Office Acoustics – 4 counter-intuitive facts

This brief guide will introduce you to some acoustic terminology and the product types available to address acoustic issues in the workplace.

Most people simply want their working space to be relatively free from distraction, yet allow a conversation to be held with reasonable privacy.

Counter-intuitive fact 1   Quietness is the enemy…

The most distracting sound to the human ear is the human voice; our brains are 'pre-programmed' to pick up on intelligible conversations – how often is your attention grabbed when someone mentions your name at a noisy party?

The general 'hum' of work activity, machine noise, air conditioning systems and even traffic noise are rarely considered to be distracting or harmful at levels up to 60 dB(A); indeed, background noise actually helps to mask speech intelligibility; if only every third word or so can be understood it's far less likely we will be distracted.

In offices that are too quiet, it is beneficial to introduce noise. One low-cost way to do so is to remove some baffles from the air-conditioning system. A better solution is to install a Sound Masking System, where an electronic noise generator is hooked up to a grid of speakers. Premium systems allow the randomised frequencies to be 'tuned' for maximum effectiveness in different zones.

Counter-intuitive fact 2   Acoustic wall panels may not help…

Acoustic wall panels are generally designed to absorb acoustic energy and reduce reverberation (See definitions below). In a large open-plan area they are likely to reduce the overall background noise level, thus reducing the masking effect of background noise and increasing voice intelligibility/distraction.

Absorbent panels are most effective *inside* designated meeting rooms, where a long reverberation tail can make it more difficult to understand each other. Additionally, many video-conferencing systems are very sensitive to reverberation, because they have inbuilt gain-levelling systems that raise the volume of reflected sound relative to the spoken word.

Some forward-thinking manufacturers are producing meeting tables and light fittings that are highly acoustically absorbent, and may obviate the need for acoustic wall panels.

Others recognise that fashionable ‘glass box’ meeting rooms are highly reverberant, and provide acoustic panels that can be attached to glass using magnetic studs.

Counter-intuitive fact 3 Acoustic booths may not work…

The problem here is perception. If you sit in a heavily-padded booth or high ‘wraparound’ chair you immediately ‘sense’ the lack of reverberation (bouncing sound) and you think its quieter. But the issue is what other people can hear of your conversation as they walk past, and in this respect, most booths have a very limited effect.

A sound wave will expand equally in all three dimensions (like a balloon being blown up) – and unless it hits a barrier it will continue on its journey. So a booth that is partially open can only capture and absorb a limited part of the soundwave; the rest escapes ‘over’ the side panels – this is called ‘flanking sound’.

Moreover, many fabric/foam booths have general absorption characteristics that are not particularly effective on the typical frequencies of human speech; 200Hz-5000Hz.

We’re not suggesting that such booths have no effect, but that they have a *limited* effect. They also help to divide space, improve the interior architecture, and provide a place to encourage communication, so they have a place in the Office environment.

However, if acoustic privacy is the primary objective, look at fully enclosed booths with an overall sound reduction level (SRI) of 35 Db(A) or more. A credible supplier should be able to provide appropriate certification.

Counter-intuitive fact 4 Plants are a great addition

Biophilia is big – and why not? Most of us enjoy the natural world; it's nice to bring some of that into the workplace. We know that plants have positive effects including the production of oxygen and the absorption of toxins, but they can also have a beneficial acoustic impact.

The primary benefit of plants – particularly large-leaved varieties – is that they *diffuse* sound; breaking it up and bouncing (reflecting) it in multiple directions, while absorbing part of the sound energy in the process. Consider the acoustic environment next time you walk through a heavily-planted forest in Summer, and you'll hear the difference that foliage can make…

Conclusion

In our experience, there is too little technical understanding of the complexities of creating effective acoustic environments. Various suppliers will offer 'tools' or 'apps' that claim to measure acoustic parameters and deliver appropriate product solutions, but if there are serious issues, we believe it is better to retain the services of a qualified acoustician.

However, it is possible to achieve a reasonably balanced and effective acoustic space by thinking carefully about what you need to achieve before purchasing furniture products that may not work as you expect.

Interion brings *knowledge* – please contact us if you would like more guidance on office acoustics.

Acoustic Terminology in Simple Terms

Reverberation

When a sounds are reflected from multiple hard services, the 'smooth echo' effect is called reverberation. Think of the sound you hear if you shout or clap within a large, sparsely furnished, room or hall. The 'Reverberation Tail' describes in seconds the length of time this effect lasts, and for office environments this should generally be less than 0.3 seconds.

Now imagine that room or hall full of soft furnishings, or perhaps plush cinema seating. The furniture reduces the reverberation tail significantly.

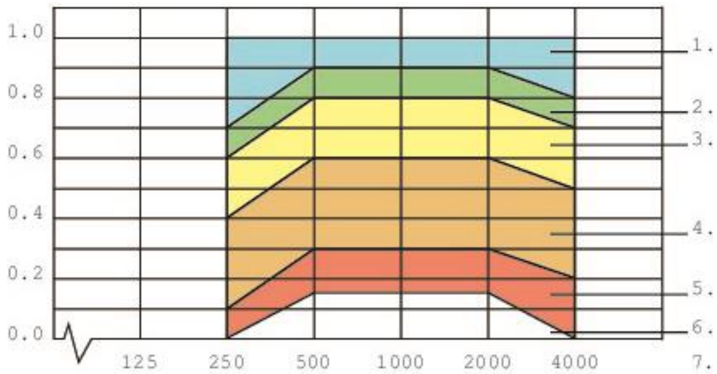
Absorption

Describes the extent to which a surface can absorb sound energy, effectively converting it into heat.

You may come across definitions of 'Class A-E' which refer to the absorbent characteristics of materials based on the following diagram (Courtesy of Echophon).

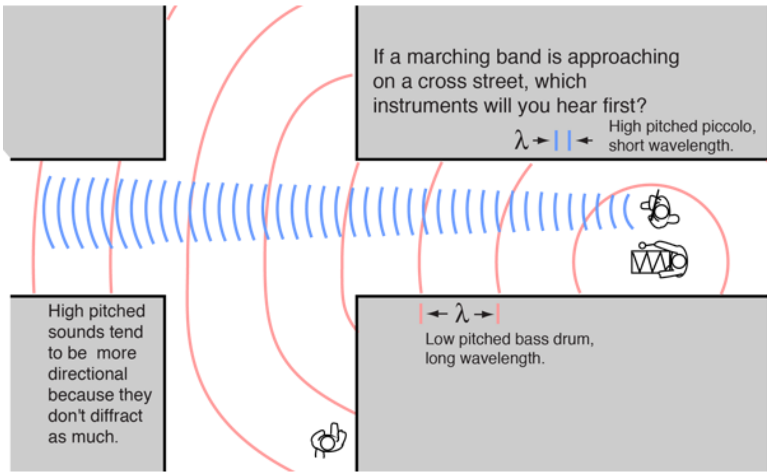
An absorption coefficient of 0.8 means that 80% of the sound will be absorbed. Note that performance tails off at the top end of typical human speech frequencies, so it is more difficult to absorb sibilant sounds like 's' and 't'.

1. Absorption class A
2. Absorption class B
3. Absorption class C
4. Absorption class D
5. Absorption class E
6. Unclassified
7. Frequency (Hz)



Diffraction

For our purposes, diffraction describes the way that sound waves 'bend around' obstacles. The following diagram illustrated that this effect is primarily limited to low-frequency sounds with a longer wavelength.



(Diagram courtesy of HyperPhysics)

Diffusion

…is the efficacy by which sound energy is spread evenly in a given environment. A perfectly diffusive sound space is one that has certain key acoustic properties which are the same anywhere in the space. These ceiling diffusers in The Albert Hall were installed to help every member of the audience share the same acoustic experience. (Courtesy of Wikipedia)

Transmission

…is the extent to which sound can 'pass through' a barrier material, measured as a 'Sound Reduction Index (SRI)' in Decibels. This measurement is most important for offices and meeting rooms formed with full-height partitions. A 'good' rating for partitioning sound reduction is 47dBA, but the maximum realistically achievable in single glazing is 42dBA.

Frequency

The number of cycles of pressure fluctuations within a given period of time.

The lower the number, the lower the sound – so a rumble of thunder is at the lower end, and the sound of a tiny bell is towards the top end. The human audible frequency scale extends from about 20Hz (ie 20 cycles per second) to 20,000Hz.

Arguably, the most important frequency range for offices is that of human speech; 200Hz to 5000Hz.

And for the technically-minded…

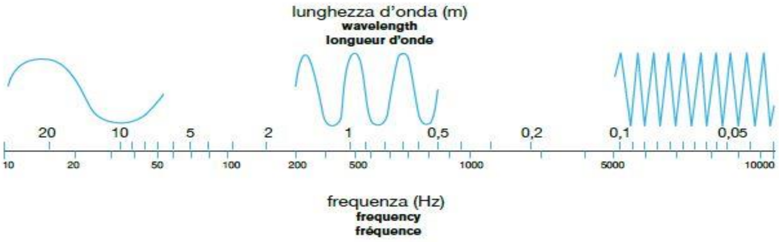
Principles of acoustics and of architectural acoustics

Sound is created by a rapid succession of compressions and refractions of pressure waves in an 'elastic medium' (Sound cannot propagate in a vacuum).

The sound source is composed of vibrations that transmit their movement to the particles in the surrounding medium. It is not the particles themselves that move from the source to the receptor, but it is their movement, or state, that is transmitted from one particle to another.

Sound propagates through a wave train (a series of compressions and refractions travelling in the same direction), which can be described by a sinusoid oscillating with period T (s) (The time taken by the wave for a complete oscillation) with frequency $f=1/T$ (Hz). Sound can also be described by its wavelength λ (lambda), which is the distance travelled by the wave in completing an oscillation.

In the following graph and table, frequency values are compared to the corresponding wavelength values for sound that propagates through air.



Frequenza _ Frequency _ Fréquence f (Hz)	Lunghezza_Length_ Longueur_ (m) λ
20	17
1000	0,34
20000	0,017

Decibels and acoustic pressure

'Acoustic pressure' is the difference between the pressure of a sound and the reference (atmospheric) pressure. Acoustic pressure can vary significantly and, for this reason, a logarithmic scale was introduced, whereby the pressure value can be expressed in decibels dB (one tenth of a Bel). This means that a 20dB difference at high levels is significantly greater than a 20dB difference at low levels.

A person with normal hearing can hear frequencies between 20 Hz and 20,000 Hz (20 KHz). An acoustic emission below 20Hz is called *infrasound*, and above 20 kHz, *ultrasound*.

Human speech occupies a relatively narrow frequency range between 200 and 5,000 Hz. Perhaps unsurprisingly, the human ear is most sensitive to this range of frequencies.

Decibel level (dB)	**Example**
140	**Jet aeroplane taking off** (possible damage to hearing)
120	**Pneumatic drill** (threshold of pain)
100	**Night club**
80	**Multi-lane city traffic at rush hour**
60	**Animated conversation, busy office**
40	**Day-time, within a house, quiet office**
20	**Night-time, within a bedroom**

Sound absorption, reflection and transmission

When a sound wave hits an obstacle, the energy is dissipated in three ways; part reflected, part absorbed (and transformed into heat), part transmitted though the obstacle.

A sound source within a closed space will generate a series of acoustic reflections and the level of sound detected is equal to the sum of the direct sound and reflected sound (reverberated sound field).

Acoustic absorption is the capacity of a material to reduce the reflected energy of a given sound. The absorption properties of materials are measured through the *sound absorption coefficient* which varies between 0, when all the energy is reflected, and 1, when all the incident energy is absorbed.

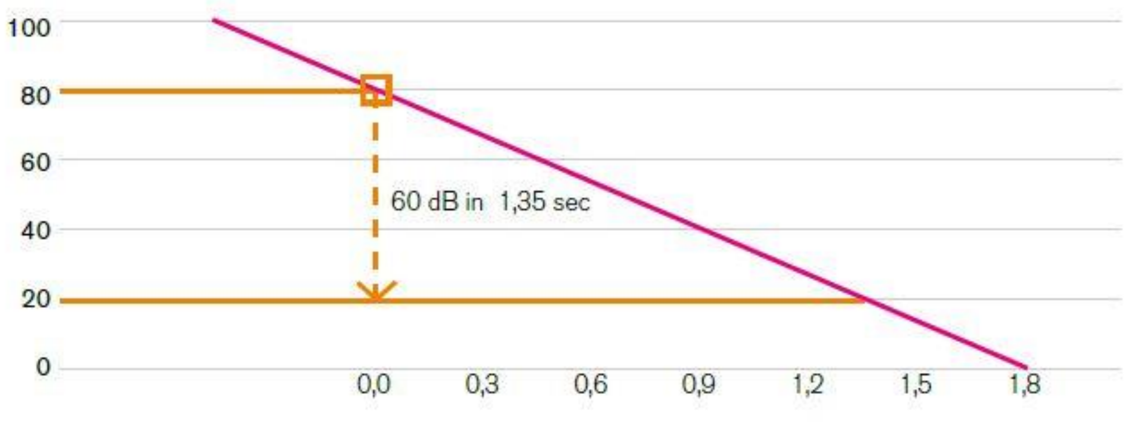
For example, a sound absorption coefficient equal to 0.3 indicates that a particular surface absorbs 30% of the sound energy that it receives.

Acoustic insulation is the degree to which a barrier prevents energy being transmitted from a source environment to a receptor environment.

It is important to note that valid acoustic *absorption* values often do not correspond to equally significant acoustic *insulation* values, or vice-versa.

Reverberation time and other parameters

When an acoustic source stops emitting the sound wave, there is a trail of sound, that is, the reflected (or reverberated) field lingers for a brief period, fading progressively. This is known as reverb time delay and can be measured using the reverberation time, RT60 defined as the interval in time between the moment at which the source is interrupted until the moment at which the acoustic level is reduced by 60 dB compared to its initial level.



The acoustic comfort of a room can also be described by other indices:

Index	Description	Measurement
STI	Speech Transmission Index	Both measure the average number of words understood
RASTI	Rapid speech transmission Index	by a listener compared to the words spoken.

D50	Definition Index	Expresses the relationship between useful energy and total energy.
NCI	Noise Criterion Index	Identifies the disturbance level caused by background noise

All of these indices are directly or indirectly correlated to the reverberation time, which is the most important factor defining the acoustic quality of a room, affecting intelligibility, sound fusion, perception of the direction of a source of sound and the more general perception of acoustic quality in a closed environment.

Acoustic properties of architectural materials

Architectural elements can achieve acoustic absorption through three approaches:

***Porous materials*:** sound energy is dissipated through viscous attrition, within materials with an open porous structure.

Cavity (Helmholtz) resonance: sound energy is dissipated through the dampening of the oscillation of a partially confined mass of air.

Membrane resonance: sound energy is dissipated through the dampening of the oscillation of a vibrating surface.

Porous materials

Fibrous materials such as fibreglass wool, mineral wool, open-cell polyurethane foam, wood fibre and felt are among the porous materials that provide good absorption. The sound absorption coefficient of these materials depends on:

- **Porosity.** Greater porosity (the relationship between the volume of the internal micro-cavities and total volume) is directly proportional to greater acoustic absorption.
- **Thickness**. Increasing thickness leads to an improvement in acoustic absorption at low frequencies, while the improvement is less marked at higher frequencies.
- **Density**. The density of the panel acts on the acoustic absorption, according to the frequency; for the same material, different densities will return different absorption values at different frequencies. Typically, a higher density will produce greater acoustic absorption at lower frequencies.
- **Shape.** A greater contact surface with the sound wave will increase the absorption capacity per unit of surface plane. The most common approach is to produce a pyramid or dimpled/bubble-shaped finish.