



# New standards and technology have pushed progress in acoustics and amplification in the classroom.

Our knowledge of classroom acoustics, and our ability to improve classroom listening and learning environments continues to evolve. Because of technological developments we can expect that “game-changing” innovations will occur, and allow us to augment listening and learning in the classroom in ways we cannot now imagine. The following description of developments in classroom acoustics and amplification is not exhaustive but provides a window on audiology’s continued involvement in the area.

One development is semantic. The term *soundfield amplification system* has been traditionally used to refer to the small public address systems used in the classroom. This term has been replaced with *classroom audio distribution system (CADS)*. *Audio distribution system* is the common term for public address systems, so CADS is now the preferred way to refer to these systems in the classroom.

Other developments include a revision of the 2002 American National Standards Institute (ANSI) classroom acoustic standard, the emergence of new classroom loudspeaker designs, smart phone acoustic measurement applications, availability of a multimedia tool to educate teachers, parents, and administrators about classroom acoustics, and development of a supplement to the



# New Developments in Classroom Acoustics and Amplification

BY JOSEPH SMALDINO

Academy's clinical practice guideline *Remote Microphone Hearing Assistance Technologies for Children and Youth from Birth to 21 Years* (2008). This supplement addresses fitting and verification of classroom audio distribution systems.

## Classroom Acoustic Standards

In recognition of the fact that undesirable acoustics can be a barrier to listening and learning in the classroom, a working group composed of a wide variety of stakeholders produced the first American standard, which was published in 2002 (ANSI/ASA S12.60-2002: *Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools*).

Since ANSI standards are reviewed on a regular cycle, another working group made up of a similar mix of stakeholders as the 2002 working group was formed to undertake the review. The working group considered revisions and debated public comments concerning the original standard. As a result of these debates and discussions, it was decided that a separate part should be devoted to issues unique to portable classrooms.

The first part of the revised standard, *American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 1: Permanent Schools* (ANSI/ASA S12.60-2010), is a wordsmithed and

refined version of the 2002 standard. The major performance requirement for furnished but unoccupied classrooms is basically unchanged from the 2002 standard. The one-hour average A-weighted background noise level cannot exceed 35dB (55 dB if C-weighting is used) and the for averaged sized classrooms the reverberation time (RT60) cannot exceed 0.6 seconds. Among other changes are improvement of the requirements for exterior walls and roofs in noisy areas, consideration of activities close to classrooms, clarification of the definition of a "core learning space," addition of the limit of 45 dBA for sound in hallways, clarification and simplification of measurement procedures, and addition of the requirement that if an audio distribution systems is deemed appropriate it should provide even coverage and be adjustable so as not to disturb adjacent classes.

The second part of the revised standard, *American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 2: Relocatable Classroom Factors* (ANSI/ASA S12.60-2009), phases in performance criteria requirements for portable classrooms. The current standard sets a 41 dB(A) limit for background noise in unoccupied classrooms, which would be lowered to 38 dB(A) in 2013 and 35 dB(A) in 2017. Reverberation



time (RT60) in unoccupied relocatable classrooms must not exceed 0.5 second in classrooms with volumes of 10,000 cubic feet or less and 0.6 second in classrooms with volumes of 10,000–20,000 cubic feet. Both parts of the standard are available without charge from the Acoustical Society of America store (<http://asastore.aip.org>).

A third part is currently under development and will focus on control of noise from informational technology in the classroom.

At this writing, compliance with the revised standards remains voluntary. Special effort was made during the crafting of the revision to include language so that it could be considered for incorporation into the *International Building Code*, which would make compliance mandatory for new school construction. Efforts to incorporate the standards into the 2012 building code failed; another opportunity will occur as the International Code Council will begin the 2015 building code development in 2013. As this article goes to press, the new ANSI classroom acoustics standards are being considered for inclusion in the revision of the *International Green Construction Code*. While final inclusion in the revised in this code (due sometime in 2011) is not a sure thing, it is a step in the right direction toward making acceptable classroom acoustics mandatory in all classrooms.

### Loudspeakers for Audio Distribution Systems

Whenever audio distribution systems are installed in a classroom, the design requirement of the installation is to make the sound equally loud throughout the room, minimize feedback, minimize late reverberation, and, finally, amplify transparently. It should not be apparent that the teacher's voice is being amplified. The loudspeakers conventionally used in classroom audio distribution systems (and virtually all loudspeaker designs) are considered a spherical-wave source. Sound from a spherical-wave source radiates in three dimensions, like an ever-expanding sphere or balloon, forward, left/right, and up/down. Spherical waves retain only one-fourth of their sound intensity with each doubling of distance from the source and often exhibit an uniform frequency response if not directly in front of the source. This distribution of energy over an ever-increasing area is heard as a dramatic reduction in sound level with distance from the source. Audiologists, of course, are familiar with this type of wave behavior and refer to it as the "inverse square law." Critics of the use of audio distribution systems in classrooms cite this rapid reduction in sound intensity and the fact that the waves irradiate in many directions as a

---

## Manufacturers of classroom audio distribution systems are taking advantage of new loudspeaker designs or implementing traditional designs in new ways.

---

potential source for the generation of late reverberation patterns. Late reverberation adds masking and distortion to speech signals and is not desirable. When installing systems with this type of loudspeaker design, to make up for the loss of intensity as a function of distance and generation of late reverberation patterns, multiple speakers (or distributed sound systems) are typically used, placing each student close to a loudspeaker so that direct sound predominates and influence of late reverberation is minimized. A well-designed distributed classroom audio distribution system can greatly improve the classroom sound quality, but it is difficult to overcome the inherent limitations of a spherical-wave sound source.

To improve on the limitations of a spherical-wave sound source, alternative types of loudspeaker designs have recently made their way into audio distribution systems. One such design is considered a cylindrical wave source. A cylindrical-wave source is shaped like a vertical line or pole. Cylindrical waves radiate sound in only two dimensions—forward and to the right/left, but not up/down. Cylindrical waves do not lose intensity with distance as fast as spherical waves. They lose only half their intensity with each doubling of distance. We hear this reduction of level with distance as modest when compared to a spherical-wave source.

Potentially, this kind of wave source will reduce the loss of speech intensity as a function of distance when compared to traditional spherical-wave loudspeaker designs. Because sound is irradiated in only two dimensions, not as many surfaces are energized, and so not as many late reverberation patterns are created to degrade speech as in a spherical-wave source. Other newer speaker designs also try to improve on the loss of intensity with distance, variation of frequency response and generation of later reverberation patterns. In addition to the cylindrical designs, flat panel, bending wave technologies and plane wave sources are being refined. The application of these speakers to classroom audio distribution systems may further enhance the effectiveness of these systems (Eargle, 2003).

Manufacturers of classroom audio distribution systems are taking advantage of new loudspeaker designs or implementing traditional designs in new ways. Each is focused on improving the signal-to-noise ratio no matter where the student is seated in the room, maximizing the clarity and intelligibility of the desired speech signal, and minimizing late reverberation distortions. Expect to see continual evolution of loudspeaker designs used in the classroom as they become available and cost-effective.



Introducing  
a fresh and  
innovative  
approach to  
better hearing

Qleaf is an advanced technology modular CIC, optimally designed for people who seek a simple and discreet solution for their hearing loss.

**Qleaf**

Visit us at [www.exsientusa.com](http://www.exsientusa.com) or call 1-866-742-0808

The following Web sites are examples (not exhaustive) of how newer loudspeaker designs are being used in classroom audio distribution systems:

- [www.phonak.com/com/b2b/en/products/more\\_products/soundfield/dynamic\\_soundfield.html](http://www.phonak.com/com/b2b/en/products/more_products/soundfield/dynamic_soundfield.html)
- [www.lightspeed-tek.com/app\\_content/files/speakers\\_DS0131US01-0.pdf](http://www.lightspeed-tek.com/app_content/files/speakers_DS0131US01-0.pdf)
- [www.centrumsound.com/frontrow\\_togo.html](http://www.centrumsound.com/frontrow_togo.html)
- [www.audioenhancement.com/content/view/144/189/](http://www.audioenhancement.com/content/view/144/189/)

### Smart Phone Acoustic Applications

As handheld smart cellular phone technology has evolved, so has the availability of applications for these phones. Because of the widespread use of smart phones and the creation of relatively inexpensive acoustic applications, sophisticated classroom acoustic measurement

technology is now readily available from application designers. One such designer is Studio Six Digital ([studiosixdigital.com](http://studiosixdigital.com)), who has developed applications for the iPhone, iPod Touch, and iPad that have the potential for allowing audiologists to conduct sophisticated acoustic measurements at an affordable price. One product, AudioTools ([studiosixdigital.com/audiotools.html](http://studiosixdigital.com/audiotools.html)), can turn the Apple product into a sound level meter, real time acoustic analyzer, audio band oscilloscope, audio generator, sound pressure level graph, and digital recorder, among other things. The software has also been developed to conduct impulse response measurements, and soon a mobile version of the Smaart acoustic test and measurement software will be available ([rationalacoustics.com](http://rationalacoustics.com)). Smaart is the most widely used software for real-time sound system measurement, analysis, and optimization and has many potential uses in classroom acoustic measurement.

Another product is the iAudioInterface ([studiosixdigital.com/iphone\\_measurement\\_micropho.html](http://studiosixdigital.com/iphone_measurement_micropho.html)). This



Sound Listening Environments Inc.

#### Hushh-ups®:

- Virtually eliminate noise caused by furniture legs scraping on uncarpeted floors.
- Are safe, durable, simple and easy to attach to chair, desk, and table legs.
- Are made using AIR inflation technology.
- Are free from chemicals found in cheaper pellet inflated balls.
- Recommended by Audiologists, Teachers of the Deaf/Hard of Hearing, and other professionals.
- Augment amplification technology such as hearing aids, FM and Sound Field Systems.
- Dramatically improve room acoustics.

ONE SIZE FITS ALL \*

No more hassle trying to size glides for a variety of chairs, desks, and table configurations!

\*Standard straight and disc bottom legs measuring up to 1.5" in diameter

[www.hushhups.com](http://www.hushhups.com)  
Tel: (800) 263-1828



interface provides a professional grade microphone system that plugs into the iPhone or iPod Touch and replaces the less-than-desirable microphones that come with these devices. When used with the AudioTools software, this upgraded microphone system may make sophisticated classroom measurements available to the audiologist at an affordable price. At this writing the iPod Touch sells for about \$300, the iAudioInterface is \$250, and the AudioTools is about \$20. Dan Ostergren and I are currently evaluating the accuracy and utility of this device for use in the classroom. We plan to present our findings at AudiologyNOW!® 2011 in Chicago.

### Multimedia Education

In the 2005 *Guidelines for Addressing Acoustics in Educational Settings*, developed by the American Speech-Language-Hearing Association (ASHA) working group on classroom acoustics, the roles of the audiologist are outlined. One of the important roles is to *educate about classroom acoustic issues*:

The negative impact of poor classroom acoustics is not self-evident to teachers, administrators, parents, or the public. Unless brought to their attention, acoustic barriers to listening and learning in the classroom are typically ignored. Audiologists must take responsibility for their own involvement, which could include (1) developing primers on room acoustics and/or the effects of acoustics on listening and learning, (2) acting as a resource person for teachers, parents, principals, and administrators, and (3) playing an active role in disseminating information concerning classroom acoustics to the general public and policymakers. [ASHA, 2005]

As part of a large U.S. Office of Education grant through the Northern Illinois University College of Education, an educational module about classroom acoustics was developed (Smaldino, 2004). The module was designed for classroom teachers but has been found to be very useful in educating parents and school administrators as well. The learning objectives of the module are:

1. Describe types of acoustic barriers in the classroom
2. Explain the importance of having favorable classroom acoustics
3. Identify steps to produce favorable acoustics in the classroom



The information is provided in an easy-to-understand, interactive, and entertaining format. Chapters include a description of acoustic barriers to listening and learning, an overview of why desirable classroom acoustics are important, and a practical section on how to produce desirable acoustics. The last section includes methods for subjective and objective assessments of acoustic conditions, a tiered approach to making classroom modifications from least to most expensive, and, finally, suggestions for the use of classroom amplification to improve listening conditions. The module is available at [projectreal.niu.edu/projectreal/modules.shtml](http://projectreal.niu.edu/projectreal/modules.shtml) and can be freely used without permission.

### Academy Clinical Practice Guidelines

A task force has been working on *Supplement B* to the Academy's clinical practice guideline *Remote Microphone Hearing Assistance Technology for Children and Youth from Birth to 21 Years* (2008). This supplement addresses fitting and verification of CADS. Expected to be released in early 2011, the supplement covers a rationale for the use of CADS, prerequisite considerations including a consideration of room acoustics and compatibility with personal FM systems, selection considerations including transmitters and receivers, setup procedures including loudspeaker placement, loudness levels, and frequency response and verification procedures for hearing impaired and normal hearing children who have special listening requirements.

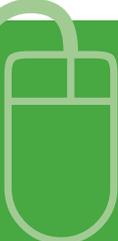
The document features a tiered approach to classroom acoustics measurement including worksheets and fitting/verification worksheets as well as an up-to-date list of references. Armed with the information in the supplement, audiologists will have a set of best practices using current technology and be prepared to incorporate new technologies as they arise. 

Joseph Smaldino, PhD, is a professor in the Department of Communication Sciences and Disorders at Illinois State University.

*Editorial Note: Through the Academy's membership in the Acoustical Society of America, we have representation on the following committees: S3 Accredited Standards Committee on Bioacoustics; S12 Accredited Standards Committee on Noise; and TAG TC 29 Electroacoustics, as well as ANSI's TAG IEC/TC29 (Technical Advisory Group).*

### References

- American Academy of Audiology. (2008) *Remote Microphone Hearing Assistance Technologies for Children and Youth from Birth to 21 Years*. [www.audiology.org/resources/documentlibrary/documents/hatguideline.pdf](http://www.audiology.org/resources/documentlibrary/documents/hatguideline.pdf).
- American National Standards Institute. (2002) *Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools* (ANSI/ASA S12.6-2002). New York: American National Standards Institute.
- American National Standards Institute. (2009) *American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 2: Relocatable Classroom Factors* (ANSI/ASA S12.60-2009). New York: American National Standards Institute.
- American National Standards Institute. (2010) *American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 1: Permanent Schools* (ANSI/ASA S12.60-2010). New York: American National Standards Institute.
- American Speech-Language-Hearing Association Working Group on Classroom Acoustics. (2005) *Guidelines for Addressing Acoustics in Educational Settings*. [asha.org/docs/html/gl2005-00023.html#sec1.1](http://asha.org/docs/html/gl2005-00023.html#sec1.1).
- Eargle J. (2003) *Loudspeaker Handbook*. New York: Springer.
- Smaldino J. (2004) Classroom acoustics: importance to successful listening and learning. Just-in-Time Learning for Teachers. Project REAL (Rockford Educational Alliance). [www.learn.niu.edu/flash/projectreal/classroom\\_acoustics\\_intro.swf](http://www.learn.niu.edu/flash/projectreal/classroom_acoustics_intro.swf).



### Also of Interest

*Public Policy Resolution on Classroom Acoustics*

Log in to [www.audiology.org](http://www.audiology.org) and search key words "classroom acoustics resolution."