

ACTIVE RESEARCH

Active projects are summarized in this report. The summaries include: the title of the project, the contract duration of the project, the names of the contractor and principal investigator, the sponsoring Technical Committee or Task Group monitoring the research and a brief description of the project.

(P) – Projected end date

1196-RP

DEVELOP SOFTWARE TO CALCULATE THE APPLICATION SEASONAL EFFICIENCY OF COMMERCIAL SPACE HEATING BOILER SYSTEMS BASED ON ASHRAE STANDARD 155P

September 2000 – February 2011 (Completion tied to Standard 155)

Iowa State University

Principal Investigator, Ron Nelson

TC 6.1, Hydronic and Steam Equipment and Systems

Boilers are estimated to account for 42% of space heating energy use in the commercial and multifamily sectors in the U.S. Significant energy savings could be achieved in commercial and multifamily buildings by optimizing the selection of commercial boiler systems in new buildings and at the time of boiler replacement. Currently, however, commercial boilers and all other types of commercial heating equipment are rated only in terms of steady-state efficiency at full load, which does not provide a meaningful indication of relative operating costs.

The objective of this research project is to develop user-friendly windows-based software will greatly accelerate adoption of seasonal efficiency analysis for commercial boiler systems. A significant obstacle to the use of any new standard is the learning curve for users to become familiar with the new terminology and inputs and learn how to do the computations. With this software, the level of effort required of new users of the standard will be dramatically reduced, and can be focused on the more important tasks of evaluating outputs and developing an intuitive sense of the factors that affect the seasonal efficiency of commercial boiler systems.

1216- RP

INLET INSTALLATION EFFECTS ON BI / AIRFOIL CENTRIFUGAL FANS, AIR & SOUND

September 2008 – June 2011 (P)

AMCA

Principal Investigator, Mark Stevens/A. Guedel

TC 5.1, Fans

The objective of this project is to obtain a body of measured inlet system effects for both air and sound for one typical size (30”) of airfoil bladed centrifugal fans. The test fan is to be AF single width single inlet (SWSI) centrifugal fan. The aerodynamic and acoustic investigations should be made with carefully selected and controlled inlet appurtenances. Tests should be in accordance with ASHRAE 51 / AMCA 210 air performance testing standard and AMCA 300 reverberant room sound testing standard with the resulting relationships cataloged as to show the relationship between aerodynamic and acoustic parameters with respect to geometric parameters.

1235-RP

THE NATURE, SIGNIFICANCE AND CONTROL OF SOLAR DRIVEN VAPOR DIFFUSION IN WALL SYSTEMS

April 2005 – June 2011 (P)

Concordia University

Principal Investigator, Dominique Derome

TC 4.4, Building Materials & Building Envelope Performance

The objective of this study is to develop a better understanding of the nature and significance of solar-driven inward vapor diffusion, in order to develop appropriate design guidelines to predict and manage this phenomenon as a

function of climate. The knowledge generated from this research project will be directly transferred to the ASHRAE HOF.

1245-RP

DETERMINE THE EFFECTS OF DUCT FITTINGS ON AIR VELOCITY MEASUREMENTS

April 2005 – June 2011 (P)
Kansas State University
Principal Investigator, Terry Beck
TC 1.2, Instruments and Measurements

There are two projects within this single research proposal. Each has its own justification of need. As to the issue of the equal area method or the log-Tchebycheff method, there is uncertainty in the ventilation measuring community as to which method is suitable for performing duct traverses under field conditions. This uncertainty has caused disagreements between the building owner or engineer and the TAB engineer, as well as between different TAB engineers. Information in the ASHRAE Handbooks and Standards concerning these measurement methods has been less than forceful due to the lack of evidence for either of the methods. This research will quantify the differences between the two methods and lead towards more accurate field measurements. Proper methods for validating the flow performance in systems, is critical for the comfort, safety and health of our buildings. Testing in the past has not quantified the differences between the two methods nor has it given an indication of the type of errors balancers will encounter when they have to make a measurement at less than ideal conditions. This result will give engineers an idea on what is the achievable accuracy of the test and balancing of systems and translate into more definitive data for design engineers to properly apply in HVAC system design.

1262-RP

RELATE AIR QUALITY AND OTHER FACTORS TO COMFORT AND HEALTH RELATED SYMPTOMS REPORTED BY PASSENGERS AND CREW ON COMMERCIAL TRANSPORT AIRCRAFT (PART 2)

January 2007 – June 2011 (P)
Battelle Memorial
Principal Investigator: Ann Louise Sumner
TC 9.3, Transportation Air Conditioning

The principal aim of this research project is to relate perceptions of discomfort or health related symptoms of flight attendants and passengers to possible causal factors, including cabin and bleed air quality and other factors such as reduced air pressure, jet lag, inactivity, humidity, flight attendant duty schedule and fatigue, circadian rhythm, stress and noise. In particular, the following specific objectives are to be addressed in Part 2 of this project:

1. Measure and characterize contaminants in cabin air that are introduced via ECS in a variety of airplane types.
2. Measure and characterize contaminants in cabin air that are not introduced via ECS. Ventilation rates shall be assessed.
3. Quantify the effect of aircraft type, maintenance, APU, engine age and operations-related parameters on cabin and bleed air quality
4. Investigate relationship of the measured cabin air contaminants, ventilation rates and other factors with reported symptoms among passengers and flight crew.

1267-RP

DEVELOPMENT OF AN ASHRAE DESIGN MANUAL FOR DISTRICT HEATING AND COOLING SYSTEMS

April 2008 – January 2012 (P)
GWA Research, LLC
Principal Investigator, Gary Phetteplace
TC 6.2, District Energy
Emirates Central Cooling Systems Corporation, Dubai (Empower) \$110k co-funder

The objective of this project is to develop a comprehensive design guide for district heating and cooling (DHC) systems and a separate design guide with additional information dedicated to district cooling (DC) only. The emphasis would be on community-wide planning, thermal distribution and consumer interconnect. Guidance is generally less accessible in these areas and familiarity in the engineering community is much less prevalent. Users of the guides will be better able to assess the applicability of DHC and DC systems and prepare feasibility studies to support their DHC and DC evaluations.

1284-RP

DEVELOP A STANDARD FOR TESTING AND STATING THE EFFICIENCY OF INDUSTRIAL PULSE CLEANED DUST COLLECTORS

April 2006 – June 2011 (P)
Blue Heaven Technologies, LLC
Principal Investigator, Robert Burkhead
TC 5.4, Industrial Process Air Cleaning

Although ASHRAE Standard 52 and RP-671 deal with test methods for evaluation of general ventilation air cleaners, their particulate loading rates are so low that they are not practical to evaluate industrial air cleaning equipment. Further, these test methods do not take into account the automatic cleaning methods that are usually in industrial air cleaners to keep a steady pressure drop, yet the cleaning action can result in increased emissions. As a result, there is a great need for a performance test procedure that addresses the higher particulate loading, and the wide variety of particulate contaminant types to permit measurement and reporting of the mass emissions and fractional collection of efficiency of industrial air cleaning devices.

1306-RP

INCIDENT-RESPONSE MONITORING TECHNOLOGIES FOR AIRCRAFT CABIN AIR QUALITY

April 2006 – January 2011 (P)
TNO Environmental and Geosciences
Principal Investigator, JBGA Havermans
TC 9.3, Transportation Air Conditioning

Research is needed to strengthen the role of a new ASHRAE Standard (ASHRAE 161) that will address incidence response monitoring in aircraft. Standard developers need to be certain that there is equipment available to support a newly developed standard by means of measurement capabilities. The results of this research project will provide a knowledge base on equipment availability and limitation. This research project is anticipated to result in demonstration of methods and technologies for characterization of aircraft engine/APU systems contaminants in aircraft cabins during an incident occurrence. Use of these methodologies will generate data that can be correlated with passenger and flight attendant complaints about air quality. Such data will also enable the aircraft manufacturers, airline companies, and regulatory authorities to analyze the underlying causes of air supply contamination in the aircraft cabin environment and ultimately institute preventive design and operations measures.

1312-RP

TOOLS FOR EVALUATING FAULT DETECTION AND DIAGNOSTIC METHODS FOR AIR-HANDLING UNITS

September 2005 – March 2011 (P)
Drexel University
Principal Investigator, Jin Wen
TC 7.5, Smart Building Systems
Iowa Energy Center in-kind donor

The primary objectives of this research are to 1) adapt an existing simulation model of an AHU into a widely used HVAC&R simulation environment so that dynamic performance data under fault-free and faulty operation for a number of different types of faults and for a range of severity levels can be generated in order to evaluate AFDD

methods for AHU systems; 2) validate the simulation model under both fault-free and faulty operation (under different types of fault and severity levels) using either existing data or data from expressly designed tests from a laboratory facility; 3) document the simulation model, its development process, and validation process; and 4) deliver both the faulty data sets and the simulation models in a form convenient enough for other researchers and professionals to use for their own AFDD studies.

1316-RP

EXPERIMENTAL EVALUATION OF THE HEAT TRANSFER IMPACTS OF TUBE PITCH IN A HIGHLY ENHANCED SURFACE TUBE BUNDLE

September 1, 2005- April 2011 (P)
Kansas State University
Principal Investigator, Steve Eckels
TC 8.5, Liquid-to-Refrigerant Heat Exchangers
Air Balance Council \$5k co-funder

This research project presents a unique opportunity to study shell-side evaporation effects with particular attention on the effect of tube pitch. Shell-side boiling is a topic of active research in both ASHRAE and the refrigeration industry in general but some gaps exist in the literature. For example, ASHRAE has funded RP-1089 and RP-751 which looked directly at shell-side boiling. In both studies, the effect of tube pitch was not studied. Tatara and Payvar also found some anomalies in the data that as of yet have not been explained or duplicated. It is thought that these anomalies are strongly related to local dryout in the tube bundle. The refrigerant wetting in the bundle is a function of many variables including surface tension, local void fraction and mass flux in the bundle. This project will measure the heat transfer impacts in a supply side evaporator as a function of refrigerant, tube pitch, refrigerant inlet quality and mass flux, and bundle heat transfer.

1320-RP

THE IMPACT OF HOUSEHOLD REFRIGERATOR STORAGE CONDITIONS ON SHELF-LIFE OF FRUITS AND VEGETABLES

September 2005 - February 2011 (P)
Iowa State University
Principal Investigator, Michael Pate
TC 8.9, Residential Refrigerators and Food Freezers

The objective of this research is to quantify the effects of low storage humidity, high fluctuations in storage temperature, and moisture condensation on the shelf life of one type of vegetable (e.g. lettuce) and one type of fruit (e.g. strawberries). Lettuce and strawberries are particularly sensitive to these test parameters. The resulting data and analysis, when published in the ASHRAE Handbook, will give the design engineer a useful benchmark of the “worst case scenario” around which he/she can engineer refrigeration and cabinet insulation systems. Additionally, the conclusions drawn from lettuce and strawberries can be easily applied to all leafy vegetables and all berries, respectively. Since most other types of fruits and vegetables have thick protective skins and other food items in a refrigerator are typically in packages, expanding this research to include other foods would increase the research cost and yield information without commensurate incremental value over the proposed research on lettuce and strawberries.

1322-RP

PRODUCTIVITY AND PERCEPTION BASED EVALUATION OF INDOOR NOISE CRITERIA

January 2005 – January 2011 (P)
University of Nebraska
Principal Investigator, Lily Wang
TC 5.1, Fans
IIAR \$10k co-funder

This project will assess various indoor noise criteria systems which are currently used to evaluate the acceptability of background noise level in buildings, often caused by mechanical systems. Subjective experiments will be run to test productivity and human perception of background noise for individuals exposed to: 1) discrete tones and 2) time-varying fluctuations in background noise spectra. Phase I of the study will first determine the effect of exposure time and test type. Phase II will then use the optimal exposure time and productivity test to complete the main study. The goal is to determine how the current noise criteria systems correlate to productivity and psychoacoustic perception under the variety of systems-induced indoor noise situations. Based on the results, suggestions or modifications to noise criteria systems may be proposed to allow the rating systems to account better for the subjective results.

1327-RP

FLOW REGIME AND PRESSURE DROP DETERMINATION FOR TWO-PHASE AMMONIA UPWARD FLOW IN VARIOUS RISER SIZES

April 2007- June 2012
Teknologisk Institut (DTI)
Principal Investigator, Thomas Lund
TC 10.3, Refrigerant Piping

This ASHRAE research project will have a significant worldwide energy impact and an annual monetary savings that is far in excess of the project cost. The advancement to the state of the art will be the publication in the ASHRAE handbooks a set of design curves that will define the optimal suction riser velocity for a range of pipe diameters and temperatures. This information will be the only data of its type available in the public domain at these pipe size ranges and with ammonia. It will be used by industrial refrigeration system design engineers and plant operating engineers worldwide.

The objective of this research project is to determine the minimum vapor velocity required to sustain vertical upward flow of liquid anhydrous ammonia when transported by vapor anhydrous ammonia in the same pipe. This velocity shall be determined for a range of pipe diameters, overfeed rates, and temperatures. The pressure drop per foot of pipe as a function of velocity, temperature, and overfeed rate will also be determined.

1332-RP

REVISIONS TO THE ASHRAE THERMAL COMFORT TOOL TO MAINTAIN CONSISTENCY WITH STANDARD 55-2004

April 2005 – January 2011 (P)
Charlie Huizenga
Principal Investigator, Charlie Huizenga
TC 2.1, Physiology and Human Environment

In 1997, ASHRAE published the ASHRAE Thermal Comfort Tool (Fountain and Huizenga, 1997) to provide a simplified, consistent method for evaluating thermal comfort under a range of thermal conditions. The software is consistent with ASHRAE Standard 55-1992 and indicates whether a set of environmental conditions are in compliance with that standard. ASHRAE Standard 55-2004, which incorporates several important changes from Standard 55-1992 (Olesen and Brager, 2004), prompted the initial need for this project. The purpose of this modest project is to make several important changes to the existing ASHRAE software so that it is consistent with the latest version of the standard.

1333-RP

HVAC DUCT EFFICIENCY MEASUREMENTS

June 2005- January 2011 (P)
Texas A&M University - Engineering Experiment Station
Principal Investigator, Charles Culp
TC 5.2, Duct Design

The objective of this project is to provide ASHRAE with additional pressure drop measurements of flex duct and duct fittings ranging in size from 6” to 16” for use in ASHRAE’s Duct Fitting Database. Testing will follow ASHRAE Std 120. Also, an as-built test protocol will be defined and tests run under this protocol. The experimental set up was funded by the AIR Distribution Institute and can be used directly for the ASHRAE project. This data will be used for the Fundamentals Handbook and to extend ASHRAE’s Duct Fitting Data Base (printed and electronic). Computational Fluid Dynamics, using Fluent, calculations and graphics are part of the ADI project and will be made available to ASHRAE.

1335-RP

EFFECTS OF TYPICAL INLET CONDITIONS ON AIR OUTLET PERFORMANCE

April 2009 – June 2011 (P)
University Nevada – Las Vegas
Principal Investigator, Brian J. Landsberger
TC 5.3, Room Air Distribution

The objective of this project is to develop guidelines that will relate manufacturers’ air outlet cataloged data that has been obtained using ASHRAE Standard 70 to field installed “application conditions.” The intent of this project is to obtain base performance data using ASHRAE standard 70 and to obtain and compare application test data of diffusers with “real life” inlet conditions. Correction factors are to be obtained for inlet conditions that represent actual installed conditions including elbows and close coupling and volume control dampers.

1339-RP

SELECTION OF DESICCANT EQUIPMENT AT ALTITUDE

April 2010 – August 2011
Mississippi State University
Principal Investigator, Nelson Fumo
TC 8.12, Desiccant Dehumidification Equipment and Components

The results of this project would have immediate usefulness to consulting engineers and anyone else involved in the selection of desiccant based equipment for non-standard altitudes. Without proven procedures to follow, the industry practice has been to add safety factors to sea level selections roughly based on air density changes. Of the 4422 locations listed in Chapter 28, over 1200 (27%) are at elevations above 1000 feet and nearly 700 (15%) above 2000 feet. Preliminary data shows that this could result in significant over sizing of equipment and excessive operating costs. It is estimated that 30% of the desiccant equipment sold for operation above 2000 feet is now oversized which represents more than \$5 million in US equipment sales and nearly \$15 million world wide.

The objective of this project is to develop and to validate a set of procedures (guidelines) to be used to restate the catalog (sea level) performance of a desiccant dehumidifier that will operate at altitude. The outcomes of the project should be used to predict the performance of desiccant equipment at altitude and to inform designers, building owners and managers, and equipment operators as to:

- a. The expected moisture removal capacity (MRC) performance of a standard desiccant unit as a function of altitude.
- b. Equipment design features and sizing issues (regeneration heat capacity, pressure drop, air temperature rise, fan selection).

1344-RP

CLEANROOM PRESSURIZATION STRATEGY UPDATE – QUANTIFICATION AND VALIDATION OF MINIMUM PRESSURE DIFFERENTIALS FOR BASIC CONFIGURATIONS AND APPLICATIONS

April 2009 – March 2011
Engsysco, Inc.
Principal Investigator, Wei Sun
TC 9.11, Clean Spaces

Enhancement of cleanroom pressurization technology requires multi-discipline efforts with applications of the latest techniques in airborne particle counting, air leakage, room flow/pressure simulation, network flow modeling, CFD, flow visualization, precision pressure and flow measurements and HVAC controls, these requirements make ASHRAE in a unique position with necessary expertise.

The potential results from this research project will affect a broad range of facilities and applications including pharmaceuticals, food processing, healthcare, museums and others. The industry currently has limited scientific research in this area, which is causing various codes and standards to reference incomplete or inaccurate data in order to have something as a value. The recommendations from the potential results will not only benefit cleanroom engineers in design, facilities, validation and manufacturing fields, but also provide a good reference to engineers in industrial ventilation, bio-safety laboratory, healthcare, smoke management and other related areas. ASHRAE will definitely benefit from the potential results for the future handbook inclusion, revision, design guides, and related code updates.

The objective is to develop, test, validate and establish a recommended minimum Pressure Differential Table (PD Table) which lists a “group” of pressure differential values as criteria for various conditions. This table is intended to replace the existing “single” pressure differential criterion.

The establishment of the PD Table should be based on the conclusions of the experiment identified under the section of “SCOPE” rather than educated guesses. This research must be conducted in a manner such that the reduction of pressure differential in the clean room will not result in an increase of particles.

1345-RP

WATERSIDE FOULING PERFORMANCE OF BRAZED-PLATE TYPE CONDENSERS IN COOLING TOWER APPLICATIONS

April 2008 - October 2011

Oklahoma State University

Principal Investigator, Lorenzo Cremaschi

TC 8.5, Liquid-to-Refrigerant Heat Transfer

AHRTI \$47k co-funder

The fouling characteristics and cleanability of brazed-plate heat exchangers are not generally known - only basic guidelines for chemical cleaning are available from the brazed plate heat exchanger manufacturers. However the effectiveness of this cleaning method is undocumented for AC&R applications and in some cases the cleaning is not possible because of installation constraints. Thus, for critical service applications, brazed-plate heat exchangers are less-likely to be specified than other heat exchangers for which the fouling characteristics are better known. For high-pressure refrigerant applications, such as with R-410A which is gaining widespread industry acceptance, brazed-plate heat exchangers generally offer lower first-costs than other heat exchanger types, require smaller refrigerant charges, and reduce overall system footprints than tubular types. This is because the internal structural design of the brazed-plate type heat exchangers allows for the use of thinner metal sections than in tubular heat exchanger designs. The resulting smaller system package sizes then require less mechanical room floor space and offer reduced floor and roof loadings in comparison to system packages that utilize tubular type heat exchangers for these applications. Successful determination of the fouling characteristics of brazed plate heat exchangers and the subsequent incorporation of the results into the ASHRAE Handbook and ARI Guideline E will allow AC&R system designers to properly select these heat exchangers for use in less-than-ideal fluid situations and to provide proper maintenance recommendations. This will lead to more flexibility in system design with high-pressure refrigerants, lower overall unit first cost and reduced condenser refrigerant operating charges on the order of 50%.

The specific objectives of this project are as follows:

- a. quantify the difference (if any) in fouling rates between brazed plate heat exchangers and tube types
- b. experimental determination of fouling on brazed plate heat exchangers using simulated cooling tower water
- c. correlation of fouling data with water quality for brazed plate heat exchangers
- d. correlation of fouling data with plate aspect ratio, chevron design & flux within the scope of this project

e. update information contained in *ASHRAE Handbook, HVAC Systems & Equipment Volume, Chapter 35 – Condensers* and possibly *ARI Guideline E– Fouling Factors: A Survey of Their Application in Today's Air-Conditioning and Refrigeration Industry*

1353-RP

STABILITY AND ACCURACY OF VAV BOX CONTROL AT LOW FLOWS

September 2007 – February 2011
Drexel University
Principal Investigator, Jin Wen
TC 1.4, Control Theory and Application

The reliable control of airflow rates in VAV systems is important for a number of reasons, most significantly: acoustics, ventilation, energy management and occupant comfort.

Stability and accuracy of VAV boxes rely on the performance of four main components: the velocity pressure sensor (traditionally provided with the box by the box manufacturer or the controls vendor); the zone controller (typically provided by the controls vendor); the box damper or air valve (integral to the terminal unit), and the modulating actuator (integral with the controller or field installed). The objectives of this project are to isolate, evaluate, and relate the performance of these components individually and as a “system” to a range of typical operating conditions.

Other project objectives include:

- Develop practical recommendations for engineers and contractors in order to successfully achieve low air flow control.
- Recommend methods of test (MOTs) for rating air flow sensors at low flow (e.g. k-factor) and for controller minimum signal.
- Perform field test to validate low flow stability of installed VAV boxes.

1356-RP

METHODOLOGY TO MEASURE THERMAL PERFORMANCE OF PIPE INSULATION AT BELOW-AMBIENT TEMPERATURES

August 2008 – July 2011
Oklahoma State University
Principal Investigator, Lorenzo Cremaschi
TC 1.8, Mechanical Insulation Systems

The overall objective of the proposed research is to design an experimental apparatus capable of measuring the effective thermal conductivity of pipe insulation systems at below-ambient temperature. The end loss, energy metering, temperature measurement, equilibration criteria, and other operational issues will be conform to the requirements of Standard ASTM C 335 and the design will be discussed with the Project Monitoring Subcommittee (PMS) for approval prior to the initiation of work on any subsequent task. The PIs will produce a set of shop drawings and a parts list for the test apparatus. Certain physical limitations are proposed for this apparatus. Firstly, the apparatus will be constructed to evaluate insulation that is applied to a 3-inch NPS pipe that is operating over the temperature range of 20 to 70°F (-6.7 to 21°C). The apparatus will be capable of testing insulation thicknesses that range from 0.5 to 2 inches (13 to 51mm) in wall thickness. The test apparatus will be located in a control environmental chamber and the exterior insulation system temperature and relative humidity will be controllable over the ranges of 75 to 100°F (24 to 38°C) and 20-90%. A total number of 86 tests will be conducted to demonstrate that the test apparatus operates successfully and to further demonstrate the flexibility of the test apparatus.

The experimental data will be used to develop empirical correlations for effective thermal conductivity as function of the mean temperature of the insulation specimen.

1360-RP

HOW DO PRESSURE DROP, EFFICIENCY, WEIGHT GAIN, AND LOADED DUST COMPOSITION CHANGE THROUGHOUT FILTER LIFETIME

April 2009 - September 2012

RTI International

Principal Investigator, Kathleen Owen

TC 2.4, Particulate Air Contaminants and Particulate Air Contaminant Removal Equipment

The principal aim of this research is to investigate the performance of in-situ air filters throughout their application and relate that performance to the ASHRAE Standard 52.2 test results. Ventilation strategies and ambient conditions will be surveyed along with such filter properties such as efficiency, pressure drop, and air flow. Collected material on the filter will be analyzed and related to the ambient conditions and to any change in performance.

1365-RP

THERMAL PERFORMANCE OF BUILDING ENVELOPE DETAILS FOR MID- AND HIGH-RISE BUILDINGS

January 2009 – December 2010

Morrison Hershfield Ltd.

Principal Investigator, Mark Lawton

TC 4.4, Building Materials and Building Envelope Performance

The objective of this project is to develop a design procedure to determine the thermal performance of building envelope details for mid- and high-rise buildings that are covered by ASHRAE/IES Standard 90.1, and to use the procedure to produce a catalogue of design thermal performance data for 40 common architectural details.

This project will have an impact on most, if not all, ASHRAE members, especially those who design for extreme hot or cold climates. The results will provide a tool for better design of building envelope thermal performance, which will contribute to improved HVAC design and moisture control, with corresponding reduced risk of thermal comfort and mold problems. The results could be incorporated into the Fundamentals Handbook, the HVAC Applications Handbook, and into ASHRAE/IES 90.1. Inclusion of this new information would increase the functionality of the Handbook and its relevance for all designers.

1383-RP

DEVELOP A RADIANT SYSTEM MODULE FOR THE SIMULATION AND ANALYSIS OF SPACES AND SYSTEMS

April 2009 – March 2011

Wrightsoft Corporation

Principal Investigator, Charles Barnaby

TC 6.5, Radiant Heating and Cooling

The proposed module will provide the basic algorithm and equations to accurately model whole building radiant energy as it affects comfort, demand for HVAC, and energy use. The module will be demonstrated by coding it as part of a publicly available building energy simulation model (e.g., TRNSYS, DOE-2, EnergyPlus).

1385-RP

DEVELOPMENT OF DESIGN TOOLS FOR SURFACE WATER HEAT PUMP SYSTEMS (SWHP)

September 2009 – August 2011

Oklahoma State University

Principal Investigator, Jeffrey Spitler

TC 6.8, Geothermal Energy Utilization

Surface water heat pumps are a relatively inexpensive but highly efficient heating and cooling alternative. In some applications, direct cooling or pre-cooling is possible without refrigeration, even in moderate climates because of naturally-occurring thermal stratification. However, little effort has been devoted to developing public domain design tools. Although a great deal of information is available from geological surveys regarding characteristics of surface water, HVAC engineers are unfamiliar with how to locate and apply this information. Finally, overloading a reservoir or stream may result in extreme temperature variations, water level fluctuations, SWHP system failures, and environmental problems. Designers need tools to optimize this important HVAC option and avoid undesirable misapplications. The objective of this project is to provide improved design data and design tools for SWHP systems. The scope includes collection, interpretation, and collation of design data; experimental measurement of convection coefficients on submerged heat exchanges, and development of design tools.

1387-RP

THERMAL ENERGY STORAGE DESIGN FOR EMERGENCY COOLING

April 2008 - October 2010
Kansas State University
Principal Investigator, Donald Fenton
TC 6.9, Thermal Storage

In a 24/7 economy, we have become acutely aware of our dependence on cooling systems as much more than a convenience, with the economic implications and, in many cases, issues of life and safety. Whether for preservation of food and medical supplies, or continued operation of data processing centers, health facilities, or critically important emergency response centers, the availability of reliable cooling is a necessity. Cooling system compressors are often essential to the continuous operation of facilities with mission critical requirements. These cooling system compressors can easily represent the largest single load on a disabled or overstressed power supply grid.

Thermal energy storage (TES) systems offer unique advantages in meeting the challenges of emergency cooling applications. Minimal power needs are, of course, the most obvious, but high discharge rates and wide temperature and flow envelopes often add to versatility and flexibility of cooling solutions using TES. Thermal storage systems can eliminate the need for compressor operation during an emergency event, thus improving reliability, reducing cost and alleviating a major burden on a power supply or cooling system infrastructure that is recovering and unstable. In comparison, battery storage is about four times more expensive per useful BTU stored, in addition to pollution concerns about battery components.

This project hence would provide guidelines not just for incorporating TES, but also for other technologies through better understanding of load requirements and management. In turn, it is expected that the design requirements, so obtained would provide guidance to manufacturers and practitioners of TES systems to more optimally design and implement TES systems, not just for traditional benefits like electric bill savings, but also for providing backup cooling.

1388-RP

REEVALUATION OF HIGH-ALTITUDE EFFECTS ON OPERATION OF GAS-FIRED BOILERS AND WATER HEATERS

September 2007 – February 2011 (P)
Gas Consultants
Principal Investigator, Carl Suchovsky
TC 6.10, Fuels and Combustion

The experience of knowledgeable gas-fired combustion appliance engineers is that different appliance types (i.e., water heaters versus furnaces versus boilers, natural-draft versus fan assisted combustion, direct-vent versus nondirect-vent, etc.) react differently to the effects of high altitude. Therefore, multiple appliance types are required to be tested and analyzed. Furnaces were previously tested on ASHRAE Research Project RP1182 because they are the highest sales volume gas appliances with the largest gas inputs and because they include a variety of the needed

combustion system types. The results of that work were strongly indicative that a much lower derate factor is appropriate for furnaces and that a follow-on project be initiated to analyze two other appliance types, boilers and water heaters.

1390-RP

SHORT-TERM CURTAILMENT OF HVAC LOADS IN BUILDINGS

September 2008 – July 2011
University of Central Florida
Principal Investigator, Lixing Gu
TC 7.5, Smart Building Systems

The objectives of this project are to identify and assess methods for managing peak loads in buildings via short-term adjustment of HVAC set points. The assessment will be based on simulation, using a method that will be made available for use by others to extend the results to other general or building-specific cases.

The proposed research will impact ASHRAE members who operate buildings and those who offer electric-utility programs intended to influence that operation in a way that benefits both parties. Short-term load control measures have been shown to be effective in very preliminary and limited simulation studies and in limited and poorly documented implementation programs. Society benefits if there are more participants in load-control programs but customers do not know what to do and may lack the necessary HVAC equipment and controls.

Controls and equipment manufacturers will benefit from pre-competitive knowledge about what strategies work for given equipment, controls, building thermal response and loads, and from an assessment of what changes are required in equipment and controls. ASHRAE can usefully provide this knowledge.

1395-RP

HEAT GAINS FROM ELECTRICAL AND CONTROL EQUIPMENT IN INDUSTRIAL PLANTS, PART 2

April 2006 – February 2011 (P)
Kansas State University
Principal Investigator, Warren White
TC 9.2, Industrial Air Conditioning

This proposed research is a follow-up to the recently and successfully completed 1104-RP, Heat Gain from Electrical and Control Equipment in Industrial Plants. This work would extend the results of 1104-RP by completing the recommended testing of equipment identified in the initial work

The design of the air conditioning systems for an industrial facility including the electrical equipment room is normally performed in parallel with the facility electrical system design. This means that the cooling equipment is sized based on any available estimated heat rejection values or on rules of thumb, guesses and assumptions. Because the heat from the electrical equipment is often a significant percentage of the total cooling load, accuracy is important to a successful air conditioning system design. This is particularly true in mission critical facilities and electronic equipment areas. Appropriately sized systems are also important for energy conservation and moisture control.

1397-RP

EXPERIMENTAL INVESTIGATION OF HOSPITAL OPERATING ROOM (OR) AIR DISTRIBUTION

September 2008- August 2010
University of Colorado
Principal Investigator, John Zhai
TC 9.6, Healthcare Facilities

The proposed research will advance the state of the art in design of operating room (OR) spaces; it may also promote advances in related fluid mechanics research areas. If a protective thermal plume is maintained above the

surgical site, the deposition of infectious particles should be reduced. The conditions that sustain the thermal plume have been predicted by earlier CFD simulations. (ASHRAE, Memarzadeh and Manning, 2003). The pertinent results will verify these predictions. Otherwise, the results will define a somewhat different but experimentally verified range of conditions. These results will have significant impact on practical OR design guidelines, but the impact will not be limited to this one, albeit important, direct application.

Other indirect advances will accrue from the proposed research. The detailed experimental results will be used to refine and improve the CFD modeling of OR air distribution, and the improved modeling techniques can be applied to air distribution engineering elsewhere in health care, such as patient protection rooms and infection isolation rooms, where similar unidirectional laminar flows are advisable. The improved engineering tools should be broadly useful in health care and in similar application such as industrial clean rooms.

1404-RP

MEASUREMENT, MODELING, ANALYSIS AND REPORTING PROTOCOLS FOR SHORT-TERM M&V OF WHOLE BUILDING ENERGY PERFORMANCE

September 2009 – August 2011
Milwaukee School of Engineering
Principal Investigator, Bass Abushakra
TC 4.7, Energy Calculations

The objective of this research is to develop a new method to determine the shortest time period for energy use monitoring involving hourly (or sub-hourly) data that will yield reliable and accurate long term energy use estimates within acceptable uncertainty limits. By evaluating the uncertainty in the measured data as the monitoring period progresses, the new method will allow users to evaluate the energy performance and calculate energy savings in commercial and institutional buildings, in a cost-effective short-term monitoring period instead of the current year-long monitoring stipulated in most M&V protocols. The new approach would resolve the problem of needing long-term monitored data, which is often very costly to obtain and/or historically unavailable. In addition, this measurement/extrapolation approach should be designed as simply as possible to meet the uncertainty targets in energy savings stipulated in M&V protocols such as ASHRAE Guideline 14.

1408-RP

THE EFFECT OF LINING LENGTH ON THE INSERTION LOSS OF ACOUSTICAL DUCT LINER IN SHEET METAL DUCTWORK

September 2008 – August 2011
University of Nevada-Las Vegas
Principal Investigator, Doug Reynolds
TC 2.6, Sound and Vibration Control

The incremental sound attenuation values (expressed in dB/ft and dB/m) for acoustically lined ductwork that are in the ASHRAE Applications Handbook are based on tests conducted on a very small sample of duct sizes, and are misleading in that they permit the assumption that the liner attenuation is linearly proportional to duct length. The proposed research will help TC 2.6 modify the incremental attenuation values to show how they depend on duct length so that air distribution system designers can minimize the use of acoustical duct liner while achieving the necessary noise reduction that it provides.

1409-RP

STABILITY OF CANDIDATE LUBRICANTS FOR CO2 REFRIGERATION

September 2009 – February 2011 (P)
Spauschus Associates
Principal Investigator, Ngoc Dung Rohatgi
TC 3.2, Refrigerant System Chemistry

The data generated in this work will enable compressor designers and manufacturers to use sound, experimental evidence to make lubricant decisions while developing compressors and systems to operate with CO₂ refrigerant. This will help ensure optimized long term chemical stability and hence reliability of these systems. This research will require the utilization of a high pressure vessel and associated techniques. Method development is outside the scope of this project, however this work will provide a basic experimental outline for this type of work. This experimental basis could provide a solid basis for ASHRAE SPC 175.

1415-RP

THERMAL AND LIGHTING PERFORMANCE METRICS OF TUBULAR DAYLIGHTING DEVICES

May, 2010 – October 2011
National Research Council Canada
Principal Investigator, Aziz Laouadi
TC 4.5, Fenestration

This research is intended to provide computational algorithms to support the development of fenestration rating standards, the ASHRAE load toolkit, and building-energy and lighting simulation software. Building designers (lighting designers, architects and engineers) will be better able to specify energy-efficient tubular daylighting devices (TDD) in commercial and residential buildings with more confidence, and to show compliance with existing building energy codes and energy efficiency standards. To speed up technology transfer to the building/fenestration design community, this research will develop a simple design guide for generic types of TDD's, which will be included in the Fenestration Chapter of a future edition of the ASHRAE Handbook of Fundamentals. The guide will also provide useful information to include in the Daylighting Chapter of a future edition of the IESNA handbook. The validated algorithms will be more likely to be adopted in fenestration rating standards since the latter do not currently provide any simulation procedure to rate TDD's. Manufacturers of TDD's will then benefit from a significant cost reduction to rate their products.

1416-RP

DEVELOPMENT OF INTERNAL SURFACE CONVECTION CORRELATIONS FOR ENERGY AND LOAD CALCULATION METHODS

April 2008 – March 2011
University of Texas-Austin
Principal Investigator, Atila Novoselac
TC 4.7, Energy Calculations

Currently there are no correlations developed for the environments with the vertical diffuser jets such as: 1) rooms with ceiling slot diffusers on external walls and 2) rooms with floor supply registers. This type of environment is common for rooms in the perimeter zone of a building, and previously developed convection correlations are not applicable because of considerably different airflow. The proposed research will significantly improve the accuracy of load and energy calculations by developing convection correlations for these two common room air flow configurations.

1418-RP

OPTIMIZING THE TRADE OFF BETWEEN GRID RESOLUTION AND SIMULATION ACCURACY: COARSE GRID CFD MODELING

September 2008 – March 2011
University of Colorado
Principal Investigator, John Zhai
TC 4.10, Indoor Environment Modeling

The overall objective of this project is to explore, through both theoretical analysis and numerical experiment, the trade-off between CFD grid resolution and simulation accuracy and to provide guidelines for proper selection of CFD grids for simulating typical indoor airflow conditions. More specific goals of the project include: (1) Investigate systematically the inherent relationships between CFD grid resolution and simulation accuracy for

typical flow types encountered in various indoor environments and understand the influence of numerical viscosity on simulation results; (2) Develop decision matrices that can provide quantitative and practical guidelines on selecting appropriate grid resolutions for typical flows in diverse indoor environments based on the requirements of computing time and simulation accuracy; (3) Demonstrate and validate the application of the developed matrices for a few representative indoor flow scenarios that have been well studied in previous physical experiments.

1420-RP

INLET AND DISCHARGE INSTALLATION EFFECTS ON AIRFOIL (AF) CENTRIFUGAL PLENUM PLUG FANS FOR AIR AND SOUND PERFORMANCE

April 2010 – March 2011
AMCA International, Inc.
Principal Investigator, Mark Stevens
TC 5.1, Fans

Very little information exists for accurately predicting the aerodynamic and acoustical response of centrifugal plenum fans to common appurtenances at the fan inlet and discharge. The existing information for these system effects on air performance is limited to housed centrifugal fans. No experimental data exists for system effects on sound.

The significance of system effects on plenum fans due to inlet and discharge appurtenances is widely accepted. Reports of installed performance indicate reductions in total efficiency of over 25% and sound power (L_w) increases of over 10 dB when compared to catalog ratings. The wasted energy was estimated in millions of megawatts per year. The estimated capital expenditures necessary to resolve the comfort and noise problems are over several million dollars. Improved knowledge of the precise values for these system effects could greatly reduce both the amount of wasted energy and unanticipated capital expenditures.

The objective of this project is to obtain a body of measured inlet and discharge system effects for both air and sound for two typical sizes (12", 27") AF.

1431-RP

ANALYSIS OF TRANSIENT CHARACTERISTICS, EFFECTIVENESS, AND OPTIMIZATION OF CLEANROOM AIRLOCKS

December 2007 – November 2010
ENGSYSO, Inc.
Principal Investigator, Wei Sun
TC 9.11, Clean Spaces

Though widely utilized as a de-contamination barrier, the performance and effectiveness of airlocks have not been thoroughly studied and proper design guidelines are not yet available in the industry. Airlocks are either designed by cleanroom architects and engineers or manufactured as pre-engineered equipment by factories based on their intuition and past experience. Due to lack of industrial standards, poor design of airlocks result in severe failures of the airlock operations such as excessive pressure loss during airlock door opening and closing; leakage of chemical fume and microbiological agent (toxic, harmful and/or infectious) into corridor and other general office areas; contamination of clean products by large particles with frequent door traffic; and unnecessary high air change rate. For applications where product quality or personal safety is critical, unreliable, poor performance, and/or malfunctioning airlocks are unacceptable.

The specific objectives of this proposed research are as follows:

1. Establish quantitative relationships between airlock parameters and its effectiveness. Conduct experiments in a selected cleanroom test lab and gather test data for various conditions.
2. Develop a CFD model to simulate test conditions, and the model needs to be validated and calibrated.
3. Utilize the results from both field tests and CFD analysis and establish the airlock design guidelines, identify the cost-effective approaches (such as better contamination result, energy saving and space saving) for performance improvement, and establish the preliminary method of airlock performance evaluation.

1444-RP

EXPERIMENTAL EVALUATION AND PREDICTION OF TWO-PHASE PRESSURE DROPS AND FLOW PATTERNS IN U-BENDS FOR R-134A AND R-410A

October 2007 – September 2011
Swiss Federal Institute of Technology (EPFL)
Principal Investigator, John Thome
TC 1.3, Heat Transfer and Fluid Flow

In compact air-cooled coils for evaporators and condensers, many 180° return bends (called U-bends) are employed. A significantly higher-pressure drop is found for tube bends when compared against straight tubes having the same total length.

In practice, the significant difference often found in predicted coil pressure drops compared to their associated bench test results is typically attributed to the effects of the U-bends. Hence, accurate designs require accurate U-bend pressure drop data, pressure drop data just after the U-bend and pressure drop prediction models to capture these two effects in order to properly optimize heat exchanger coils while at the same time optimizing the efficiency of the cycle. Taking into account the large number of U-bends in these kinds of units and the much higher pressure drop across the U-bends, the presently proposed project is an important stepping stone towards the realization of more effective use of pressure drops and thus higher energy efficient units.

The key objectives of this project are (1) Perform experimental test matrix on U-bends for two bend radii using four tube diameters with the refrigerants R-134a, R-410A and ammonia to obtain U-bend pressure drop data and its effect on the pressure drops in a straight tube downstream of the U-bend; (2) Determine the flow pattern at the outlet of the U-bend; (3) Develop new prediction methods incorporating two-phase flow patterns in order to predict pressure drops in the U-bends and its effect on the straight tube pressure drop with attention to U-bend radius effects for vapor qualities up to 0.9 and mass velocities of 100, 230 and 300 kg/m²s, as an extension to an existing straight tube flow pattern based model.

1448-RP

VENTILATION REQUIREMENTS FOR REFRIGERATING MACHINERY ROOMS

September 2009 – January 2011
CPP, Inc.
Principal Investigator, Ronald Petersen
TC 4.3, Ventilation Requirements & Infiltration

ASHRAE Standard 15 - Safety Standard for Refrigeration Systems- includes requirements for the ventilation of refrigeration machinery rooms to maintain safety. The theoretical basis for these requirements has never been established so their effectiveness in providing refrigeration room safety is in question. Given the 3 order of magnitude range of acceptable refrigerant concentrations vs. the more limited range of ventilation required by the Standard, it is likely that refrigeration rooms are either significantly under-ventilated or over-ventilated. The objective of this project is to conduct research to establish a technical basis for the refrigeration room ventilation requirements. This will include examining historical refrigerant release accidents to establish the most likely accident scenario, and then determine ventilation system requirements from basic principles needed to maintain safety during and after such an accident. The results are intended to be used as the basis of an addendum to Standard 15 revising machinery room ventilation requirements.

1449-RP

ENERGY EFFICIENCY AND COST ASSESSMENT OF HUMIDITY CONTROL OPTIONS FOR RESIDENTIAL AND SMALL COMMERCIAL BUILDINGS

September 2008 – September 2011
Building Energy Corporation
Principal Investigator, Armin Rudd

TC 6.3, Central Forced Air Heating and Cooling Systems
AHRTI \$50k co-funder

This project will have four parts; 1) The project team will develop a list of equipment types and system approaches that can provide humidity control in residential buildings, with emphasis on all types of humid climates. Project team will examine field data from Building America and other sources to identify promising approaches to humidity control. 2) The project team will perform limited model development in areas where gaps remain in the ability to model latent performance of some systems. 3) The project team will perform computer simulation studies of humidity control approaches and system options in small buildings as a function of system type, building load characteristics, and ventilation rates for a range of climates in IECC/DOE climate zones 1 through 6 in the Moist (A) portion of the climate zone map. A range of occupancy loads will be simulated. Results will be normalized to weather conditions. 4) Efficiency and cost analysis will be performed as part of this project in order to provide clear ranking of the ability and effectiveness of various approaches and technologies to achieve indoor RH control.

The results will help design engineers specify the most cost-effective means of providing humidity control in homes. Understanding the most critical factors influencing the performance will help manufacturers provide contractors with the installation requirements necessary to achieve high performance. Developers of codes and standards will be able to utilize the results to specify systems appropriate to their locations. Due to the current high level of interest in humidity control, especially for the purpose of preventing mold growth, it is expected that manufacturers will respond to the results quickly, developing and marketing the most effective technologies to contractors and residents. Code and standard developers in locations with widespread humidity concerns should also be able to respond to the results quickly, allowing for the pace typical of code and standard development.

1455-RP

ADVANCED CONTROL SEQUENCES FOR HVAC SYSTEMS – PHASE I AIR DISTRIBUTION AND TERMINAL SYSTEMS

April 2009 – March 2011
Taylor Engineering, LLC.
Principal Investigator, Mark Hydeman
TC 1.4, Control Theory and Application

This research project is intended to be the first of two phases: Phase I: Air Distribution and Terminal Systems and Phase II: Central Plants and Hydronic Systems. This first phase will include developing comprehensive optimized control sequences for the following common air distribution and terminal subsystems: Generic thermal zones, Single zone systems, Variable air volume terminal units, and Variable air volume systems.

Logic diagrams will be developed for the sequences so that the logic is not vague, as is inherent in any written sequence. Sequences will be tested and debugged using simulation. Future research projects will be implemented to test the sequences in real buildings.

Once the research project is complete, the sequences and flow diagrams will be proposed as appendices to Guideline 13 via the addenda process. This will allow them to be publicly reviewed. Including the sequences in Guideline 13 will also allow them to be maintained over time, such as fixing bugs and incorporating new energy saving or diagnostic sequences via addenda, and also provides a good way for them to be disseminated – control sequences and control specifications go hand in hand

1457-RP

BY-PRODUCT PRODUCTION FROM PHOTOCATALYTIC OXIDATION ASSOCIATED WITH INDOOR AIR CLEANING DEVICES

September 2007 – September 2011
University of Wisconsin
Principal Investigator, Dean Tompkins
TC 2.3, Gaseous Air Contaminants and Gas Contaminant Removal Equipment

Over the past 3-5 years, there is increasing commercial interest and available products that treat indoor air contaminants with technology that employs photocatalytic oxidation. Photocatalysis is becoming a widely used method for the purification and deodorization of indoor air and industrial exhaust. The process is being incorporated into room air cleaners, in-duct cleaning devices, and in-vehicle ventilation cleaning devices. Photocatalysis typically uses titanium dioxide (TiO₂) and an ultraviolet (UV) light source to drive the photocatalytic oxidation (PCO) reaction. Research has shown that photocatalysis oxidizes the pollutants introduced into a variety of breakdown products.

Research has shown that simple volatile organic chemicals (VOCs) like ethylene are oxidized to carbon dioxide and water, but the fates of the more complex larger VOCs typically found in an indoor air environment are unknown. It is important to determine whether they are also reduced to non-threatening carbon dioxide and water, or whether they react to form irritating products like aldehydes which could deteriorate the indoor air rather than improve it. This research is precompetitive because it will expand the understanding of PCO technology and ensure that air cleaners based on this technology improve indoor air quality.

The overall objective of the project is to establish a method for the analysis of by-products from photocatalytic oxidation indoor air cleaning devices. In so doing, the investigators will characterize (measure and report) the by-product production from the photocatalytic oxidation associated with indoor air cleaning devices.

1466-RP

DEVELOPMENT OF A CALIBRATION REFERENCE DEVICE FOR USE WITH TEST STANDARD ANSI/ASHRAE 52.2-2007

April 2008 – April 2011

University of Minnesota

Principal Investigator, Thomas Kuehn

TC 2.4, Particulate Air Contaminants and Particulate Air Contaminant Removal Equipment

AHRTI \$10k co-funder

An earlier ASHRAE-supported study, RP-1088, found discrepancies between test facilities established to perform filter testing in accordance with ASHRAE Standard 52.2. Different MERV ratings were assigned to the same filters by different test facilities in a round robin test. Thus there is a need to provide some sort of inter-laboratory calibration so that each facility provides the same filter rating as any other facility when testing the same filter.

The objective of this project is to develop at least one primary calibrated reference device that would allow laboratories that test particulate air filters in accordance with ANSI/ASHRAE Standard 52.2-2007 to verify that their MERV rating procedure provides the value intended. The calibration particle size will range from 0.3 to 10 microns and the pressure drop will not exceed 1.5 inches of water at the calibrated flow rate that will be in the range of 450 to 2000 cfm. The contractor also agrees to provide at least five exact copies of this device to testing laboratories that request them on a unit cost basis providing the cost of each does not exceed \$10,000. This would provide test laboratories a means of checking their entire test facility and protocols for compliance with the intent of the Standard.

1467-RP

BALANCING LATENT HEAT LOAD BETWEEN DISPLAY CASES AND STORE COMFORT COOLING

September 2009 – August 2011

University of Colorado

Principal Investigator, Michael Brandemuehl

TC 10.7, Commercial Food and Beverage Cooling Display and Storage

AHRTI \$84k co-funder

Supermarket energy costs for heating, cooling, dehumidification, and refrigeration are a major store operating cost and often exceed store profits. While most of this cost is associated with maintaining refrigerated conditions for products, much is also spent to maintain suitable environmental conditions in the supermarket sales area. Each of these requirements is inexorably linked to the other. Failure to control store temperature and humidity can cause

excessive energy consumption by refrigeration equipment and hamper product marketing due to frost build-up on frozen products and fogging of display cases. Conversely, most of the energy used to operate the refrigeration equipment serves to reduce the building cooling and dehumidification requirements.

The overall objective of this project is to provide a comprehensive assessment of the potential for energy savings in supermarkets by optimized design and operation of the combined HVAC and refrigeration systems. The assessment will include the effects of climate, space temperature and humidity set-point controls, HVAC system type and characteristics, and the design and operation of the refrigerated cases. Furthermore, the project will address the overall layout of HVAC and refrigeration system components in supermarkets, including HVAC zoning, the location of supply and return air, and the overall air distribution patterns in the supermarket.

1468-RP

DEVELOPMENT OF A REFERENCE BUILDING INFORMATION MODEL (BIM) FOR THERMAL MODEL COMPLIANCE TESTING

September 2009 – January 2011

Texas A&M University

Principal Investigator, Mark J. Clayton

TC 1.5, Computer Applications

Although new computer technologies for representing buildings are expected to transform the processes for architectural engineering design services, a prerequisite for that transformation is the establishment of standards for data exchange among disparate software systems. Of particular interest to ASHRAE and ASHRAE members are the standards by which information provided by architects using Building information Modeling (BIM) software can be transferred automatically to energy analysis and simulation software. Achievement of such data exchange capability is expected to greatly increase the efficiency and accuracy of energy analysis and enable building designs to achieve higher levels of energy efficiency. Because of increasing awareness of impacts of environmental degradation, energy efficiency standards and air pollutant regulations are being made more stringent, which in turn increases interest in more efficient and effective design processes for building energy systems.

The objective of the proposed research is to establish reference models of buildings using multiple Building Information Modeling software systems that represent the information needed to perform automated energy simulation and analysis. The project includes a review of prior work, identification of building features and their relative impact upon energy performance, development of accurate energy models of the reference buildings, and well-defined inputs and outputs to BIM and energy simulation from the reference models. This will allow independent software developers to validate their software processes against an ASHRAE reference model.

1469-RP

THERMAL COMFORT IN COMMERCIAL KITCHENS

September 2009 – August 2011

KEMA, Inc.

Principal Investigator, John Stoops

TC 5.10, Kitchen Ventilation

The restaurant industry is the largest employer outside of the government and employs over 12.2 million people in the United States (National Restaurant Association, 2005). Understanding the current state of thermal comfort in commercial kitchens is paramount to understanding and providing a controlled and comfortable environment for the kitchen worker. The results of this research will have immediate usefulness to engineers and kitchen consultants involved in the design of HVAC systems and operation of restaurants and institutional kitchens. The information will make possible a more accurate determination of kitchen worker comfort and how it is affected by heat loads.

1472-RP

EXPERIMENTAL VALIDATION OF MODELING TOOLS FOR MIXED GAS REFRIGERATION CYCLES

September 2007 – July 2011
University of Wisconsin-Madison
Principal Investigator, Gregory Nellis & Sanford Klein
TC 10.4, Ultra-Low Temperature Systems and Cryogenics

Refrigeration cycles involving a multi-component, multi-phase working fluid have become increasingly important for a number of cryogenic applications; perhaps the most significant of these are cryosurgical systems and the production of liquefied natural gas (LNG). This project seeks to verify the optimization algorithm, which was developed under completed ASHRAE research RP-1246.

The design and optimization algorithm developed in RP-1246 will be applied to the specific heat transfer surface and operating conditions that are relevant to cryosurgical probes and used to predict the performance of a commercially available cryosurgical system. A series of parametric performance tests on this equipment will provide verification of the design tool and will quantify the range of its utility. Finally, the optimization algorithm developed by RP-1246 will be used to optimize the gas mixture and operating conditions for the cryosurgical in order to demonstrate the utility of this tool to the cryogenics.

1475-RP

UPDATING HEAT AND MOISTURE PRODUCTION RATES OF MODERN SWINE AND THEIR HOUSING SYSTEMS

April 2009 – May 2012
U.S. Department of Agriculture – Agricultural Research Service
Principal Investigator, Tami Brown-Brandl
TC 2.2, Plant and Animal Environment

The heat and moisture production (HMP) data currently being used for ventilation design and environmental control of animal facilities are mostly 30 to 50 years old. Fifty years ago, pigs were almost exclusively raised outdoors; today, pigs are predominantly raised indoors to improve food safety, manure management, handling ease, animal well-being, and performance. Raising pigs indoors requires extensive engineering and animal expertise. Many years of research have been dedicated to building design and understanding the interaction between the building and animals. Important criteria in facility design are animal HMP. An animal's heat production (HP) is a product of the inefficiencies related to breakdown and use of food stuffs. HP is significantly influenced by genetics, nutrition, and thermal environment.

The objective of this research project is to systematically update the heat and moisture standards for model swine production conditions.

1476-RP

WOVEN COMPRESSOR ENABLING ECONOMIC AND SCALABLE R718 CHILLERS – PHASE 1: PROOF OF CONCEPT

September 2009 – October 2010
Michigan State University
Principal Investigator, Norbert Muller
TC 8.2, Centrifugal Machines

The objective of this project is to demonstrate that it is possible to wind/weave an operational light-weight, high strength composite turbo-impeller with integrated motor and bearings on a commercially available winding machine. This new concept then provides a very much needed economical and scalable compressors as the enabling key component for the breakthrough of utilizing water (R718) as one of the most natural refrigerants in novel, environmentally friendly, high efficient chiller concepts that can be successful in the US HVAC&R market and beyond.

1477-RP

DEVELOPMENT OF TYPICAL-YEAR WEATHER FILES FROM THE *ISH* DATA BASE OF HISTORICAL WEATHER DATA FOR 2,500 INTERNATIONAL LOCATIONS

September 2007 – February 2011
White Box Technologies
Principal Investigator, Joe Huang
TC 4.2, Climatic Information

This project has a single objective of producing a large data set of 3,800 typical-year weather files for non-US locations suitable for use in building energy simulations. For record-keeping purposes and to permit reanalysis or further improvements in modeling solar radiation, etc., the project will provide to ASHRAE the processed historical year weather files, and archive them in a format such as IWEC that would document the provenance of each data element, whether they are as reported on the raw weather files, interpolated, or calculated

1478-RP

MEASURING AIR-TIGHTNESS OF MID- AND HIGH-RISE NON-RESIDENTIAL BUILDINGS

September 2009 – August 2011
Wiss, Janney, Elstner Associates, Inc.
Principal Investigator, Wagdy Anis
TC 4.3, Ventilation Requirements and Infiltration

The results from this project will be able to help ASHRAE members (including HVAC designers, IAQ consultants, researchers and other professionals) to better design healthy and energy-efficient mid- and high-rise non-residential buildings by better understanding the as-built performance of building envelope materials and designs eventually helping to take the guess work out of the effects of envelope infiltration on system sizing and building design.

In addition, the ASHRAE Presidential Ad Hoc Homeland Security Committee specifically recommended research on test methods for determining building tightness and collection of data on building tightness in its May 2006 memo on CBR Strategies and Information/Methods Gaps. That memo further recommends research on design methods based on building tightness and expected pressures and methods for monitoring and controlling building pressurization, which are expected to be pursued as a separate follow-up project.

1486-RP

FAULT DETECTION AND DIAGNOSTICS FOR CENTRIFUGAL CHILLERS - PHASE III: ONLINE-TIME IMPLEMENTATION

April 2008 - April 2011
University of Nebraska - Lincoln
Principal Investigator, Haorong Li
TC 7.5, Smart Building Systems

A significant portion of the energy and maintenance costs for operating commercial HVAC systems is associated with chillers. Although current control systems typically monitor many variables, the monitored information is seldom used for detecting and diagnosing faults or improper operations. At best, these systems incorporate automatic shutdown procedures that guard against catastrophic failure.

Automated fault detection and diagnostics (FDD) for HVAC systems in general and chillers in particular, has the potential to reduce energy and maintenance costs and improve comfort and reliability. Inadequate maintenance can lead to inefficient operation (energy costs), a loss in cooling capacity (comfort), and increased wear of components (reliability). However, excessive maintenance leads to unnecessary costs. In addition, early diagnosis of equipment problems can reduce the costs associated with repairs by improving scheduling and reducing on-site labor time.

The objective of this project is to evaluate the effectiveness of two electrically driven chiller FDD methods and to produce a specification for an algorithm that could be incorporated within commercial products. First, the methods

will be evaluated online in a laboratory environment, followed by evaluation in the field. One method to be tested and procedures for conducting the evaluation were determined from Phase II of research project 1275-RP.

1487-RP

THE DEVELOPMENT OF SIMPLIFIED RACK BOUNDARY CONDITIONS FOR NUMERICAL DATA CENTER MODELS

April 2009 – September 2010
University of Colorado
Principal Investigator, John Zhai
TC 4.10, Indoor Environmental Modeling

The most important issue of a data center facility is to provide an environment that ensures a reliable and uninterrupted operation of the data processing equipment. As blade servers make it possible to pack more and more computing power into ever smaller spaces, electronic equipment heat levels have risen exponentially in data centers over the past years, resulting in significant increase in power and cooling demands along with energy costs.

The overall objective of this project is to develop simplified rack boundary conditions for a single common rack type (front-to-back airflow) that can be implemented in a full-room CFD simulation of data center for accurate airflow and heat transfer analysis. The target rack should represent a popular rack type fully loaded with reasonably uniform-airflow IT equipment over a practical range of equipment airflow rates, equipment power, and room ambient temperatures. Both laboratory experimentation and CFD simulation will be performed to build and validate one (or several) compact rack model (or models) with sufficient modeling accuracy and practical usability. “Server simulators” will be employed in the research to simulate IT devices that produce heat and feature uniform airflow across their front and rear faces. This project will focus to develop appropriate and generic rack computer models that can accurately capture the macro-influence of racks to the local, regional and global airflows in a data center, with an emphasis on the interactions of various heat transfer and airflow driving forces.

1488-RP

LABORATORY TESTING OF FLAT OVAL DUCT FITTINGS TO DETERMINE LOSS COEFFICIENTS

September 2008 - January 2011
Tennessee Technological University
Principal Investigator, Stephen Idem
TC 5.2, Duct Design

The objective of this research is to test four common flat oval junction fittings to determine their total pressure loss coefficients, and thereby update the ASHRAE Duct Fitting Database (2006). Both main and branch loss coefficients will be reported. The tests will be conducted in compliance with ANSI/ASHRAE Standard 120-1999, “Method of Testing to Determine Flow Resistance of HVAC Ducts and Fittings”. This research will improve the ASHRAE database by testing fittings not in the database. Furthermore, access to these data will allow designers to (1) accurately select fittings from a large diverse set of information, and (2) improve the use of duct design programs such as T-Duct that utilize the database. More reliable data and/or a large database of fitting loss coefficients will help HVAC engineers to better design ductwork for their clients, enabling more accurate pressure drop calculations and less safety factor. This will allow fans to be sized properly, reducing energy consumption and wasted material.

1493-RP

CFD SHOOTOUT CONTEST - PREDICTION OF DUCT FITTING LOSSES

September 2010 - December 2011
Zhiqiang Zhai & University of Charlotte - North Carolina
Principal Investigator, Zhiqiang Zhai and Ahmad Sleiti
TC 5.2, Duct Design

To date, \$402k has been spent by ASHRAE to test various duct fittings. We are nowhere near finished. There are a number of round, rectangular, and flat oval fittings that are yet to be tested. Flat oval duct tests have recently started. The cost of testing continues to rise. The quality of testing is sometimes questionable, if not unacceptable. If this project is successful, then we can begin to consider using CFD as our source of fitting losses, and test them virtually, rather than test actual fittings. Once the models have been validated, we can test all of our future fittings computationally. Not only will the fittings currently not tested or validated be available to the members much sooner, but at a considerably lower cost. The ASHRAE Duct Fitting Database can then be reasonably “complete” one day.

1507-RP

BINARY REFRIGERANT FLAME BOUNDARY CONCENTRATIONS

September 2009 – January 2011 (P)
Safety Consulting Engineers
Principal Investigator, Andrew Kusmierz
TC 3.1, Refrigerants and Secondary Coolants
AHRTI \$18k co-funder

ASHRAE and the industries they serve are faced with the need for new refrigerants to meet environmental, energy, and safety requirements. SSPC 34 will classify these working fluids for safe handling. To ensure the validity of flammability safety classifications issued by SSPC34, standard reference data is needed. Tools such as the proposed flammability property database will allow for the development of blends that are properly investigated and classified to meet demanding future needs.

1512-RP

CFD RESOURCE DECISIONS IN PARTICLE TRANSPORT MODELING

August 2010 – July 2012
University of Texas Austin
Principal Investigator, Atila Novoselac
TC 4.10, Indoor Environmental Modeling

Prediction of particle dynamics in a built environment is very important for designing and maintaining a healthy indoor environment. Processes that include dispersion around the sources, their transport through the space, as well as the distribution in the vicinity of an occupant, define the human exposure to the particles. Apart from dilution which assumes perfect mixing, relatively little research has been carried out on the transport of disease carrying particles from sources to the occupant. Therefore, there is a need for reliable and affordable modeling methods that can simulate particle dynamics in indoor environments.

The objective of the proposed work is to provide the engineering and research community with critical CFD parameters suitable for particle transport modeling in a built environment where disease bearing particles can cause human exposure and health risks.

1515-RP

THERMAL AND AIR QUALITY ACCEPTABILITY IN BUILDINGS THAT REDUCE ENERGY BY REDUCING MINIMUM AIRFLOW FROM OVERHEAD DIFFUSERS

September 2010 – July 2012
University of California - Berkeley
Principal Investigator, Edward Arens
TC 2.1, Physiology and Human Environment

Simulations show that reducing zone minimums in a typical office building from 30% to 20% can save \$100/k ft²-yr in fan, cooling, and reheat energy (approximately a 10% reduction in total energy use). Multiplied across the millions of square feet of commercial space served by VAV boxes, the potential economic and environmental

benefits are substantial. Savings can be achieved in new construction and in existing buildings through low cost control system re-programming. The opportunity for savings in existing buildings with minimal financial investments is a particularly exciting application for this work.

Because this study will involve observations across a range of supply air volumes and temperatures, the study will have an additional benefit of providing ASHRAE with detailed information about local thermal discomfort in actual occupied buildings. This can be used to validate some of the local discomfort provisions in Standard 55, which are at present based solely on laboratory studies.

The research could also have far reaching implications in terms of getting changes made to the ASHRAE Handbook, to manufacturers' literature and to the way engineers calculate minimum flow rates. It will also support proposed changes in Standards 90.1, 62.1 and 55.

1517-RP

VALIDATION OF A LOW-ORDER ACOUSTIC MODEL OF BOILERS AND ITS APPLICATION FOR DIAGNOSING COMBUSTION DRIVEN OSCILLATIONS

September 2010 – March 2012

Secat, Inc.

Principal Investigator, David Herrin

TC 6.10, Fuels and Combustion

During the development of higher efficiency, lower emission boilers, tonal noise can be an unacceptable problem. This is caused by oscillations of the flame which result in pressure oscillations in the combustion chamber that are radiated as noise. This occurs whenever the pressure oscillations feed back on the flame, via the mixture supply system, in such a manner that the flame oscillations increase. The interaction of the boiler, burner, and flame is so complex that breaking the circle is best accomplished with the help of a computer model.

The objective of this research is to develop a procedure for quickly and efficiently modeling the acoustic behavior of gas fired heating boilers as a tool for diagnosing the cause of combustion oscillations.

ASHRAE members who would benefit immediately from the proposed research are engineers engaged in the development of high efficiency, low NO_x gas fired boilers for residential and small commercial applications. It is expected that the results will also benefit engineers involved in the development of gas fired furnaces and liquid fueled boilers as the demand for lower NO_x emissions from those products spreads in the near future. Together, gas and oil burning boilers and furnaces are used to heat the vast majority of homes and small commercial buildings. The ultimate beneficiaries are the owners of buildings in which better heating appliances are to be installed and sustainable low emission solutions are to be provided.

1522-RP

ESTABLISHMENT OF DESIGN PROCEDURES TO PREDICT ROOM AIRFLOW REQUIREMENTS IN PARTIALLY MIXED ROOM AIR DISTRIBUTION SYSTEMS

September 2009 – August 2011

Building Energy & Environmental Engineering, LLP.

Principal Investigator, Zheng Jiang & Qingyan Chen

TC 5.3, Room Air Distribution

Under Floor Air Distribution (UFAD) systems have been proved to provide higher ventilation effectiveness if they are properly designed and they also have the potential to conserve energy. Several methods have been developed for estimating the supply airflow requirements of UFAD systems, but all involve arbitrary assignment of certain convective heat gains to the upper region of the space and estimated return air temperatures. Therefore, it is necessary to conduct research to develop a scientific guide for designers of UFAD systems.

This project will quantify the convective heat transfer into a stratified occupied space by conducting measurements and simulations for an interior zone and a perimeter zone with the UFAD system. By combining the ASHRAE 1373-RP database, this project will develop a design guide for determining the supply airflow rate and key temperatures in the system.

The information resulting from this research project would be used to assist the designer in accurately estimating supply airflow requirements and predicting resultant space vertical temperature gradients. This is a natural sequence to the information and design guidance provided by the aforementioned UFAD design guide. The information would be available to all designers of UFAD systems and would standardize the supply airflow calculation procedure according to the degree of mixing maintained in the lower portion of the space.

1544-RP

ESTABLISHING BENCHMARK LEVELS AND PATTERNS OF COMMERCIAL BUILDING HOT WATER USE

April 1, 2010 – March 2013
Applied Energy Technology Company
Principal Investigator, Carl Hiller
TC 6.6, Service Water Heating Systems

The information available with which designers size and lay-out hot water systems in the commercial sector is antiquated and sadly in need of updating. We also need a better understanding of how people use water in commercial and institutional buildings.

The objective of this project is to obtain measured hot water use in a sampling of significant building types that will enable Table 7 of the Service Water Heating chapter of the ASHRAE Handbook to be revised and updated. High time resolution monitoring of hot water use will enhance the understanding of the diversity (how many uses occur at the same time) of hot water uses by providing data on number, timing and duration of draws, rather than just aggregate water use over long (e.g., day, week, month) periods.

1547-RP

CO₂-BASED DEMAND CONTROLLED VENTILATION FOR MULTIPLE ZONE HVAC SYSTEMS

September 2010 – March 2012
University of Nebraska - Lincoln
Principal Investigator, Josephine Lau
TC 4.3, Ventilation Requirements and Infiltration

ASHRAE Standard 90.1 defines demand controlled ventilation (DCV) as a system that provides “automatic reduction of outdoor air intake below design rates when the actual occupancy of spaces served by the system is less than design occupancy.” Standard 90.1 has required DCV, with some exceptions, for densely occupied spaces since the 1999 version, which also required that the DCV system be in compliance with ASHRAE Standard 62.1. The Standard 62.1 User’s Manual includes an appendix showing the underlying theory and a control scheme for using carbon dioxide (CO₂) concentration for DCV in accordance with the Ventilation Rate Procedure (VRP) of ASHRAE Standard 62.1. The 2007 version of the Manual only addresses CO₂ DCV for single zone systems. The 2004 version of the Manual also included an approach for multiple zone recirculation HVAC systems (MZS) but errors were found in the approach so it was removed. The authors of the Manual and the SSPC 62.1 subcommittee monitoring the Manual’s development felt that before any MZS DCV control logic could be included in the manual, research had to be done to ensure that the many complexities of the subject were properly addressed. Until questions are answered concerning MZS DCV, CO₂ DCV cannot be properly implemented in MZS with any assurance that it will be Standard 62.1 compliant and provide significantly improved energy performance. This research will ensure that it is possible to fully comply with both Standard 90.1 and Standard 62.1 with respect to multiple zone DCV systems.

1580-RP

STUDY OF THE INPUT PARAMETERS FOR RISK ASSESSMENT OF 2L FLAMMABLE REFRIGERANTS IN RESIDENTIAL AIR CONDITIONING AND SMALL COMMERCIAL REFRIGERATION APPLICATIONS

June 1 2011 – May 2012
Navigant Consulting, Inc
Principal Investigator, William J. Goetzler
TC 3.1, Refrigerants and Secondary Coolants

Regulations for the phase-out of R-134a in the automotive industry from 2011-2017 in the European Union (EU) are already in place and anticipated to spread to other regions and applications (e.g. Waxman-Markey legislation – American Clean energy and Security Act in US Congress). Understanding the safety implications of using mildly flammable 2L low global warming potential (GWP) refrigerants will allow faster and more widespread adoption and result in greater environmental benefit. The information from this study will also provide valuable input for improving or modifying codes and standards to allow safe use of mildly flammable refrigerants. The data can also be used in future risk assessments to be conducted by the stationary HAC&R industry or by individual OEMs.

The objective of the effort is to provide critical information regarding the flammability risks of class 2L refrigerants in air conditioning and refrigeration applications. This information will be used as input to risk assessments for class 2L refrigerants in order to assist in the evaluation of how and whether such refrigerants can be safely and successfully commercialized.

1583-RP
ASSESSMENT OF BURNING VELOCITY TEST METHODS

September 2010 – March 2012
National Institute of Advanced Industrial Science Technology (AIST)
Principal Investigator, Kenji Takizawa
TC 3.1, Refrigerants and Secondary Coolants
AHRTI \$30k co-funder

Regulations for the phase-out of R-134a in the automotive industry from 2011-2017 in the EU are already in place and anticipated to spread to other regions and applications (e.g. Waxman-Markey bill in the US Congress). By obtaining accurate values for burning velocity of mildly flammable low GWP refrigerants, the likelihood of adoption of these refrigerants will significantly increase and the long term environmental impact on climate change will be very significant. Substantial quantities of these new refrigerants could be in use in the 2012-2020 timeframe. Also, rules for refrigerant toxicity and safety classification under ISO 817 will probably be adopted by ASHRAE in the future in order to harmonize both systems and prevent confusion in the marketplace. Therefore, this is an important program for ASHRAE as well as ISO.

The objective of this project is to critically evaluate two different burning velocity test methods (vertical tube and spherical/cylindrical) to determine their precision and accuracy and potential for test method simplification and cost reduction without sacrificing quality. This should allow more widespread use of burning velocity measurement to support the new refrigerant flammability classification standard ISO 817 and ASHRAE Standard 34. The plan is to have one ASHRAE project, but potentially two separate budgets and contracts if two contractors with expertise with one specific method are chosen.

1589-RP
EFFECTS OF FIN DESIGN ON FROST AND DEFROST THERMAL PERFORMANCES OF MICRO-CHANNEL HEAT EXCHANGERS

September 2009 – October 2011
Oklahoma State University
Principal Investigator, Lorenzo Cremaschi
TC 8.4, Air-to-Refrigerant Heat Transfer Equipment

Microchannel-type heat exchangers have been recently adopted by the heat pump industry because of their compactness and efficiency for heating and cooling in residential and commercial applications. If these heat exchangers are used in outdoor coils, they are subjected to significant frost growth and frequent defrost cycles, which ultimately limit their heating performance during winter.

This project aims to study the effect of fin design modifications on frost and defrost thermal performance of microchannel and fins heat exchangers. Transients cases of initial frost accumulation, defrost, and subsequent re-frost cycles are going to be experimentally investigated. The proposed experimental work broadens the fin geometries studied in the cited references. It also focuses mainly on the onset of heterogeneous frost nucleation and the effects of the fin design modifications on the frost growth rate. The project also aims to isolate and quantify the impact on frost accumulation due to fin geometry, flow depth, finbase surface temperature, and fin contact resistance. The modeling efforts combined altogether with the experimental tests will be able to determine potential improvements in frosting and defrost performance from incremental modifications of the fin and microchannel tubes design.

1590-RP

IMPLEMENTATION OF TOTAL COST OF OWNERSHIP (TCO) PRINCIPLES INTO HIGHER EDUCATION AS AN INTEGRATED DECISION MAKING TOOL

September 2009 – July 2011

APPA

Principal Investigator, Douglas Christensen

TC 7.8, Owing and Operating Costs

The research effort will focus on the “Implementation of Total Cost of Ownership (TCO) Principles into Higher Education as an Integrated Decision Making Tool”. This study will focus on the principles of TCO and will be in alignment with both interoperability and sustainability practices. APPA will invite up to 25 institutions to participate in this study. The data collected from these institutions will provide the necessary data for analysis and establishment of a “standard of practice” for the industry and could result in a Standard for applying TCO and/or a guideline for utilizing TCO in Facilities Management.

The study will also help to significantly expand the ASHRAE Service Life and Operating Cost Database with additional buildings and equipment.

1596-RP

VENTILATION AND INDOOR AIR QUALITY IN RETAIL STORES

September 2010 – December 2012

University of Texas - Austin

Principal Investigator, Jeffrey Siegel

TC 4.3, Ventilation Requirements and Infiltration

Retail buildings in the United States account for approximately 20 percent of commercial sector energy consumption and represent the fastest growing commercial subsector (DOE, Energy Efficiency and Renewable Energy, Building Technologies Program, 2009). The potential for impact from this project on both indoor air quality and energy efficiency is significant.

The primary objective of the proposed investigation is to develop a robust database of indoor air quality, ventilation, occupant surveys, and building measurements for the U.S. retail building stock. This database will be used to determine the relationship between ventilation rate and indoor air quality and occupant satisfaction with the goal of recommending appropriate minimum ventilation rates for different categories and locations of retail establishments.

The primary user of these results within ASHRAE will be ASHRAE SSPC 62.1 and TC 4.3. Building designers will also be provided with data that will allow improved application of the Standard 62.1 IAQ Procedure.

Funding for the project and ASHRAE administrative costs is provided through a \$1.5 million dollar grant from the NIST Measurement Science and Engineering Research Grants program.

1597-RP

STOCHASTIC CONTROL OPTIMIZATION OF MIXED-MODE BUILDINGS

April 2010 – March 2013
University of Colorado - Boulder
Principal Investigator, Gregor Henze
TC 1.4, Control Theory and Application

Mixed-mode ventilation systems provide good indoor air quality and occupant thermal comfort using natural ventilation whenever the outdoor weather conditions are favorable, but revert to mechanical systems for HVAC whenever external conditions are too harsh. No complete study to date has attempted to optimize the control of mixed-mode buildings in a way that takes the variability and stochastic nature of user behavior into account. A novel feature of this work is the fact that the same set of occupants will be surveyed in the same building under two different modes of operation, i.e., the impact of compounding experimental conditions that typically afflict human comfort studies and reduce the power of generalization, is minimized. As a result, this form of analysis will yield more in-depth knowledge on the robustness of the rule-based control algorithms derived from the optimization study by demonstrating how a range of user behaviors influence the response of the building. The project will also seek to leverage recent research done by the USGBC and the State of California Energy Commission (CEC) and may be the basis for further collaboration between ASHRAE, USGBC, and CEC on research and possible co-funding support.

1613-RP

UPDATE CLIMATIC DESIGN DATA IN CHAPTER 14 OF THE 2013 HANDBOOK OF FUNDAMENTALS

June 2011 – November 2012
Numerical Logics, Inc.
Principal Investigator, Didier Thevenard
TC 4.2, Climatic Information

The climatic design conditions in the ASHRAE Handbook of Fundamentals (HOF) Chapter 14 are fundamental for the sizing and design of building energy systems to allow for optimal energy efficiency measures and ensure that the design conditions are related to the energy system capacity to meet the climatic loads in a probabilistic sense. Regular updating of the climatic conditions is critical in this respect for many practical reasons and to show due diligence in a world of changing climate.

The objective of this project is to update the climatic design condition tables for the 2013 ASHRAE Handbook - Fundamentals and in Standard 169, and provide an update of the Weather Data Viewer. The project will focus on expanding the amount and quality of the data, add new elements such as precipitation, provide indications of climatic trends for temperature and humidity for all stations, and update and improve the clear sky model that was introduced in the last version of the Handbook.

1633-RP

DATA AND INTERFACES FOR ADVANCED BUILDING MAINTENANCE AND OPERATION

July 2011 – June 2013
KGS Buildings LLC
Principal Investigator, Stephen Samouhos
TC 1.4, Control Theory and Application

The objective of this project is to develop a set of standard data-driven metrics, interfaces and dashboards for advanced building operation and management, segmented by building typology and stakeholder needs; proto-type those dashboards, document methods of data collection, and test those metrics with real building data. Provide this body of work to help fill the void in standards literature for informing designers and practitioners on how they can

use building data to improve building operations, energy efficiency, comfort, and sustainability. Perform fundamental field work by evaluating energy management system (EMCS) data and interfaces in 50+ buildings across the United States including 5 different EMCS platforms and 6 different building types, interview 50+ stakeholders, prototype and test 15+ complete dashboards, and review the pertinent technical literature.