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A networked sound-masking, paging, and music system installed in the three-story, 72,000-sf Farm Mutual Reinsurance Plan's headquarters, Cambridge, Ont.

Sound-Masking Systems

OPTIMIZE SPEECH PRIVACY IN THE WORKPLACE

BY NIKLAS MOELLER, MBA, K.R. MOELLER ASSOCIATES LTD.

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Since most office-based workers spend more than half their time on focus work and on the telephone, speech privacy and noise control are vital to their ability to concentrate and their satisfaction with their workplaces. The work environment should support these activities; instead, workplace design trends—open plan, higher-density office spaces—are steadily eroding many means of controlling acoustics. Partitions are getting lower and lower, absorptive finishes are being replaced with hard, exposed surfaces, and closed rooms are being built with less sound–absorptive demountable walls.

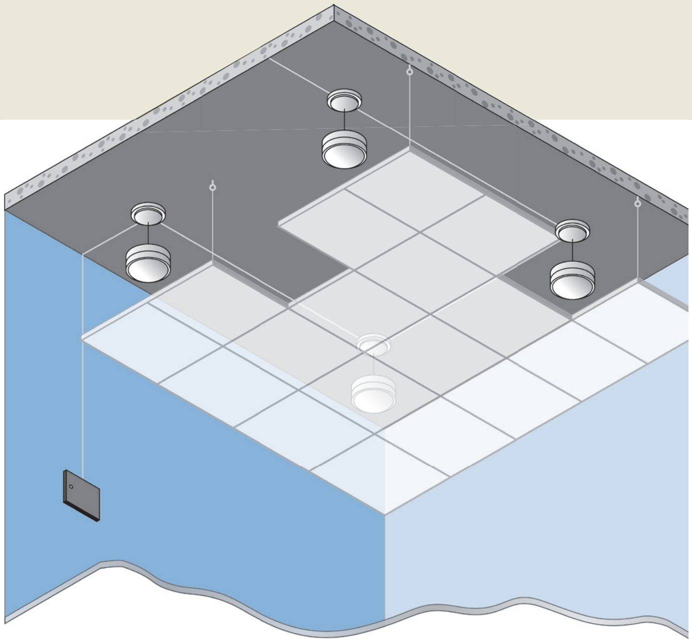
Whether designers are making these choices for the sake of aesthetics, sustainability, or short-term budget goals, they all impact acoustic performance. The situation is compounded by improvements in construction materials and mechanical and office equipment, which have lowered the ambient—or background—sound level. The resulting "you-could-hear-a-pin-drop" environment allows conversations and noise to be easily heard and understood, even from a distance. What ambient sound remains lacks the correct mix of frequencies needed for effective acoustics.

Sound-masking technology addresses this problem by distributing engineered sound throughout the workspace, raising its ambient level in a controlled fashion. We've all experienced this type of effect—the drone of an airplane engine, the buzz of a busy restaurant, even the rustling of leaves in the wind. All have the potential to mask sounds we'd otherwise hear.

LEARNING OBJECTIVES

After reading this article, you should be able to:

+ **EXPLAIN** sound masking's role in achieving effective acoustics.
+ **DIFFERENTIATE** between sound masking, white noise, and pink noise.
+ **IDENTIFY** the three main types of masking architecture: centralized, decentralized, and networked.
+ **DESCRIBE** the importance of achieving spatial uniformity in the masking sound in order to improve occupant privacy, concentration, and comfort.



COURTESY SCREEN SOLUTIONS

A sound-masking system consists of a series of loudspeakers, which distribute an engineered background sound throughout a facility. The loudspeakers can be installed above a suspended ceiling (as shown) or in an open ceiling. The system should be tuned by a qualified technician.

Adding more sound might seem contradictory to the goal of achieving effective acoustics. But with proper use of sound-masking technology, the new level obscures noises that are lower in volume and reduces the disruptive impact of those that are higher in volume by minimizing the degree of change perceived by listeners. Conversations are also covered or their intelligibility is reduced. As a result, occupants perceive treated spaces as quieter and more private.

When introducing sound to a workplace, it must be as comfortable and unobtrusive as possible; otherwise, it risks becoming a source of irritation, as was the case with the original sound-masking systems of the late 1960s, which used white-noise generators.

WHAT ARE WHITE NOISE AND PINK NOISE?

Though the term white noise still tends to be used interchangeably with sound masking, it is a very different type of sound from that produced by modern masking technologies.

White noise is a random broadband sound—meaning it includes a wide range of frequencies—that typically spans the audible range of 20 Hz to 20,000 Hz. Graphical representations of this type of noise vary, depending on the horizontal axis. If the horizontal scale shows individual frequencies, volume is constant; if the horizontal scale is in octaves, each octave's volume increases by three decibels. That's because each octave contains double the number of frequencies than the one before; as a general rule, then, 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 say white noise sounds like "static"—an uncomfortable, hissing sound, much like the sound of the "snow" that emanated from old television sets. No wonder people turned down or turned off these early masking systems soon after they were installed: they were annoying!

Pink noise is another term often inaccurately substituted for sound masking. It too is 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. 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. To most observers, pink noise sounds less hissy than white noise, but its relatively louder low frequencies give it a rumbling quality, like that of a waterfall.

Modern sound-masking systems do not emit white noise or pink noise. So how do they work?

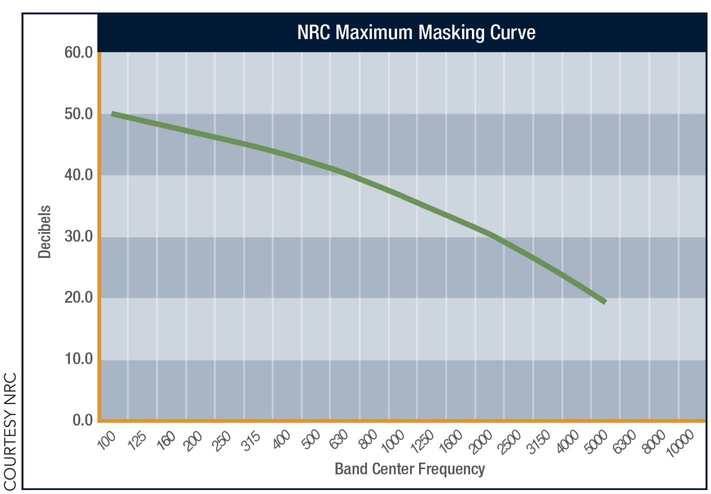
BALANCE THE SOUND-MASKING CURVE

A sound-masking spectrum—often called a *curve*—is engineered to balance acoustic control and comfort. It is usually issued by an acoustician or an independent party, such as the National Research Council, rather than by the masking system vendor.

A masking curve includes a wide range of randomly generated frequencies; however, it is narrower than the full audible range—typically from at least 100 Hz to 5,000 Hz, and sometimes as high as 10,000 Hz. Furthermore, 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; regardless of its out-of-the-box settings; regardless of the orientation of its loudspeakers (i.e., upward- or downward-facing, sometimes called "direct-field"), the sound is influenced as it interacts with its environment, such as the facility's layout, furnishings, or materials. 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, *the sound-masking system must be tuned for the particular environment in which it is installed.*

Tuning should be handled by a qualified technician, but not until the ceilings and all furnishings are in place, and with mechanical sys-



COURTESY NRC

A sound-masking spectrum, or "curve," is typically specified by an acoustician or supplied by an independent third party, such as the National Research Council (shown here), rather than by the system's vendor.

tems operating at normal daytime levels. Since conversations and human activities can make accurate measurement difficult, tuning should be done prior to occupation of the space or after hours. The technician uses a sound level meter to measure the masking sound at ear height, analyzes the results, and adjusts the system's volume and equalizer controls accordingly. This process is repeated until the desired curve is attained at each tuning location.

ENSURE SPATIAL UNIFORMITY

Most people compare the sound of a professionally tuned masking system to that of softly blowing air. But there's much more to the tuning process than simply providing a pleasant auditory experience: it also ensures 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's 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 (plus or minus two A-weighted decibels), yielding an overall range of 4 dBA. However, such wide swings in overall volume across the space mean that occupants can understand up to 43% more of a conversation in some areas than they can in others: this is not optimal for privacy. Advances in masking technology now permit the tolerance to be set as low as ±0.5 dBA (a range of 1 dBA), yielding far more consistent results and providing dependable masking coverage throughout the workspace.

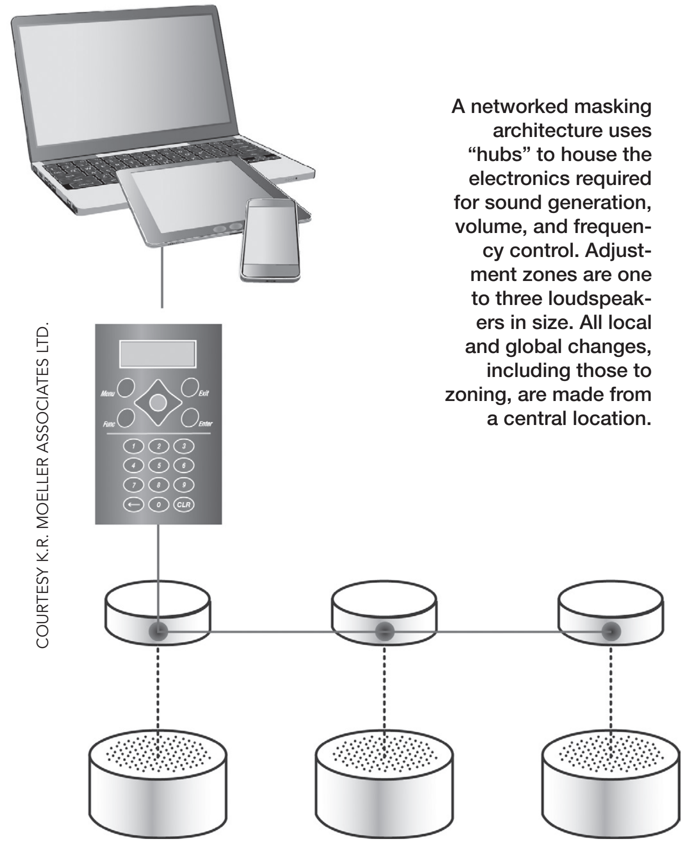
HOW THE TECHNOLOGY EVOLVED

Since sound-masking technology was first introduced in the 1960s, numerous advancements have made tuning a more precise and efficient exercise.

Centralized sound-masking architecture originated in the 1960s. In this configuration, the equipment used for sound generation, volume, and frequency control is located in a closet or utility room and connected to a large number of loudspeakers, forming a zone.

The facility is divided into basic categories: open plan, closed room, corridor, reception, etc. A zone is created for each type, and each zone is set to a "best average" level. However, the sound fluctuates as it interacts with the workplace environment. If the volume must be increased due to a performance deficiency in a particular area, that change is applied to the entire zone, making it too loud in others, or vice versa. Most designs offer volume control at each loudspeaker, but it is usually limited to a few large steps. Frequency adjustments are applied to the entire zone.

Because the sound cannot be finely adjusted in local areas, centralized system specifications allow a wide tolerance, even as much as ±2–3 dBA, yielding an overall range of 4–6 dBA.



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A networked masking architecture uses "hubs" to house the electronics required for sound generation, volume, and frequency control. Adjustment zones are one to three loudspeakers in size. All local and global changes, including those to zoning, are made from a central location.

Decentralized sound masking was developed in the mid-1970s to address the tuning obstacles posed by large zones.

In this configuration, the electronics used for sound generation, volume, and contour control are integrated into "master" loudspeakers. Each master is connected to two satellite loudspeakers, which repeat their settings. Therefore, a decentralized system's zones are only one to three loudspeakers in size (225 to 675 sf). Each zone also offers fine volume control, allowing local variations to be addressed; this enables a more consistent masking level to be achieved across the facility.

However, the ability to adjust the frequency is still limited in decentralized systems. The acoustician has to use a screwdriver or an infrared remote control to make changes directly at each master. Moreover, a sound-masking system's settings should be tuned whenever changes are made to the physical characteristics of the workspace (e.g., furnishings, partitions, ceiling, flooring) or to occupancy (such as relocating a call center into an area formerly occupied by accounting staff). Since it is likely that these kinds of changes will occur over the system's lifespan, engineers needed to develop a more practical way of adjusting the sound.

Networked sound-masking systems (above image) were introduced in the early 2000s. This technology links the system's components together throughout the facility or even across an entire campus. Components are addressable in order to provide full control over all settings from a control panel, laptop, or tablet. Adjustments can easily be made as needed, maintaining peak performance over the life of the system.

When designed with small zones of one to three loudspeakers offering fine volume control (0.5 dBA) and frequency control (one-third octave), networked architecture can provide consistency in the overall masking volume not exceeding ±0.5 dBA (1 dBA overall), yielding much better results than previous architectures.

Some networked sound-masking systems can be automatically tuned by a computer, which first measures the sound and then rapidly adjusts the masking output to match the specified curve, improving the efficiency of the tuning process.

Zoning for functions such as paging and occupant control are independent from each other and handled digitally rather than by hardwiring, allowing changes to be made without altering the system's physical design. Furthermore, networked architecture allows integrators to offer functions not possible with earlier configurations, including on-demand paging, 24-hour monitoring, email notification, programmable in-room controls, and integration with other building control systems.

Vendors have also experimented with combining architectures in so-called hybrid sound-masking systems—for example, by providing individual zones for closed rooms and large zones across open plans. However, centralized sound-masking architecture is unable to adjust for acoustical variations across the floor plate, which can be considerable, even within an open plan. So designers should consider carefully before specifying a hybrid system.

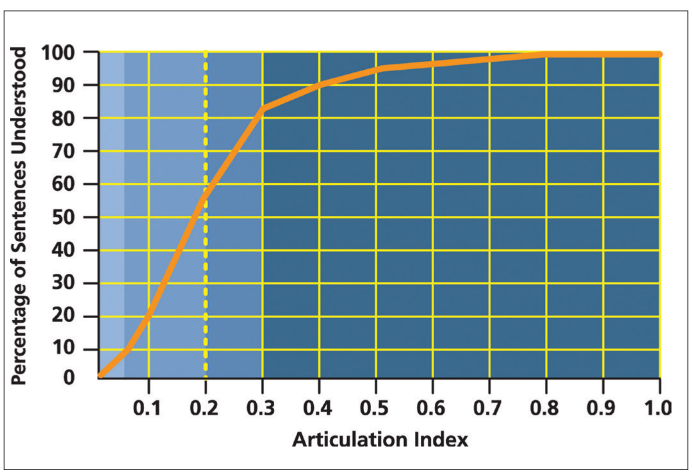
MEASURE THE IMPACT VIA THE 'AI' TEST

Articulation Index (AI) tests conducted between two workstations illustrate the importance of keeping tolerance as low as possible and consistently meeting the specified sound-masking curve throughout the facility.

AI is calculated using a test signal that includes the frequencies known to specifically impact speech comprehension. This signal is measured at one meter from the "source" and again at the "listener" location. The background sound level is also measured at the listener location in order to quantify how loud the test signal is relative to it—a value known as the signal-to-noise ratio (SNR). This value is critical: the lower the SNR, the less the intelligibility and the greater the speech privacy. For AI, SNR is measured in each of 15 frequency ranges (from 200 Hz to 5,000 Hz). Each of these ranges is weighted according to the degree to which it contributes to speech comprehension. The final AI value ranges from zero, where conversation is completely unintelligible, to 1.0, where everything is heard and understood.

In this case study, occupants sit about 15½ feet apart within an open plan. The partitions are 64 inches in height; the ceiling tile is highly absorptive. Without sound masking, the ambient sound level is only 40.6 dBA, and the listener can discern 85% of the other person's conversation. When masking is applied, speech comprehension quickly declines: for each decibel increase in masking volume, comprehension drops by an average of 10%. With the masking set to 48 dBA (the typical maximum level for comfort) with a narrow tolerance of ±0.5 dBA, the listener can understand just 14–25%. At a broader tolerance of ±2 dBA, occupants can understand up to 59%—barely an improvement over the unmasked conditions.

Though this example focuses solely on volume, variations in frequencies can similarly impact masking performance.



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The relationship between Articulation Index and intelligibility is not linear. A value of 0.5 means a listener can understand approximately 95% of a conversation, not 50%; at 0.1 AI, a listener can hear about 20% of a conversation. The lower the AI value, the greater the degree of privacy.

UNDERSTAND THE RISKS OF POOR MASKING

Poor masking performance carries real risk, particularly in facilities where there is a perceived need for or expectation of speech privacy—banks, law offices, government facilities, military installations. The Health Insurance Portability and Accountability Act of 1996 requires healthcare providers to take "reasonable safeguards" to ensure speech privacy during in-person and telephone conversations with patients and between employees. Speech privacy also needs to be protected in commercial offices, call centers, hotels, and many other types of facilities.

Speech privacy is vital to employees' overall satisfaction with their workplaces. A decade-long survey of 65,000 people conducted by the Center for the Built Environment, UC Berkeley, found that lack of speech privacy is the number one complaint in offices. Participants expressed irritation at being able to overhear in-person and telephonic conversations, as well as concern for their own level of privacy.

Though some may dismiss the importance of speech privacy when designing an open plan, studies show that it has a significant impact on productivity. Research conducted by Finland's Institute of Occupational Health shows that unwilling listeners demonstrate a 5–10% decline in performance when undertaking tasks such as reading, writing, and other forms of creative work. Taking the necessary steps to lower speech intelligibility within an open-plan space may increase occupants' output and reduce error rates.

When properly designed and tuned, sound masking can also reduce the need for high-spec walls and other acoustic treatments, help keep acoustics under control as densities swell, and enhance flexibility, often allowing an organization to remain in its current facility for a longer period.

SET PRECISE PERFORMANCE STANDARDS

Writing or evaluating a sound-masking specification can be difficult. ASTM Subcommittee E33.02 on Speech Privacy—part of ASTM Committee E33 on Building and Environmental Acoustics—is working on proposed standard *WK47433, Performance Specification of Electronic Sound Masking When Used in Building Spaces.*

The specifier, user, or other qualified person involved in the procurement process should be appointed guardian of the choice of system. The guardian must ensure that the system actually meets the criteria outlined and is properly tuned.

A minimum guideline would require the masking sound to be measured in each 1000 sf of open area and each closed room, at a height between 4 to 4.7 feet from the floor (at ear height rather than directly below a loudspeaker), and adjusted within that area as needs dictate. Some systems can adjust for smaller areas, but this is an acceptable baseline. Masking volume is typically set to 40–48 dBA. The results should be consistent within a range of ±0.5 dBA or less. The curve should be defined in third-octave bands and range from 100 Hz to 5,000 Hz (or as high as 10,000 Hz). A variation of ±2 dB in each frequency band is a reasonable expectation.

After tuning the masking sound, the vendor should provide a detailed report verifying the results. The report should indicate areas where the sound is outside tolerance and provide an explanation for the variance—for example, due to noise from mechanical equipment or the HVAC system. Such due diligence is necessary to ensure that the sound-masking system is providing the intended effect for all occupants.

Variations can significantly impact speech privacy, noise control, and occupant comfort. That's why it is vital to deliver the masking sound within the highest degree of precision and consistency possible.

Fortunately, this goal can be achieved at reasonable cost with modern sound-masking architecture.

> EDITOR'S NOTE

*This completes the reading for this course. To earn **1.0 AIA CES learning units**, study the article carefully and take the exam posted at* **www.BDCnetwork.com/SoundMasking**.