store
- 4** Fidelity Investments
- 5** Purdue Federal Credit Union
- 6** Evans, Piggot and Finney Eye Care
- 7** Amazon @ Purdue

PURDUE MEMORIAL UNION MAP: SECOND FLOOR

SECOND FLOOR



Gender Neutral Restroom Men's Restroom Women's Restroom Elevator

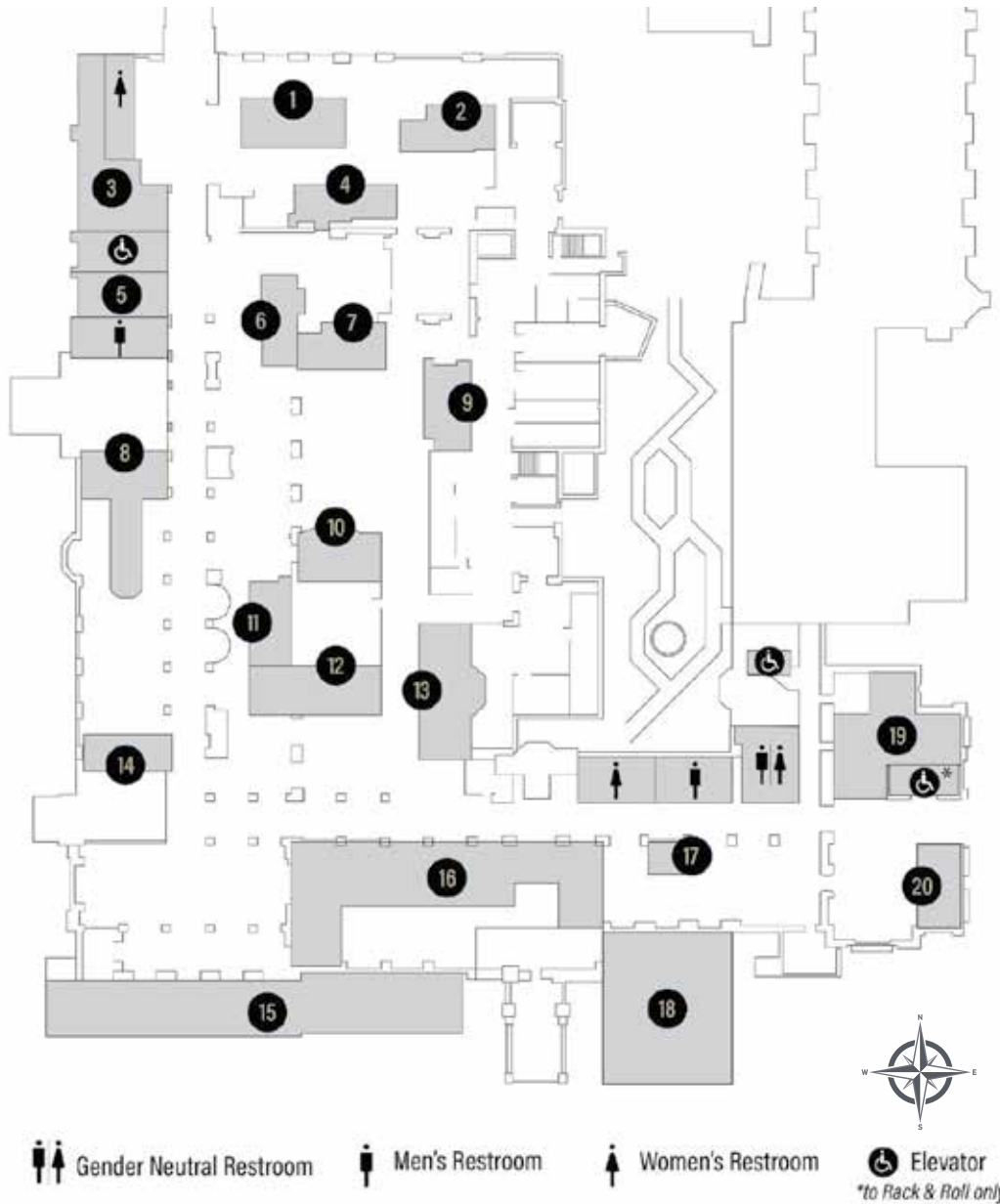
EVENT VENUES

- 1 288 Meeting Room
- 4 263 Meeting Room
- 5 256/258/260 Meeting Rooms
- 6 **West Faculty Lounge**
- 7 **Director's Room**
- 8 Sagamore Meeting Room
- 9 **East Faculty Lounge**
- 12 Anniversary Drawing Room
- 13 South Tower

OFFICE SUITES

- 2 Veteran Success Center
- 3 Purdue Student Union Board
- 10 Administration Office
- 11 UCH Sales & Event Services

PURDUE MEMORIAL UNION MAP: GROUND FLOOR



FOOD VENUES

- 1 BBQ District
- 2 Fresh Fare
- 4 Latin Inspired
- 6 Sol Toro
- 7 Pizza & Parm
- 8 Starbucks
- 9 Zen
- 10 Sushi Boss
- 11 Chef Bill Kim's
- 12 Aatish
- 16 Walk-Ons
- 19 Boilermaker Market

EVENT VENUES

- 3 G083 Meeting Room
- 5 G077 Meeting Room
- 13 Fireside Lounge
- 14 Hail Purdue Stage
- 15 West Terrace
- 17 Ever True Stage
- 18 East Terrace
- 20 1869 Meeting Room





Ray W. Herrick Laboratories

Ray W. Herrick Laboratories

177 South Russell Street
West Lafayette, IN 47907-2099

FOR 50 YEARS

Purdue University has played host to the International Compressor Engineering Conference (beginning in 1972), the International Refrigeration and Air Conditioning Conference (added in 1986) and the International High Performance Buildings Conference (added in 2010). These conferences provide a perfect venue to present research and development work, as well as network with top experts in the field.

The conferences technical sessions run simultaneously enabling attendees to attend sessions of interest from any conference. Conference registration includes online access to the conference schedule, presented papers and all social networking events. The conferences will be conducted in English.

ENGINEERING.PURDUE.EDU/HERRICKCONF

An equal access/equal opportunity university.

2024

HERRICK CONFERENCES

COMPRESSORS | REFRIGERATION | BUILDINGS