TC Cover Sheet
TC 6.3, Central Heating and Cooling

January 24, 2006

Attendance (ending year of membership)

Members Present
John Andrews (06)
Paul Francisco (08)
Michael Lubliner (09)
Keith Temple (09)
Evelyn Baskin (08)
James Cummings (07)
Gary Nelson (07)
Mark Olsen (06)
William Rittelmann (07)
Bryan Rocky (07)
Jeff Siegel (07)
Iain Walker (08)

Members Absent
Mark Modera (08)
Martin Petchul (06)
Steven Tice (07)
Arun Vohra (07)

Corresponding Members Present
Chuck Gaston
Roger Hedrick
Stephen Kowalski
Dianne Griffiths
John Proctor
Harvey Sachs
Jim Vershaw

Guests
Jason LeRoy
Brandon Tudor
Bert Phillips
Jim Lutz
John Talbott
Paul Haydock
Eric Lardi
Darrell Howell
Collin Olson
Sunil Nanjundaram
Byron Horak
Larry Markel
Boualem Ouazia

Distribution

All entries shown on committee roster

ASHRAE TC6.3
Central Forced Air Heating and Cooling

Minutes of Meeting
January 24, 2006
Chicago, Illinois

Call to Order

The meeting began at 1:03 p.m. in the Clark 5 room of the Palmer House Hotel. A quorum was not present. Copies of the Agenda and the Denver minutes were distributed and introductions were made. The list of current voting members was reviewed.

Announcements

Chair John Andrews discussed various items from the TC Chair's breakfast. Program theme for Quebec is "Cold Climate Design" and the program schedule is revised to provide more shorter sessions. There is also a revision to the symposium paper review process. The session chair will nominate three reviewers, ASHRAE will pick two, and name a third who is totally unknown to the session chair.

On the research side, there are now more projects proposed than there is money to fund them. ASHRAE has a new strategic plan, and they want RTARs to show how the project relates to the strategic plan.

After the TC Chairs meeting, there was a meeting of the chairs of TC which are concerned with residential buildings. These included 8.11, 9.5, 6.3 and some others in Section 6. The discussion included ways to facilitate more efficient buildings, and was quite wide ranging but did not come to any real conclusions. Another topic was whether ASHRAE should develop a "standard house" similar to how ASHRAE considers the headquarters building the "standard commercial building." Areas where interests of multiple TCs overlap includes hybrid systems, such as hydronic/forced air systems, and areas where there might be gaps in coverage were also discussed. The group will continue to meet in the future, and anyone who is interested is invited to attend.

Harvey Sachs discussed a project underway which is looking for field performance data. He distributed a letter describing what they are looking for (Attachment 1).

Minutes of Last Meeting

Minutes of the Denver meeting were discussed A quorum was achieved at 1:14. Moved by Keith Temple, seconded by Jeff Siegle to accept the minutes. Motion passed 10-0-0.

Subcommittee Reports

Handbook

Chuck Gaston discussed handbook activities. The TC will need to approve revisions in about a year. The focus is on Chapter 28 of the Systems and Equipment handbook. The subcommittee meeting focused on identifying individuals who can contribute

Programs

Keith Temple distributed a program plan (Attachment 2). The TC has continued its streak of having at least one program at every meeting for at least the last 6 years. There were 2 programs in Chicago. Paul Francisco discussed the Tuesday morning symposium which had about 50 attendees and was quite successful. Bryan Rocky described a forum scheduled for Wednesday morning which will be on where the industry will be in 2020.

Keith Temple discussed the program plan. Priority 1 is a forum, "The Role of Forced-Air Systems During Extraordinary Events." This has been approved by the TC in the past, but not accepted by the society. Keith Temple moved, second by Bryan Rocky, that the TC put forward this program as the top priority. Motion carried 11-0-0.

The second priority is a seminar, "Forced Air Heat Pump Systems – Past, Present and Future." Mike Lubliner described the planned presentations. Harvey Sachs pointed out that if the abstract is tweaked to emphasize cold climates, it would fit with the Quebec City theme and this might improve chances for acceptance of the program. He also asked about an apparent weakness in the "Future" aspects of the planned program. There was also discussion about the impact of the revisions to the program blocking plan and whether two back to back sessions will be needed. Mike Lubliner moved that the second priority session be "Heating with Forced Air Heat Pump Systems – Past, Present and Future," with a request for back to back sessions if enough speakers commit. Second by Mark Olsen. Passed 11-0-0.

Another proposed program is a symposium for Dallas, "HVAC System Improvements in Manufacturered Housing," to be chaired by Iain Walker. Harvey Sachs has heard that the theme of the Dallas meeting will be something like "Energy Consumption in Buildings – How Low Can We Go?" Paul Francisco was concerned that we not be too concerned about meeting themes as they relate to Symposia, since the research lead time for these programs is so long. Paul Francisco moved that the TC sponsor this symposium for Dallas, second by Mike Lubliner. Carried 11-0-0.

The other programs shown on the program plan were discussed in subcommittee. Keith asked that anyone who can contribute to any of the programs contact him or the identified program chair. A proposal was made for forum in Long Beach, "Energy Tax Credits for Residential HVAC – Is It Working and What Does It Cost?"

Research

Mike Lubliner discussed the Research Subcommittee meeting. The RTAR on latent cooling options was discussed in the subcommittee, and an improved RTAR was the result. There was a need identified to coordinate the RTAR on heat pumps with TC 8.11. Mike will evaluate with 8.11 whether this should be modified. If so, then a letter ballot will be used to approve the changes in time for the May 15 ASHRAE deadline. If no changes are needed, then the previous lette ballot TC approval is still valid. No motion is needed at this time.

Jim Cummings discussed the revised RTAR on latent cooling (Attachment 4). This includes revisions from the subcommittee meeting as well as some comments from 8.11.. TC 8.11 will cosponsor the RTAR. The major revisions from the Denver version were discussed. This includes refocusing on small commercial as well as residential. Also, there was a reduction in focus on field validation. Multifamily applications were also removed. Mike Lubliner moved that the TC approve the RTAR as amended, seconded by Jeff Siegle. Carried 11-0-0.

Mike Lubliner mentioned some potential research topics that were raised at the SubC meeting. These will need additional work so we may be in position to vote on some of them in Quebec.

1. CO_2 heat pumps
2. New construction efficiency implications for HVAC – national survey
3. Comparing residential equipment sizing methods vs. real world
4. Pro's and Con's of interior wall register locations
5. Air balancing for optimum annual performance
6. Air system design to facilitate use renewable energy
7. Design guidelines & energy performance of small combo systems (Htg. Clg. DHW, vent)
8. Standardized diagnostics interfaces & controls for 2020 HVAC systems
9. Consumer costs to achieve energy performance/IAQ/humidity control
10. Zoning forced air systems w/o dampers
11. Value analysis of HVAC energy costs, comfort etc.
12. Do HVAC efficiency increases result in bottom line energy savings?
13. LAME loads implications for HVAC systems
14. Ventilation strategy impacts on general conditioning
15. Removing H_20 from HVAC coils

Harvey Sachs mentioned a possible effort to flag obsolete data in the Handbooks as a way of warning designers and hinting that new data may be needed. Mike will bring this up in Quebec.

Standards

Mike Lubliner reported on the SubC meeting. There was discussiong of planned field testing of air handler efficiency in California in 2008. There has apparently been discussion between ACEEE and GAMA that fan energy should be left out of current DOE rulemaking on furnace efficiency.

There was discussion of a standard for measuring leakage of the air handler cabinet. Florida legislation includes leakage of the cabinet.

There was also discussion of whether it would be appropriate to develop a standard for light commercial buildings that would parallel Std. 152. The SubC concluded that they are not yet ready. Possible changes to Std. 152 were also discussed. No recommendations were approved. The DeltaQ test method was also discussed, and it was noted that an addendum to 62.2 which would require use of DeltaQ was withdrawn. Jim Cummings discussed the commercial duct leakage MOT standard, and expressed concern that an SPC should be formed to help drive the research, and that if we wait until the research is complete, nothing might ever happen. He also suggested that joint sponsorship with another TC, such as 9.5, would be beneficial.

The TC recommends that SubC members proceed with development of a TPS for the cabinet leakage MOT standard. Jim Cummings will distribute the relevant Florida legistration to the SubC.

Web Site

The website was down at one point in the fall, but it is now working again. It was pointed out that it was out of date, in that several recent minutes were not posted.

ASHRAE Learning Institute

Chuck Gaston discussed ALI activities. They are interested in any concepts for training sessions that might turn a profit.

New Business

No new business.

Adjournment

The meeting adjourned at 2:44 p.m.

ATTACHMENT 1

American Council for an Energy-Efficient Economy
1001 Connecticut Avenue, NW • Suite 801 • Washington, DC 20036
VOICE: 202.429.8873 • FAX: 202.429.2248 • WEB: www.aceee.org
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. . . building a sustainable energy future

January 20, 2006

Dear Colleagues - re: Residential HVAC Field Performance Studies

ACEEE is working with other groups[1] on some potential advances for residential air conditioning performance and ratings. We seek your help in identifying field studies anywhere in North America that might have data and/or results on system performance in the field. Our specific task is the following:

Review available residential air conditioning field performance data and programs. This could be considered as an extension of Neme and others, 1999.[2] That paper summarized studies that showed that external static pressure is about twice as high as the assumptions in the air conditioner rating method. This implies lower airflow than the design values of ~400 cfm/ton, and reduced efficiency as currently measured. To even raise the question of whether the defaults should be changed, we're particularly interested in the influence of construction style, duct location, and system parameters on field performance. Parameters of interest would include:

1. Location, state or region of the building(s).
2. Air conditioner performance: charge, air-flow, in-field performance, air-handler power…
3. Duct/distribution system performance: leakage, external static pressure.
4. System parameters:
   a. Equipment location (attic, crawl, basement, or within thermal envelope).
   b. Duct location (predominantly attic, crawl, basement, or within thermal envelope).
   c. Duct materials (predominantly metal, duct board, flex-duct).
5. House construction (platform wood-framed, SIP, other).
6. House age or age group.
7. How houses were selected: random, problem house, or other?

Recognizing the varied needs of measurement program sponsors, we'd like to know about any studies you have done, are doing, or know about. Please let me know of anyone you have heard might be doing a study that might be relevant.

We plan to do a "meta-analysis" or review. Where necessary, we can use summary data, and can use aggregated data to protect information that might be confidential. Of course, we'd prefer data sets by house. We certainly will credit all sources of data.

Thanks for your interest, and we hope that your contributions will help improve performance of air conditioning systems.

Sincerely,

Harvey M. Sachs, Ph.D.
Buildings Program Director
hsachs@aceee.org

[1] NYSERDA, CEC, FSEC, Wisconsin FoE and ECW, Advanced Energy (NC)

[2] Neme, C., J. Proctor, and S. Nadel. 1999. *Energy Savings Potential from Addressing Residential Air Conditioner and Heat Pump Installation Problems.* Report A-992. . Washington, D.C.: American Council for an Energy-Efficient Economy.

ATTACHMENT 2a

TC 6.3 – Program Plan
June 2005

Meeting	Symposium	Seminar	Forum
Chicago January 2006	Managing Return Air in Residential and Small Commercial Buildings (3 authors - Francisco) **Tuesday 8:00 to 10:00**		A look forward to 2020 for small forced-air H and C systems (Rocky) **Wednesday 10:15 to 11:05**
Quebec City June 2006 program due 2/10/06		*2. Forced Air Heat Pump Systems – Past, Present and Future (Lubliner)*	1. The Role of Forced-Air Systems During Extraordinary Events (Siegel)
Dallas February 2007 papers due 4/7/06 program due 8/4/06	*HVAC System Improvements in Manufactured Housing (Walker)*	*Lessons about Small Forced-Air Systems from Weatherization Programs (Francisco)*	
	Field Degradation of HVAC System Performance (Francisco)	*Design Considerations for Multi-zone Residential Forced-Air Systems (rittelmann)*	*Design Considerations for Multi-zone Residential Forced-Air Systems*
Long Beach June 2007 papers due 9/29/06 program due 2/9/07	*Field Degradation of HVAC System Performance (Francisco)*		*Energy Tax Cedits for Residential HVAC – Is It Working and What Does It Cost?*
New York January 2008 papers due 4/07 program due 8/07		*Forced-Air Distribution Systems in the Conditioned Space (Lubliner)*	

Other Potential Topics:

Seminar or Symposium: Consequences of Oversizing Forced Air Heating and Cooling Systems (Proctor)

Seminar or Symposium: Advanced Air Distribution Systems (Vohra)

HVAC System Improvements in Modular Homes

Results of ARTI Research Projects

ATTACHMENT 2b

TC 6.3 – Past Programs

Meeting	Symposium	Seminar	Forum
Minneapolis June 2000	Field Validation of ASHRAE Standard 152P (Andrews) 21 attendees	Depressurization and Venting Issues for Residences (Hemphill) 44 attendees	Residential HVAC in Cold Climates (Jakob) 11 attendees
Atlanta January 2001		Exploring Alternative Energy Efficiency Factors (Temple) 30 attendees	Residential Cooling and Dehumidification in Hot and Humid Climates (Jakob) 35 attendees
Cincinnati June 2001		Update on Standards for Residential and Light Commercial Central Systems (Haydock) 50 attendees	Experiences with Residential HVAC in HUD-Code Manufactured Homes (Lubliner) 22 attendees
Atlantic City January 2002	Depressurization and Venting Issues for Residences (Jakob) 37 attendees		
Honolulu June 2002		Uncontrolled Airflows in Small Commercial Buildings (Kweller) 50 attendees	
Chicago January 2003	Advances and Issues in Residential Thermal Distribution System Efficiency (5 speakers - Andrews) 35 attendees		What should the "Design of Small Forced Air Systems" Chapter of the Handbook include on Duct Design? (Temple) 7 attendees
Kansas City June 2003	Advances and Issues in Residential Thermal Distribution Efficiency (5 speakers - Temple) 35 attendees	Impacts of Duct Systems on Indoor Air Quality (5 speakers - Siegel) 50 attendees	
Anaheim January 2004	Factors Influencing the Energy Performance of Forced-Air Systems (3 speakers -Lubliner) 60 attendees		
Nashville June 2004	Forced Air Distribution System Performance (5 speakers - Andrews) 60 attendees	Best Choice Cooling System Airflow Rates for Different Climates (5 speakers - Cummings)	
Orlando February 2005		What can ASHRAE Standard 152 Tell Us About Conditioning Our Houses? (4 speakers - Francisco) 20 attendees	
Denver June 2005	HVAC Systems and Performance in Building America Homes (Vohra) 50 attendees	How Should Thermal Distribution Efficacy be Defined? (Rittelmann) 40 attendees	What Often Ignored Factors Affect Performance of Residential Forced-Air Systems (Gaston) 15 attendees

ATTACHMENT 3

RESEARCH TOPIC ACCEPTANCE REQUEST

TC: 6.3 Central Forced-Air Heating and Cooling Systems

Title: Energy Efficiency and Cost Assessment of Humidity Control Options for Residential and Small Commercial Buildings

Research Category: Energy Conservation and Indoor Air Quality
Research Classification: Basic/Applied
TC/TG Priority: 1
Estimated Cost: $150,000
Other Interested TC/TGs: TC 8.11, Unitary and Room Air Conditioners and Heat Pumps
Possible Co-funding Organizations: The National Center for Energy Management and Building Technologies (NCEMBT) in Alexandria, VA
Handbook Chapters to be Affected by Results: Chapters 9, 16, 28, and 45 of HVAC Systems and Equipment, Chapter 1 of HVAC Applications, Chapters 9 and 12 of Fundamentals.

State-of-the-Art (Background): A consensus exists that forced-air cooling systems, as installed in residences and small commercial buildings (about 5000 ft^2 and less), sometimes permit indoor relative humidity to vary outside of an acceptable range. The definition of "acceptable" refers to both thermal comfort and the inhibition of fungi and other biological growths harmful to human health and/or building structural integrity. The load latent heat ratio (LHR) has increased in many applications as the sensible thermal efficiency of buildings has increased (with improved envelopes, windows, lighting, etc.) and ventilation requirements have also increased. Typically, standard DX cooling systems serving residential and small commercial buildings control RH acceptably when operated in full-capacity mode. However, research has found that continuous fan operation degrades latent cooling performance substantially, especially at part-load operations (90+% of the time)[1]. Importantly for residential applications, degradation has also been documented with fan "auto" operation (i.e., when the fan cycles on and off with the compressor)[2,3].

Furthermore, operation at nominal airflow rates (400 cfm per ton) may yield LHR performance that is unable to meet the latent-to-sensible load ratio (LSR) that can occur during hot and humid weather. Proposals to improve the ability of systems to control humidity include use of lower air flow rates, varying of the air flow rate in response to humidistat control, capacity variation to reduce cycling (including two-stage cooling capacity), use of stand-alone dehumidifiers, dehumidifiers integrated into the air distribution system (ADS), various types of reheat (gas, electric, hot-gas), and advanced technology options such as heat pipes, runaround coils, enthalpy exchange enhanced AC operation, condenser sub-cooling, desiccant dehumidification, enthalpy recovery ventilation, conditioning of ventilation air before mixing with return air, and dedicated ventilation air conditioning systems. With new ventilation requirements for residences in ASHRAE Standard 62.2, the importance of controlling ventilation latent load is increased. Except for dehumidifier use, which if used for many hours of the year detracts significantly from a system's overall energy efficiency, none of these choices has penetrated the residential and small commercial marketplace to any significant extent. It is not sufficient to simply identify which approach or technology can achieve humidity control, but rather at what initial cost and energy efficiency. It is important that both the humidity control performance and the energy efficiency of each approach be examined and compared in order to identify the most effective means for efficient and reliable indoor humidity control.

Advancement to the State-of-the-Art: This project will provide an analysis of energy and humidity control performance of various options in hot and humid climates for small buildings (stand-alone residential and small commercial). State-of-the-science building simulation models will be implemented to make the comparative analysis of the effectiveness and efficiency of various systems and approaches.

The models used must have the capability to model the various system types, various airflow rates, variations in airflow rates, dual path recirculation and ventilation air streams, and leakage characteristics of envelope and ADS. Realistic levels of envelope and ADS air leakage will be assumed for the modeling, since uncontrolled air flows often introduce high latent loads that vary with equipment operation. Modeling should, at a minimum, be performed on stand-alone buildings in 5 to 10 cities that represent hot and humid climates.

While simulation models have improved in recent years, gaps remain in the ability to model some systems. Model development will likely be required in several areas, including the part-load performance of dehumidifiers (cycling capacity and efficiency), the control behavior of humidistats, and desiccant enhanced AC. Model development will require limited validation against existing data or tested models. Existing data for air leakage characteristics of small building envelopes and ADS should be collected to reflect realistic infiltration rates from natural and mechanical forces. Modeling should also examine the impacts of compliance with ASHRAE Standard 62.2.

The focus will be on residential applications (but not excluding small commercial) for a range of weather conditions found primarily in hot and humid climates. A variety of approaches and system options will be examined for a range of building load LSRs, that will quantify the humidity levels and energy costs achievable by various systems.

<u>Justification and Value</u>: Currently a joint ASHRAE/ARTI project, *Evaluating the Ability of Unitary Equipment to Maintain Adequate Space Humidity Levels* (1254 RP), is using modeling to assess commercial building applications. The target buildings of that study include a small office, large retail, classroom, restaurant dining, and small hotel. TC6.3, the sponsor of this RTAR, is specifically tasked to examine forced air heating and cooling system issues in small buildings, including residences. While 1254-RP is examining commercial buildings, the work proposed here focuses on residential buildings (and small commercial buildings that operate in a manner similar to residential). Important differences exist between residential and commercial buildings and equipment that make the 1254-RP project different from this RTAR. These include different envelope, internal, and ventilation loads, time-of-day and time-of-week operation schedule, and thermostat fan control (typically “auto” versus “on”). The differences that exist between residential and commercial buildings in just two areas (ventilation requirements and fan operation [continuous versus intermittent]) justify a separate study for residential applications. The importance of this project is that it will provide important information regarding best approaches to residential humidity control. The need exists for a study of humidity control approaches and options in residences that will not only provide valid information but that will have sufficient credibility with major stakeholders (industry, government, researchers) that they will use it in planning their future activities. The content of the Work Statement and the composition of the Project Monitoring Subcommittee will be designed to achieve this.

Project results will benefit the Society. Model development will add to the capability of modeling/simulating part-load operations. Modeling results from various hot and humid locations can be incorporated into ASHRAE handbooks in the form of guidance on system design and selection, and tables that show likely energy and humidity results from various design decisions.

<u>Objective</u>: This project will have three parts; 1) The project team will develop a list of equipment types and system approaches that can provide humidity control in small buildings. 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 weather conditions emphasizing outdoor

dew point temperatures above 65°F (but not excluding dehumidifier use during cooler weather). A range of occupancy loads will be simulated. Results will be normalized to weather conditions.

Applicability to ASHRAE Research Strategic Plan (RSP): This project will contribute to achieving the following RSP goals in residential buildings.

Energy and Resources, Goals 1 and 2. The project will assess opportunities for a wide range of innovative cooling system options to provide improved humidity control in an energy-efficient manner. As residential buildings approach the 50% and 70% energy-reduction design goals, latent-to-sensible cooling load ratios are expected to increase greatly, especially in the hot, humid climates in which new residential construction is increasingly taking place.

Indoor Environmental Quality, Goal 2. The project will aid in the assessment of the degree to which innovative cooling-system designs can provide healthy and comfortable conditions directly related to indoor relative humidity.

Tools and Applications, Goal 6. The information collected in this project will provide a solid theoretical basis for developing and selecting innovative residential cooling systems.

Equipment, Components, and Materials, Goal 1. The project will identify those innovative approaches to simultaneous control of temperature and humidity that are most likely to perform effectively at acceptable cost.

References:

1. Henderson, Hugh. *The Impact of Part Load Air Conditioner Operation on Dehumidification Performance: Validating a Latent Capacity Degradation Model.* IAQ 98, Paper #98-32, February 1998.

2. Shirey Don B. III and Henderson Jr., Hugh I. P.E., *Dehumidification at Part Load.* ASHRAE Journal April 2004,

3. Henderson, H.I., D. Shirey and R. Raustad. 2003. 'Understanding the Dehumidification Performance of Air-Conditioning Equipment at Part-Load Conditions.' Presented at CIBSE/ASHRAE Joint Conference: Sustainability, Value & Profit, Edinburgh, Scotland. 24-26 September.

ATTACHMENT 4

RESEARCH TOPIC ACCEPTANCE REQUEST

TC: 6.3 Central Forced-Air Heating and Cooling Systems

Title: Impact of Operating Variables on the Heating Capacity and Seasonal Efficiency of High-SEER Residential Heat Pumps

Research Category: Energy Conservation
Research Classification: Basic/Applied
TC/TG Priority: TBD
Estimated Cost: $120,000
Other Interested TC/TGs: TC 9.5, TC 8.11 (TBD)
Possible Co-funding Organizations: TBD (USDOE, STAC, NETL)
Handbook Chapters to be Affected by Results: Chapters 8, 9, 16, and 45 of HVAC Systems and Equipment, and Chapter 1 of HVAC Applications

State-of-the-Art (Background): There is evidence[1-7] that the performance of forced-air heating systems with heat pumps, as actually installed with ductwork, controls etc., may differ markedly from what would be expected on the basis of standardized tests of the equipment only, and that these differences are usually in the direction of lower-than-expected efficiency. Factors contributing to these differences include energy losses from duct systems and air handler, inappropriate sizing of equipment, incorrect refrigerant charge, inadequate airflow, and inefficient control strategies that cause resistance backup heat to be used when it is not needed. A detailed field study has been funded by the Northwest Energy Efficiency Alliance (NEEA) to quantify the extent of these problems as they relate specifically to the Pacific Northwest. The NEEA field study collected measurement of indoor coil airflow, refrigerant charge, duct leakage and controls. The NEEA study also funded a preliminary laboratory investigation at the Mechanical Engineering Department at Purdue University to identify the optimal operating performance in the heating mode over a range of refrigerant charge levels, indoor airflows, outdoor operating conditions, and expansion devices, for a typical HSPF 7.0 heat pump. Using field and laboratory data, simulation models are being used to access the impact of installation and equipment factors on heat pump heating mode performance and to identify the optimal operating performance in the heating mode, for standard efficiency heat pumps.

Advancement to the State-of-the-Art: This project will conduct laboratory investigations on at least three heat pumps manufactured in response to higher SEER federal standards. The lab testing will continue to evaluate COP and capacity performance in the heating mode over a range of refrigerant charge levels and indoor airflows at a variety of outdoor operating conditions. The lab data will be instrumental in designing, improving and justifying cost-effective utility programs and help those who rely on heat pump computer simulation models to assess the benefits of requiring field testing of indoor coil air flows and refrigerant charge, as part of their high efficiency heat pump rebate programs throughout the nation.

Justification and Value: The project will expand the state of knowledge related to the impact of airflow and refrigerant charge impacts on the new generation of heat pumps when operating in heating mode. This information can be used to give a more precise picture of the energy-use implications associated with heat pumps field commissioning and/or servicing testing protocols. It is unclear what the heating performance impacts of reduced airflow and/or refrigerant charge at various outdoor temperatures will be associated with the new generation of high efficiency heat pumps that may employ new refrigerants and equipment/component needed to achieve new SEER standards.

This research will also provide needed and credible lab data for ASHRAE members and those who conduct simulation analysis and assess energy performance implications for USEPA Energy Star, USDOE Building America and PATH, and other residential programs that utilize energy-efficient heat pumps. The proposed research will help provide useful education and outreach support to ASHRAE Guideline/Standards related to commissioning of air-source residential and small commercial heat pump systems. The research will provide useful information for the HVAC Systems and Equipment Handbook chapters 8 & 9, and support Energy Star, USDOE Building America and LEEDs energy efficiency programs.

<u>Objective</u>: Acquire laboratory test results required for computer modeling to assess the relative importance of various energy performance issues affecting heat pumps in the heating mode, such as indoor coil airflow and refrigerant charge at various outdoor temperatures. Publish these lab results in ASHRAE Transaction in a useful format for those stakeholders involved with promoting heat pump performance and commissioning in heating climates.

<u>Applicability to ASHRAE Research Strategic Plan (RSP)</u>: This project will contribute to achieving the following RSP goals in residential buildings.

Energy and Resources, Goals 1 and 2. The project will assess the degree to which off-design values for major operating variables will detract from the intended improvements of advanced heat-pump designs. Unintended negative impacts on efficiency of equipment and systems cannot be tolerated if the energy-efficiency goals are to be met.

Indoor Environmental Quality, Goal 2. The project will aid in the assessment of the degree to which off-design operating conditions will impact residential thermal comfort.

Tools and Applications, Goal 6. The information collected in this project will provide a solid experimental basis for developing selection and sizing guidelines for high-efficiency residential heat-pump systems.

Equipment, Components, and Materials, Goal 1. It is important to identify those operating variables that are most critical to the efficient, reliable, and comfort-providing operation of residential heat-pump systems, so that manufacturers and installers can appropriately focus their attention on those that have the greatest impact on performance.

References:

1. Francisco, P.W., D. Baylon, B. Davis, and L. Palmiter 2004. Heat Pump Performance in Northern Climates. ASHRAE Transactions, Vol. 110, Pt. 1.
2. Parker, D. Fairy, P. Climate Impacts on Heating Season Seasonal Performance Factors and Seasonal Energy Efficiency Ratios for Air Source Heat Pumps - Poster session?
3. Gu, Lixing, Muthusamy, Swami, Fairy, P. 2003. System Interaction in Forced-Air Thermal Distribution Systems: Part 1 – Equipment Efficiency Factors. ASHRAE, Transactions, CH-03-07
4. Bullock, C 1978. Energy Savings through setback with residential heat-pumps. ASHRAE Transaction 84(2):352-363
5. Bouchelle, M. Parker D. 2000. Factors influencing space heat and heat pump efficiency from a large scale residential monitoring project. Proceedings of 2000 Summer Study on Energy Efficient Buildings, ACEEE
6. Palmiter, L. Purdue Heat Pump Lab Testing Results. Presentation made TC 6.3 at ASHRAE TC 6.3 Research sub-committee meeting in Denver June 2005.
7. Lubliner, M. Andrews, J. Baylon D. Heating with Residential Heat Pumps, ASHRAE Journal Oct. 2005

ATTACHMENT 5