Four Examples of 'Lost Science'

Those Who Forget the Past

Editor's Note: Forum columns are invited commentary. Letters with differing perspectives are welcome. To suggest a topic or submit a letter, contact Fred Turner at 404-636-8400 or fturner@ashrae.org.

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As the engineering community designs building HVAC systems, it is assumed that we are employing the lessons of experience and good science. This knowledge mainly exists in codes and ASHRAE handbooks, standards and guidelines.

It has become apparent that much of the knowledge, which has been accumulated at great expense and often from painful experience, is not being used.

Keeping abreast of all the new ideas and codes is a full-time job for the designer. This becomes nearly impossible when regulations that were imposed to solve problems and were subsequently proven to be either ineffective or counterproductive are being reissued by a new generation of politicians who are apparently unaware of the failure of these past regulations.

As manufacturers of HVAC equipment, we often see specifications for products that we know cannot provide acceptable environments. We have three real-time choices when we are presented with these specifications:

1. We can provide products that we know, based on research and past history, will cause problems in the future.
2. We can contact the engineer and attempt to get the specifications revised. (It is tricky, of course, explaining to an engineer that his design is flawed.)
3. We can choose not to bid on these projects, knowing that someone else will most likely select Option 1.

A fourth option is to see as many design professionals as possible, explaining the current state-of-the-art, through lunch-and-learn sessions, technical development seminars, and one-on-one meetings with key engineering personnel to keep this from happening in the future.

The following are examples of apparent "lost science."

Overhead Heating

Issue: Heating perimeter zones from the ceiling became possible when perimeter glass became better, and in response to needs for better space utilization along the glass. A number of technical papers presented in the late 70s defined the parameters of this design, and established a repeatable method of test for evaluation of these spaces (ASHRAE Standard 113, *Method of Testing for Room Air Diffusion*). The *ASHRAE Handbook—Fundamentals*, Chapter 31 incorporated these results in the early 80s, and overhead heating became a "standard" method of heating perimeter zones.

Observation: Today we see a surprising number of designs that are obviously established in the absence of an understanding of these studies. This is evidenced by the cfm and kW settings specified on VAV terminals as well as discharge temperature requirements for small package units. Discharging low velocity, highly heated air at the ceiling may work in residential applications with low returns, but it will ensure highly stratified, poorly ventilated spaces with uncomfortable occupants in commercial applications with overhead returns. One of the authors has recently polled more than 2,000 consulting engineers regarding awareness of the overhead heating "rules." Almost none were aware of the ASHRAE design limitations.

Discussion: Since 1983, the *ASHRAE Handbook—Fundamentals* has provided specific guidance on the maximum room discharge temperature difference (not to exceed 15°F [8°C]) for effective control of the perimeter environment. In fact, the authors and others have conducted several hundred tests of perimeter designs in full-scale mock-ups, all confirming the ASHRAE guidelines.

Temperature Regulations

Issue: Imposed by President Carter in the late 70's, the Emergency Building Temperature Regulations (EBTR) established 68°F (20°C) heating and 78°F (26°C) cooling setpoint in federal buildings in response to the Arab oil embargo. These regulations found their way, in various forms, into other state, local, and corporate codes, regulations and guidelines.

Observation: Several studies and many observations have all confirmed that energy consumption often increases when these arbitrary setpoints are enforced. While the negative effect on productivity cannot be measured, it is obvious. It is rumored that the U.S. General Services Administration (GSA) actually had a study confirming this increase in energy use (one of the authors saw a draft of the study), but it was never made public. In response to the current energy crisis in California, the EBTR has again been imposed on federal buildings there.

Discussion: Calculations show that with a few climatic exceptions, the maximum savings is on the order of 1% per 1°F (0.6°C) setpoint modification for the HVAC system. The discomfort created by this causes occupants to add their own

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measures, such as fans or heaters. When system conflicts result, the actual effect is to increase the energy consumption of the building. One should remember that a cooling fan is a 100% energy-to-heat converter, which adds to the interior load to be sent to the cooling system. In one building investigated in the early 80s, the occupants had installed 1.5 w/ft^2 (16.2 W/m^2) of fans to offset the 80°F (27°C) space temperature that resulted from the 78°F (26°C) setpoints. Buildings with constant volume reheat systems, such as the library at the University of Richmond, used more gas for heating in July than in January. Humidity levels in schools can be significantly increased, resulting in better breeding grounds for mold and mildew.

The Open Plan Office

Issue: The open plan office became a reality in the 1970s. A number of parameters were investigated and, usually, understood as design parameters. Basically, the overall design produces well-mixed air distribution and a measure of speech privacy. Many researchers conducted studies on both thermal parameters and IAQ/ventilation mixing measures and showed that with properly selected and located ceiling diffusers, using air diffusion performance index measures, high levels of comfort and excellent ventilation mixing are expected. Acoustical privacy often required background sound-masking systems along with high quality ceiling tiles and partitions.

Observation: We and other VAV and GRD manufacturers observe that diffusers are often being selected without regard to the effect of VAV turn down on diffuser performance, noise generation. We also recognize an unfounded concern over the performance of air-distribution systems in conjunction with partitions. The consequence is that occupants complain of “stuffiness,” which is most often a thermal comfort issue and not an air quality problem, and is usually a result of poor delivery of cool HVAC air to the occupant’s location. It may result in selection of expensive, but probably unnecessary, alternate designs such as individual task air conditioning to solve this non-problem.

Discussion: Several papers have been presented on the proper selection of diffusers. In at least one case, all the diffusers on a project were replaced with ones meeting the ASHRAE requirements (at the design engineer’s expense). The overall cost difference between a properly performing diffuser and a lower cost (non-performing) alternate is small in the scope of the whole building, but significant to the supplying contractor. Diffusers that make a little noise (NC-40) at full flow in a VAV system do not detract from open plan speech privacy, and often work best when selected at this performance level. In the 80s and 90s, the personal computer was often a major source of background noise in a cubicle, and with the increase of laptops as the main computer for many “mobile” workers, this source of “good” noise is often significantly missing. This makes the diffuser generated noise even more important to the acoustical design.

Acoustical Specifications

Issue: Specification of acoustical parameters is an important issue in the selection of VAV terminals. Certified octave band sound power data has been available since the 80s through Air-Conditioning and Refrigeration Institute (ARI) Standard 880, *Air Terminals,* originally released in 1981 (updated in 1991, 1994 and 1998). Following ARI-880, an application standard, ARI Standard 885-1998, *Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets*, was developed and released in 1990. This standard provides accepted methods of determining the path attenuation factors for estimating and specifying sound levels, both in the room (typically as NC), and at the source (as octave band sound power).

Observation: In the consulting engineer poll mentioned above, the engineers were questioned regarding awareness of the ARI 885 standard. Of those polled, only five actually had copies of the standard, which is available at no cost from the ARI website (www.ARI.org/std). Even today, specifications are frequently received requiring tests to the ADC test code (obsoleted in 1984 in favor of the ARI standard) or worse, to ASHRAE Standard 36B, which was obsoleted in 1972. Often, these specifications require a set room NC level based on one of the above obsolete test codes with no guidance on the acoustical assumptions to be employed in the analysis. These specifications often omit significant variables such as design inlet static pressure, which is critical to any analysis. Other specifications simply contain a favored manufacturer’s published NC levels, which may be based on nothing that is specific to the design.

Discussion: When no guidance is given, the supplier has the option of selecting whatever application factors favor his selection. As the engineer has probably been burned in the past with this approach, products are often specified at much lower sound levels than necessary. This results in oversizing units and/or adding unnecessary silencers, which results in poor operation, poor ventilation, excessive energy use and shortened motor life. Sound power should be used to compare products, and each octave band should be reviewed within the design parameters to ensure the desired outcome.

Summary

As an industry, we have conducted significant research into the proper way to apply systems to buildings to maintain energy efficiency, first costs, comfort and productivity. These lessons have apparently been lost on many in the design community, as well as the agencies and politicians affecting the operation of buildings. The information is available, often in the ASHRAE handbooks, and certainly in the body of ASHRAE-sponsored research. Manufacturers are being asked to provide products that we know will not perform when installed. Due to competitive pressures, we often have no choice but to meet the flawed specifications with products that will cause discomfort when applied as specified. Setting uncomfortable temperatures has repeatedly been shown to create reduced productivity and often actually increase energy consumption as occupants try to maintain their comfort levels, causing the systems to be operated in ways contrary to both their design and good sense. History has shown how to do it right. All we have to do is look back.