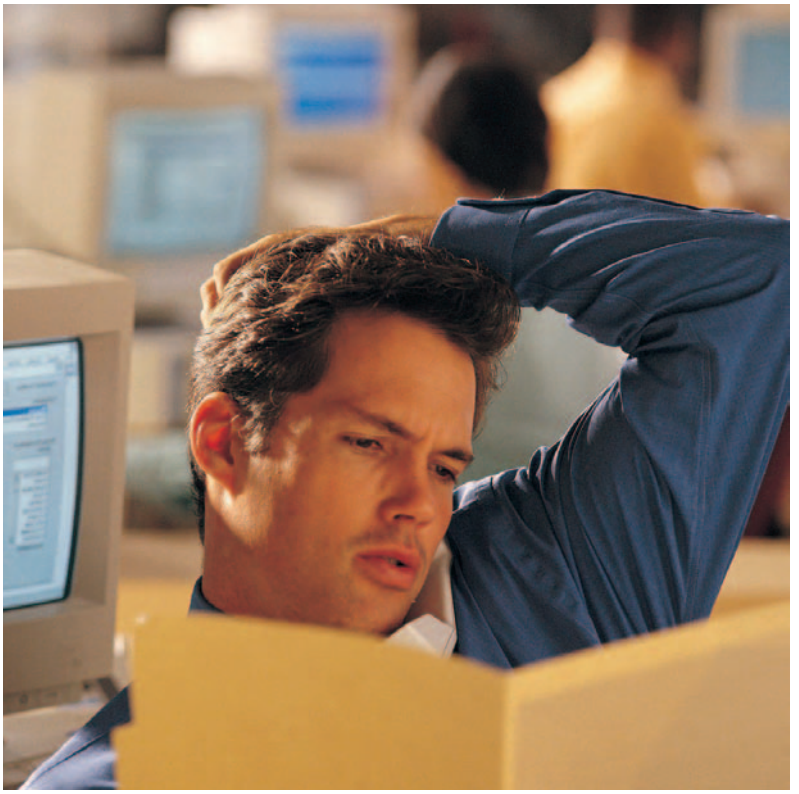


Office Acoustics

Attaining speech privacy in open and closed plan environments.

Armstrong®

The message is loud and clear: office employees have long considered the intrusion of unwanted noise as one of the leading sources of workplace dissatisfaction.

Over the years, study after study has measured employees' satisfaction with their workplace environment and the results have continued to point to noise as a major cause of reduced effectiveness, higher stress and declining job satisfaction.

The studies also indicate the majority of acoustical complaints in offices relate to speech privacy – overhearing an unwanted conversation or feeling that they are being overheard. A 2003 study conducted by the Center for the Built Environment (CBE) at UC Berkeley, for example, showed that as many as 72% of office workers are dissatisfied with speech privacy in their workplace.

Moreover, a study conducted by the Buffalo Organization for Social and Technological Innovation (BOSTI) found that office workers spent the majority of their time (over 62%) trying to do quiet, focused work at their desks or on the computers. Is it any wonder, then, that their findings have also shown that 65% of people in open plan offices are "often distracted" by noise?

Increased Noise Levels

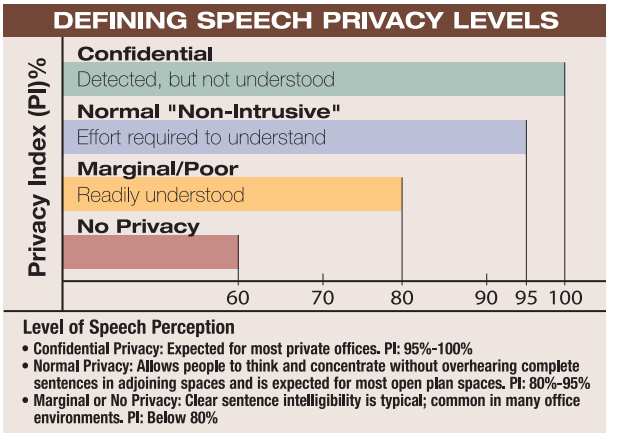
And, the office environment isn't necessarily going to get much quieter because of the following factors, all of which create a work environment that requires a greater level of acoustical attention:

- Increased workstation densities, which means more employees are working in closer proximity to each other than ever before.
- Creation of "teaming" areas that increase noise levels as a result of interactive conversations required in this type of environment.
- More widespread use of speakerphones and the tendency of employees to speak more loudly when using them.
- A growth in the architectural trend toward open plenum or exposed roof deck designs and the reverberation problems that accompany them.

As a result of trends like these, architects, interior designers, building owners and facility managers all need to be more aware of speech privacy because it is quickly becoming a concern in a variety of buildings ranging from healthcare facilities, where physician-patient confidentiality is critical, to owner-occupied and for-lease office buildings, where privacy is needed in meeting rooms and board rooms as well as in open and closed offices.

Speech Privacy Levels

In order to attain a specific level of speech privacy for a particular architectural space, it is important to be familiar with the acoustical performance parameters that influence it. These are described in the box below.



The term speech privacy itself refers to how well an overheard conversation is understood by an unintended listener. The commonly recognized levels of speech privacy are:

Confidential – Represents a Privacy Index (PI) rating of 95% to 100%. Nearby conversations may be partially overheard, but definitely not understood. Co-workers may hear muffled sounds but the meaning of spoken words is not intelligible, and they are not distracted from their work.

Non-Intrusive (Normal) – Represents a PI rating between 80% and 95%. Nearby conversations can be partially overheard, and some words or phrases may be intelligible. Co-workers may hear some

Acoustical Wall Panels

Acoustical wall panels complement acoustical ceilings by dampening that portion of sound that travels horizontally. As a result, they offer an attractive, functional way to add acoustical benefits to a space.

Acoustical wall panels usually consist of a 3/4" to 1" thick mineral fiber or fiberglass substrate with a vinyl or fabric covering. Depending upon the substrate and installation method, they can absorb 50% to 90% of the sound striking them, reducing noise not only within a space but also between spaces.

Panels with a fiberglass substrate are ideal for use in applications such as perimeter walls in open plan spaces, while those with a mineral fiber core are generally used in closed offices and areas requiring a tackable surface.

The panels are easy to install over existing walls, which makes ideal for retrofit applications, or they can be installed directly to studs.

of the conversation but the loudness of speech is not distracting, and they can generally continue with their work.

Non-intrusive speech privacy is the most common design goal for most open plan office environments, especially where "knowledge worker" productivity is a key issue. However, it is generally not an adequate design goal in functional environments such as medical facilities, law firms, financial service organizations or human resource departments, where confidential privacy levels are generally required.

Marginal (Poor) – Represents a PI rating of 60% to 80%. Most nearby conversations can be overheard and are likely intelligible. Co-workers can understand most words and sentences, and the loudness of speech can be distracting to them.

No Privacy – Represents a PI rating of 60% or less. All conversations can be clearly overheard and are fully intelligible. Co-workers can understand all words and sentences and the loudness of speech can be a constant distraction.

Balanced Acoustical Design

One of the most effective methods for achieving speech privacy in office environments is the use of an approach called balanced acoustical design. It consists of three key elements, which are often referred to as the "ABCs of Balanced Acoustical Design." If any of the elements is missing or out of balance, speech privacy will be compromised. These elements are:

- **Absorb** sound within a space by the use of high performance acoustical ceiling and wall treatments that prevent unwanted sound from building up due to reflections and/or intruding into an adjacent space.
- **Block** sound transmission between spaces with a combination of high performance ceilings and effective partition wall or furniture panel design and layout.
- **Cover** the remaining intruding sound with an evenly distributed electronic sound masking system that can be adjusted to meet the desired privacy level.

Electronic Sound Masking

Speech privacy depends on the difference in the level of intruding sound, which is the speech level of a nearby conversation, compared to the level of background sound, which in many cases comes from the air delivery system. To attain speech privacy, the level of background sound must be higher than the level of intruding sound.

Proper choice of acoustical ceiling and wall treatments will help lower the level of the intruding sound. In the past, background noise contributed by HVAC equipment was generally sufficient to assure adequate speech privacy. However, with the advent of quieter HVAC equipment, particularly variable air volume (VAV) systems and underfloor air distribution systems, this is no longer the case.

Consequently, a different source of controlled background sound is needed to override the intruding sound of speech and to preserve the privacy of a conversation without being obtrusive in and of itself. That sound is called electronic masking sound.

Elevate Background Sound

Masking sound systems provide a level of background noise similar to traditional HVAC systems. When this electronically generated sound is used correctly, unwanted sound, such as an intruding conversation, generally goes unnoticed.

To be most effective, the masking sound should cover the space uniformly, making nearby conversations less intelligible throughout the space. By ensuring that less speech is overheard and understood, occupants can realize better concentration and workplace effectiveness.

Sound masking should be considered a component in the design of all open spaces because it covers up the residual speech not controlled by other architectural sound control elements. Achieving the full privacy potential of closed offices often requires that sound masking also be provided in order to elevate background sound or to offset less than adequate architectural design.

Sound Masking Systems

Sound masking is generally provided in one of two ways: by installing masking speakers in the plenum, or by installing masking speakers in the ceiling plane.

Traditional sound masking speakers are hung in the ceiling plenum by chains or wires from the deck above. In a typical system, the electronic masking sound is directed upward to create a reverberant sound field within the plenum. The masking sound then transmits down through the ceiling plane at reduced levels as it passes through the ceiling tiles, lighting fixtures, etc. on its way into the occupied space.

As a result of new speaker technology, systems are now available that can provide direct sound masking from speakers installed in the ceiling plane. The speakers are flat panels that look like 2'x 2' acoustical ceiling tiles and simply lay in the grid like normal ceiling tiles, radiating sound downward directly into the space below in a non-directional pattern. This design provides more effective, uniform sound masking because it is not sensitive to plenum obstructions.

Choice of Ceiling Is Key

The attainment of speech privacy is dependent on good acoustical design and the proper selection of interior systems and materials.

In that regard, the proper choice of a ceiling can serve to both limit the sound intrusion between spaces and affect the quality of sound within a space. The ceiling is thus a key element in creating an acoustical environment that can maintain speech privacy.

When selecting ceilings, the use of the same acoustical ceiling throughout the entire space is not always the best choice. That's because in terms of speech privacy, there is a significant difference in the acoustical requirements of ceilings used in closed spaces and those used in open spaces. As a result, different areas require different ceilings, and different applications of the ABCs of balanced acoustical design.

Open Plan Areas

Disruptive noise and lack of speech privacy can be a salient problem in open office plans. Intrusive noise can significantly reduce employee concentration and work output, and lead to decreased job satisfaction. In addition, overheard conversations can lead to unintentional confidentiality breaches in sensitive work areas.

Ceilings: Key Element of Effective Workplace Environments

Proper choice of an acoustical ceiling goes a long way toward creating a better workplace environment. However, improved acoustics isn't the only benefit. There are numerous other features incorporated into today's ceilings that can help optimize office design even further.

High light reflectance – Proper lighting is critical to an effective workplace. Poor lighting can cause eyestrain and fatigue, which can hamper an employee's ability to concentrate. High light reflectance ceilings, meaning those that have a Light Reflectance (LR) value of 0.83 or higher, can help improve this situation by creating brighter, more evenly lit, spaces. They also reduce glare and enhance daylighting in the room.

Sag resistance – Commercial buildings often have to cycle or shut down their HVAC systems for periods of time, causing increased humidity levels. Humidity resistant ceiling panels specifically designed for these types of applications are available. These ceilings stay flat and can be installed in high humidity applications other than outdoors or where subjected to standing water.

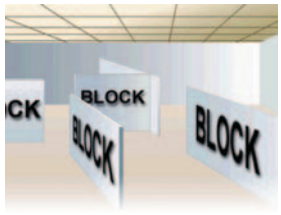
Mold/mildew resistance – High humidity conditions can also lead to the growth of mold and mildew on any surface, including ceiling panels. To help remedy this situation, acoustical ceiling panels are available with a fungicide that inhibits the growth of mold and mildew on the painted surface on the front and back of the panel when used in accordance with good design, construction and maintenance practices.

Sustainability – Owners and architects are more sensitive today to the need to build environmentally friendly facilities. Many acoustical ceilings used in offices are made with recycled content, some containing as much as 82%. In addition, Armstrong offers a Ceiling Recycling Program that enables building owners to ship old ceilings from renovation projects to one of its plants as an alternative to landfill disposal.

Reducing distracting noise and achieving speech privacy in open plan areas is not difficult as long as the ABCs of balanced acoustical design are followed:

Absorb noise with a high performance acoustical ceiling – In open spaces, the main function of the ceiling is to absorb sound that would normally bounce off the ceiling into a nearby space or cubicle. For speech privacy, a fiberglass acoustical ceiling with an AC rating of 180 or higher and an NRC of 0.80 or higher is the best choice.

Always base your product selection on ceilings with UL-classified acoustical performance. This will ensure that the ceiling meets or exceeds published values. Also, the ceilings should be at least 9' high to meet the published AC rating.



Block noise with effective furniture systems and layout – In open plan offices with cubicles, furniture panels should be 60" or higher with an STC rating of 24 or higher. Use four-sided cubicles – anything less compromises privacy in some direction – and prevent direct "line-of-sight" sound paths by staggering the location of the entrances to the cubicles.

Cover intruding noise with sound masking – For best results, the sound masking should cover the key speech frequency range at a minimum sound level. The human voice has a frequency range from 125 Hz to 8000 Hz. However, most speech sounds fall between 500 Hz and 4000 Hz.

Closed Plan Areas

The audibility of speech between adjacent closed spaces is not a problem until it becomes intelligible. Unfortunately, Privacy Index ratings for many closed rooms often indicate less than confidential speech privacy, even with doors closed.

Confidential speech privacy in closed spaces can be achieved by once again using the ABCs of balanced acoustical design:

Absorb noise with an acoustical ceiling. In closed spaces, the main function of the ceiling is to limit the transmission of sound between adjacent rooms, especially when these spaces share a common ceiling plenum.

Acoustical Indicators

Noise Reduction Coefficient (NRC) – Indicates the ability of a material, such as a ceiling, to absorb sound over all angles of incidence. It is expressed as a number between 0.00 and 1.00, and indicates the average percentage of sound that the material absorbs. Ceilings with an NRC rating less than 0.50 are considered poor absorbers; those with an NRC greater than 0.80, very good absorbers.

Sabin – Indicates the ability of an individual "space absorber," such as an acoustical canopy, cloud or baffle, to absorb sound. The number of Sabin per unit is approximately equal to the total surface area of the unit that is exposed to sound (in sq. ft.), multiplied by the absorption coefficient of the material. The higher the Sabin rating, the more effective that unit will be in controlling reflected sound within the space.

Articulation Class (AC) – Indicates the ability of a ceiling to absorb sound at angles between 40° and 60°, the angles at which most sound is reflected off the ceiling between two adjacent work stations divided by partial-height furniture panels. Ceilings with an AC less than 150 are considered low performance; those with an AC equal to or greater than 200, high performance.

Ceiling Attenuation Class (CAC) – Indicates the ability of a ceiling to block sound in one closed space from passing up into the plenum and transmitting back down into an adjacent closed space that shares the same plenum. Ceilings with a CAC less than 25 are considered low performance; those with a CAC equal to or greater than 35, high performance.

Sound Transmission Class (STC) – Indicates the ability of a partition wall or furniture panel to block the transmission of sound through it and into an adjacent space. Wall systems with an STC less than 35 are considered low performance; those with an STC equal to or greater than 55, high performance.

Privacy Index (PI) – Indicates the degree of speech privacy attained in open or closed spaces. It is expressed as a percentage, and takes into account the combined acoustical performance of everything in the space, including ceiling, walls, floor covering and furniture. The higher the percentage, the better the speech privacy.

Metal, Wood Ceilings

Mineral fiber panels suspended in a metal grid are the most popular acoustical ceiling systems used in commercial spaces today. However, there is a trend toward an increased use of ceiling materials other than traditional mineral fiber panels. The reason for this is a desire to create more dynamic acoustical ceiling visuals. Two of today's more common alternatives to mineral fiber panels are metal and wood.

Metal Ceilings

One reason for the increasing use of metal ceilings is their durability; another is aesthetics. Metal ceilings are available in a variety of finishes that can impart a very high tech or sophisticated look to a space. And, even though it is metal, this type of ceiling can provide very good acoustical control when designed for that purpose.

However, in order to achieve good sound absorption, the panel faces must be perforated, and the panel backloaded. Perforations vary in size depending on aesthetic appeal, although today there are microperforated panels in which the holes are so small, they are essentially invisible.

Perforated panels are usually supplied with a black, sound absorbent acoustical fleece liner, or both a liner and an encapsulated fiberglass batt behind the perforations. The NRC of perforated panels can range from 0.65 to 0.90 depending on the backing.

Wood Ceilings

One reason wood ceilings continue to increase in popularity is their beauty. Wood is often the most elegant architectural element within a space. Wood ceilings are thus perceived as upscale and stylish, even when used with a standard suspension system and standard light fixtures. Wood ceilings also impart a warm ambiance to a space.

As in the case of metal, wood ceilings are available in a variety of finishes and sizes. Perforated versions are also offered for better acoustical performance compared to non-perforated panels. The NRC of perforated panels can be as high as 0.75 depending on the backing used.

For speech privacy, use a mineral fiber ceiling that is installed continuously across the ceiling plane, and combines moderate sound absorption (NRC 0.60 to 0.70) with good ceiling attenuation (CAC 35 or higher).

It may be necessary to supplement the ceiling system by providing closure/seal components to stop sound leaks around ceiling penetrations. It is especially important to control sound leaks through air return openings.

Block noise with an effective combination of wall construction and ceiling. If space relocation is not an issue, use a floor-to-slab fixed stud wall construction (drywall and fiberglass insulation) with a minimum STC 40 rating. If space relocation is an issue, use either fixed stud walls or relocatable walls of floor-to-ceiling height with an STC 40 rating or higher, and a ceiling with a minimum CAC 35 rating.

All components of the wall system should be engineered for STC performance and the removal of problematic sound leaks from doors, wall system joints, and seals at the ceiling and floor interface. Construction of the wall is critical since any crack in it or in the wall joints will allow sound to intrude into the adjoining space.

Cover intruding noise with sound masking. Use electronic sound masking to cover speech intelligibility between adjoining spaces. Coordinated performance between the sound masking and ceiling/wall system is essential in achieving speech privacy.

Each component must be engineered to ensure the design of the sound masking system complements the architectural performance over the key speech frequency range. The result will provide the appropriate level of speech privacy with the minimum level of masking sound.

Open Plenum Areas

In addition to the acoustical issues related to typical office spaces, there are additional considerations that may need to be taken into account because they affect acoustical performance.

One such example is the trend toward open plenum or exposed roof deck designs, sometimes called the "warehouse look." Open plenum designs can cause problems because sound reflecting off the roof deck results in excessive reverberation. In addition, if the exposed roof deck is less than 15 feet high, reflections between adjacent open plan cubicles can cause distractions for nearby occupants.

Many noise issues related to open plenum or exposed roof deck designs can be addressed through the use of acoustical ceiling clouds and canopies. Designed for use in either new construction or retrofit applications, acoustical clouds are an ideal way to define spaces in open plenum areas and enhance acoustics without sacrificing design flexibility.

Clouds and Canopies

Ceiling clouds located above work areas provide a type of interrupted ceiling plane. As such, they help control reflections between cubicles and distant reverberation noise, thus reducing occupant distractions.

Acoustical clouds actually provide greater sound absorption than a continuous ceiling of the same surface area because the sound is absorbed from both the front and back surfaces of the cloud. In fact, the more "live" the space, the greater will be the effect on reverberation time from the addition of clouds.

Acoustical canopies also help reduce reverberation time in the space below them, but are much different in size and look compared to acoustical clouds. For example, pre-packaged cloud systems are available in squares and rectangles in sizes ranging from 6'x 6' to 14'x 14', while acoustical canopies are generally only about 47"x 76" in size. Visually, acoustical clouds are flat, while canopies are curved.

The ability of acoustical canopies to combine an aesthetically pleasing visual with sound absorbing properties that provide spot acoustics makes them ideal for use in open plenum areas as well as over spaces such as workstations and reception desks. Use of multiple canopies improves acoustics even more.

Ceiling Height

Ceiling height is another key factor affecting the performance of architectural sound controls. When it comes to height, it is easier to achieve speech privacy with high ceilings than with low ceilings, and the range of ceiling options is also expanded.

High ceilings provide better acoustical performance than low ceilings due to the longer paths sound must travel. This impacts all sound, whether it is a voice intruding from an adjacent office, or masking sound radiating down from the ceiling plane. High ceilings allow a wider range of ceiling panels, even less than 200 AC, to be used in open plan designs.

In contrast to high ceilings, which offer greater performance options, low ceilings present several acoustical design challenges. Selection of an acoustical ceiling system, for example, becomes more critical due to the shorter paths that sounds must travel. For open plan designs, this means a ceiling with an AC of 200 or more can be the only viable option for achieving acceptable speech privacy.

Lighting Fixtures

For years, the ceiling plane has had to incorporate lighting fixtures, sprinklers, air diffusers and the like. Today, as building systems require more technology, the ceiling plane is becoming even more congested with addition of sensors, actuators and other types of similar equipment.

It is important to remember that lighting fixtures and other devices installed in the ceiling plane may adversely affect an acoustical ceiling's performance. This applies to both the sound absorbing and sound blocking performance of the ceiling system.

For example, when choosing light fixtures, especially for an open plan office, it is critical to minimize sound reflection off the surface of the fixtures. Typical flat lens lighting fixtures are generally the worst offenders. For open plan applications, pendant lighting fixtures are a much better choice.

A Quieter Workplace

A balanced acoustical design consisting of high performance acoustical ceilings and walls to absorb sound; effective wall, ceiling and furniture design to block sound; and a sound masking system to cover sound is an easy and economical way to help meet speech privacy needs, boost employee satisfaction and increase workplace effectiveness. The successful use of this design solution will help provide office employees with the level of speech privacy necessary for them to feel more comfortable in their workplace environment.

Resources

This information on speech privacy in closed and open plan office environments has been provided by Armstrong Ceiling Systems. There are additional resources available to you for all of your speech privacy design needs that include:

- Speech Privacy in Office Design CEU course at armstrong.com/ceu
- Speech Privacy Predictor tool through your Armstrong representative
- Your Armstrong Ceiling Systems representative at 1-877-ARMSTRONG
- Answers to your technical questions through TechLine™ at 1-877-ARMSTRONG or techline@armstrong.com

Speech Privacy Predictor

An interactive software program from Armstrong provides users with the opportunity to calculate the speech privacy level of a space before construction or renovation of the space begins. Called the "Speech Privacy Predictor," the design aide is a valuable tool for use in office areas where improving speech privacy can mean better workplace effectiveness, and in healthcare facilities where HIPAA regulations require higher degrees of speech privacy.

The Predictor helps users make better design decisions by providing a method of examining various architectural design concepts and material selections and how they impact the level of speech privacy within the space. A detailed Speech Privacy Project Summary at the conclusion of the program documents the results of the process.

Architects, interior designers, building owners and facility managers who wish to use the Speech Privacy Predictor must contact their local Armstrong sales representative. For help in locating the nearest representative, call 1-877-ARMSTRONG (1-877-276-7876).

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