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Rethinking Acoustics

Understanding 'silence' and 'quiet' within the built environment

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By Viken Koukounian, PhD, P.Eng., and Niklas Moeller

Acoustics is a vital part of our everyday experience of the built environment; however, the role background sound plays in making these environments more comfortable for occupants is often overlooked. As a result, the misconception persists that acoustical dissatisfaction and lack of speech privacy can be resolved merely by limiting noise levels or blocking transmission.

Given today's focus on health and wellness, it seems prudent to revisit our acoustical lexicon with the intention of developing deeper awareness of the differences between background sound and noise as well as their implications for our experience within facilities.

Refining our understanding of "noise" and "sound," as well as terms such as "silence" and "quiet," allows for a more nuanced discussion of occupants' needs and expectations, and fosters opportunities to improve building design practices.

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Learning Objectives

After reading this article, you should be able to:

1. Establish a common language when discussing acoustical issues.
2. Explain the role minimum background sounds plays in human perception of acoustics.
3. Capitalize on the ways in which sound masking can be used as an architectural design tool.
4. Address concerns regarding sound masking and the Lombard effect.

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Indeed, it is only by controlling background sound—in contrast to limiting background noise—that one can realize certain benefits, such as increased speech privacy and improved specification of construction requirements, as well as the associated labor and cost savings.

ARCHITECTURAL ACOUSTICS

The study of acoustics dates back thousands of years. Given its roots are deeply entangled with those of mathematics and physics, it is unsurprising the typical approach to acoustic investigation is quantitative. Consideration of "soft" parameters (i.e., subjective and descriptive) is relatively scarce until the last century.

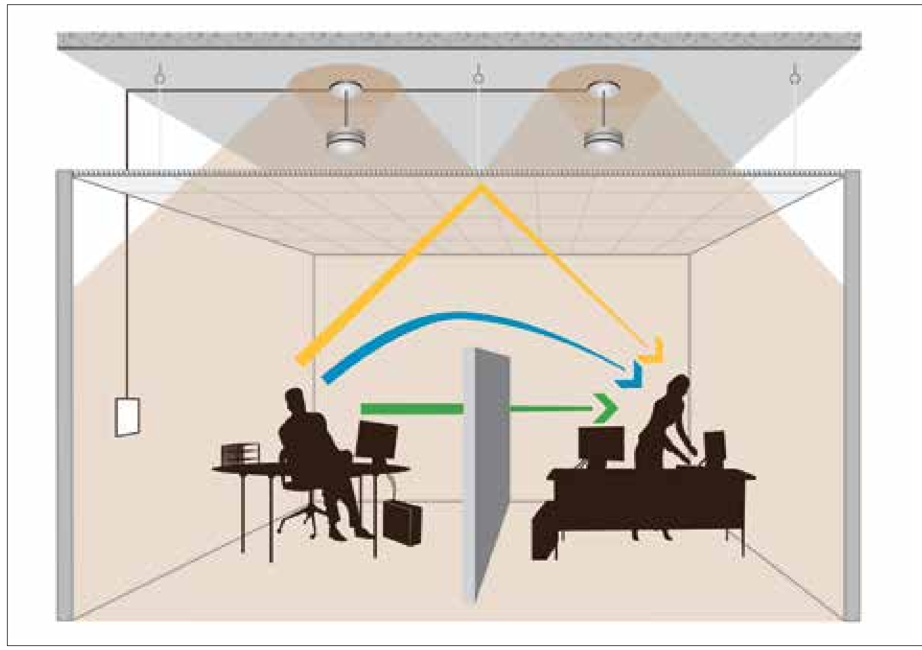
Interest in evaluating human response to acoustics gained momentum in the 1900s with the rise of architectural acoustics—also known as building or room acoustics. Most notably, contributions from Bell Telephone Laboratories, Bolt Beranek & Newman Inc., and others formed the foundation for psychoacoustics, a branch of psychology focusing on the perception of sound and its physiological effects. Research examined occupants' assessment of intruding noise (e.g., annoyance, distraction, inadequate acoustical privacy) in their environment.

Motivated by the need to develop an objective approach to effective architectural acoustical design, William Cavanaugh et al. published *Speech Privacy in Buildings* (1962), asserting neither acoustical privacy nor acoustical satisfaction could be guaranteed by any single design parameter. This work was instrumental in what became to be understood as the ABCs: of architectural acoustical design:

- "A" is for "absorb," which involves providing sufficient, but not excessive, absorptive materials, in order to reduce the amount of sound energy within the space;
- "B" is for "block," which involves providing sufficient isolation within the space; and
- "C" is for "cover"—or one might say "control"—which involves management of the spectral distribution and overall level of background sound within the space with the intention of masking speech and noise (rather than, for example, adding biophilic sounds with the intention of increasing occupant connectivity with the natural environment).

Although the authors of *Speech Privacy in Buildings* appreciated the importance of background sound, they tended to use the words "noise" and "sound" interchangeably—a practice deeply rooted in historical habits, which continues today.

Image courtesy of KR Moeller Associates Ltd.



The ABCs of architectural acoustical design involve using a variety of methods and materials to absorb, block and cover noise with the intention of creating an environment that is more comfortable for occupants and supportive of their tasks.

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An individual's assessment of sound depends on a variety of factors, such as their expectations for the environment, the task in which they are engaged, the sound's level and frequency content, as well as the level and spectral distribution of background sound present within the space.

The signal-to-noise ratio

Initially, acousticians such as those at Bell Telephone Laboratories were primarily interested in evaluating the conditions needed to clearly hear sounds. They determined the critical factor was the level of the desired sound—called the "signal"—relative to that of the background sound present in the listener's location. In most cases, the background sound used during testing was broadband and did not contain information (i.e., noticeable patterns, such as running speech, nature sounds, traffic noise); however, it was termed "noise" because it could potentially interfere with the intelligibility of the desired sound. The ratio of the desired sound to background sound was termed the signal-to-noise ratio.

In the above case the "signal" is the

sound one wants to hear because it conveys useful information, while the "noise" is an unwanted input challenging one's ability to clearly hear the desired sound. As acousticians developed an understanding of background sound as a fundamental component of speech privacy, the methodology—and the terminology—remained the same. Hence, the word "noise" continued to be used to describe the background—or, in this case, the masking—sound, despite the fact it was now being viewed in a positive light.

Understandably, the term "noise" can cause confusion when the "signal" is the unwanted sound and the "noise" is actually the desired background sound. Meanwhile, the general public tends to use "noise" as a non-technical descriptive word, typically when relating negative acoustical experiences—ones that are uncomfortable, annoying, disturbing, or even painful.

To highlight the difference in the way in which "noise" is used, consider an individual working in an office, who complains about "noise" to a colleague. There are several sources of sound within the space (exterior traffic, a fan, and a radio playing music), but the source bothering the individual is a heated debate taking place in the meeting room adjacent to a workspace. In this scenario, the terms are defined in this way:

- **Sound** – there are four sound sources identified in the workplace.
- **Signal** – the noise capturing the individual's attention (i.e., the debate) and, hence, the cause of their complaint.
- **Noise** – the individual uses the word "noise" to describe the debate. However, if the term is used in a technical assessment of this environment, the "noise" is actually the combination of all other sound sources (i.e., the traffic, fan, and radio), excluding the signal (i.e., the debate).

Technical use of the word "noise" requires a "signal." In this case, noise accounts for the combination of sounds (i.e., it considers everything that is not the signal), while the signal only considers the source of the sound that is of interest.

THE LOMBARD EFFECT AND MASKING SOUND

Subconsciously raising one's voice level in order to be more clearly heard within a noisy environment is known as the "Lombard effect"—or, colloquially, the "cocktail-party effect." Sometimes, people express concern it will be triggered by the increased ambient level provided by a sound masking system.

In brief, this concern is unwarranted. For reference, masking is usually set to 45 to 48 dBA in open areas and 40 to 45 dBA in closed rooms. Research shows the Lombard Effect begins when "disturbing noises exceed 45 dBA"—a value near the typical limit of masking. The literature also shows the impact of raising background noise levels to 48 dBA is negligible—prompting less than 1 dBA increase in speech levels.*

Moreover, there is a distinct difference between "disturbing noises" and masking sound. The latter is designed to be as comfortable as possible. In fact, when the masking system is properly engineered, installed, and tuned, the sound is unobtrusive to occupants.

In closed offices, there is even less concern due to the lower masking levels typically specified for these environments. Not only would the person speaking not feel "triggered" to raise their voice, but the intelligibility of speech at normal levels would be unaffected. Rather, masking would perform its intended function: bolstering speech privacy (transmission of sound out of the room) and the perception of privacy (intrusion of noise into the room).

* Read H. Lazarus' article, "Prediction of Verbal Communication in Noise–A Review: Part 1," from the 19th volume of Applied Acoustics (1986) and J. H. Rindel and C. L. Christensen's article, "Dynamic sound source for simulating the Lombard effect in room acoustic modeling software," from the proceedings of InterNoise 2012 in New York, NY.

THE HUMAN FACTOR

What turns a "sound" into a "noise" in the common vernacular? Humans demonstrate remarkable tolerance to sound and are only susceptible to its disruptions when they become aware of it—typically when the level of sound is too high, its qualities are unbalanced (e.g., it is too "hissy" or "rumbly"), or it presents with temporal instability of its dynamic range (i.e., the change and/or rate of change in sound level over time).

Context

A person's assessment of sound generally depends on personal preferences and expectations for the occupied environment as well as the activity in which they are engaged. For instance, consider a conversation at "normal level" in two environments: a library and a busy restaurant. In the former, nearby occupants engrossed in a task requiring concentration are likely to find the conversation too loud, annoying, and disruptive. In the latter, the level of conversation may not be sufficiently loud to allow for clear communication. Expectations are based on an understanding of the purpose of the space and the task at hand.

Content

One's description of sound tends to focus on two main properties: its level (often referred to as volume) and its spectral distribution. A "hissy" or "screechy" sound is one that has a lot of high frequency information (e.g., a young child screaming). A "bassy" or "rumbly" sound is one with a lot of low frequency information (e.g., a lion roaring). A space without a balanced sound spectrum can sound worse than one with a higher sound level, but with a balanced spectrum.

Cover

The human experience is also determined by the space's background sound level, which is considered to be the collection of all (ambient) sounds within it. Often, a room is too "silent" (i.e., its ambient level is too low) and a source of sound becomes uncomfortable (e.g., a clock ticking, cars driving by, people talking, lights humming). In these cases, the "signal" is disturbing because its level is higher than the background sound. The disruptive impact of these annoying noises can be lessened by reducing the signal-to-noise ratio, which is achieved by raising the background sound level. In some cases, it is possible to raise the background sound level sufficiently to completely cover up these unwanted sounds.

THE NEED FOR CONTROL

Given both the scientific and human factors, one can readily see there are advantages to controlling background sound, rather than accepting large variations in its level and spectra.

The consequences of neglecting this principal parameter of architectural acoustical design is an environment that is perceived to be "noisy," as presented in Figure 1 (next page). The alternative—to add sound to

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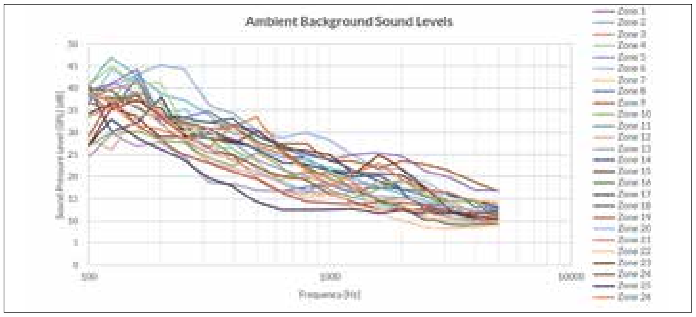


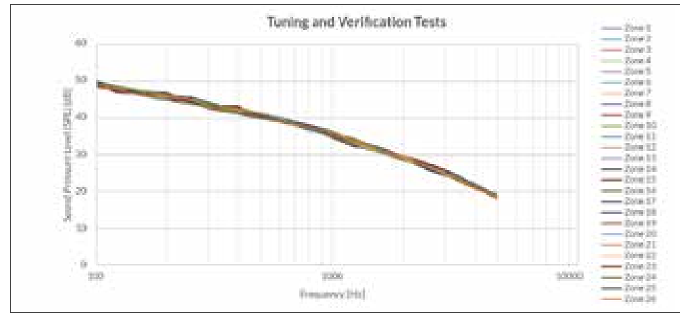


Figure 1 (left): Many people assume that the acoustic conditions are uniform throughout a facility, but without the use of a properly designed and commissioned sound masking system, it is never the case. In this example of an unmasked space—one floor, primarily consisting of open plan—the "natural" background levels of the unoccupied space vary considerably between the 26 zones in which ambient measurements were taken. Figure 2 (right): These inconsistencies can be addressed using a sound masking system—the only acoustical treatment that can accurately control the background sound level within a facility. Here, you can see the difference when masking sound is applied and tuned so that it consistently meets the NRC curve within each zone to ensure uniformity of acoustic conditions throughout the space. The acoustically consistent environment is more comfortable—or "quiet"—for occupants.

reduce the perception of a noisy environment—might seem counterintuitive, but consider Figure 2. By precisely controlling the spectrum and level of sound (in this case, to a target overall sound pressure level of 47 dBA), one can make the space sound more comfortable.

The difference between one's experience in a space with a very low ambient level and one with a higher ambient level suggests just as there is a need to differentiate between "sound" and "noise," there is value in distinguishing between a "silent" space and a "quiet" one. Whereas "silent" infers the absence of sound, a "quiet" space can be characterized by a constant ambient sound that is comfortable and not readily noticeable by its occupants. Spaces such as these are perceived to be less "noisy" and more comfortable—or "quiet."

EVOLUTION OF SOUND MASKING

Advanced technologies—called sound masking systems—have been developed to control the level and properties of ambient sound within commercial spaces. These systems consist of a series of loudspeakers installed in a grid-like pattern in an open ceiling or above the ceiling treatment. The loudspeakers' output is controlled using additional equipment. The first instances of their installation followed publication of Cavanaugh's influential *Speech Privacy in Buildings* book. However, at the time, there were several obstacles to their adoption as an effective acoustical design strategy.

First, these early systems were widely considered failures due to technological limitations and a lack of understanding and application of acoustical theory, which affected both their design and commissioning (e.g., large zones, limited control over volume and frequency settings). Ultimately, they failed to deliver a consistent, comfortable sound.

Second, their deployment coincided with sudden awareness and aggressive regulation of "noise exposure." Although earlier efforts were made in other countries, the most comprehensive attempt to combat noise nuisance came in the form of the United States of America's *Noise Control Act of 1972*. Many other governments and organizations have since used this document as the basis for their own regulations regarding occupational health and safety, environmental noise, transportation noise, and built environments (e.g., HVAC, building services), the primary focus of which is to limit sudden or prolonged exposure to high "noise" levels that would cause hearing loss.[1]

However, research shows the definition of "noise" should also include "unwanted sound" (e.g., that which interferes with one's ability to concentrate on the task at hand or get a good night's rest). These noises do not meet the same criteria as those damaging physical structures, but their impact is nonetheless undesirable. Background sound can have a positive and mitigating effect here and, hence, the need to make the distinction. Rather than trying to create a silent, library-like space in which there is little to no sound at all (i.e., a "silent" space), the goal is to create a "quiet" space—one in which there is little to no unwanted sound.

Last, developing the masking spectrum was an iterative process spanning several decades. With the development of methodology to assess the acoustical privacy of spaces—namely, the articulation index (AI)—discussion turned toward specification of reasonable targets for acoustical privacy and renewed interest in determining what type of background sound would work best and how it could be delivered. After all, if the intention is to improve privacy, one not only needs to control the level of background sound but also ensure the sound has specific qualities. In the 2000s, the National Research Council (NRC) refined the spectrum, based on tests measuring both comfort and effectiveness, resulting in the cost-effective open-plan environment (COPE) masking spectrum (Figure 3, next page).

It is important to note delivery of effective "masking" is not a product of the sound generating and control equipment (i.e., the electrical signal), but rather the ability of the sound masking system to adapt the generated sound that is actually delivered to the space and which is dependent on the space's architecture—its layout, furnishings, and finishings. To achieve the desired effect,

[1] In the current discussion of appropriate noise exposure limits for activity-based spaces (e.g., for learning, recovery, sleep)—such as those set by the World Health Organization (WHO)—the focus continues to be on sound level with little consideration of the other factors playing into human evaluations of acoustics. There is little appreciation of psychoacoustical parameters, which would consider the existing level and spectrum of background sound in review of the intruding sound from the noise source. By way of example, lacking understanding of the existing level and spectrum of sound in space, it is impossible to conclude sleep disruption can occur as a result of intruding traffic noise at any defined value (e.g., 30 dBA).

the sound produced within the space must be adjusted to a specific spectrum through a post-installation process called tuning.

Ensuring effective performance also requires verification. ASTM E1573-18, Standard Test Method for Evaluating Masking Sound in Open Offices Using A-Weighted and One-Third Octave Band Sound Pressure Levels, offers guidance and instruction on the measurement procedure to evaluate the performance of a commissioned masking system. Measurements are performed in every 93 square meters (1,000 square feet) of open space and a representative number of closed rooms to review effectiveness of the tuning process against performance targets and tolerances, and to provide an indication of the spatial uniformity of the masking sound.

In the last decade or so, great advancements have been made with regard to masking technology's ability to accurately and consistently achieve a comfortable and effective masking sound across treated spaces. When designed with small zones no larger than 21 to 63 square meters (225 to 625 square feet) offering fine volume (i.e., 0.5 dBA) and frequency (i.e., 1/3 octave) control, a networked-decentralized architecture can provide consistency in the overall masking volume not exceeding ±0.5 dBA, as well as highly consistent masking spectrums, yielding much better tuning results than possible with previous architectures. Some systems can also be automatically tuned using software, which first measures the sound within a zone and then rapidly adjusts the volume and frequency settings to achieve the specified curve.

Photos courtesy of KR Moeller Associates Ltd.

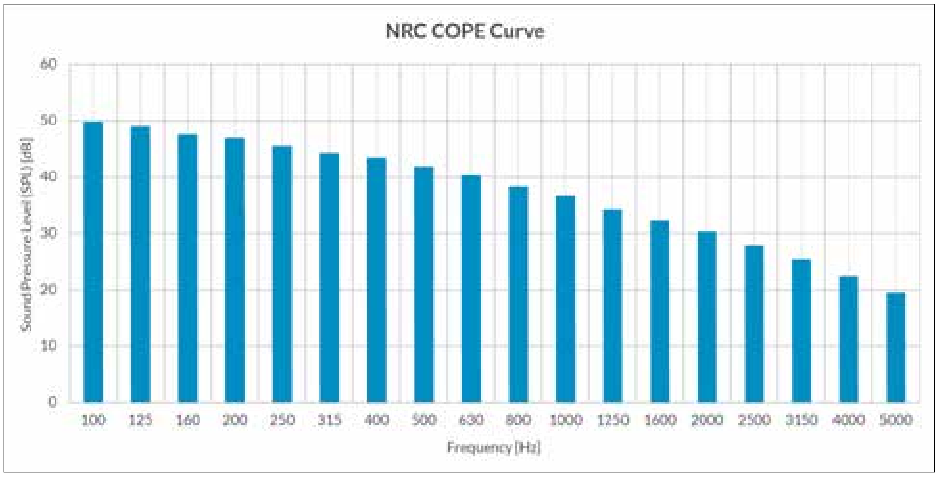


Figure 3: The National Research Council (NRC) Cost-Effective Open-Plan Environment (COPE) masking spectrum. The slope is approximated by 4.90 dB/oct. between 125 and 5,000 Hz. While the low frequencies do not contribute as greatly to speech privacy as the frequencies in the middle to high range, they are necessary for comfort. Without those, occupants would perceive the sound as "hissy."

STANDARDIZING SOUND MASKING

The importance of managing background sound levels using sound masking technology is now recognized in many standards, guidelines, and building codes, including:

- Standards Australia/New Zealand (AS/NZS) 2107:2016, Acoustics, Recommended design sound levels and reverberation times for building interiors;
- Canadian Standards Association (CSA) Z412-17, Office Ergonomics – an application standard for workplace ergonomics;
- Facilities Guidelines Institute (FGI) documents such as Sound & Vibration (2010), FGI Guidelines for Design and Construction of Hospitals (2018), and FGI Guidelines for Design and Construction of Outpatient Facilities (2018);
- General Services Administration's (GSA's) PBS-P100, Facilities Standards for the Public Buildings Service (2017);
- Green Building Initiative's (GBI's) Green Globes for New Construction 2019;
- The U.S. Green Building Council's (USGBC's) Leadership in Energy and Environmental Design (LEED) v4.1 Building Design & Construction (BD+C) and Interior Design & Construction (ID+C);
- International WELL Building Institute's (IWBI's) 2014 WELLv1 and 2018 WELLv2;
- ASTM 1374-18e1, Standard Guide for Office Acoustics and Applicable ASTM Standards;
- The American National Standards Institute/Acoustical Society of America (ANSI/ASA) S12.70-2016, Criteria for Evaluating Speech Privacy in Healthcare Facilities; and
- The International Organization for Standardization (ISO) 3382-3, Acoustics – Measurement of room acoustic parameters – Part 3: open plan offices and ISO 22955, Acoustics – Acoustic quality of open office spaces.

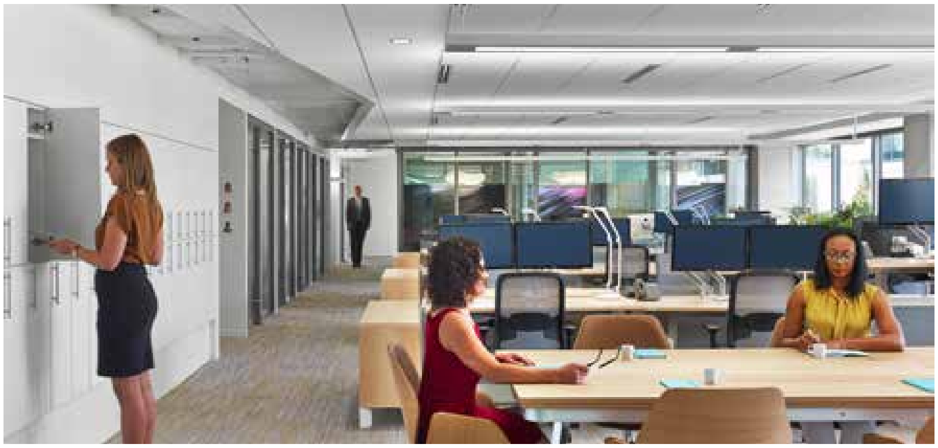
However, many have yet to capitalize on the ways in which masking systems can be used as a tool in architectural design. For that reason, the strategies employed by two of these documents are worth further discussion.

(continued on next page)

Photo courtesy of Jon Evans Photography

A sound masking system uses a series of loudspeakers installed in a grid-like pattern in an open ceiling or above the ceiling treatment in order to control the level and properties of background sound within commercial spaces.

Photo courtesy of American Society of Interior Designers (ASID)



Providing the background sound level and spectrum within a space are precisely controlled, occupants perceive the space to be quiet.

ENSURING MINIMUM BACKGROUND SOUND LEVEL

In closed rooms, speech privacy depends on the background sound at the listener's position being higher than the residual voice level penetrating the wall. This point is highlighted in ASTM E2638, Standard Test Method for Objective Measurement of the Speech Privacy Provided by a Closed Room. Background noise is presumed to be due to building systems (i.e., HVAC) and is, therefore, highly variable. In the absence of continuous masking sound, the measurement—and, hence, any conclusion based on it—is valid only at the time it is done.[2]

To promote a more well-rounded design approach, AS/NZS 2107:2016 specifies criteria acknowledging several benefits of minimum background sound levels, including the "insurance policy" it provides against loss of acoustic isolation and speech privacy. The document introduces guidance with regard to adequate level and spectrum for the built environment. While this standard specifically excludes setting performance guidelines for masking sound, it promotes sound masking systems as a possible solution building professionals may consider to ensure acoustical privacy and satisfaction.

USING A POINT-FOR-POINT EXCHANGE

An even more beneficial approach was proposed by renowned acoustician, William Cavanaugh, when he said, "an increase in the background sound level has the same effect on intelligibility as an increase in the transmission loss."[3] It is on this basis that Sound & Vibration 2.0: Design Guidelines for Health Care Facilities—the companion document to the FGI's 2018 Guidelines for Design and Construction of Hospitals and 2018 Guidelines for Design and Construction of Outpatient Facilities—allows for a point-for-point exchange in kind between the measure of isolation—the sound transmission class (STC)—and the background level (dBA).

Historically, background sound levels were (and continue to be) not uniform in level and spectra, and highly variable over time and throughout the built environment. As a result, partition walls were often overbuilt in an effort to reduce the transmission of sound from source to receiver. Rather than employing effective controls for background sound, designers and engineers heavily overcompensated by using additional materials to provide greater isolation and absorption. This hyper-focused approach on objective components of acoustics consistently failed to appreciate the importance of human factors—namely, that a space can be perceived as quiet.

It is in the consideration of the pseudo-subjective evaluation of acoustical privacy—estimating acoustical privacy of a space using a combination of objective metrics (i.e., measure of isolation and background sound)—that we have the opportunities to realize cost savings at the design stage of a project.

Consider the following simplified scenario, which is intended to quickly illustrate the approach:

- An enclosed room conforming to a field-tested STC-45 rating requires a 30 dBA background sound level for speech privacy; and
- Alternatively, if the minimum background sound level is raised to a constant level of 35 dBA, the composite performance of the construction of the environment (walls, ceiling, floor) can be reduced to STC-40 rating.

A mere 5 STC points may not seem significant, however the cost savings in terms of materials, labor, and time can be. Also, if one reduces the STC rating of the partition by five points and raises the controlled background sound levels by 10

Photo courtesy of Vincent Lions Photography

Factoring in a precisely generated and consistently delivered masking sound during a project's design phase allows one to reduce material, construction, and labor requirements, particularly for enclosed spaces. A masking system also acts as an "insurance policy" for the future. Should the space underperform—which can occur for any number of reasons—the masking sound level can be raised to improve acoustical privacy and satisfaction.

[2] In any case, the dBA levels produced by traditional HVAC varies and this equipment cannot generate a spectrum conducive to speech privacy.

[3] Reference from Speech Privacy in Buildings (1962).

dBA to a level of 40 dBA, acoustical privacy is more assured and the psychoacoustics of the space are improved.

A more assertive effort could pursue the reduction of the STC rating of the partitions from STC-45, which relies on 30 dBA of background sound, to an STC-35 with 40 dBA of background sound.[4] Providing the background sound is precisely generated and consistently delivered by the masking system, this enhanced design process affords the opportunity to explore new options:

- Greater selection of materials (performance, cost);
- Cost of labor associated with installation (difficulty, time required);
- Building to the ceiling instead of to the deck, with appropriate selection of acoustical tile with isolation properties (ceiling attenuation class [CAC] criteria);
- Reduction in quantity of materials and labor (installation time, difficulty, and complexity);
- Ease of reconfiguration of a space due to demising walls;
- Layout consideration and post-building adjustments (facility flexibility);
- The cost of continuing the partition above the ceiling to the deck is more significant and the difficulty in installation (height of plenum, penetrations, interferences); and
- Reduction in material waste and environmental repercussions.

As mentioned earlier, using masking to control background sound levels also acts as an "insurance policy." Should the space underperform—which can occur for any number of reasons—there remains the opportunity to raise the background sound level upward to 45 dBA for enclosed spaces and 48 dBA for open areas to improve the psychoacoustical measures of the space.

CONCLUSION

Although sound is ubiquitous—a constant and inescapable experience—its positive role within the built environment is not commonly appreciated, leading to ongoing debate about the control (or lack thereof) of background sound levels within various types of facilities. Reviewing the technical and popular use of various words allows one to gain appreciation for how they can lead to misunderstandings of what it takes to achieve an effective acoustic environment and, more specifically, the role played by background sound set to a controlled level and spectrum. The distinction between "noise" and "sound" is expansive, and the implications are significant in terms of subjective and objective attributes of the built environment. It is by refining the definitions of those terms, as well as that of "silence" and "quiet," that appreciable opportunities can be fostered to improve the design of the built environment and promote occupant well-being.

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4 Again, this considers field-tested sound transmission class (STC) values reflecting composite acoustic performance of all sound transmission paths.

UNDERSTANDING ACOUSTICAL PRIVACY

Typing the word "privacy" into a search engine yields a lengthy steam of entries describing the many ways in which it can be violated, including reports of hackers acquiring credit card information, various groups mining social networking sites, and voice-activated electronics with the ability to eavesdrop on their owners.

Our preoccupation with the vulnerabilities exposed by the internet and electronic products is understandable given their relatively rapid spread into almost every aspect of our lives. But we should not forget that privacy can still be violated in traditional ways—whether by deliberate eavesdropping or simply being in audible range of a conversation. While privacy legislation tends to focus on securing access to information stored on computers and within filing cabinets, attention also needs to be paid to our built environment.

Many immediately equate acoustical privacy with speech privacy, but there is more to this concept than the ability to clearly hear what another person is saying. For example, even if the conversation taking place in the room next to you is unintelligible, you may still be able to identify the speaker's tone and determine whether they're happy, sad, or angry. This type of information can be considered private under certain circumstances, such as when overheard outside of a human resource manager's office.

How much we understand of a conversation also depends on whether or not we can see the speaker. This effect—known as visual cues—has been quantified by various studies. Generally speaking, if you can only understand 20 percent of someone's conversation when you're not looking at them, the ability to see their lips increases that amount to nearly 55 percent. If you start at 50 percent, visual cues increase it to almost 90. In other words, there's also a visual component to acoustical privacy, which is important to bear in mind when designing a space.

A lack of acoustical privacy carries real risk, particularly in facilities where there is a perceived need for it—or an expectation on the part of its users. Examples that readily spring to mind are hospitals, banks, law offices, and military facilities. However, other types of spaces—such as commercial offices—have privacy needs as well. The degree required usually depends on the activities the space hosts.

It is easy to understand the need for acoustical privacy—or even acoustical security—from a speaker's perspective, particularly in environments where occupants are discussing medical or financial information, but a lack of acoustical privacy can have impacts beyond divulging sensitive information to unintended parties. This fact becomes clear when we look at the conversation from the viewpoint of the (often involuntary) listeners, rather than that of the individuals talking.

When a noise or voice enters "our space," some degree of annoyance is typical, but it can also make us feel as though our privacy is being invaded or our sense of physical separation from others violated. Perhaps the most relatable examples of this sensation are when the guest in a neighboring hotel room turns up their television's volume or the patient at the other end of a waiting area starts speaking on their cellphone. If we can inadvertently hear a conversation, we also become self-conscious about our own level of privacy. In some contexts, it creates a sense of unease, which in turn impacts our ability to freely communicate. For instance, if we visit a medical clinic and hear what is happening in the adjacent exam room, we are less inclined to disclose information to the doctor, knowing that we too can be overheard.

Photo courtesy of Vincent Lions Photography

The degree of acoustical privacy afforded by the built environment can even impact an organization's brand image. We want to be in control of our personal information when meeting with a financial or legal advisor, for example, and a positive acoustical experience can reinforce our confidence in their firm. This level of protection is also indispensable for staff to effectively negotiate. In some countries, protecting verbal communication within particular types of facilities is actually mandated by law. The U.S. Health Insurance Portability and Accountability Act (HIPAA) is a good example.

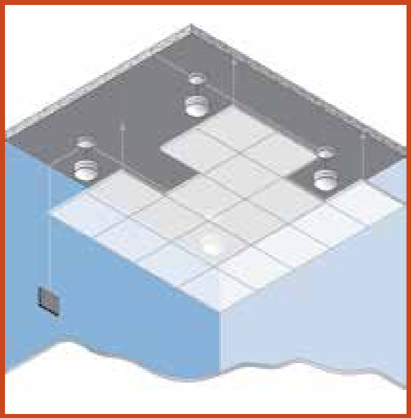
Acoustical privacy is also vital to employees' overall satisfaction with their workplace. A decade-long survey run by the Center for the Built Environment (CBE) found that lack of speech privacy is the number one complaint in offices. Participants expressed irritation at being able to overhear in-person and telephone communications, as well as concern for their own level of privacy.

The topic of workplace satisfaction also emphasizes the need to consider those occupying spaces other than closed rooms. Although some might dismiss the importance of acoustical privacy when designing open-plan space, studies show that it has a significant impact on productivity. For instance, research conducted by the Finnish Institute of Occupational health shows that unwilling listeners demonstrate a 5 to 10 percent decline in performance when undertaking tasks such as reading, writing, and other forms of creative work. Simply hearing that someone is speaking can disturb concentration, but this problem is amplified when you can clearly understand what they are saying. Essentially, if you can follow a conversation, it is much harder to "tune out."

Although an organization might not consider privacy a goal within open plan, it is impossible to justify increasing distractions. Occupants working in an acoustically comfortable environment have an easier time concentrating on their tasks, and also suffer less stress and fatigue. An organization may decide it is more motivated by the need for a high-performance workplace than acoustical privacy, but taking the steps required to lower speech intelligibility allows them to reap both rewards. The only difference is how you see the benefit: from the perspective of the group listing rather than the person talking.

Photos courtesy of KR Moeller Associates Ltd.

UNDERSTANDING SOUND MASKING



Sound masking systems are a common component of today's interiors, from their original use in commercial offices to relatively newer applications such as patient rooms in hospitals and guest rooms in hotels.

This technology uses loudspeakers to distribute an engineered background sound throughout a facility, raising its ambient level in a controlled fashion. The new level obscures noises that are lower in volume and reduces the disruptive impact of those that are higher by minimizing the degree of change perceived by listeners. Similarly, conversations are either entirely covered up or their intelligibility is reduced, improving speech privacy and decreasing the number of disruptions to occupants' concentration.

Most people have experienced this type of effect—for example, when washing dishes at their kitchen sink while trying to talk to someone in the next room. They can tell the other person is speaking, but it is difficult to understand exactly what they are saying because the running water has raised the ambient level in their area. In fact, everyday examples are virtually endless: the drone of an airplane engine, the murmur of a crowd in a busy restaurant, or even the rustling of leaves in the wind. They all have the potential to mask sounds the listener would otherwise hear.

Of course, when introducing a sound to a workplace or a health-care facility, it is vital to ensure that it is as comfortable and unobtrusive as possible. Otherwise, it risks becoming a source of irritation and rather than helping to solve an acoustic problem, it becomes one itself—as was the case with the original masking systems developed in the late 1960s which used white noise generators.

White noise is a random broadband sound—meaning it includes a wide range of frequencies—that typically spans the audible range of 20 to 20,000 hertz (Hz). Graphical representations of this type of noise vary depending on the horizontal axis. If it shows individual frequencies, volume is constant; however, if the scale is in octaves, each octave's volume increases by three decibels (dB) because each octave contains double the number of frequencies than the one before it, and as a general rule, the combined volume of any two sounds of equal volume is three dB higher. Thus, a graph depicting white noise shows either flat or increasing volume.

Most people describe white noise as "static" with an uncomfortable, hissing quality. Those old enough to remember analog televisions compare it to the "snow" broadcast when the antenna lost the transmission signal and picked up electromagnetic noise instead. It is unsurprising that these early masking systems were typically turned down or off soon after they were installed.

"Pink noise" is another term often inaccurately substituted for "sound masking." It is also a random broadband sound, but instead of being equal in volume at each frequency, volume decreases at a rate of three dB per octave as frequency increases. However, because these decreases are offset by the increases created by the doubling of frequencies in each octave, pink noise is constant in volume per octave. Subjectively speaking, this sound is less hissy than white noise. On the other hand, the relatively louder low frequencies give it a rumbling quality, prompting comparisons to the sound of a waterfall.

Given these descriptions, it is understandable why modern sound masking systems do not emit white or pink noise—or, in fact, any of the other colors (e.g., brown, blue, or purple).

A sound masking spectrum—often called a "curve"—is engineered to balance effective acoustic control and comfort. It is usually provided by an acoustician or an independent party such as the National Research Council (NRC), rather than by the masking vendor. The curve includes a wide range of randomly generated frequencies; however, it is narrower than the full audible range—typically from at least 100 to 5,000 Hz, and sometimes as high as 10,000 Hz. Further, the volume of masking frequencies is not equal, nor do they decrease at a constant rate as frequency increases.

It is important to understand that the curve defines what the sound masking system's measured output should be within the space. Regardless of how the system is designed, its out-of-the-box settings, or the orientation of its loudspeakers (i.e., upward- or downward-facing, sometimes called "direct-field"), the sound is influenced as it interacts with various interior elements within the facility, such as the layout and furnishings. If the sound is to meet the specified curve, the system's volume and frequency settings have to be adjusted in small, localized zones. In other words, it must be tuned for the particular environment in which it is installed.

Tuning is handled by a qualified technician after the ceilings and all furnishings are in place. Because conversations and activities can prevent accurate measurement, it is done prior to occupation or after hours. Basically, the technician uses a sound level meter to measure the masking sound at ear height. They analyze the results and adjust the system's volume and equalizer controls accordingly. They repeat this process as often as needed until they meet the desired curve at each tuning location.

Most people compare the sound of a professionally tuned masking system to that of softly blowing air. However, there is much more significance to the tuning process than simply providing a pleasant auditory experience. One must also ensure that the sound performs its intended job.

The effectiveness of the masking sound is directly related to the sound masking system's ability to closely match the specified curve. Some degree of variation is expected; it is impossible to achieve perfection in every tuning location. However, because variations in the masking sound can profoundly impact performance, the specification should not only provide a target curve, but also a "tolerance" that indicates by how much the sound is allowed to deviate from that curve across the space. Achieving consistency is also important for comfort; a uniform sound fades into the background more easily and occupants come to consider it a natural part of their space.

Historically, tolerance was often set to ±2 dBA (i.e., plus or minus two A-weighted decibels), giving an overall range of 4 dBA. However, such wide swings in overall volume across the space can allow occupants to understand up to 43 percent more of a conversation in some areas than they can in others. Advances in masking technology now permit tolerance to be set as low as ±0.5 dBA (i.e., a range of 1 dBA), yielding far more consistent results and providing dependable masking coverage throughout the installation.