Classroom Acoustics

ANSI STANDARD

BY STEVEN J. THORBURN

ore than three-quarters of the teachers in a recent poll gave the acoustics in their classrooms a failing grade. The problem is most commonly a "signal to noise" ratio issue, which results in poor speech intelligibility. In lay terms, the room is too noisy and it takes a long time for sound to decay within the room. Studies by Maxwell and Evans (1997) have shown that students in schools with high background noise levels tested lower than students in schools with lower background noise levels.

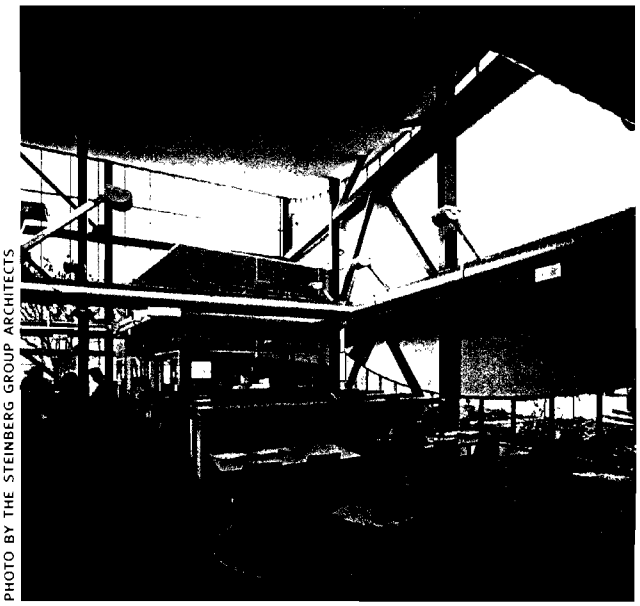
Recently, the American National Standards Institute (ANSI) approved a new set of recommended acoustical specifications for schools (ANSI S12.60-2002). "The criteria, requirements, and guidelines of this Standard are keyed to the acoustical qualities needed to achieve a high degree of speech intelligibility in learning spaces," according to Paul Schomer, standards director for the Acoustical Society of America (ASA), which publishes the "Classroom Acoustics Design Guide" (2000).

"If followed, this Standard removes acoustical barriers to learning," he says. "It provides equal access to education for a sizable minority of school children in the United States who may have mild-to-moderate hearing, learning, or attention deficits, suffer frequent ear infections, have limited English language skills, or may otherwise suffer from a substandard acoustical environment. For teachers, working in a classroom that conforms to this Standard can reduce or eliminate voice strain and reduce stress."

The new ANSI Standard covers:

- *Background noise* from both inside and outside the building,
- *Sound transmission* of walls, floors, ceilings, and doors,
- *Impact insulation* of floor-ceiling assemblies above core learning spaces, and
- *Reverberation times* or the length of time for sound to decay.

The quieter a room is, the lower its background noise level, enhancing speech intelligibility and raising the room's "signal to noise" ratio. In the case of a teacher in a classroom, "signal" means speech and "noise" is the base noise level in the classroom without the teacher speaking. (Noise is measured in Room Criteria (RC) or Noise Criteria (NC) values, which are commonly used to describe the noise from HVAC systems. The primary difference between the NC and



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RC curves is that the RC curves are more stringent in the low (rumbling) and high (hissy) frequencies.)

When documenting the noise level in a room from the mechanical systems, all sources must be considered: How much noise is being transmitted though the wall or roof from the air conditioner unit itself? How much noise travels from the unit down the ductwork to the diffusers? Do the air diffusers create their own noise due to the airflow/air turbulence as air passes thorough the grill? And finally, how is the unit mounted to the structure and is it properly vibration isolated?

Mounting units over or in hallways, and then ducting the air into the classrooms, can resolve many of these acoustical issues. This helps to attenuate the noise from the unit. Silencers or mufflers can be installed in the duct run and acoustical lining can be added to further reduce the noise. If air quality is a concern, one may wish to install AP/Armaflex (manufactured by Armacell), instead of traditional acoustical duct lining.

Unlike noise coming from within a building, exterior noise sources are measured by the A and C weighted decibel (dBA/dBC) system. The A-weighted decibel is filtered to respond to the way we hear, while C-weighting is closer to a true flat response. According to the Standard, the building shell should control outside noise sources to levels of 35 dBA. If the exterior C-weighted sound level is more than 45 decibels above the A-weighted sound levels, the Standard requires additional acoustical mitigations, for example at schools near airports, major rail lines, or roads

with a high volume of truck traffic.

Following are the design goals for background noise levels from the building's HVAC system, as well as from other sources such as light ballast, electrical transformer, elevator equipment etc.

Classroom Size	*A-weighted Noise Level*	*NC/RC*
Less than 10,000 cu. ft.	35 dBA	approx. 30
10,000 to 20,000 cu. ft.	35 dBA	approx. 30
More than 20,000 cu. ft.	40 dBA	approx. 35

The Standard calls out an A-weighted noise level criterion for overall background noise and must be translated to the more traditional NC/RC rating. While this may seem contrary to conventional wisdom, the goal of maximizing the signal to noise ratio for improved speech intelligibility is best determined with A-weighted noise levels. In addition, any room that has microphones for distance learning applications should be designed to a lower level of no more than NC/RC 25.

To establish sound isolation between rooms, one must look at all the pathways for sound to enter the room: doors, windows, penetrations of the walls by ducts, pipes and conduits, and holes made in walls by recessed electrical panels and fire extinguisher cabinets. These can all significantly reduce the insulating effect of the partition.

ANSI's minimum Sound Transmission Class (STC) of 50 for classrooms is supported by the ANSI Classroom Acoustics Standard, as well as by our own experience. Here are the recommended minimum STC ratings in the ANSI Standard:

Room Relationships	*STC Rating*
Classroom to corridors, office, etc.	45 STC
Classroom to classroom or outside	50 STC
Classroom to public space, e.g., restroom	53 STC
Classroom to music room, gym, etc.	60 STC

Classroom doors are recommended to have a STC rating of 30 or more. In addition, the Standard calls for minimum Impact Insulation Class (IIC) values of 45 to 50 (measured without carpeting) for floor-ceiling assemblies above core learning spaces. Higher ratings are advised if gymnasia, dance studios, or other high floor-impact activies are located above core learning spaces.

Another section of the Standard for acoustical design of classrooms covers control over the build-up of noise in the room itself. This is typically measured in Reverberation Time (RT60), or the length of time it takes for sound to decay 60 decibels or to one millionth of its initial level. Reverberation can be reduced by installing sound absorbing panels or acoustical tile ceiling system. A major design challenge in classrooms concerns the need for wall-mounted writing

surfaces to be abuse resistant while also non-reflective of sound.

The suggested Reverberation Times for classrooms are:

Classroom Size	*Reverberation Time*
Less than 10,000 cu. ft.	0.6 seconds
10,000 to 20,000 cu. ft.	0.7 seconds
More than 20,000 cu. ft.	consult an expert

In addition to these specifications, the Reverberation Time for distance learning rooms should be less than 0.5 seconds, with no discrete echoes.

Several trade groups challenged the ANSI Standard, arguing that it was "not in the best interest of the public" and appealed to have the standard withdrawn. Included in the appeal was a declaration by the groups of what they said would be added costs in implementing the Standard. The trade organizations were the Air-Conditioning & Refrigeration Institute, (ARI), the School Facilities Manufacturers Association (SFMA), and the Modular Building Institute (MBI).

The ANSI Appeal Board upheld ANSI S12.60-2002 on June 10, 2003. The ANSI Appeals Board is the third and final level for appeals of proposed standards. The appeals to the Standard have been heard and the Standard has been upheld in all appeals.

While primarily directed at K-12 schools in the United States, the new Standard also could be applied internationally and at the college level. ANSI S12.60-2002 (Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools Standard) is 50 pages long. This article is intended only as a summary of its major provisions. The entire document can be downloaded for $35 from the ANSI webstore (http://webstore.ansi.org/ansidocstore/). ●

STEVEN J. THORBURN, PE, IS CO-FOUNDER OF THORBURN ASSOCIATES, INC., AN INTERNATIONAL ACOUSTIC AND AUDIOVISUAL SYSTEM DESIGN AND ENGINEERING FIRM WITH OFFICES IN NORTHERN AND SOUTHERN CALIFORNIA AND NORTH CAROLINA. HE CAN BE REACHED AT SJT@TA-INC.COM OR (510) 886-7826

FOR MORE INFORMATION

"CHRONIC NOISE EXPOSURE AND READING DEFICITS: THE MEDIATING EFFECTS OF LANGUAGE ACQUISITION" BY EVANS, G.W. AND MAXWELL, L., *ENVIRONMENT AND BEHAVIOR* (1997), 29(5), PP. 638-656.

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