



# Acoustics in Open Office Situations





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## Introduction

The working world has a love-hate relationship with open office plans and a good deal of that centers around noise. Dealing with noise means paying attention to acoustics.

“The trend is to open office planning,” says Dave Paoli, Shiner & Associates, Chicago, IL. Paoli, an acoustics consultant, often is called in early in the planning process. While employers believe that an open office plan promotes collaboration and teamwork, employees often have other views. In other words, what is sound to one person, may be noise to another.

On December 30, 2014 the Washington Post ran a personal essay attacking open office plans. Written by Lindsey Kaufman, an advertising professional, it noted that after one day in a new, open plan office, she ran out to buy noise cancelling head phones.

It’s no surprise that studies have shown that the better employees are at screening out distractions, including and especially noise, the more effectively they can work in an open office situation.

The noise level depends on the type of open office plan, as well as attention paid to acoustics. Are there cubicles? If so, how high are the walls? How many sides (three sided with the fourth open or three plus sided, with only a small “doorway” opening on the fourth side)? If they aren’t in cubicles, are the employees at desks or sharing a long table? Besides conversation, what else produces noise? HVAC? Computer monitors? Telephones? Office machinery, such as copiers? And has anyone paid attention to acoustics?



## Effects of Noise in Open Office Plans

Other people's voices seem to stand out as the most often cited sources of distraction when working in an open office. The biggest objection? Workers can't control the noise around them, nor their own privacy (who hears them).

It exacts a toll. Research has shown that noise distraction causes loss of productivity and that the more important and intense the task, the more likely noise was to disturb those performing it. This was backed up by other studies, including one that concluded that the participants remembered fewer words, rated themselves as more tired, and were less motivated when working in a higher noise environment compared to low noise.

In fact, Sound Expert Julian Treasure, in his TED talk, cited a statistic showing that noisy open offices can reduce productivity by a whopping 66 percent.

Other studies have shown that poor office acoustics affect employee health and safety, causing, among other things, increased stress, which can be linked to high blood pressure, digestive disorders, headaches, hypertension and ulcers.

Research indicates that noise in open offices can affect everything from health to motivation. Some controlled studies have demonstrated that typical noise from an open-office situation produced behavioral after-effects, such as lack of motivation and an unwillingness to make computer work station adjustments that would provide added comfort and reduce risk for injury.

A Scandinavian study showed that workers in medium-sized to small open plan offices had the lowest

health status, compared to those in cell and flex offices, who had the best. The latter also had better job satisfaction.

This means that the spaces must be designed with acoustics in mind from the very beginning. Every component must be taken into consideration, including the furniture, partition height and composition (if you plan to have cubicles), ceiling height and materials, wall treatments (as well as shape and placement), the HVAC noise level and design, as well as the room's depth, materials and mechanical systems.

"It is clear that companies must increase their awareness of the acoustic environments of open-office spaces if optimal business success is to be achieved," said Tiernan Carsia in her 2002 piece, "Designing Work Spaces for Higher Productivity." "A primary inhibitor of productivity is office noise; but the majority of employers do not recognize the severity of the potential problem."

To underscore that, a Yankelovich Partners survey, done for the American Society of Interior Designers (ASID) showed that 70 percent of respondents believe their productivity would increase if their offices were quieter and 54 percent said noise often bothered them. They cited conversations between office mates, office equipment and mechanical systems as the worst noise sources.

A subsequent study, done for ASID by L.C. Williams and Associates, showed, however, that 81 percent of business executives polled said that they were not concerned that office noise would affect productivity.



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## Acoustic Challenges in Open Office Plans

To work, open-office spaces need to be carefully planned and acoustics must be considered from the very beginning. “Every component of an office must work in concert in order to experience an ideal acoustic setting,” says Tony Sola, an acoustical consultant and instructor of architectural acoustics at Arizona State University.

Planners of open-office situations must take a range of acoustical goals into consideration, including controlling noise in common areas, establishing some level of privacy and sound absorption for employees at their desks and providing a private space for confidential discussions. In other words, leveraging the perceived benefits, while minimizing distractions.

Normally the goal in a traditional open plan is to minimize distracting noises by providing sound absorptive surfaces and raising the background sound level to allow employees to concentrate.

The challenges inherent in a particular office depend on the type of work. For instance, a governmental office, especially one in which workers meet with the public about sensitive subjects, would need a higher level of privacy than certain kinds of commercial work. In the

latter, the goal might be to minimize distracting noises, providing the amount of sound absorption or “blocking” background noise so that employees can concentrate. In some cases employers may actually want more sound, so as to project a semblance of excitement.

When privacy needs are dependent on government regulations, such as HIPAA in medical office buildings or SSA guidelines in government office, it is important to use the ABC concept (A – using sound absorbing materials in both speaker and listener areas; B – using sound blocking materials between the talker and listener areas; C – the need for controlled background masking of a particular sound content and level). Typically this requires moderate to high NRC on the room surfaces, moderate to high CAC in ceilings, STC in the walls and moderate electronic background sound.

In order to make speech unintelligible to casual listeners, designers must ensure that there is a relatively high level of background sound, voices are kept low and sound absorbing material has been applied to most surfaces above, behind and around the speakers, so that none of the conversation is reflected into the surrounding spaces.



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## The Goal of Speech Privacy

New trends call for “benching” – variations of employees working side-by-side at long tables. They usually fall into one of three categories:

1. Those with limited acoustical and visual barriers and little to no flexibility
2. Those designed to integrate with other products, such as lower storage, panels and height adjustable tables. They are designed to address flexibility, mobility and storage
3. Those that are a variation on the cubicle, with lower height panels, divider partitions and mobile storage units

Some users cope with the sounds endemic to benching by creating their own masking or white noise, for instance, by listening to music or other sounds using a smart phone or MP3 player and earbuds.

Some countries have building codes that require owners to consider the noise environment around the site when designing and building. This isn't usually the case in the United States, but if workers will be able to open windows in an office, it's a good idea to take it into consideration.

Another challenge is to determine the amount of privacy or the level of sound that will be tolerated and still allow work to be done. For instance, managerial functions usually require a higher level of privacy than do others in the office. Confidentiality at the managerial level can be described as the inability for others to understand a spoken phrase, but allowing the capacity to catch a word or two.

Both the ASTM measurement standards and the architectural needs are changing to meet new trends in office design to the combination of focus and collaboration spaces.

Loud ventilating systems and/or office equipment can interfere with work and office conversations. Individual speakers will adjust or modulate their voices to maintain an acceptable “signal to noise” ratio for listeners. Known as the Lombard effect, it is multiplied by the number of speakers in a room, increasing the decibel level.



## Options for Noise Control

It is important to gauge a client's expectations at the outset. This includes the levels of privacy required for the work to be done, which will vary with the functions represented within the open plan office.

Often acoustic consultants will recommend securing an appropriate acoustic environment by covering most of the ceiling area with sound absorptive material, supplemented by more sound absorbing material on selected walls.

In cases where thermo active decks are used, usually to make the building more sustainable and reduce its environmental impact, the design interferes with the ability to cover the entire ceiling with sound absorbing material.

Although many offices continue to be designed using the traditional mix of open plan and closed plan, more are now taking a new approach which includes a variation of the open plan design to accommodate today's work processes

This approach takes three aspects of work into consideration: 1) focused individual work, 2) collaboration within teams, and 3) privacy work for individuals or teams.

Sound design in the workplace needs to address these diverse situations:

1. Open plan (focus) – In those areas where workers will be doing individual tasks that require high concentration, low noise distractions are crucial; ceilings should have a high NRC and a moderate CAC, with a goal of both behavioral (Quiet Zone designation) and technological (headset phones) remediation.
2. Open plan (collaboration) – These areas are for 'teaming' activities, making the goal speech intelligibility within the team and low noise intrusions between teams. These spaces need moderate to high NRC and moderate CAC, but may also need some spot acoustics for added control.

3. Closed plan (privacy) – These areas need good speech intelligibility within, and even better speech privacy between, to provide confidentiality. They require ceilings with a high CAC (Ceiling Attenuation Class) rating in order to block sound from adjoining rooms. They also need to have a moderate NRC (Noise Reduction Coefficient) to control reverberation and reduce unwanted sound.

NRC (Noise Reduction Coefficient) is a measure of how much noise is absorbed by a surface material. Generally in traditional open office spaces where concentration is the main concern, the higher the NRC the better. High performance is considered to be NRC 0.80 or higher.

CAC is a measure of the ceiling's ability to attenuate the sound traveling between adjoining rooms when the common wall stops at the ceiling level, forming an open and continuous plenum above the ceiling. Sound leaks due to recessed lights and air distribution devices, like open return air grilles, can decrease the ceiling system's performance. A ceiling with moderate to high CAC is effective in reducing mechanical noise, such as that emanating from plenum mounted HVAC equipment with VAV fans, as well as from activity noise originating from an upper floor, i.e. foot traffic.

There is more to acoustics in open plan offices than the right ceiling treatments. They are a crucial component, but must be a part of an overall plan, which includes, among other things, sound absorbing materials on selected walls, placement of office equipment and HVAC systems. Office equipment should be strategically placed so as to minimize its sound impact on neighboring work areas. This can include enclosing them in cubicles or other confined spaces, while still providing access to those who need to use them.

Office layout is an important consideration, as well. This means, for instance, that individual work stations should be positioned so that there are no uninterrupted sound paths between connected or neighboring work stations. Adding acoustical absorption to horizontal and



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vertical surfaces can help the acoustics in undivided work spaces (i.e. bull-pen offices), but it usually won't provide speech privacy.

There is a difference of about 9dB between the sound level when the speaker and listener are close and facing one another than when they are facing away from each other. So, employee orientation when working at a desk is important and will depend on how much or little direct interaction is necessary for the work to get done.

Ventilation systems should be designed to be reasonably quiet, but with an understanding that some background noise will help mask what would otherwise be disruptive activity noises. Other noise sources also should be chosen to impact ambient noise as little as possible. For instance, telephone ringers can include low-level tones, as well as flashing or blinking lights.

In addition to acoustic materials on the ceilings and walls, as well as design components, such as carpeting on the floors, acoustic consultants often recommend sound masking. Blending many sounds sometimes serves to mask individual sounds. Without this masking, the individual sounds can be distracting. Research shows that low frequency sounds can mask higher frequency sounds, even if the difference is only slight.

This works in part because the human ear perceives sound differently at different frequencies. Any sound measuring system used to evaluate acoustics in a space should account for these differences. Frequency weighting networks "weight" the contribution of different frequencies to the overall sound.

Not only can sounds prove to be a distraction, but research has shown that employees also worry about other people being able to hear them, i.e. privacy. So, the question is how to deliver voice privacy in an open plan office, especially in situations in which people are working side-by-side at long tables or with low walled cubicles. Some types of open plan offices, such as call centers that handle credit card information, are required by law to provide speech privacy.

Masking helps in these situations, as does so-called spot acoustics. When cubicles are merely lower-height panels, the panels do not play a significant role in acoustical control. Without any barriers to block speech, the spoken word can be heard 50 to 70 feet away without any type of sound masking and as much as 25 to 35 feet away with sound masking.

In addition to using sound masking, acoustic control can mean providing multiple venues for work, each supporting specific types of activities. These can include separate rooms with high NRC and CAC acoustic panels, sound seals around doors and retractable door bottoms to help seal a closed door.

## Summary

Well planned acoustics are crucial to the success of any open office situation and should be a part of the initial planning and design. The overall plan must take the functions and locations of those working within the environment into consideration, as well as the requirements for noise control and sound privacy. Good noise control will comprise a number of components and there is no one size fits all solution.





## Acoustics Glossary

**ABCs of noise control** – Fundamental components of noise control: absorb sound within the space to improve speech intelligibility; block sound between spaces to improve speech privacy and cover sound with properly balanced background noise from HVAC system or electronic sound masking.

**Absorption** – When sound waves contact a room surface such as a ceiling, wall or floor, a portion of the sound energy is reflected back into the room, and the rest is considered to be absorbed primarily by conversion into heat due to friction within a porous material, or by vibration of a solid material.

**Absorption coefficient** – The fraction of sound energy that is absorbed at any surface. It has a value between 0 and 1 and varies with the frequency and angle of incidence of the sound.

**Acoustic baffles** – Individual sound absorbing units, usually suspended from a ceiling deck, for the purpose of absorbing sound in a large space.

**Acoustic blades** – Similar to acoustic baffles, but suspended relatively close together in larger groupings. Also used for the purpose of absorbing sound in a large space, but they are also part of a design aesthetic.

**Acoustical capacity** – The number of people needed to create a -3dB signal to noise ratio, i.e. the lower limit for sufficient quality of verbal communications under specified preconditions. Primarily used as a rule of thumb for evaluating restaurant noise control.

**Acoustic cloud** – A small section of suspended horizontal acoustical treatment used to absorb or reflect sound.

**Ambient Noise** – see Background noise level.

**Architectural acoustics** – A branch of acoustical engineering. Using science and engineering to attain good sound within a building. Most often designed by acoustic consultants.

**Attenuation** – A reduction in sound level (loudness) as a result of absorption, blocking, or increasing distance away from a source

**Audible frequency range** – The range of frequencies which can be detected by an individual with normal hearing sensitivity. The typical range of audibility spans from 20 Hz to 20 kHz and is reduced over one's lifetime.

**Average room absorption coefficient** – Total room absorption divided by total room surface area.

**A-weighting** – A frequency-response adjustment of a sound-level meter that makes its reading conform, very roughly, to human response. Units are typically written as dB(A) or dBA.

**Background noise level** – The noise level in a space, which is a composite of sound from HVAC, equipment, activity noises, etc., from both near and far, but excluding specific sources of interest such as a person talking in an adjacent space.

**CAC** – Ceiling Attenuation Class. A measure for rating the performance of a ceiling system as a barrier to airborne sound transmission through a common plenum between adjacent closed spaces such as offices. A ceiling system with a CAC < 25 is considered low performance, whereas one with CAC ≥ 35 is high performance.

**Café effect** – Cumulative increase in noise in a room as people raise their voices in order to be heard above background sounds.

**Cocktail party effect** – Ability of a listener to focus on a particular conversation partner or source, despite interfering background noise.

**dB** – Decibel (see decibel).

**dBA or dB(A)** – A-weighted sound pressure level (see A-weighting).

**Decibel (dB)** – A measure for rating the level of a sound, which uses a logarithmic scale. The sound level in dB is often represented as dBA, where the “A” indicates a specific frequency weighting used to represent how humans perceive loudness. A sound level of dBA < 30 is a very low level, whereas dBA > 90 is a high level.

**Direct Sound** – Sound that reaches the listener directly, without being reflected off any surface or transmitted through any material, and thus is unaffected by the room conditions.

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**FSTC (field sound transmission class)** – Same as STC, but measured in the field and used to quantify actual as built partition transmission loss, incorporating corrections for the sound absorption of the room.

**Hertz (Hz)** – Measure of sound frequency in cycles per second. The human voice, like many sounds, is composed of a combination of many frequencies. Typical human hearing range is 20 Hz – 20,000 Hz.

**Kilohertz (kHz)** – One kHz equals 1,000 Hz

**Lombard effect** – Tendency of speakers to speak louder and at a higher pitch when there is loud noise around them in order to make themselves heard and understood.

**Lombard Reflex** – Actual change in a talker's articulation in order to be heard and understood over background noise, i.e. talking louder, higher pitch and better articulation.

**Masking Sound** – Electronically generated background sound of a specified level and frequency content, that is introduced into occupied environments to provide masking of intrusive noises and to enhance speech privacy.

**Noise isolation class (NIC)** – A single-number rating calculated in accordance with Classification E 413 using measured values of noise reduction. It provides an estimate of the sound isolation between two enclosed spaces that are acoustically connected by one or more paths. The number represents the approximate attenuation, in dB, between two spaces.

**Noise Reduction Coefficient (NRC)** – A measure for rating the overall sound absorption performance of a material when used in an enclosed architectural space such as an office, where sound is being reflected at many angles of incidence. Specifically, it is the 4 frequency averaged absorption coefficients @ 250, 500, 1000 and 2000 Hz, rounded to the nearest 0.05. A material with NRC < 0.50 is a poor absorber, and NRC > .80 is a very good absorber.

**Pink noise** – Random noise containing equal power between each octave. The result is noise that sounds lower in pitch.

**Privacy Index (PI)** – A measure for rating the speech privacy performance of an architectural space. A privacy level of PI > 95% represents confidential speech privacy, a PI between 95 – 80% represent normal or non-intrusive privacy, and PI < 80% is poor privacy.

**Reverberation time, RT60** – A measure for rating the quality of the acoustic environment within an architectural space, and its appropriateness for various uses. Specifically, the reverberation time is the time it takes for reflected sound within a space to decrease by 60 dB after the sound was made. An RT60 < 1 sec. is beneficial for good speech intelligibility, whereas RT60 > 1.5 sec is appropriate for symphony music.

**Sabin** – Unit of total acoustic sound absorption named for Wallace Clement Sabine, the founder of the field of architectural acoustics.

**Signal-to-noise Ratio (SNR)** – The difference between the level of a desired signal to the level of the background noise. Often expressed in decibels.

**Sound Transmission Class (STC)** – A measure for rating the performance of a wall system as a barrier to airborne sound transmission between adjacent closed spaces, such as offices. A wall system with an STC < 35 is considered low performance, whereas one with an STC > 55 is high performance.

**Speech privacy** – A general term that includes both the need by the talker to have privacy from being overheard by unintended listeners and the need by the listeners not to be annoyed or distracted by unwanted nearby conversations.

**Sound** – Pressure variations the ear can detect.

**Spot Acoustics** – Using acoustical treatments to affect a localized section of an architectural space.

**Threshold of hearing** – Lowest sound level that can be heard by the human ear.

**White noise** – Random noise containing equal power at all frequencies. The result is noise that sounds higher in pitch.



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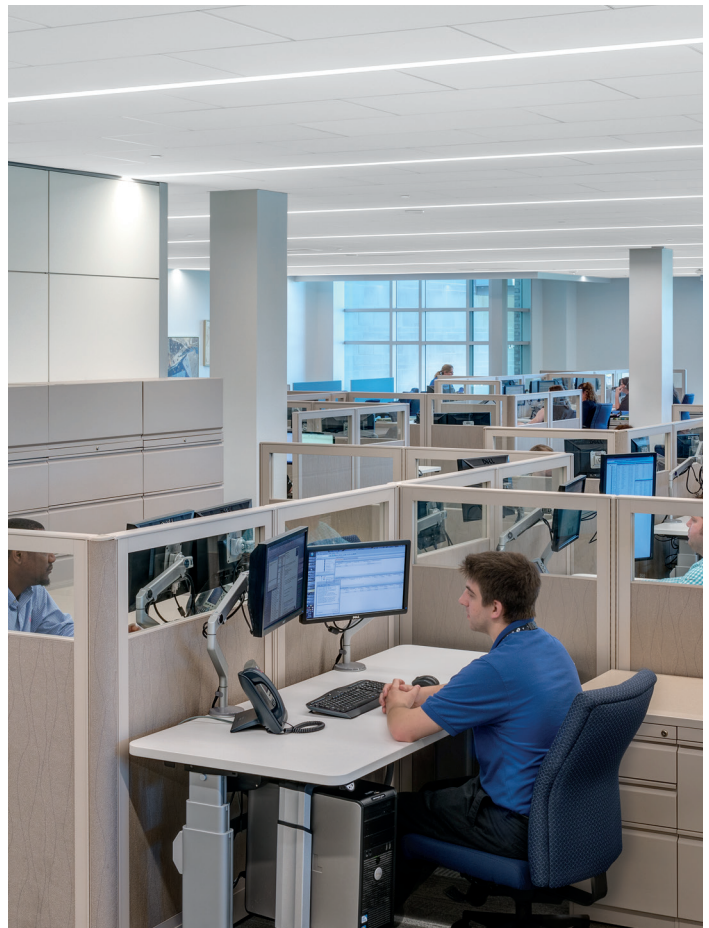
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