Case study: breaking the HVAC sound barrier in California schools

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The ability to hear properly, especially in preschool and elementary school classrooms, is one of the most important factors in a child's ability to process and learn new information.

But according to the Institute for Enhanced Classroom Learning, children in today's classrooms have difficulty understanding 20% to 30% of what their teachers say because of excessive ambient background noise, reverberation, and a poor signal to noise ratio (SNR). Current solutions to the problem of classroom hearing, and the related technology associated with these solutions, often suggest using classroom amplification equipment to solve ambient noise problems. And while this approach can help it is not the preferred approach according to a position statement by the Acoustical Society of America.
Ambient noise can include the students themselves, ceiling fans, hallway noise, the hum of lights and computers, outside lawn mowers, and HVAC equipment. The SNR is the most important consideration within a classroom's acoustical environment. Reverberation, the echoing of sounds off the walls in a room, is also relevant but can be compensated for—and for a relatively low cost—with minor environmental or structural changes if overall ambient noise levels can be reduced.

In the case of a classroom environment, SNR is basically how much louder the teacher's voice is above other noises within the room. In a classroom environment the teacher is the S, or signal, in SNR. And if the teacher's voice is at 65 decibels (dBA), a normal level for speaking, and all other background noises (students, HVAC systems, mowers, outside traffic noises, etc.) are at 55 dBA, the SNR is 10 dBA. The higher the SNR, the better the learning environment for children. Ambient noise and reverberation affect SNR. Increased ambient noise, including HVAC equipment, will lower the overall SNR making it harder to hear, teach and learn.

In any environment, children with normal hearing require an SNR of +15 dBA. Therefore a teacher must speak at least 15 dBA louder than the ambient noise in the classroom in order for students to fully understand what is being taught.

In the example mentioned above, it means that the teacher would have to talk very loudly at a 70 dBA level in order to be heard by the students. Speaking at this decibel level is a common source of voice fatigue for teachers.

One of the biggest contributors to classroom ambient noise level has traditionally been the school HVAC system, regardless of whether it is roof- or wall-mounted. Most HVAC systems currently on the market today operate at ambient noise levels that are considered to be too high for most classroom instruction. But what if a school's HVAC system could be removed as a factor in ambient classroom noise levels?

In 2002, due to the increasing realization of the problem regarding classroom acoustics, the American Standards Institute (ANSI) along with the Acoustical Society of America (ASA) set out to create a lower overall ambient noise national standard for acoustics in the classroom. The result came to be known as S12.60-2002, which set an acoustical standard of 35 dBA for all background sound (ambient) levels. Unfortunately, while ANSI's new standard was significant, when it came to new construction, it did not take into effect relocatable classrooms which are harder to insulate and therefore can have more ambient noise, especially for older models still in operation.

Relocatable portable classrooms have been around and in use by school districts all over the country since the late 1960's. Factory built and often modular in size, they're used to provide additional classroom space when there is a shortage of capacity.

Shortly after the 2002 ANSI standards were developed, one HVAC manufacturer, **Bard Manufacturing** began to consider development of a new HVAC unit to try to meet the stricter ANSI acoustical standard. Although not a mandatory standard and therefore not enforceable, Bard became convinced that development of new equipment was both technologically possible and fulfilled a need that existed within the marketplace. Bard Manufacturing then teamed up with **Geary Pacific Supply** its product distributor for the western United States, to develop this new product.

"Many in the industry thought that ANSI's new standard would be nearly impossible to meet, especially with a vertical wall mounted unit," said Irv Derks, Bard's vice president of engineering. Bard, however, agreed with the intent of the standard,

which was to help improve the learning environment in schools. Therefore, Bard embarked in the development of an acoustically improved HVAC system.

Shortly thereafter, in early 2004, Geary Pacific organized a meeting of industry stakeholders, including representatives from the California Air Resource Board, the U.S. EPA, the California Department of Health Services and the California Department of Education, in Sacramento, to discuss the idea of what features the next generation of classroom HVAC equipment should include.

What came from that meeting was that the next generation of HVAC units needed to be more energy efficient, environmentally friendly, green, and provide an ambient noise level of no more than 45 dBA. However Bard, in conjunction with Geary Pacific, wasn't satisfied to simply meet the requirements that were discussed in the Sacramento meeting. They planned to adopt them for sure, but also work to develop the equipment to exceed all minimum requirements, including the more stringent ANSI acoustical standard of 35dBA.

So in conjunction with the Lawrence Berkeley National Laboratory (LBNL), Bard and Geary Pacific began a multifaceted approach to developing a quieter, more energy efficient unit with better ventilation capability and one that used next generation refrigerants—or "green" refrigerants—as its base. They decided that the unit not only had to work well with new construction but also be easily retrofitted to older construction, including portable classroom units.

Involvement by LBNL included a two-step testing process of a prototype unit designed and constructed by Bard at their manufacturing plant in Bryan, Ohio. "Over a series of many months, LBNL compared the energy efficiency and the ventilation capability and did the acoustical comparisons to a standard wall mount in an actual portable classroom at their facility," said Irv Derks with Bard. What they found was that the new Bard Quiet Climate II unit not only was more energy efficient but it also ventilated better.

From there, LBNL and Bard, in a concerted effort with Geary Pacific, employed a field test program in which 10 prototype units were shipped and installed by Geary Pacific in two different California schools—five in Fontana and the other five in Modesto. Ultimately, the field tests backed up the original tests conducted by LBNL. However, Bard was still not completely satisfied with the acoustical improvements and continued in the development of additional acoustical; enhancements to drive

the sounds levels down as far as technically feasible. Once developed, some of the 10 classrooms were retrofitted with the improvements which resulted in significant additional reduction in the ambient sound level.

Around the same time that LBNL was wrapping up the field tests, Geary Pacific decided they needed to find out how the unit would function in a real-world portable classroom environment. Using space at their branch located in Riverside, California, Geary Pacific acquired and set up an older, portable classroom, complete with desks and the other accoutrements found in a typical classroom. Then they replaced the existing wall mounted HVAC unit with Bard's new Quiet Climate-2 unit.

"We wanted to put in place an older classroom, like those developed around 1992, to demonstrate what the new unit could do in a practical application," said Maury Tiernan, Geary Pacific's Bard Product Manager. "The older classrooms are more typical of what's in service at many schools and so we wanted to demonstrate how the Bard unit would do when retrofitted to an older, existing classroom."

Shortly thereafter, Geary Pacific decided to bring in two of the original co-authors of the ANSI standard to conduct their own tests within the classroom and see how the Bard unit performed acoustically.

Louis Sutherland, who served as the chief scientist and deputy director for the Acoustic Research Group of Wylie Laboratories, and as the co-chair—along with David Lubman—of the large ANSI Working Group that wrote the Classroom Acoustics standard, was one of the acousticians who conducted tests within the classroom at Geary Pacific's Riverside location. "We took measurements at a number of selected positions of the ambient sound level before the air conditioning unit was turned on, and just as an anecdote, the reps from Geary Pacific said, 'okay, now it's on', and I said 'you're kidding', said Sutherland. The unit was on and by my own hearing I couldn't tell any difference between when it was on and when it was off."

Sutherland's more scientific tests essentially backed up what he heard, or in this case didn't.

"When we reviewed our test results they showed that the lowest ambient noise level with the HVAC system turned off was about 33 dBA, said Louis Sutherland. When

we then turned on the HVAC system at three different power levels of operation, the noise levels ranged from 35 to 39 dBA." What Sutherland quickly realized was that in most instances, Bard's Quiet Climate II unit ultimately met the 2002 ANSI standard of 35 dBA.

Geary Pacific's success in a practical application test of the Bard Quiet Climate lead them to convince Val Verde Unified School District in Perris, California in the early Spring of 2007 to purchase a unit for their audiology lab that tests students for hearing disabilities.

According to the school's audiologist, Randy Lerner, the environment for testing and evaluating students has improved by 20% due to a considerable reduction in ambient noise from 58 dBA to 37 dBA.

"With the old unit I used to have to turn it off during a testing session because it was so loud. Now my students comment on how quiet the lab is and that's when the unit is on," said Lerner.

Geary Pacific's goal is to convince more school districts of the benefits of the Bard unit. "It's difficult, because in some instances many schools don't have it within their budget to retrofit classrooms for the new units," said Tiernan. "However, we feel that the two main things the Quiet Climate II unit delivers on are, it uses 44% less energy than standard units on the market today and it's 10 to 15 dB quieter. These facts alone certainly are compelling enough reasons to reconsider that it's the right time for a change."

The ears of students across the U.S. and the teachers who work so hard to educate would probably most certainly agree.