QUEST® TECHNOLOGIES

USER APPLICATION NEWS NOTE 6

Monitoring Noise in Classrooms

INTRODUCTION

Studies around the world have shown that classrooms are extremely noisy environments. A University of Florida Professor visited 26 different schools and about 600 different classrooms and discovered that 50% of the student population could not hear past the first two rows. A University of Kansas analysis found that the speech intelligibility rating in most U.S. schools is 75 percent or less, meaning listeners with normal hearing can only understand 75% of spoken words. Researchers at Ohio State University have found that the acoustics of many classrooms are poor enough to make listening and learning difficult for children. Under new U.S. Guidelines, classrooms would need to keep noise levels below 35dB. Studies have shown that most classrooms in the U.S. have a sound level of 45dB or greater. The purpose of this application note is to provide information on the issue of noise in classrooms. The main topics to be discussed will be adverse effects of noise, sources of noise, determining the levels of noise and potential corrective actions. This application note is intended to offer an overall perspective of classroom noise and the steps one might take to understand actual noise exposure in classrooms.

ADVERSE EFFECTS OF NOISE

In its simplest definition noise is unwanted sound. When we consider the adverse effects of noise it may be easy to understand that too much noise can be annoying. Anybody who has been awakened from a sound sleep by a noisy neighbor knows just how annoying noise can be. At high enough levels or for long enough periods of time noise can also damage the human ear. This damage can result in impaired or total loss of hearing. Noise in classrooms can impair or prevent our ability to understand and comprehend speech. In fact, classrooms can be so noisy that most students from kindergarten to high school are likely to experience significant problems hearing the voice of a teacher. It is easy to understand that noise of significant volume can overpower speech from someone in the same room, preventing us from hearing what is being said. Environmental noise levels during regular school activities is sometimes 4 to 38 dB above values currently agreed upon for optimal speech recognition by normal-hearing children and the situation would be no different for hearing-impaired children taught in special classrooms. Studies have shown that children with hearing problems or for whom English is a second language have an especially hard time following what a teacher says. These students are more vulnerable to learning and behavioral disabilities.

NOISE SOURCES

The sources of classroom noise fall into two general categories, either internal or external. Noise is either being generated inside a classroom or entering the classroom from an outside source. Some examples of internal noise sources include: fans, heating, ventilating and air conditioning systems, occupants or even desks and chairs as they get dragged across a hard surface floor. External noise sources or noise outside the classroom may include: adjacent heating and cooling systems, adjacent hallways and rooms (other classrooms, gymnasiums, cafeterias), construction or remodeling, roadways, trains, and airplanes.

NOISE MEASUREMENTS

As with any other problem that may not be blatantly obvious, our first step would be to determine if and to what extent noise exists and then determine if this level of noise is a problem. The simplest way to determine the background level of noise in a specific classroom is to use a sound level meter. This is best accomplished by monitoring an unoccupied classroom with any heating, ventilation or air conditioning systems running as they normally would when the classroom is occupied. Next if possible monitor the same classroom with any other internal or external noise sources that would be present during regular classroom hours. Studies suggest that the background noise level in classrooms when students are present should be close to 30 dB. The lower the background noise the more likely the verbal communication between students and instructors within the classroom will be heard and understood. Students working in classrooms where the background noise levels are maintained at or below 30 dB are likely to be motivated and offer challenging discussions with instructions in a normal tone of voice.

Certain classrooms, for hearing-impaired or non-native language students may require even lower background noise levels. Those needs should be addressed on an individual basis as they may require a more complex method of measurement than using a basic sound level meter.

Another factor to consider when determining the background noise level is the actual size of the classroom. When sound moves away from its source it becomes lower in volume. A simple example of this is listening to a radio at a distance of 2 feet will sound louder than the same radio at the same volume if we move it to a distance of 10 feet. This same general principal is true in a classroom. If we sit in the front of the classroom, the instructor/teacher will sound louder than if we sit in the back of the classroom. Therefore it is a good idea to get background noise readings that represent the entire classroom.

Another simple test that two people can do is for one person to stand in the front of the classroom and speak in a normal tone. The second person moves to different areas of the classroom to verify the person speaking can be heard and understood throughout the classroom. If different locations in a classroom are found where the speaker is not understood, using a sound level meter can help determine if the problem is simple signal loss due to distance or a more complex acoustical design issue.

Since not all noise sources may be from within the classroom, we would want to expand our search to sources outside the classroom. Again there are some simple tests two people can perform to help evaluate this. For example while one person stays in the classroom of interest the second person can go to adjoining classrooms or hallways. As the second person speaks or makes noise, the first person listens to see if those noises are entering the classroom being evaluated. Using a basic sound level meter can give you definitive information as to the level of noise entering the classroom being evaluated.

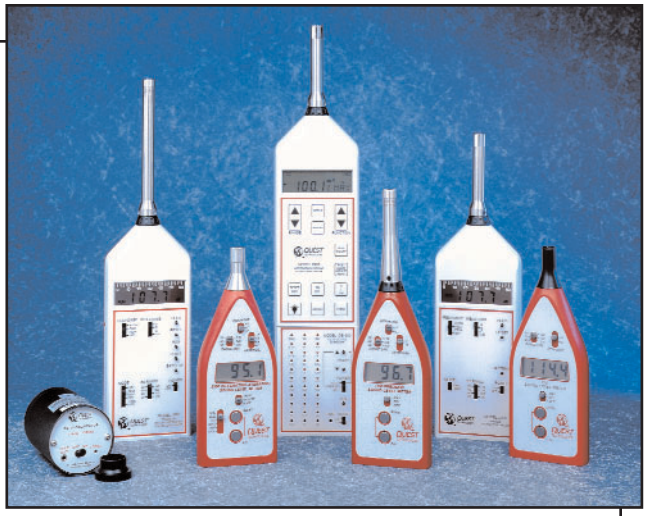
CORRECTIVE ACTIONS

We now have data that will help us determine if we actually have a problem or not. Background noise levels that are too high may interfere with a student's ability to hear and understand what is being said. Corrective actions may include reducing background noise, increasing (amplifying) the instructor's/teacher's level of speech, or improving the classrooms acoustical design. Each of these means of addressing the problem has it's own pros and cons. Reducing background noise may appear to be the optimal choice but it may be the most costly or simply not possible. For example, if a nearby airport causes the background noise, it would be unlikely that an established school or airport would be moved. While amplification of instructor's/teacher's voice may be an inexpensive option. Although this solution does not help the situation where students respond to questions and each other. Improving the overall acoustics of a classroom can be a very complex and costly task.

We should not lose sight of the fact that there may be less costly options to reduce noise or it's adverse effects in a classroom. Consideration of room function and placement, for example do not put an English classroom next to a noisy gymnasium or cafeteria. When creating new spaces for an expanding school, consider the acoustical needs of the rooms during the design stage. It may be more economical to design a new room than to try to retrofit an existing classroom. Be sure to consider all factors of a decision about a classroom. For instance if a particular room gets too hot, an air conditioner placed in that classroom may seem like the logical choice. However a better solution may be central air, a more realistic solution may be to not have students sitting next to the air conditioner while it is running. In some instances it may be more economical to add low cost items such as wall covering and drapes that help improve the acoustical properties of a classroom without the extreme cost of rebuilding.

Our ultimate goal should be to provide classrooms that provide students the opportunity to learn what is being taught. Noise in classrooms is just one issue that may hamper that goal. Consideration of all involved parties needs to be taken into account. Not just the costs to build and operate the schools but also the cost to the students and society if they do not learn what is being taught.

SOLUTION



The Sound Level Meter

At Quest Technologies we manufacture a full line of sound level meters (SLM) that can help you determine if you are having a problem with noise in the classrooms. The SLM performs three basic operations. It uses a microphone to convert the energy in the sound into an electrical signal. An electronic circuit then conditions the signal to provide meaningful results. Finally, the SLM communicates the results to the operator in one or more ways.

Before we address the specifics of various kinds of meters, we should address the most basic question of all, "How should I hold the SLM?" Should the microphone be pointed at the noise source or should the face of the microphone be oriented at some other angle such as at a right angle to the sound wave? The answer depends on the type of microphone being used. There are three different types of microphones available: free-field, random incidence and pressure. Free-field microphones should typically be pointed directly towards the noise source. Random incidence microphones should typically be held at a 70° angle to the source. Pressure microphones should typically be held at a right angle to the noise source. The rule here is to follow the manufacturer's recommendations with respect to microphone orientation. Generally, low frequency sounds are not affected by the microphone orientation as much as high frequency sounds. Again, this depends largely upon what type of microphone element is used in the SLM.

The Basic SLM

Features vary considerably from meter to meter and from manufacturer to manufacturer. Perhaps surprisingly, so can performance and accuracy. No matter what type of SLM is used, at least two requirements of the meter should always be met. These include some method for performing a field calibration of the SLM and an independent certification that the SLM meets Type I or Type II standards of performance and all other applicable SLM standards.

In its most basic form, the SLM will provide the operator with an indication of the instantaneous SPL being detected. Often a basic meter will also provide an indication of the maximum SPL encountered as well. Results from Basic SLM's are almost certainly limited to presentation through the display of the meter. Rarely are there capabilities for these meters to output results to a printer or computer. There may or may not be provisions in the meter to allow the operator to change certain characteristics of the SLM's signal conditioning circuits. These characteristics in a basic meter may or may not include the weighting network and the response time constant.

Weighting networks most common today consist of "A", "C" and "Z" weighting. Each of these weighting networks is a "standard" that dictates how the SLM will recognize the amplitude of the SPL based on the frequency of the sound. For instance, "A" weighting circuits simulate how the human ear responds to sound. We know that humans can hear within a fixed range of frequencies and humans perceive that sound is louder or softer as frequency changes.

Response time constants define how quickly an instrument must be able to recognize and process changing SPL's. The most common options today are "Fast", "Slow", "Peak" and "Impulse" time constants. If it were not for the existence of frequency weighting and response time constant standards, results from meter to meter and manufacturer to manufacturer would almost certainly vary widely and prohibit the effective measurement in classrooms.

Integrating SLM's

Depending upon your school district's requirements, you may need an SLM that computes the average SPL over a prescribed amount of time. These types of SLM's are referred to as Integrating SLM's because they automatically calculate the average SPL. All Integrating SLM's calculate this result based on a given doubling or exchange rate. Some SLM's may be fixed for a specific exchange rate at the factory. Others may include provisions for setting the exchange rate in the field. In either event, it is important to note which exchange rate the SLM is using and that it matches your requirements. Since it is possible for requirements to change, it is always more favorable to have an SLM that allows the exchange rate to be changed by the user without requiring factory modification, or worse yet, replacement. Integrating SLM's may include provisions for printing results or uploading them to a computer. Generally speaking, unless the meter also documents the performance of a field calibration in its output, the value of the hard copy results is greatly diminished.

Datalogging SLM's

After integration, the next mostly commonly sought after capability in an SLM is datalogging. Datalogging SLM's provide much more detail of the noise-testing event. This can include a minute-by-minute profile of the sound source's SPL levels. At a minimum, these kinds of meters should provide hard-copy and computer upload of test results correlated to the real-time and date of the event.

Octave Band SLM's and Real Time Analyzers

At the top end of the spectrum for SLM's you will find devices that are capable of determining and reporting the SPL and average SPL at various frequencies. Generally speaking, once frequency content of the sound is a concern, specialists in acoustics are required to perform these tests.

ABOUT QUEST TECHNOLOGIES

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PERTINENT WEBSITE LINKS

ASHRAE Journal On-Line	http://www.ashraejournal.org/features/archives/feb00-feature1.htm
Noise Pollution Clearing House	http://www.nonoise.org/quietnet/qc/
The Acoustical Society of America	http://www.asa.aip.org/classroom/booklet.html
National Hearing Conservation Association	http://www.hearingconservation.org

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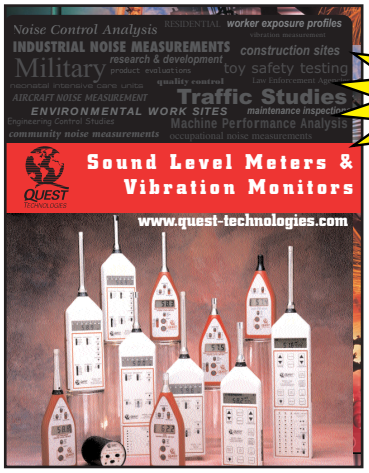
If you have any questions concerning our technology, pricing, availability or would like to schedule a product demonstration, you may contact our customer service representatives at (800) 245-0779, 262-567-9157



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