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Limiting Classroom Sound, and the Fury Surrounding a New Standard

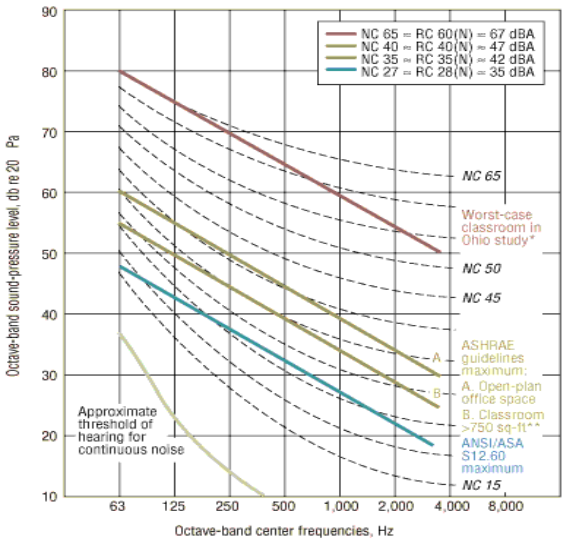
Engineers, audiologists, and manufacturers debate ANSI/ASA S12.60, a new standard that aims to make new classrooms very quiet.

By Tim Baker,
Managing Editor

Acoustical consultant Mark E. Schaffer is a supporter of the controversial new ANSI/ASA standard: S12.60, Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools. As an original member of the Working Group on Classroom Acoustics, which wrote the standard, Schaffer said "I think it's a good standard and you must keep in mind that we designed it to comply with the American Disabilities Act (ADA)." However, using the sound levels in his sleepy Pacific Palisades, Calif., office as a baseline, even he was a bit surprised at how stringent the new guideline--in practice--actually is. Holding a sound level meter to his PC, which sits under his desk, the meter read 45 dBA. At ear level, the computer registered 35 dBA--the maximum allowable background noise for new classrooms under ANSI/ASA S12.60. When a helicopter flew overhead, the meter went off the charts. "Wow, I never actually measured the sound in my own office," Schaffer said.

While no one disagrees that noise in American classrooms is a growing problem with an undeniably negative impact on learning,2 critics of ANSI/ASA S12.60 worry that the standard sets an unrealistic goal. (To obtain a copy of the standard, visit the ASA Standards Store at asa.aip.org. Copies cost $35.) The usual sound attenuation techniques--carpeting and sound absorbing ceiling tiles, for example--won't bring typical classroom background noise anywhere close to 35 dBA. The typical American suburban home at night with all major appliances turned off has a background noise level of between 30-50 dBA.

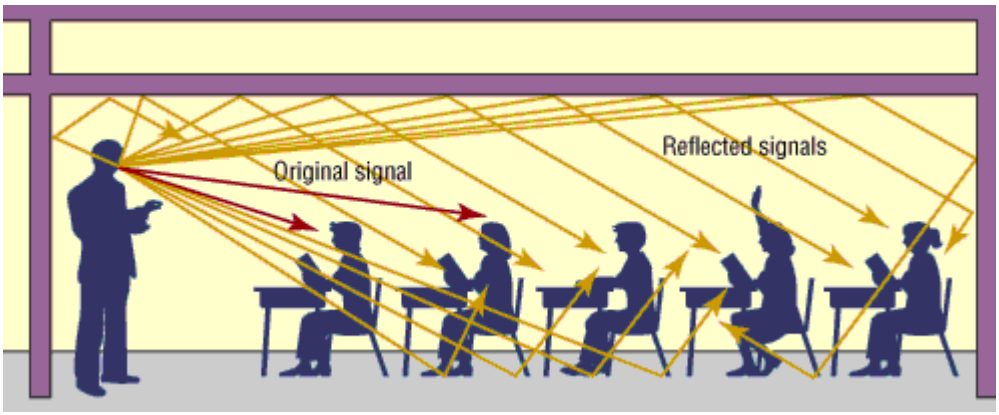
"No current sound attenuation technologies exist to bring unit ventilators or wall-mounted package units down to this level," Schaffer admits. Unit ventilators are the preferred way to condition new classroom space in many parts of the country. While voluntary, the standard's goals may soon be mandatory in several states. And since the standard was written to codify the broad requirements of the ADA regarding "mild to moderately hearing impaired" students, litigation-shy school districts might be wise to consider this guideline a mandatory building code (see sidebar "The Catalyst for ANSI/ASA S12.60"). Critics and supporters agree that implementing the standard requires a major shift in how classrooms are currently ventilated.



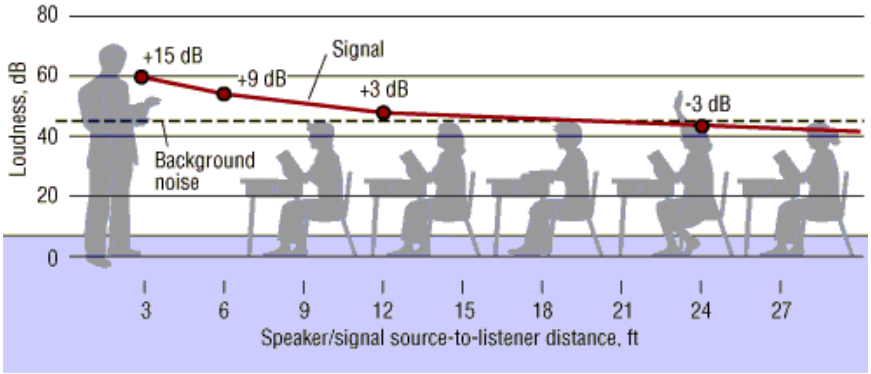
ANSI/ASA requirements

There are three thresholds set by ANSI/ASA: background noise, reverberation time, and signal-to-noise ratio. Background noise must not exceed 35 dBA--or the buzz of a single PC at ear level. Reverberation time must not exceed 0.6 sec in a traditional classroom or 0.7 sec in an auditorium-type classroom, and the signal-to-noise ratio (SNR) should be at least 15 dBA. In other words, the difference between a signal--such as a teacher's voice--and the background noise, should be 15 dBA or higher. However, Peggy B. Nelson, an audiologist with the University of Minnesota, explains that by meeting the background noise and reverberation time requirements, the SNR of plus 15 dBA will take care of itself.

"We started by first looking at the performance of students at various sound levels," Nelson, another original member of working group, said. "We know that children need a greater difference between the signal that they're listening to and the background noise--or the SNR.3 Children require a greater difference for speech intelligibility than do adults." The group determined the voice level a teacher could sustain for the duration of a class period is about 60 to 65 dBA. That 65 is the A-weighted sound level of the signal at 1 m from the teacher's mouth. Since a signal will lose about 5 dBA for every doubling of that distance, by the time the teacher's voice reaches the back of a typical classroom, the signal would be about 50 dBA, said Nelson "We knew we wanted a plus 15 dBA signal-to-noise ratio based on the research, so you end up with a 35 dBA."



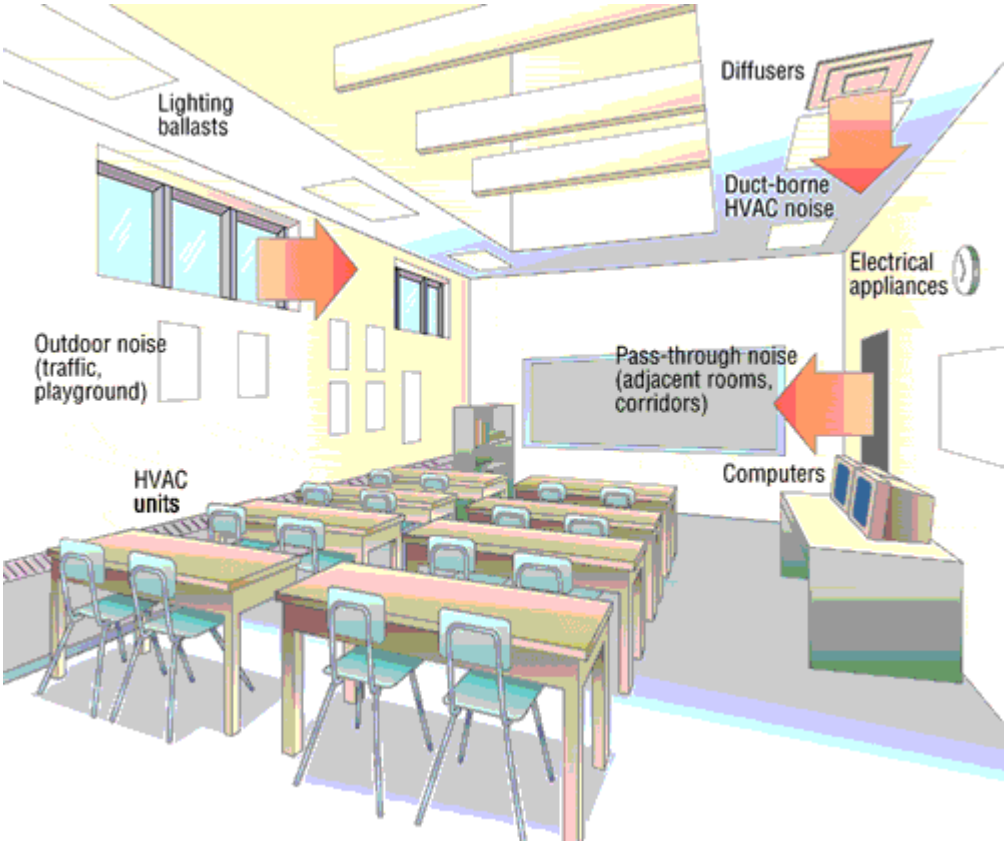
This is an overly simplistic description of how the committee reached its conclusion, Nelson stressed. "It (35 dBA) nicely turned out in agreement with a lot of the other international standards and was a little less conservative than the ASHA (American Speech, Language , and Hearing Association), which recommended 30 dBA for background noise." she said.



Competing lobbyists

From its very first meetings in 1997, the American National Standards Institute/Acoustical Society of America Working Group on Classroom Acoustics felt the heat from both sides of this issue, Nelson said. ASHA strongly favored lowering the bar even farther with a background noise threshold of 30 dBA and a very brief reverberation time of 0.4 seconds., "which is really, really quiet,"" said Nelson. Ultimately, the group concluded that this goal was too impractical.

On the other side of the fence, The Air-Conditioning and Refrigeration Institute (ARI) wanted a background noise level nearer to the low 40s dBA. "ASHRAE was working on a level of NC-35 (noise criteria) or about 40 dBA, which would have thrown the whole equation off," said Nelson. "Either the teachers would have had to talk louder or the rooms had to be smaller, or we had to assume that kids were going to miss part of it. I don't think 36 or 37 dB of noise is going to be fatal for the intelligibility of noise in a room for any child. When you get into the low forties, I think there is quite a bit of evidence that they are going to miss part of the message."



The tension between competing stakeholders only intensified as the standard neared completion in December of 2002.

"My committee circulated the standard which got ANSI upset over what they considered copyrighted material, although they wanted us to support it," said Mark Fly, director of engineering at Governair and a member of ASHRAE TC 2.6. It should be noted that the 2003 ASHRAE Fundamentals Handbook recommends designing classrooms to the noise levels specified by S12.60.

Members of the working group reject the notion that the standard was written in any way except in a fully transparent and inclusive atmosphere. "The ASA was really unhappy when there was

some free copying of copyrighted material," said Nelson. "But it would be hard to say that this working group railroaded anything. We started in 1997, and there were public meetings with ASHRAE members and ARI members. Also, the ASA gave me permission to publish a summary of our recommendations, which I did in 2000. So that was out in public; the 35 dBA and the 0.6 reverb time. People knew from 2000 what we were honing in on."

ARI has made it's position on S12.60-2002 clear: "In its current form, ANSI S12.60-2002 creates an overly stringent requirement by setting a single SNR for classroom and core learning spaces."

The Impact of ANSI/ASA S12.60-2002

The new standard virtually precludes the use of packaged ventilation units for classrooms. Instead, school districts that want to comply with the standard will have to opt for the more quiet, and expensive, central stations with ducted air-distribution.

The consensus is that the standard leaves very little room for anything but ducted systems with air-handlers or fan coil units outside of the classroom. This is good for those who make these systems, plus the makers of diffusers, VAV boxes, grilles, and registers. The standard poses a challenge to those who make unit ventilators, wall-mounted package units, water-source heat pumps, fan coils or any of the other ways engineers in the U.S. currently deliver conditioned air into schools. While this is probably going to be good for his business, Int-Hout admits he opposed the standard. "My opinion is that it's too quiet. I don't think you need 35 dBA. I think you can certainly do with 10 higher."

The new standard will likely transform schools--which are relatively inexpensive and simple construction projects--into "custom equipment acoustical engineering projects," said Fly.

"There are other issues even if you can get the mechanical equipment that quiet," said Int-Hout. "There's a reverberation time requirement that is onerous." The standard will likely make mandatory the use of wall-to-wall carpet, curtains, and it may preclude blackboards all the way around the room, Int-Hout speculates. Blackboards and floor tiles are often to blame for the echo effect in many classrooms.

There's is also an outside ambient noise requirement in S12.60, which means schools can't be built near busy roads or highways, or in airport approaches, Int-Hout said. "I don't see how this can happen unless they soften the requirements a little bit."

Technical Challenges

With the existing technology, it is simply "impossible for unducted systems" to meet this standard, Schaffer said. "It's a real technical hurdle. I've worked with two companies that make wall-mounted package units to either modify the inside of the unit or to add a sound-attenuation system to achieve 35 dBA, but it's simply too hard with existing systems," Schaffer added. The problems are size and cost. Schools like unit ventilators and wall-mounted package units because they are relatively cheap and are small enough to be mounted on an outside wall or slipped into a window opening in retrofit projects. However, to make them comply with S12.60 would translate into much larger and more expensive units, according to Schaffer.

"No current sound attenuation technology would help," Schaffer said. There are three noise sources from wall-mounted package units: the evaporator fan, the condenser fan and the compressor. All three produce noise and vibration. The noise that is generated by these components which comes right off the equipment and travels through the air, wall, or cabinet to the listener is called the "airborne noise." The energy that is caused by the vibration of these components shaking the cabinet, which is then radiated as noise, is the "structure-borne noise." Both of those components of noise must be controlled to get down to the criterion level, according to Schaffer.

The airborne noise path presents a very difficult challenge. Fans typically create significant noise. Even if this could be reduced, the structure-borne noise presents an even more daunting problem, Schaffer said. "You have to decouple either the cabinet from the building or the individual components from the cabinet with spring isolators. But the manufacturers typically don't use spring isolators. They use thin neoprene grommets and bushing that provide very little isolation." By Schaffer's calculations, adding spring isolators and the necessary space for airborne noise control would easily double the size of a wall-mounted package unit, which typically are about 7-by-4-by-1.5 ft in size.

The Cost of ANSI/ASA S12.60-2002

The impact of the standard will be regional. In Florida, for example, central A/C stations are needed to dehumidify the air. In northern states, schools are heated by centralized plants. But in the West, shallow South and Mid-Atlantic states--which coincidentally are the fastest growing areas of the country--the impact could be enormous.

"The current way is to use these package units and the beauty of that is all you need is enough electrical power to each classroom: just enough power to power up this box," Schaffer said. "In order to do it the way I'm recommending with ducted systems, requires a central plant with piping distributed throughout the school. Location of the central plant, the size of the plant, so many things go into this that it's hard to do a cost comparison. I would be surprised if the cost premium (of centralized ducted system over packaged unit ventilators units) is as much as 20 percent, in the extreme case. That's a very rough number." (Table below)

Test environment		Hearing sensitivity	
RT	SNR	Normal	Slightly impaired
0.0 sec	Quiet	94.5	83.0
	+ 12 dB	89.2	70.0
	+6 dB	79.7	59.5
	0 dB	60.2	39.0
0.4 sec	Quiet	92.5	74.0
	+12 dB	82.8	60.2
	+6 dB	**71.3**	**52.2**
	0 dB	47.7	27.8
1.2 sec	Quiet	76.5	45.0
	+ 12 dB	68.8	41.2
	+6 dB	54.2	27.0
	0 dB	**29.7**	**11.2**

It is also one of the higher estimates. One published account estimates that complying with the new standard will add about 2 percent to the cost of a new school construction. However, at an estimated $20 billion budgeted annually for school construction and renovation over the next four years, this standard could cost taxpayers $500 million.

"My personal opinion is I would be concerned from an industry standpoint that we are enacting a standard that is unenforceable," said Fly. "That's my personal opinion based on the fact that my wife is an educator and I know what kind of financial constraints they are up against all the time. The (background sound) levels are achievable, but it is going to be at a high cost. (The standard) will make classrooms very expensive facilities. We're talking about a standard that it is in the range of NC-25, which is low by anybody's estimation. Concert halls are around NC-15."

Modular classrooms

Whether or not the new standard is too onerous for brick and mortar schools, there is little debate regarding its impact on portable classrooms. These modular, temporary spaces, often the only option for rapidly growing school districts, cannot be built to the new standard. Their thin walls let in too much noise and the standard way to condition the air is with wall-mounted package units.

"We are always trying to improve our products through an ongoing R&D effort," said Irv Derks, PE, head of engineering at Bard Manufacturing, a manufacturer of packaged, wall-mounted air conditioners, heat pumps and gas/electric units for modular classroom space and school renovation projects. "We worked closely with the Los Angeles Unified School District to meet their target for background sound levels of 50 dB, and provided them with a unit that averages between 43-50 dB."

Aside from the technical challenge of making unit ventilators that meet the standard, Derks questions the need to make classrooms so quiet "We support a reasonable standard, but we also feel there is a lack of scientific data that supports the 35 dB background sound level." Derks cites the recent unanimous rejection by the International Code Commission to include the new standard in the IBC as proof that the standard is unreasonable and impractical.

New Technology

As with any challenge, there is great opportunity. One solution may be a variation of the DX split-system common to the residential market. These units connect an indoor evaporator fan-coil unit to the condenser and compressor outside the building with copper tubing.

Split systems can be quieter than package units. "In fact, all over Asia, there are split systems that are designed to be quiet, but at the moment, the standard split systems do not go as large as 4 tons," said Schaffer. Four tons is typically the minimum requirement for classrooms. Schaffer is aware of one company that has developed a split system fan-coil unit that is large enough for classrooms. "Even though the sound level is in the low 40s, it's a big improvement over wall-mounted units."

Sidebar: The Catalyst for S12.60

What many fear will become the ultimate enforcer of ANSI/ASA S12.60-2002--the lawsuit-- in fact, was what triggered the creation of the new standard. According to audiologist Peggy Nelson, a mother of a hearing-impaired child sued her school district in Georgia to bring her child's classroom into compliance with the ADA regarding noise levels for those with light to moderate hearing impairment. She won the case and inspired the ANSI/ASA standard.

Some expect a wave of lawsuits to quickly transform the new voluntary standard into an enforceable provision of the ADA. "Schools know that they'll be hanging out there in the wind if they don't comply." said Dan Int-Hout, chief engineer of Krueger. "It may take a couple lawsuits before it happens, but certainly they'll be liable if they don't." Schaffer agrees: "Ultimately, this will have to become law."

Another trigger for the standard was a controversy at the L.A. Unified School District several years ago. Voters approved a bond issue to equip all classrooms with air conditioning. The units that were chosen were loud, said Nelson, measuring at 60 dBA, in some cases. "The teachers literally had to turn them off to do any teaching and then to turn them on to let the students work."

Sidebar: Are Classrooms Louder Today?

Probably. IAQ concerns have made ventilation more important--and louder. Computers add to the din, and teachers often now opt for an interactive classroom setting, which means more competing voices.

Even critics of ANSI/ASA S12.60 agree. "I heard an interesting story from an engineer who designs schools in West Virginia," said Dan Int-Hout. There are two schools of thought in West Virginia that are allowed by the local authorities for ventilation. One is to use unit vents and the other is to use a dual-duct 100 percent outside air systems. They have indoor air quality problems in a number of schools with the unit vents, and none in the dual duct systems. Why are there IAQ problems in the schools with the unit vents? Because the teachers turn them off so that they can be heard. It's a real problem."

More classrooms have A/C, audiovisual equipment, aquariums, and computers--all with fans and motors, which makes for louder spaces.

Sidebar: Inching Toward Compliance

While central ventilation systems are the most obvious solution to noisy classrooms, there are other options to help inch the din down a dBA or two:

- Sloped ceilings from the front to the rear, which diminishes echo, but not sound carry.
- Trapezoidal shaped rooms reduce reverberation time.
- Thicker walls.
- Walls that extend to the ceiling to prevent noise seeping in from hallways and adjacent rooms.
- Staggered doors to reduce classroom-to-classroom noise migration.
- Caulk that is soundproof rated.
- Using drywall of two different thicknesses on both sides of walls. The two thicknesses absorb sound at different pitches, and will therefore filter more noise.

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