



Dan Int-Hout

You Have to Prove It

BY DAN INT-HOUT, FELLOW ASHRAE

Today's computers operate at tremendously high speeds, which makes it ever more possible to perform complex calculations for estimating a building's performance. Increased demand and availability of these powerful tools have stemmed from the need to calculate room air motion, predict acoustics, predict energy savings, show compliance to codes and standards, and/or gain points for LEED, Energy Star, or other rating systems.

While the effort is not without merit, the lack of validation of the equations and constants used in these complex calculations may generate unrealistic conclusions. For this reason, it is essential that these calculations be validated. Failure to do so may result in more expensive designs that fail to show the energy savings that engineers once touted during the design phase.

Some validations, such as computational fluid dynamics (CFD) calculations for room air motion and pollutant transport, have been prepared for many years and are relatively easy to model. ASHRAE TC 4.10, Indoor Environmental Calculations, has been responsible for a number of research projects that have defined such methods. The most notable was the work of Baker and Kelso¹ in 1990 on CFD and room air motion, who laid much of the early groundwork.

Later, in a study by Chen² in 2009, a procedure for verification of CFD analysis was developed, which showed it was possible to accurately predict the performance of displacement ventilation systems. Essam Khalil, in Cairo,³ performed both CFD and physical measurements in a hospital operating room, proving that there was an excellent correlation between calculations and physical measurements.

It is, however, more difficult to model the air currents resulting from complex mix of convective, radiative, and conductive heat flows in a typical office with high induction air outlets. In fact, through Internet research we performed, we found very little data that draws a parallel between CFD and physical measurements in these situations. What has been accomplished is defining the means by which these highly variable air currents are to be measured. ASHRAE Standard 113, which

was developed early in the 1980s, along with accurate omnidirectional low air speed anemometers and sensitive temperature probes, provides for a relatively easy method (although not inexpensive) to measure room air currents and temperatures.

Both powerful spreadsheets and laboratory instrumentation allow visualization of the data gathered using Standard 113. Air Diffusion Performance Index (ADPI) "draft temperature" measurements can be plotted in color to give a quick visual performance analysis. *Figure 1* is a plot of draft temperatures for a typical office diffuser in cooling mode, 1 cfm/ft².

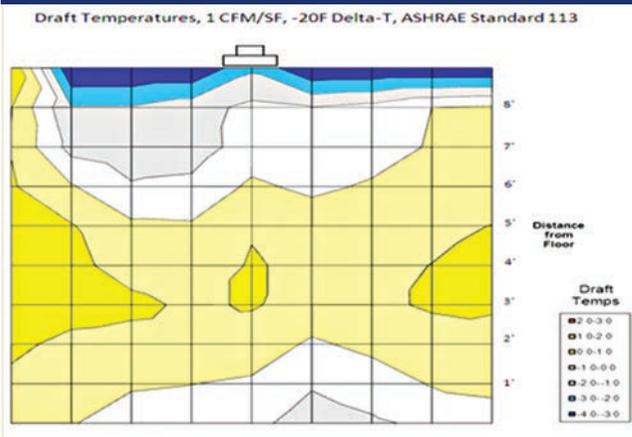
Using the latest generation laboratory instrumentation, one can plot measurements of air jets quickly and easily. *Figure 2* shows a plot of an air nozzle in a large space.

The advantage of taking measurements over performing calculations is that there is no question of the methodology used.

Acoustics has long been a "mystery," given the complex equations involved to predict sound levels in spaces. AHRI has taken available ASHRAE tables and equations, as well as data obtained from manufacturers and a joint AHRI/ASHRAE study (RP755), and incorporated them into an acoustical application standard, AHRI 885, *Standard for Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets*. Included is a spreadsheet that incorporates the most common elements and provides calculations for both sound discharged from ducted devices as well as sound radiated from ducts and connections.

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FIGURE 1 Draft temperature plot.



LEED V4, to be released soon, will require that sound levels in classrooms from HVAC equipment not exceed 40 dBA. This can be demonstrated by using either the ASHRAE Handbook or AHRI 885. Standard 885 requires that sound power determined from standards such as AHRI 880 (air terminals) or AHRI 260 (other mechanical equipment types) be used as input values to the calculation of room sound pressure.

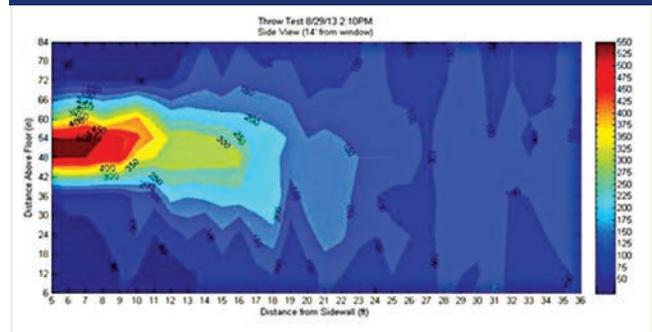
The AHRI 885 calculations can be applied with confidence, as they have been used and validated for more than 25 years. Even better, validation of acoustics can be easily accomplished using one of the many available apps for smart phones. If acousticians or engineers fail to do this validation, one can be assured occupants in a noisy environment will!

Up until recently, energy calculations have not provided well-documented validations. In fact, manufacturers of fan-powered VAV terminals have learned that none of the available building energy calculators have been able to accurately predict the product's effect on system or building performance. This is, in large part, due to the many variables that have not been taken into account, such as the unit type (series or parallel), the application, or the components within (a new EC motor). To address this, researchers at Texas A&M performed a study, which was jointly sponsored by ASHRAE and AHRI, and later by a consortium of manufacturers, where they developed both data and models that define these effects.

Several programs are used by engineers to calculate HVAC energy use, which are available from the federal government as well as several manufacturers. The challenge now is for the program suppliers to incorporate these proven models into their calculations to better predict HVAC energy use.

Armed with the tools to do these calculations, the task at hand is to make sure the outputs accurately reflect reality.

FIGURE 2 Jet velocity plot.



Only then can we begin to believe the claims of room air motion, acoustics, and energy savings we see in designs.

References

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2. Zhang, Tengfei (Tim), Kisup Lee, and Q. Chen. 2009. "A simplified approach to describe complex diffusers in displacement ventilation for CFD simulations." *Indoor Air* 19(3):255-267.
3. Kameel, R., E.E. Khalil. 2002. *Computer-Aided Design Flow Regimes in Air-Conditioned Operating Theatres*. Cairo Univ, Giza, Egypt. ■

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