Discussions for the Technical Papers from the 2016 ASHRAE Annual Conference in St. Louis, Missouri

This is a compilation of the written questions and comments submitted to authors by attendees at the 2016 ASHRAE Annual Conference in St. Louis, Missouri. All authors were given the opportunity to respond.

The questions/comments and authors' responses are published with the papers in the hardbound volume of *ASHRAE Transactions*, Vol. 122, Part 2.

ST-16-006

Evaluation of Refrigerant Mixtures in Three Different Cold-Climate Residential Air-Source Heat Pumps

A. Hakkaki-Fard, PhD **Z. Aidoun, PhD** **P. Eslami-Nejad, PhD**

Georgi Kazachki, Director HVACR Advanced Technology, Dayton Phoenix Group, Dayton, OH: 1) Why didn't you include R-32 in the analysis? 2) How do you plan to control the composition of R-32/CO2 in the system (i.e., how do you plan to control the boiler/rectifier)?

Ali Hakkaki-Fard: 1) R-32 is flammable (group A2) and can therefore not be used alone as a refrigerant in residential applications. Moreover, according to Hakkaki-Fard et al. (2015) it is shown that by decreasing the percentage of R-32 in the mixture of R-32/CO2, the heating capacity of the mixture decreases. Therefore, the R-32/CO2 mixture has much better performance than R-32 for cold-climate heat pumps studied in this article.

2) The technical design of a system with variable mixture control is not the goal of this study at the current stage of research. However, according to Hakkaki-Fard et al. (2015), Figure 1 schematically presents such a system, as proposed by Halm et al. (1999). In short, the variable mixture control system is integrated between the evaporator and the compressor and is composed of two accumulators, a heater and a rectifying column. When an increase in the capacity of the heat pump is required, the expansion valve opens and the accumulator above the rectifying column is partially filled with liquid refrigerant. This refrigerant flows to the low accumulator and enriches the lower boiling component flowing to the compressor and, hence, the system capacity increases. When a decrease in the capacity is required, the low accumulator is heated and the higher boiling component in the cycle is enriched.

ST-16-007 (RP-1665)

Examination of the Reactions of R-40 with R-134a and POE Refrigeration System Materials

Stephen Kujak
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Edward M. Hamilton
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Rosine Rohatgi, Co-owner/President of Spauchus Associates, Inc., Clyde, NC: What caused the explosions with R-40?

Stephen Kujak: A complete understanding of what led to the explosion is not known since no forensic investigation has been published around the events. Servicing of the unit was underway in each of the events, so some combination of servicing actions and the reactivity of the trimethylaluminium (TMA) pyrophoric being exposed to air led to the explosion, an overpressure event occurring from the breakdown product driven by the reactivity of the R-40, or some other combination of reactive by-products of the R-40 led to compromising the pressure rating of the equipment, which led to a sudden release of reactive materials, and then the TMA reacted with air that led to the outcome.

ST-16-017

Performance Analysis of a Ground-Source Heat Pump System Using Mine Water as Heat Sink and Source

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Jack L. Skinner, PhD, PE

Donald M. Blackketter, PhD, PE

Jeffrey D. Spitler, Professor, Oklahoma State University, Stillwater, OK: The mine water temperature is quite a bit higher than the expected undisturbed ground temperature. What is the reason for this?

Xiaobing Liu: The mine water temperature was measured on site. According to a study conducted by Hagan (2015), water in the studied mine shafts is thermally well mixed, and the measured mine water temperature is 27°C at both 100 and 400 m below the surface. The observed geothermal gradient is 22.5°C/km at the site. Given that the depth of one of the mine shafts is 1 km and the mines are connected underground, it is believed that the 27°C mine water temperature is the result of the geothermal gradient and the mixing of water due to the convection driven by the temperature difference at the top and bottom of the shaft.

Hagan, T. 2015. Temperature and pressure sensing in three flooded underground mine workings in Butte, Montana, USA. Graduate theses and non-theses, Paper 21, Montana Tech, Butte, MT.

ST-16-019 (RP-1561)

Mesoscale Climate Modeling Procedure Development and Performance Evaluation

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Fuquan Yang, PhD

Michael Case, Program Manager, U.S. Army ERDC CERL, Champaign, IL: 1) Were TMY3 files generated for the WRF data presented? 2) Were future climate change scenarios studied?

Xin Qiu: 1) Yes. WRF data can be used to generate site-specific TMY3 data, as long as the study site is in the modeling domain. We suggest using minimum 8-year WRF model data, and longer is better. 2) No, this project only dealt with historical climate. However, the model has capability to simulate future climate scenarios.

ST-16-023

Modeling Airflow through a Perforated Duct

Jesse Maddren, PhD, PE
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John Farrell

Alan Fields

Cesar Jarquin

Albert Black, Senior Engineer, McClure Engineering, St. Louis, MO: It appears that you inferred initial flow from successive velocity traverses. Why did you not meter the flow leaving the fan?

Jesse Maddren: We didn't meter the flow through the fan because we didn't have an apparatus that was capable of measuring volumetric flow rate with sufficient accuracy.

Matthew Boss, Sales Manager, L.R. Gorrell Co., Raleigh, NC: Did you collect data on the angle α of V_o as a function of distance down the duct? This would be valuable in application of perforated duct systems.

Maddren: No, we didn't measure the discharge angle from the perforated duct. The discharge angle can be calculated using the equations presented in the paper.

Kevin Gebke, New Product Development Engineer, DuctSox, Peosta, IA: Customer application? Angle of airflow?

Maddren: The work was conducted in support of a mechanical contractor that was interested in using a perforated duct system for a sound stage. In this application, they wanted to deliver large amounts of air due to the high heat gain but also maintain low air velocities and minimize noise. As mentioned in the previous response, we didn't measure the discharge angle.

Mike Monroe, Senior Engineer—Algorithms, Emerson Climate Technologies, Sidney, OH: What is envisioned use case?

Maddren: Quiet cooling on a concert stage.

ST-16-024

Low Evaporator Airflow Detection Using Fan Power for Rooftop Units

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Steve Liescheidt, Engineer, SPPECSS Consulting LLC, St. Louis, MO: How was the building "power factor" taken into account in the building of the text?

Yunhua Li: We measured actual power, not amps; therefore, this was not a factor. The power is directly measured by VFD.

Gang Wang, Assistant Professor, University of Miami, Coral Gables, FL: 1) How did you convert the VFD power ratio to the fan power ratio? 2) How did you consider the motor efficiency?

Li: 1) When both the fan and the compressor are running, the VFD power is the sum of fan power and compressor power. When the compressor is off, the VFD power is the fan power only. There is no need to convert the VFD total power ratio to the fan power ratio because the baseline at each mode are different. The fan power ratio is used in heating mode and free cooling mode. The total power ratio is used in mechanical cooling mode.

2) In fan mode, the motor efficiency is assumed to be the same at the minimum fan speed operation. So, we use VFD output power to estimate the fan power. At other modes, the motor efficiency at different speeds is calculated using the equation provided (by reference shown in context).

ST-16-025

Characterizing the Performance of Fixed-Airflow Series Fan-Powered Terminal Units Using a Mass and Energy Balance Approach

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Matthew Boss, Sales Manager, L.R. Gorrell Co., Raleigh, NC: Confirm that the power usage of PSC motors was essentially constant over range of airflow at 0.372 W/cfm.

Dennis L. O'Neal: We looked at PSC motors from three manufacturers in the *ASHRAE Transactions* paper "Modeling Fan-Powered Terminal Unit Fan/Motor Combinations Controlled by Silicon Controlled Rectifiers" (AT-15-028). For voltages above about 160 V, the PSC fan motor power usage was relatively flat at an average value of 0.372 W/cfm for units ranging from 1/8 to 1 hp. There was scatter in the data, which could be expected because of the different designs from different manufacturers.

Louis Starr, Engineer, Northwest Energy Efficiency Alliance, Portland, OR: 1) Does the modeling you did for PSC motors include part-load operation of motors? 2) Does oversizing fan-powered boxes result in lack of control of airflow at low airflows?

O'Neal: 1) The part-load modeling for this paper only included ECMs. The PSC motors we evaluated had an average 0.372 W/cfm, which was relatively constant for SCR voltages down to about 160 V.

2) The scope of this study did not look at "lack of control" at low airflows for the ECMs. However, what I remember from our discussions with the manufacturers who provided data to us was that they typically didn't like to see the speed of the ECMs go below about 20% of the maximum setting on the controller. I would expect an engineer to follow the manufacturer's recommendation on minimum speed (or airflow) from the fan/motor combination, which would limit how much oversizing could be done with an ECM FPTU.