ACOUSTIC PRIVACY WITHIN THE BUILT ENVIRONMENT

INTRODUCTION

Typing the word ‘privacy’ into any search engine yields a virtually endless stream of entries describing the ways in which this basic human right can be violated. There are reports of hackers acquiring credit card information, law enforcement agencies mining social networking sites, and members of the public using drones to take aerial photographs. More recent headlines indicate that voice-activated televisions can even 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.

However, we should not lose sight of the fact that privacy can still be violated in ‘traditional’ ways. In fact, it can even be lost to those who do not intend to infringe upon it. People are often exposed to sensitive information simply by being within audible range of a conversation.

Current privacy legislation tends to focus on securing access to information stored on computers or within filing cabinets, but attention also needs to be paid to our built environment. When examined in this context, privacy has both an acoustic and a visual component. This course primarily focuses on the former, except insofar as it is affected by the latter.

WHAT IS ACOUSTIC PRIVACY?

Many people immediately equate acoustic 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 ascertain whether they are happy, sad or angry. This type of information can be considered private under certain circumstances, such as when issuing from behind the closed door of a human resources manager’s office. The same can be said for non-verbal noises like those overheard from an adjacent hotel room.
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 are 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 is also a visual component to acoustic privacy, which is important to bear in mind when designing a space.

Furthermore, acoustic privacy should not only be considered from the perspective of the person speaking, but also that of the listener(s). The reasons will become clear when we explore the various impacts of a lack of privacy.

WHERE IS IT NEEDED?

A lack of acoustic 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 include hospitals, bank branches, law offices, government and military facilities. However, other types of spaces—such as commercial offices, call centers, hotels, to name but a few—have privacy needs as well. The degree required typically depends on the type of activities the space hosts.

WHY IS IT NEEDED?

It is easy to understand the need for acoustic privacy—or even acoustic security—from a speaker’s perspective, particularly in environments where they are discussing medical information, financial planning, personal relationships, trade secrets, matters of national security, and similarly confidential topics. However, a lack of acoustic privacy can have impacts beyond divulging sensitive information to unintended parties. This fact becomes clear when we shift our perspective from the person talking to that of the involuntary listener.

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 loudly into their cell phone.

If we can inadvertently overhear a conversation, we can also become self-conscious about our own level of privacy. In some contexts, it can create 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 examination room, we might be less inclined to disclose information to the nurse or doctor, knowing that we too can be overheard.

The degree of acoustic 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 acoustic experience can reinforce our confidence in their firm. This level of protection is also indispensible for staff to effectively negotiate the terms of various agreements.

In some countries, protecting verbal communication within particular types of facilities is actually mandated by law. The Health Insurance Portability and Accountability Act (HIPAA) introduced by the U.S. Department of Health and Human Services in 1996 is a good example. It requires healthcare entities to take “reasonable safeguards” to ensure speech privacy during both in-person and telephone conversations with patients and between employees.

Acoustic privacy is also vital to employees’ overall satisfaction with their workplace. A decade-long survey of 65,000 people run by the Center for the Built Environment (CBE), University of California, 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 telephone communications, as well as concern for their own level of privacy.

WHAT ABOUT THE OPEN PLAN?

The topic of workplace satisfaction also emphasizes the need to consider those occupying spaces other than closed rooms. Though some may dismiss the importance of acoustic privacy when designing an open plan, studies show that it has a significant impact on productivity. For instance, research conducted by Finland’s Institute of Occupational Health shows that unwilling listeners demonstrate a five 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 greatly magnified when you can clearly understand what they are saying because, if you can follow a conversation, it is much harder to ignore it.

Though an organization might not consider privacy a goal within an open plan, it is impossible to justify increasing disruptions. Taking the steps required to lower speech intelligibility within this type of space increases occupants’ output and reduces error rates.

ASSESSING SPEECH INTELLIGIBILITY

But how do we assess speech intelligibility within the built environment?

To begin, we cannot talk about this subject without getting into the concept of degrees because we do not need to understand every word of a conversation in order for privacy to be violated. Due to the redundancies and patterns in speech, we can follow much of what is said even if we only hear half of it, and particularly if we have previously been part of a similar conversation. Furthermore, private details can be exposed even if we only hear a small part of the discussion.
We must also acknowledge that it is very difficult to subjectively assess degrees of speech intelligibility. For example, a listener would have a hard time indicating with any precision whether they can understand 40, 55 or 70 percent of what someone else is saying.

Fortunately, there are ways to measure and quantify the degree of privacy afforded by a built environment. The Articulation Index (AI) remains the most widely used method. It was developed at Bell Labs in 1921 by Harvey Fletcher as he sought to quantify speech comprehension over telephone lines. During the 1950s, those involved in the speech privacy sciences adopted his invention as a measure of exactly the opposite: how much one could not understand.

To calculate AI, one uses a test signal that includes the frequencies known to specifically impact speech comprehension. This signal is measured at 1 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, because 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 to 5,000 Hz). Each of these is weighted according to the degree to which it contributes to speech comprehension. The final AI value is between 0 (where conversation is completely unintelligible) and 1.0 (where everything is heard and understood).

AI ratings are challenging to interpret in a meaningful way, so studies have been done to correlate them to subjective ‘privacy’ categories; however, the value of these groupings is somewhat diluted by the wide range of comprehension within each one. ‘Confidential’ privacy is from 0 to 0.1, ‘Normal’ from 0.1 to 0.2 and ‘Marginal’ from 0.2 to 0.3. If AI is above 0.3, there is effectively no privacy.

As shown in Graph 1, the relationship between AI and actual comprehension is not linear. On a 0–1.0 scale, many would expect a value of 0.5 to mean that a listener would understand 50 percent of a conversation, but—as is clear from the graph—they would actually understand approximately 95 percent. The shaded areas along the left of the graph show the Confidential, Normal and Marginal privacy ranges, indicating just how low an AI is required for true privacy.

A more recent arrival on the acoustical scene is a metric called the Privacy Index (PI). PI is based on AI, in that it is calculated as 1 minus the AI value, multiplied by 100, and expressed as a percentage; in other words, 1 - AI x 100 = PI (%).

However, PI can be misleading. Part of the problem likely stems from its use of the word ‘privacy,’ which can cause users to come to the wrong conclusion about the rating’s meaning. The fact that it is expressed as a percentage creates even more potential for confusion. For example, with an AI of 0.3, you arrive at a PI of 70 percent. If you refer to Graph 1, the reason to avoid this metric is obvious. When told the PI is 70 percent, most people would assume that they would only understand 30 percent of what is being said. In reality, you would understand nearly 85 percent. Therefore, building professionals should be cautious when investigating acoustical solutions and interpreting related PI statements.

HOW SOUND TRAVELS

In order to design the built environment for acoustic privacy, it is also important to understand the three ways in which sound—and, hence, voice—travels to a listener.

Sound follows a direct path when it travels uninterrupted from the source to the listener or penetrates a barrier between them, such as a wall. This transmission path contributes the most to high levels of speech reaching the listener. However, it can also travel on a reflected path. This type of transmission occurs when sound bounces off of the various surfaces within the space, such as the floors, ceilings, walls, and furniture. Finally, sound can travel in a diffracted path—that is, it can bend around obstacles. This pathway is generally less significant than the first two.

Because speech travels in these various ways, it can be difficult to contain. Several methods must be utilized because no single technique can sufficiently address all transmission pathways.

DESIGNING FOR ACOUSTIC PRIVACY

Of course, the louder a person speaks, the more likely they are to be heard. Building occupants should always try to be mindful of their voice level, but proper etiquette is only effective to a point. The remainder of the acoustical burden has to be borne by the design using a three-tiered approach called the ‘ABC Rule,’ which stands for absorb, block and cover. Acoustic privacy is achieved by using a well-designed combination of all these tactics. The very brief outline provided below only touches on the interior fit out and furnishings, not the shell.

As mentioned above, the ‘A’ in the ‘ABC Rule’ stands for adding absorption. As speech
sounds hit various surfaces within a facility, they are reflected back into the space. If those surfaces are comprised of hard materials such as concrete, glass and metal, the reflected sound energy remains high and overall volumes rise. A high percentage of hard surfaces also increases reverberation (i.e. echo) within the space, making it uncomfortable. In order to control this type of transmission, absorptive materials must be applied to the ceiling, walls and workstation partitions. Because the ceiling is usually the largest unimpeded surface within a facility, organizations should invest in the best acoustic tile they can afford and ensure consistent coverage throughout their space.

‘B’ stands for blocking speech transmission using walls, windows, doors and other physical structures. This method is most obviously used in the construction of closed rooms, but it is also extremely useful within the open plan. If there are no barriers between occupants in these spaces, speech travels more easily and the ability to see (and be seen) further reduces privacy due to our natural capacity for lip reading. Again, though some might argue that privacy is not expected nor needed within the open plan, understandable speech disrupts occupants’ concentration. For this reason, workstation partitions should be no lower than seated head height (60 to 65 inches; 1524 to 1651 mm). Even the direction in which a person faces affects their voice’s volume within the neighboring workspace; therefore, occupants should be seated facing away from each other on either side of partitions.

Today, there are numerous pressures to reduce the height of workstations or eliminate them altogether. This trend has had a dramatic impact on the acoustical performance of open plans because though other treatments can reduce overall volume levels and deal with noises generated from farther away, they have no effect over short distances. When barriers are dispensed with, local noise sources remain highly intelligible and disruptive.

**QUIZ**

1. ‘Acoustic privacy’ is simply another term for ‘speech privacy.’
   a. True  
   b. False

2. Acoustic privacy is only required in areas where confidential conversations are taking place.
   a. True  
   b. False

3. Studies show that unwilling listeners demonstrate a ____% decline in performance when undertaking tasks such as reading, writing and other forms of creative work.
   a. 2 to 3  
   b. 5 to 10  
   c. 10  
   d. 20

4. When used to rate speech intelligibility, ‘AI’ means:
   a. Auditory Insufficiency  
   b. Articulation Index  
   c. Audio Index  
   d. Acoustic Indicator

5. A Privacy Index (PI) of 70 percent indicates that a listener will only understand 30 percent of what is being said.
   a. True  
   b. False

6. Sound travels to a listener along a:
   a. Diffracted path  
   b. Reflected path  
   c. Direct path  
   d. All of the above

7. Acoustic privacy is achieved by:
   a. Using physical structures to block sound transmission  
   b. Applying absorptive materials to the ceiling, walls and workstations  
   c. Covering speech and noise with a sound masking system  
   d. All of the above

8. If a sound masking system’s loudspeakers are installed facing downwards, the sound does not need to be tuned in order to meet the specified curve.
   a. True  
   b. False

9. Because variations in the masking sound affect the level of speech privacy and noise control it provides, it is important to keep tolerance to a minimum.
   a. True  
   b. False

10. Occupants in closed rooms:
    a. Have a higher expectation of privacy than occupants in open plans  
    b. Will not benefit from the application of sound masking  
    c. Have privacy if the room’s door is closed  
    d. All of the above

**SPONSOR INFORMATION**

Introduced in 2003 by industry leader KR Moeller, the LogiSon Acoustic Network is the world’s first networked sound masking, paging and music system. TARGET software accurately tunes the masking sound to the specified spectrum, maximizing speech privacy and noise control. Worldwide distributors provide turnkey services and expert support. Visit www.logison.com.
CONTINUING EDUCATION

Diagram 1: The area of intelligibility around a speaker is not circular. Its shape is determined by numerous factors including the orientation of the person speaking, as well as the physical barriers and absorptive/reflective materials used within the space. Image © K.R. Moeller Associates Ltd.

‘C’ stands for covering, which involves installing a sound masking system. This technology consists of a series of electronic components and loudspeakers typically installed above the suspended ceiling, which distribute a comfortable background sound throughout the facility. Though many compare the output of a well-designed and professionally-tuned masking system to that of softly blowing air, it has been specifically engineered to cover the range of frequencies in human speech, improving privacy. The sound also covers up incidental noises arising from general workplace activities or minimizes their disruptive impact on occupants by reducing the amount of change between baseline and peak volume levels within the space.

All of us have experienced this type of effect—for example, when washing dishes at the kitchen sink while trying to talk to someone in the next room. We 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 our 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. All have the potential to mask sounds the listener would otherwise hear.

THE IMPACT OF BACKGROUND SOUND

Most people are familiar with using walls, doors, workstations, and a well-planned layout to physically block voices and noises, as well as the benefits of installing ceiling tiles, wall panels and soft flooring to absorb them. Fewer understand the role that sound masking plays in achieving acoustic privacy.

As shown in Diagram 1, the area of intelligibility around an individual is not a simple circle. Rather it is a complex shape determined by numerous factors including the speaker’s orientation, physical barriers, and absorption/reflection.

In any space, voices and noises diminish in volume over distance. However, background sound levels are often so low in indoor environments that speech carries intelligibly over 30 to 50 feet (9 to 15 meters) or more in open space. By increasing the background sound level, sound masking reduces the signal-to-noise ratio (SNR). As shown in Diagram 2, voices disappear below the new level after a much shorter distance.

The exact length is, of course, a function of the entire acoustic design of the space. However, as illustrated by the AI measurements conducted between the two workstations shown in Diagram 3, sound masking plays an integral role. This open-plan area’s acoustical design was suitably planned. The partitions are 65 inches (1651 mm) tall and perform well in terms of both absorption and isolation. The ceiling tiles are highly absorptive (0.95 NRC). The lighting system is indirect so as to not reflect too much voice/noise back down into neighboring work areas. A sound masking system is installed above the suspended ceiling.

Graph 2 shows the results of the AI tests conducted between these two workstations. Despite the high performance acoustical design elements, speech comprehension is nearly 85 percent when the sound masking system is off, because the existing background sound

<table>
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<tr>
<th>Per Cent of Sentences Understood</th>
<th>48 dBA</th>
<th>47 dBA</th>
<th>46 dBA</th>
<th>45 dBA</th>
<th>44 dBA</th>
<th>43 dBA</th>
<th>42 dBA</th>
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<td>59</td>
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Graph 2: The results of the AI tests show that, despite using absorption and blocking strategies, speech comprehension remains nearly 85 percent until sound masking is applied. Comprehension drops by an average of 10 per cent for each decibel of increase in the masking volume. Image courtesy K.R. Moeller Associates Ltd.
Therefore, it is vital for the masking sound to be delivered within the highest degree of precision and consistency possible. Fortunately, this goal can be cost-effectively achieved with modern sound masking architecture. When designed with small zones of 1 to 3 loudspeakers offering space, one can usually expect a 10 percent reduction in performance for each decibel below the target masking volume. In other words, such a broad tolerance can lead to a 40 percent performance loss in unpredictable locations across the facility, as indicated by Graph 3.

MEETING THE SPECIFIED CURVE

When installing a sound masking system, it is vital to ensure that the engineered sound it distributes is not only effective, but as unobtrusive as possible. Unlike ‘white noise’ or ‘pink noise’—terms often, but mistakenly, used in this context—sound masking follows a non-linear curve specifically designed to balance acoustic control and occupant comfort. A successful implementation involves achieving both goals, in equal measure.

No sound masking system can accomplish these objectives ‘out of the box.’ Regardless of its design, where its loudspeakers are located or whether they face upward or downward, the sound changes as it interacts with various elements across the facility’s interior. In order to meet the specified curve, the system must be tuned. To do so, an acoustician or trained technician measures the sound at ear height, examines the results, and adjusts the system’s volume and frequency settings accordingly. This process can be time-consuming, but it is essential to ensure the sound provides the intended effects and that they are enjoyed equally by all occupants.

Tuning should be handled after the ceilings and furnishings are in place, and with mechanical systems operating at daytime levels. Because activity and conversation prevent accurate measurement, it should also be done prior to occupation of the facility or after hours. The exact method varies by product, but basically the acoustician or technician uses a sound level meter to measure the masking sound at ear height (i.e. the level at which occupants experience its effects), analyzes the results, and adjusts the volume and frequency settings accordingly. They repeat these steps until they meet the curve at each tuning location.

However, it is impossible to achieve perfection in every tuning location. Consequently, a masking specification will also include a ‘tolerance’ indicating how much the sound is allowed to deviate from the target curve across the treated space. Because variations can affect performance and comfort, it is vital to keep this value to a minimum. Outdated specifications might allow for a wide tolerance of ±2 dBA, giving an overall range of 4 dBA across the space. One can usually expect a 10 percent reduction in performance for each decibel below the target masking volume. In other words, such a broad tolerance can lead to a 40 percent performance loss in unpredictable locations across the facility, as indicated by Graph 3.

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fine volume (i.e. 0.5 dBA) and frequency (i.e. 1/3 octave) control, networked sound masking architecture can provide consistency in the overall masking volume not exceeding ±0.5 dBA (i.e. 1 dBA overall), yielding much better results than previous architectures. Some networked systems are tuned using a computer, which rapidly and accurately adjusts the masking output to match the specified curve.

CONSIDERATIONS FOR CLOSED ROOMS

Maintaining an adequate background sound level is also important in closed rooms. Generally speaking, an occupant's expectation of privacy is higher in this type of space than within an open plan; however, many people continue to exclude sound masking from private offices and meeting rooms, primarily in the belief that closed spaces are afforded sufficient speech privacy and noise control via physical isolation.

Ideally, sound masking should be implemented as a facility-wide solution. Intentionally omitting it from particular areas runs contrary to the goal of ensuring this technology is as effective and unobtrusive as possible. Occupants will walk in and out of treated areas that differ in ambient volume (sometimes by as much as 10 to 12 dBA), calling their attention to the sound and, if the loudspeakers are visible, also reveal its source. The same can be said of attempting to spot treat an area where a more obvious acoustical issue exists, such as within an open plan or outside a boardroom. A sound masking system's role is to control the acoustic conditions throughout a facility in the same way that temperature and lighting are controlled. One does not want cold or dark areas and, similarly, one should strive to achieve a consistent acoustic environment—not have a low ambient volume in one area and an effective one in others.

In any case, modern construction does not always allow for a high level of physical

containment, allowing speech to transmit into adjoining spaces. To preserve flexibility, walls are often built to below the suspended ceiling or using demountable partitions, and may be largely composed of glass. Construction budgets can also limit wall options. Even if walls are built deck-to-deck, voices find their way from one room to another through a variety of pathways. Of course, an open door is a room's biggest Achilles' heel, but other common channels include passing through the plenum, return air grilles, and ductwork, gaps along the window mullions, ceiling, and floor—and the walls themselves.

If the background sound level in those spaces is lower than the speech passing through the wall, it will still be possible to hear and understand a conversation. In other words, the degree of speech privacy experienced in closed rooms is still largely determined by SNR.

In almost all situations, it is better to benefit from the contribution of a reasonable amount of isolation along with a raised ambient level. Every decibel of increase in the ambient volume the masking provides leads to an increase in speech privacy, regardless of how a voice gets from one space to another. Levels for sound masking in closed rooms range from approximately 40–45 dBA, depending on the size of the room and other conditions. In other words, sound masking typically adds approximately 5–12 dBA of ambient volume, which is why one sometimes hears that sound masking ‘adds 10 STC points’ to walls.

Indeed, when masking is included as a part of the acoustical planning for private offices, companies can also save on wall construction by reducing the STC ratings of walls and using floor-to-ceiling rather than deck-to-deck construction.

Compared to a wall built from the floor to the suspended ceiling, the additional costs of materials and labour for deck-to-deck construction are obvious. However, there are other ways that it can substantially add to the initial budget. Each time a wall is built above the suspended ceiling, the ceiling grid must be restarted—a time consuming process. The separated plenum space requires separate return air ducts and may necessitate additional HVAC control zones. Return ducts may need to be treated to prevent the transfer of sound along their length from one location to another.

It is also more difficult and costly to renovate, because moving such a wall requires changes to the ceiling grid, tiles and HVAC returns. Furthermore, vigilance must be maintained to ensure that penetrations in the wall’s structure are controlled. As noted above, even minor ones can substantially reduce acoustic performance, allowing sound to be transmitted to and from neighboring spaces. This level of care can be challenging to sustain throughout the life of the space.

Budget wise, sound masking may represent 1 to 2 dollars of cost per square foot of space, but it offsets much more than that in terms of construction above the ceiling. The ability to provide private rooms with walls to the ceiling also increases the ease and cost-effectiveness of relocating them to suit future needs.

An exception to this guideline might be a large training room, where speech intelligibility is vital and, therefore, sound masking is omitted. Such rooms should be well isolated using deck-to-deck construction with higher STC walls.

SPEECH SECURITY

Of course, eavesdropping can also be intentional and handled in a much more sophisticated manner than leaning one's ear against a glass and putting it up to the wall.
Though this course focuses on acoustic privacy rather than acoustic security (such as may be required by military facilities, corporate boardrooms, laboratories, and so on), it may be interesting for readers to know that—without the proper treatment—windows, doors, ducts, pipes, floors, ceilings and walls present opportunities for electronic forms of eavesdropping. Speech causes vibrations on these structures, which can be picked up by probes or microphones and translated into intelligible speech. These types of listening devices are difficult to detect because they can be used at a considerable distance from the target facility.

If an organization suspects that it might be subject to such a threat, a sound masking system can be connected to transducers, which transfer the masking sound to the aforementioned physical structures, impeding the use of audio surveillance equipment. In this case, it is key to ensure that the system produces a truly random masking sound (i.e. rather than on a loop) so that it cannot be filtered out of recordings.

**IN CONCLUSION**

Attention must be paid to the topic of acoustic privacy within our built environment. Though this conclusion is obvious to organizations that consistently deal with sensitive information, the methods they utilize to achieve it are the same as those needed to accomplish other valuable acoustic goals—the only difference is how one sees the benefit: from the perspective of the person talking or that of the group listening. People 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 that it is more motivated by the need for a high performance workplace than acoustic privacy, but taking the steps required to lower speech intelligibility allows them to reap both rewards.