Discussions for the Technical Papers from the 2014 ASHRAE Annual Conference in Seattle, Washington

This is a compilation of the written questions and comments submitted to authors by attendees at the 2014 ASHRAE Annual Conference in Seattle, Washington. 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. 120, Part 2.

Engineering and Economic Analysis of Air Conditioners in the Kingdom of Saudi Arabia— Upgrading the Minimum Energy Performance Standards

John Proctor, PE
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Hugh Henderson, Principal, CDH Energy Corporation, Cazenovia, NY: Is the cyclic test you proposed an addition to the ISO standard or just an addendum to the KSA procedure?

John Proctor: We proposed that a cyclic test be developed that used indoor conditions similar to those found in housing rather than the very low (dry coil) test used in establishing SEER. If a cyclic test were developed, it could be implemented independently in the Kingdom of Saudi Arabia or as an addition in other standards such as ISO.

Generalized Performance Maps for Single- and Dual-Speed Residential Heat Pumps

Simbarashe Nyika
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Kelly Kissock, Professor, University of Dayton, Dayton, OH: How much do your results vary with other manufacturers?

Simbarashe Nyika: We cannot say for sure how our results compare with heat pumps from other manufacturers in the industry as we did not have access to this level of detailed data from other suppliers. However, we anticipate the difference is small. We consulted the recent study by NREL (Cutler et al. 2012) of 260 cooling-only and 200 reversible ducted heat pumps rated between SEER 13 and SEER 21 based on manufacturer performance tables and found that it was possible to use a single model to describe the performance of heat pumps from various manufacturers with the same SEER rating.

Cutler, D., J. Winkler, N. Kruis, and C. Christensen. 2012. *Improved modeling of residential air conditioners and heat pumps for energy calculations*. Report NREL/TP-5500-56354. Golden, CO: National Renewable Energy Laboratory. www.nrel.gov/docs/fy13osti/56354.pdf.

Hugh Henderson, Principal, CDH Energy Corporation, Cazenovia, NY: Your comparison to the ASHRAE secondary toolkit using the 1982 coefficient was not the best baseline. I would suggest using the EnergyPlus DX coil coefficient, which has been updated.

Simbarashe Nyika: At the time of writing the paper, the EnergyPlus Engineering Reference guide (DOE 2014) referenced the 1993 ASHRAE toolkit, which in turn references the 1982 coefficients. As of July 21, 2014, the EnergyPlus reference guide still shows the same information. The engineering reference did not list any default coefficients and asks for these as input from the user.

DOE. 2014. *EnergyPlus Engineering Reference*. Washington, DC: U.S. Department of Energy. http://apps1.eere.energy.gov/buildings/energyplus/pdfs/engineeringreference.pdf.

Generalized Performance Maps for Variable-Speed, Ducted, Residential Heat Pumps

Simbarashe Nyika   **Seth O. Holloway**   **W. Travis Horton, PhD**   **James E. Braun, PhD, PE**
                       Associate Member ASHRAE   *Member ASHRAE*   *Fellow ASHRAE*

Kelly Kissock, Professor, University of Dayton, Dayton, OH: If these models are steady state, they don't include cycling losses. Thus, is it true that these models overpredict performance for units in real applications with cycling?

Simbarashe Nyika: Yes, this is true. When using these models in a building simulation, it is necessary to account for the cyclic losses at low-load conditions. There are several schemes available in the literature to account for the efficiency degradation from cycling, such as applying a cyclic degradation coefficient based on run fraction. These models are still useful for a large range of operation conditions and can be modified for the extremely low-load operation using one of the available cyclic degradation schemes for energy use and dehumidification performance.

Since this paper covers variable-speed heat pumps, extended periods of cyclic operation are less frequent than for fixed-speed units. The model is applicable down to minimum part-load ration of 0.21 in heating operation and 0.31 in cooling operation, which covers the majority of operation in many residential applications, especially when the equipment is properly sized.

Temperature Trends for Locations Listed in the Tables of Climatic Design Conditions in the 2013 *ASHRAE Handbook—Fundamentals*

Didier Thevenard, PhD, PEng   **Mark W. Shephard**
Member ASHRAE

David Claridge, Professor, Texas A&M University, College Station, TX: Please restate the time period used for making these determinations.

Didier Thevenard: The time period used in this study is the same that was used for the calculation of climatic design conditions in the 2013 *ASHRAE Handbook—Fundamentals*.

For most stations it is the 1986–2010 period, although about 200 hundred stations used the 1982–2006 period. It should also be noted that many sites did not have data for all years within these time frames; some stations had as little as eight years of data.

Evaluation of the Thermal Performance of Two Nonstandard Borehole Configurations

Parham Eslami-nejad, PhD

Michel Bernier, PhD, PE
Member ASHRAE

Odile Cauret, PhD

José Acuña, Research Engineer, KTH Royal Institute of Technology, Stockholm, Sweden: Would there be differences in your conclusion for short-term performance? What are the effects of the large temperature differences, i.e., 5 to 7 K? How did you choose the combination flow rate versus depth?

Michel Bernier: This study shows the potential system performance improvement using the two proposed borehole configurations. This work is based on the assumption of a steady-state condition. Therefore, we cannot conclude on the short-term transient performance. Many factors are involved in the evaluation of the short-term performance of such boreholes. For example, the operating period or how often the system is working determine how significant transient effects affect the short-term performance. Perhaps, the next step for us would be to improve the model and evaluate the system operation under real operating conditions.

The temperature difference is not that large, and it is in the range encountered in typical systems. Furthermore, comparing the thermal resistance per unit borehole length of the new configuration against the conventional one can give a good idea of the superior performance of the new configurations.

The selected borehole length and flow rate correspond to typical conditions.

Chuck Gaston, Assistant Professor, Penn State University–York, York, PA: Have you considered unequal cross sections? If the upward path has a smaller cross section, it would have less time for interaction with the downward flow, and the downward flow would have more time for interaction with the earth.

Michel Bernier: Good point. However, we haven't modeled unequal cross sections. It would certainly be worth trying to achieve an optimum design for new configurations.

Effects of Unequal Borehole Spacing on the Required Borehole Length

Massimo Cimmino
Student Member ASHRAE

Michel Bernier, PhD, PEng
Member ASHRAE

José Acuña, Research Engineer, KTH Royal Institute of Technology, Stockholm, Sweden: Would the results be different for other load profiles? How dependent is the result on the load profile? Can you say something about the optimum borehole distance for a balanced load profile?

Massimo Cimmino: The results are mostly dependent on the average annual load imbalance. The variations in total required borehelole length increase for greater annual load imbalances. The optimum borehole distance for balanced load profiles was not studied.

Quality Control Assessment of Vertical Ground Heat Exchangers

Jasmin Raymond, PGeo, PhD
Associate Member ASHRAE

Louis Lamarche, PE, PhD

Marc-André Blais, PE

Stephen Hamstra, President, Greensleeves LLC, Zeeland, MI: Have you considered a similar methodology to confirm quality control for projects that are in operation and cannot be taken off line?

Jasmin Raymond: No. It would be very interesting to perform similar tests on an entire GHE field, but it would be much more complex and should involve selection of the appropriate *g*-function to model the thermal response of the whole system. Performing appropriate flow rate and temperature measurements for the whole system would additionally be challenging.

Michel Bernier, Professor, Polytechnique Montreal, Montreal, QC, Canada: When you compared your models with your experiments, did you assume that the U-tube was perfectly placed in the borehole? In other words, is pipe placement in the borehole responsible for part of the discrepancy between your results?

Jasmin Raymond: Yes, it was assumed that the pipes are centered in the borehole. The effect of pipe placement on the borehole thermal resistance could be determined with the multipole model or with numerical simulations if that is of interest.

José Acuña, Research Engineer, KTH Royal Institute of Technology, Stockholm, Sweden: What is the error that the pumping power adds to your analysis during heat recovery? Why did you decide to use the *p*-linear approach?

Jasmin Raymond: Heat transferred to the pipe fluid during the tests was considered for the analysis of recovery data. Both *p*-linear and arithmetic average methods were used as they are commonly used by practitioners for analysis of TRT. The idea behind this research was not to find the best method but to evidence limitations belonging to each method.

Installation and Results of Variable-Frequency Drives at a Mid-Sized Power Generation Facility

Scott A. Achelpohl, PE

Jeffrey A. Green
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James A. Mathias, PhD, PE
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Philip Farese, Vice President of Product Development, Advantix Systems, Sunrise, FL: Did you need to address harmonics in your mounting structure when varying motor operation with your VFD?

Scott A. Achelpohl: The harmonics were not examined in relation to the specific interaction with the mounting structure. The motors and fans in this case are structurally isolated from the main boiler supports, being placed on concrete pedestals at ground level. Had the equipment been located on the main structure, then the harmonics of the support structure would have required examination. The fans and motors were put through a harmonic vibration check to determine if any speeds needed to be locked out of the system between 1800 and 3600 rpm (VFD frequency between 30 and 60 Hz). Having found no observable increase in vibration, that ended our examination.

Analyzing the Effects of Airflow Disturbances on Measurement and Control Equipment Positioned Downstream and Close to an Air Duct Elbow— For the Purpose of Optimizing System Performance Using a CFD Technique

Ali M. Hasan, CEng
Member ASHRAE

Reza Ghias, Senior CFD Analyst, Southland Industries, Rockville, MD: What was the validation criteria for CFD? What was the Re number impact on this study?

Ali Hasan: It was suggested in the paper that experimental work should be conducted. Experimental work is a way of verifying CFD analysis.

In general, CFD analysis can be relied on provided the following items are correctly arranged:

- model mesh
- boundary conditions
- turbulence model
- solver settings

Re number was not looked into since the aim was just stabilization of streamlines.

However, what can happen with Re is as follows:

$$\text{Re} = \frac{\text{density} \times \text{velocity} \times \text{hydraulic diameter of duct}}{\text{dynamic viscosity}}$$

The Re number, as the equation shows, is in fact the ratio of inertial forces to viscous forces. In high Re values, inertial forces dominate, and with low Re numbers, viscous forces dominate.

Parameters such as velocity and hydraulic diameter are user defined, whereas fluid density and dynamic viscosity are fluid specific but are programmed in the software package; however, to fix these values, fluid temperature must be entered. What is also interesting in the above equation is that the fluid temperature impacts the inertial and the viscous parts of the equation, even though temperature is not mentioned in the equation.

The Re numbers will be higher in the highly disturbed region when compared with the substantially stabilized airflow region.