ACOUSTICS 1.01

SONIUM

AYRES
Lightweight Panel Systems

CONTENT

1. INTRODUCTION

The desire for quietness and comfort is becoming more and more important, not only in private life but also at work. Creating solutions for good acoustics, especially in public areas and the work environment, has become an increasingly challenging task for designers and architects. Unpleasant noise, and exposure to loud living or working environments, are increasingly perceived as stressful.

On the other hand, there are the current trends in the design and building physics of modern home and office architecture which make it much easier to minimise inappropriate acoustic conditions in a room. Walls and ceilings with sound absorbing properties are also often significant tools in the acoustic design of modern living, learning and working environments.

The acoustics of a room are influenced by many factors: Apart from the basic shape of the room, other features such as floor, wall and ceiling coverings determine the propagation of sound in a room. The size and positioning of sound absorbing surfaces, as well as sound reflecting surfaces, decide whether the acoustics or a room are considered "good" or "bad". In this sense "good" acoustics means that the room acoustical conditions are suitable for the main use of that room. The acoustics in a room should contribute to our perception of speech, music or other sounds as neither too loud nor too quiet, allow us to communicate clearly and effortlessly, and make us feel comfortable.

As part of a complete range of aluminium honeycomb lightweight panels, AYRES offer comprehensive acoustic solutions which combine sound absorption with attractive design options, in a fibre-free and lightweight material: **SONIUM®** panels.

SONIUM® panels are particularly suitable for this purpose, as they offer a variety of fabrication and value engineering possibilities.

SONIUM® sound absorbing panels are suitable for:

- Wall panels, including fixed wall panelling and partition walls
- Ceiling systems
- Retrospective installations in existing room situations, e.g. ceiling clouds
- Machinery enclosures
- Ducting
- Cleanrooms

AYRES ACOUSTICS 1.01, compiled by Dr. Christian Nocke, provides simplified information and guidance on the complex subject of acoustics. It also explains the important differences between the key concepts of Sound Insulation and Sound Absorption.

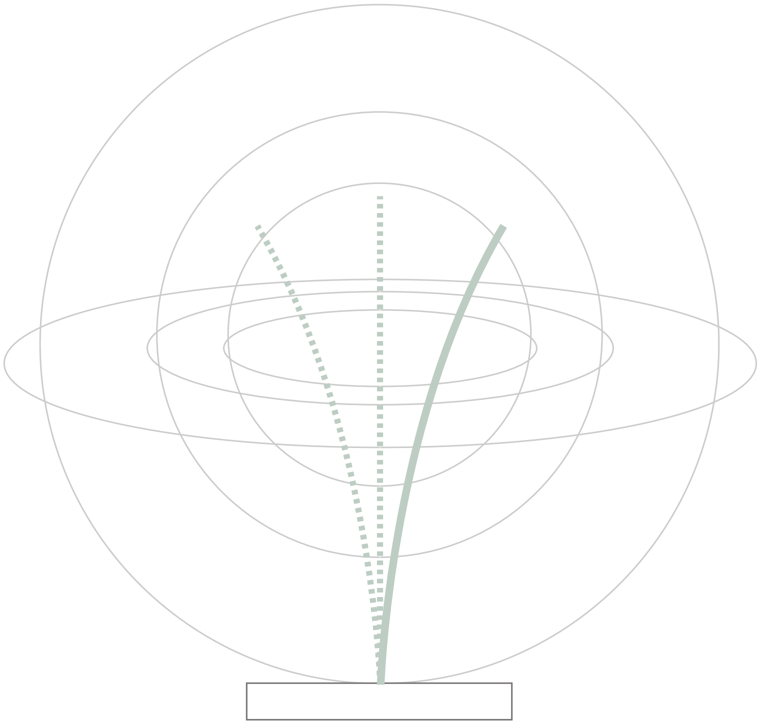
2. WHAT IS SOUND?

2.1 SOUND

Sound can be harmonious tones, music, bangs, noise, crackling, and also spoken words. All of these sound events cause a slight variation in air pressure, which propagates in the surroundings of its source. We therefore refer to the sound pressure of a tone, of noise, speech or music. The louder the sound event, the greater is this pressure variation and the higher is the sound pressure. Sound propagates into all three directions of space; length, width and height. With many sound sources the sound radiation depends on the orientation of the source, however in most cases it is sufficient to assume a roughly uniform, omnidirectional sound radiation.

A sound wave is a variation of air pressure or density in time and space. Sound waves can travel though a medium such as air, liquids such as water, or solid matter, for example masonry; giving rise to airborne, fluid-borne or structure noise. In general terms, sound can be defined as the propagation of pressure and density variations through an elastic medium: gasses, liquids, or solid matter. When sound penetrates through a wall, the incident airborne noise is converted into structure noise (vibration of the wall) and subsequently transmitted as airborne noise again on the other side of the wall (though reduced by the insulation properties of the wall).

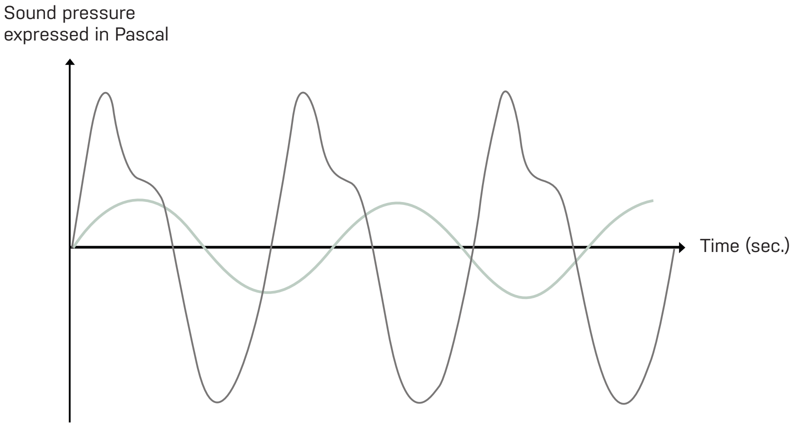
Undesirable sounds are commonly referred to as noise. This definition highlights the subjective nature of noise perception. Music in a concert or voices in a conversation can be sound but a neighbour's music, or the conversation of others, can be noise.



2.2 SOUND PRESSURE

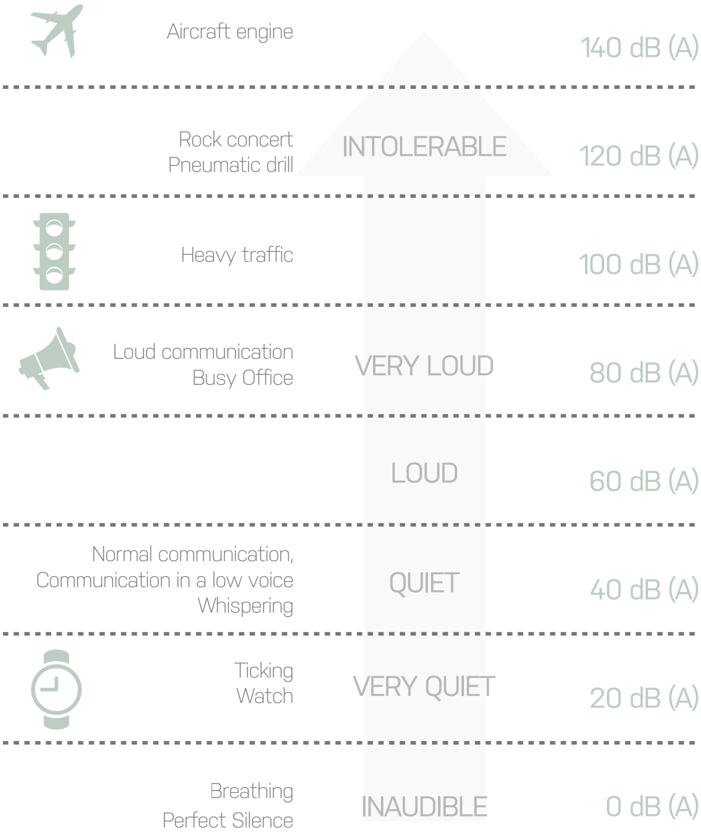
Variations in air pressure are referred to as sound pressure.

The air pressure of any sound event can be determined, whether it be a single tone, a sound, a noise, speech or music. The louder the sound event, the greater the pressure variations and consequently the higher is the sound pressure. Minor sound pressure variations are perceived as quiet sounds. Human hearing is able to perceive a minimum sound pressure of 20 μPa = 0.00002 Pascal. This is a very low value and demonstrates the sensitivity of the human ear.



2.3 THE DECIBEL SCALE

Sound pressure level, or sound level, is normally expressed using the Decibel scale. In the definition of the decibel scale, a sound level of 0 decibels is the threshold of sound pressure perception of human hearing. The decibel is a logarithmic unit of measurement from 0 decibel (dB) to 140 dB. Exposure over long periods of time to more than 80 dB, or exposure to more than 120 dB for very short sound events (eg. a loud bang), can lead to irreversible hearing damage.



Aircraft engine		140 dB (A)
Rock concert Pneumatic drill	INTOLERABLE	120 dB (A)
Heavy traffic		100 dB (A)
Loud communication Busy Office	VERY LOUD	80 dB (A)
	LOUD	60 dB (A)
Normal communication, Communication in a low voice Whispering	QUIET	40 dB (A)
Ticking Watch	VERY QUIET	20 dB (A)
Breathing Perfect Silence	INAUDIBLE	0 dB (A)

2.4 SOUND PRESSURE INCREASE FOR MULIPLE SOUND SOURCES

Doubling the number of identical sound sources results in an increase of the sound level by 3 dB; a 10-fold increase in the number of identical sound sources increases sound level by 10 dB, a 100-fold increase in the number of identical sound sources increases sound level by 20dB.

Sound source (e.g. Alarm Clock)	Increase of dB value
1	62dB
2	62 + 3 = 65dB
3	62 + 5 = 67dB
4	62 + 6 = 68dB
5	62 + 7 = 69dB
10	62 + 10 = 72dB
15	62 + 12 = 74dB
20	62 + 13 = 75dB
50	62 +17 = 70dB
100	62 + 20 = 82dB

The table below offers a simplified rule of thumb for the addition of two dissimilar sound sources. First of all, the difference between the two sound levels has to be established.

Level difference between two levels	0 to 1	2 to 3	4 to 9	more than 10
Level increase (to be added to the larger value)	- 3 dB	+ 2 dB	+ 1 dB	+ 0 dB

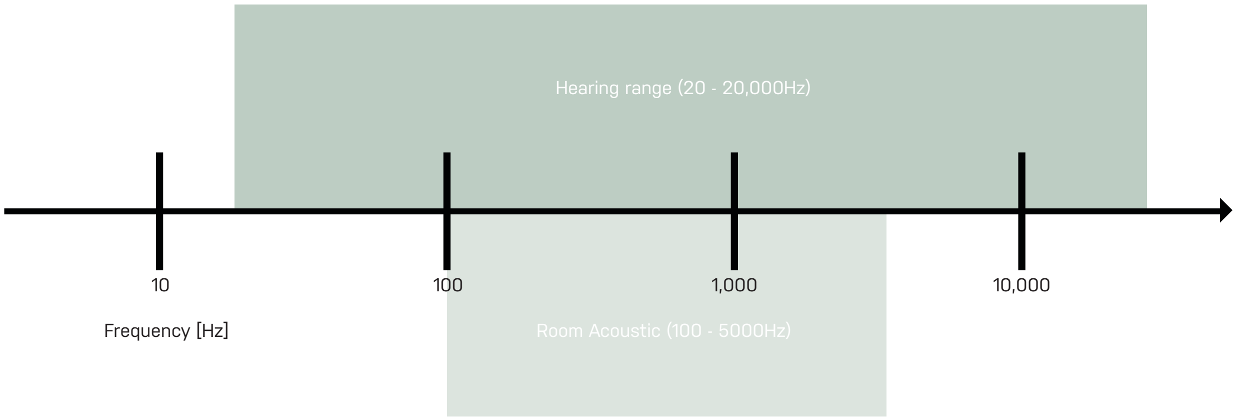
2.5 FREQUENCY

Human beings perceive the sound pressure level as the volume of sound, i.e. its loudness. This is clearly an important property of sound. Equally important is the frequency content of the sound, i.e. its spectrum. Pure tones are sound events of a single frequency. A mixture of tones of different frequencies can be referred to as noise or sound, depending on the frequency mix.

The sensitivity of human hearing is highly dependent on the frequency. It is particularly perceptive in the frequency range of human speech between 250 Hz and 2000 Hz. This is very useful when we listen to someone speak, and disruptions in this frequency range are particularly annoying and can strongly affect communications. Towards higher or lower frequencies, our hearing ability decreases. Acoustic design always needs to take into account the sound frequencies relevant for the human ear, to create optimum conditions for human perception.

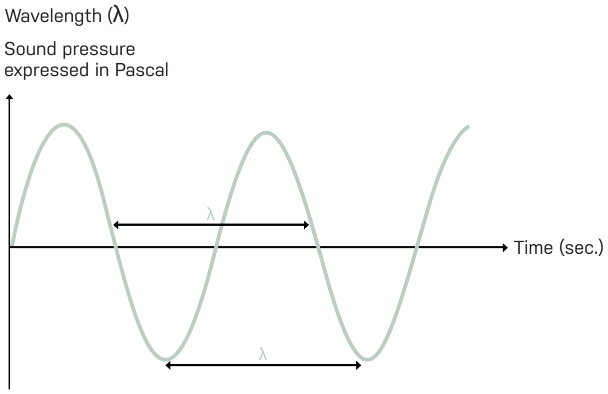
A noise loudness rating to meet the demands of human hearing needs to take into account the frequency characteristics of the human auditory system. Medium frequencies, at which the human auditory system is particularly sensitive, need to be weighted more heavily than the high and low frequencies. This weighting results in the term dB(A) for sound pressure levels, i.e. the so-called A-weighted sound pressure level. Nearly all regulations, guidelines, standard values, limit values, recommendations and references to sound pressure levels use values expressed in dB(A).

To achieve good room acoustics, planning should be carried out within the frequency range between 100 Hz and 5000 Hz, even though the total range of human hearing is from about 20 Hz to 20'000 Hz.



2.6 WAVELENGTH

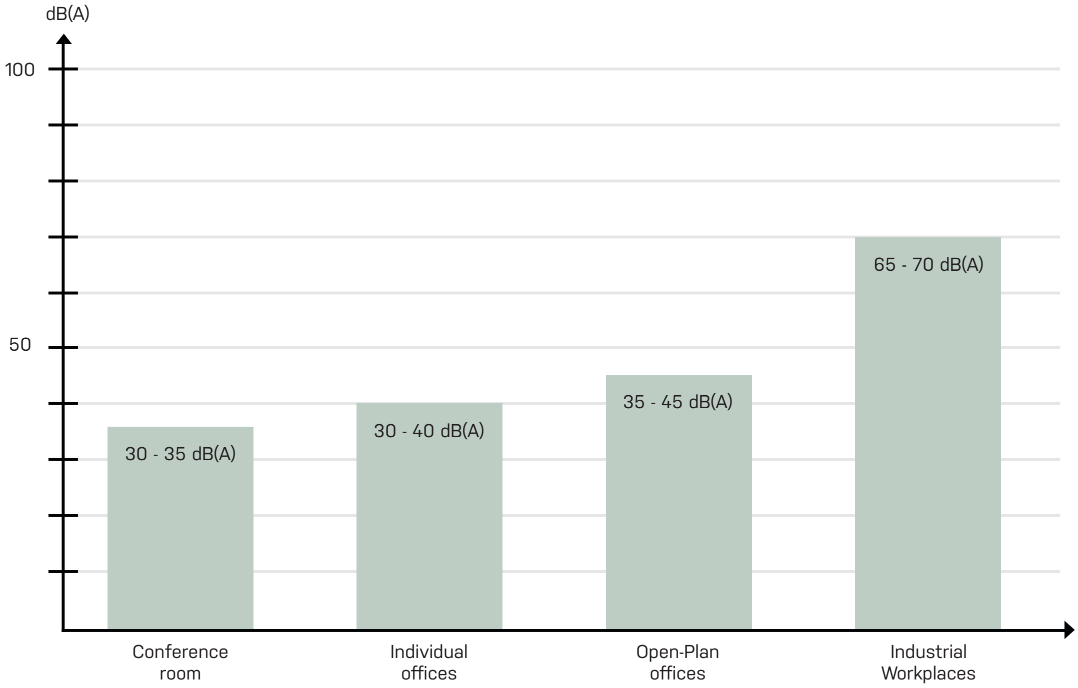
Each frequency of sound is associated with a sound wave of a particular wavelength. In air, a 100 Hz wave has a wavelength of 3.40 metres, whereas a 5000 Hz wave has a wavelength of only about 7 centimetres. Accordingly, the sound waves relevant for room acoustics have a length of between 0.07m and 3.40m. Clearly, the dimensions of sound waves are well within the range of dimensions of rooms.



2.7 RATING LEVELS

The relevant parameter for an assessment of noise at a particular location is the Rating Level; which consists of the measured, time-averaged sound pressure level in a room, adjusted for the type of the noise and its duration of impact. The rating level is usually based on a rating period of 8 hours, during which it is normally sufficient to capture short, representative periods of time. High background noise levels impair concentration and affect cognition. Consequently, many regulations and standards contain recommendations in terms of maximum permissible background noise level.

The following table shows the recommended background noise level values in accordance with DIN EN ISO 11690:



3. SOUND INSULATION VS. SOUND ABSORPTION

How can a noisy room be made quieter?

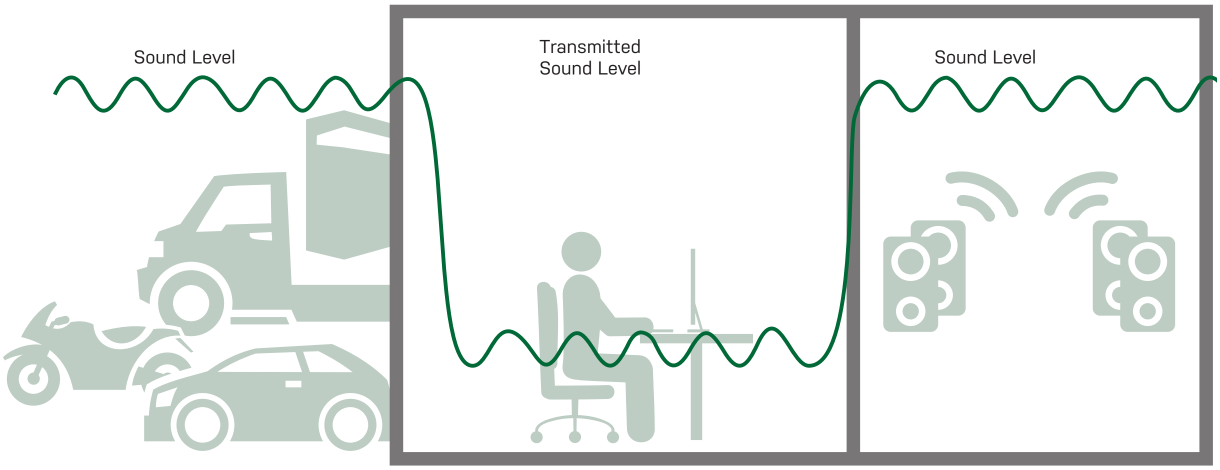
There are two fundamentally different approaches to this question, depending on where the noise is coming from.

Sound Insulation is used to reduce noise coming into the room from outside, or from adjacent rooms. Sound Insulation is the ability of components (walls, ceilings, doors, windows, etc.) to minimise the sound transmission into a room. A high degree of sound insulation is usually achieved using solid, heavy components which hinder the propagation of sound. These components are sometimes referred to as sound barriers.

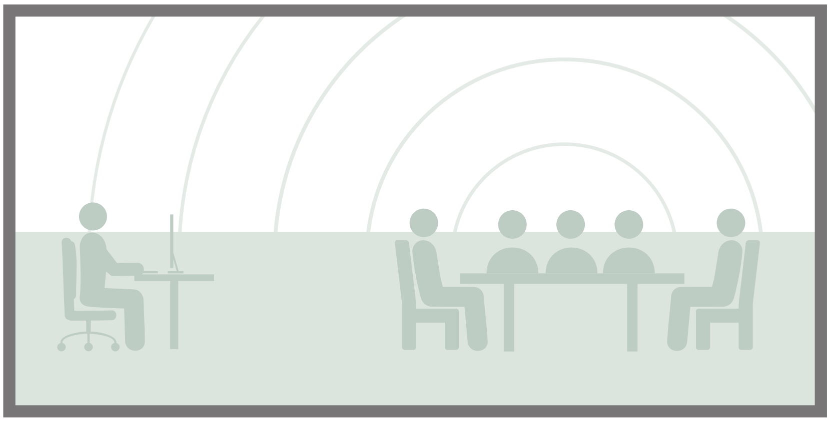
The sound insulation of walls and partitions is described by the sound transmission loss, or rated sound reduction loss (R'w). This can be measured on site, in a laboratory, or even calculated.

Sound Absorption, on the other hand, aims to reduce noise generated within a room. Sound absorption is provided by the surfaces and materials used in the room.

The sound absorption of a surface is described by a frequency-dependent sound absorption coefficient, usually simplified into averaged values such as w (Weighted Sound Absorption Coefficient) or NRC (Noise Reduction Coefficient).



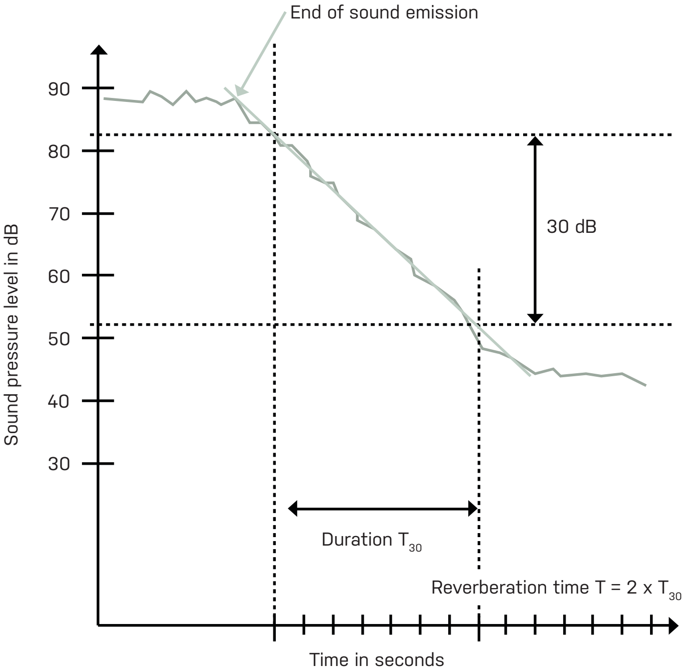
Sound transmission
between adjacent
rooms



Acoustic quality
within a room.

4. ROOM ACOUSTICAL PARAMETERS

The most important and well known parameter of room acoustics is reverberation time. Roughly speaking its value gives the duration for an acoustic event to become imperceptible in a room. Reverberation time is defined as the time taken by a sound to decrease by 60 dB from when it stops. The measurement is carried out for a 30 dB decay and the resulting value is doubled.



Reverberation time depends on the air volume of a room. The larger a room, the longer is its reverberation time.

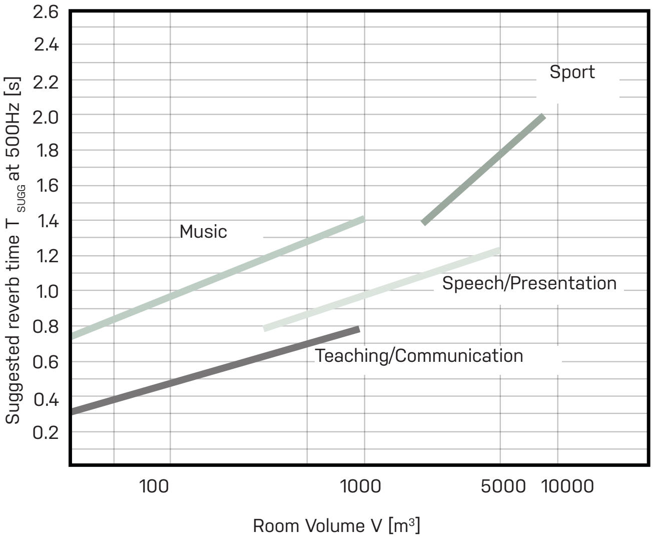
Equally important is the total sound absorption in the room. The greater the total sound absorption in the room, the more rapid the decay of sound takes place.

Apart from the sound absorption given by the surfaces of a room, the absorption by furniture, people, and damping in the air can also be added. The reverberation time of a room can often be estimated with sufficient accuracy from information about room size, materials of room surfaces, and furnishings.

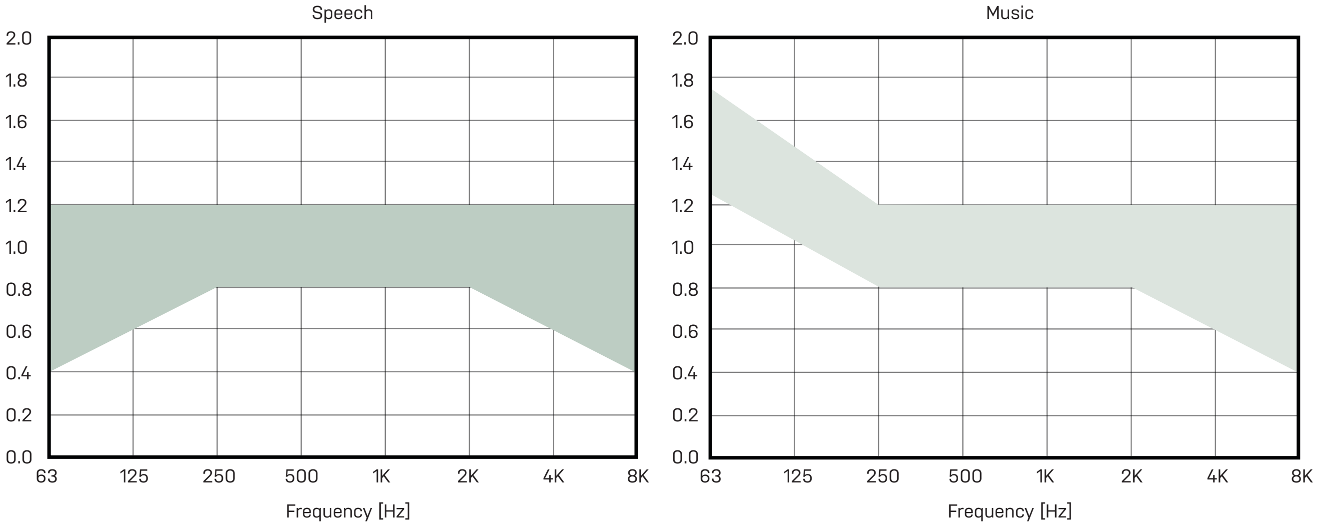
As the sound absorption coefficient of most materials shows a variation with frequency, the reverberation time of a room also changes with frequency. Measurements of the reverberation time normally cover the frequency range from 100 Hz to 5000 Hz. This range may be extended to 63 Hz and 8000 Hz for special demands.

The optimum reverberation time of a room depends on its main use. Especially for music, there are a large number of suggestions for the optimum reverberation time; varying even with the kind of music and the personal taste of the audience. In general, rooms meant for speech require the shortest values for the reverberation time, which improves speech intelligibility.

Optimum reverberation times



As important as the value of the reverberation time is its frequency profile. The following graphics show suggestions for rooms intended for speech, and for music. Rooms used for speech should have little variation over frequency; a tolerance of ± 20% may be acceptable. For music, an increase in reverberation time to towards low frequencies is acceptable, or even judged as favourable by many people.



Suggestions for the frequency profile of reverberation time

Excessive reverberation times at low frequencies are often experienced as a dull or booming impression in a room. By contrast, excessive high frequency reverberation gives a shrill or sharp impression. These subjective perceptions are often the reason for complaints about loudness, as too little sound absorption or too long reverberation also disturb good intelligibility. The deficits are compensated for by raising the voice, hence increasing the sound level and exacerbating the problem. Other acoustical defects of a room are the miss-positioning or incorrect tuning of sound absorbers, giving rise to an irregular reverberation time over frequency. Known acoustical problems in a room can easily be revealed objectively by a measurement of the reverberation time. The results then clearly indicate how the refurbishment should be carried out. Detailed proposals about the required sound absorbers, their surface areas, and their positioning can be worked out from the measured values.

In principle, it cannot be claimed that a material with a high sound absorption coefficient is more advantageous compared to one with a lower value. Only the combination of the surface area and the sound absorption coefficient of a material defines the total sound absorption of a room. A larger area with a lower sound absorption coefficient may be more suitable for the achievement of good room acoustics than a small, highly absorbing area.

5. SOUND ABSORPTION

5.1 MECHANISMS OF SOUND ABSORBERS

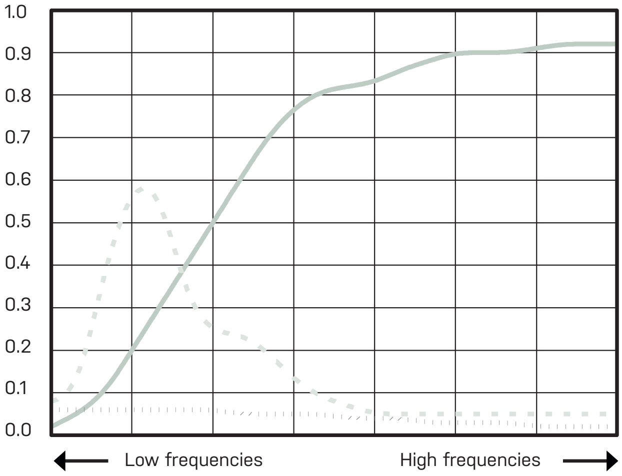
Although there are a large variety of different sound absorbing materials, only two basic mechanisms of sound absorption can be distinguished:

- porous sound absorbers, and
- resonant sound absorbers

At the surface of a porous sound absorber, the incident sound wave enters the material. The sound energy is converted to heat energy by friction in the pores of the material. This mechanism reduces the reflected sound energy: sound is absorbed.

By contrast; resonant sound absorbers consist of a system that may vibrate, for example, a column of air (like the air in an empty bottle, when blowing across the mouth of the bottle). This excitation works very well at the resonance frequency of the system. The vibration converts incident sound energy into vibrational energy and thus lowers the reflection of sound.

The sound absorption of porous sound absorbers generally increases with increasing frequency, whereas resonant sound absorbers have maximum sound absorption at certain, relatively narrow frequency ranges. Typical sound absorption characteristics of both types are sketched in the following graphic.



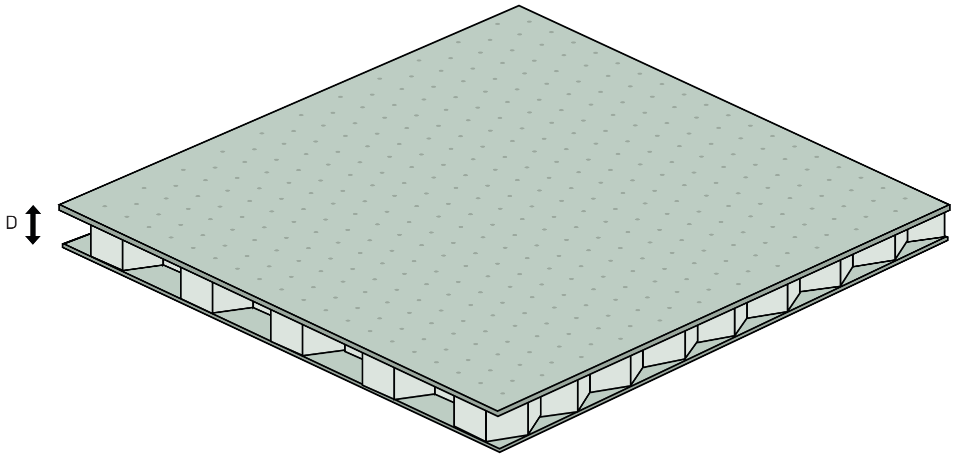
Sketch of frequency dependence of the sound absorption of different materials

Zero is no absorption, and 1 is complete absorption.
In general, sound absorption strongly depends on the frequency. Some materials like concrete or glass do not absorb sound at all, and may be referred to as sound reflecting materials.

5.2 MICROPERFORATION

A microperforated sound absorber is a special type of resonant sound absorber. These sound absorbers are regarded as a highly effective system to absorb sound: The tiny holes that form the microperforations cause a conversion of sound energy into heat energy. The friction of the air in each individual hole is amplified by resonance in the air within a micro-perforated panel and gives rise to the impressive acoustic properties of microperforated sound absorbers.

The distance D between a SONIUM panel facing and its backing may be altered. By changing this distance, sound absorption can be tuned to absorb desired frequencies. The thicker the panel, the more absorption at lowest frequencies. Thinner panels absorb higher frequencies.



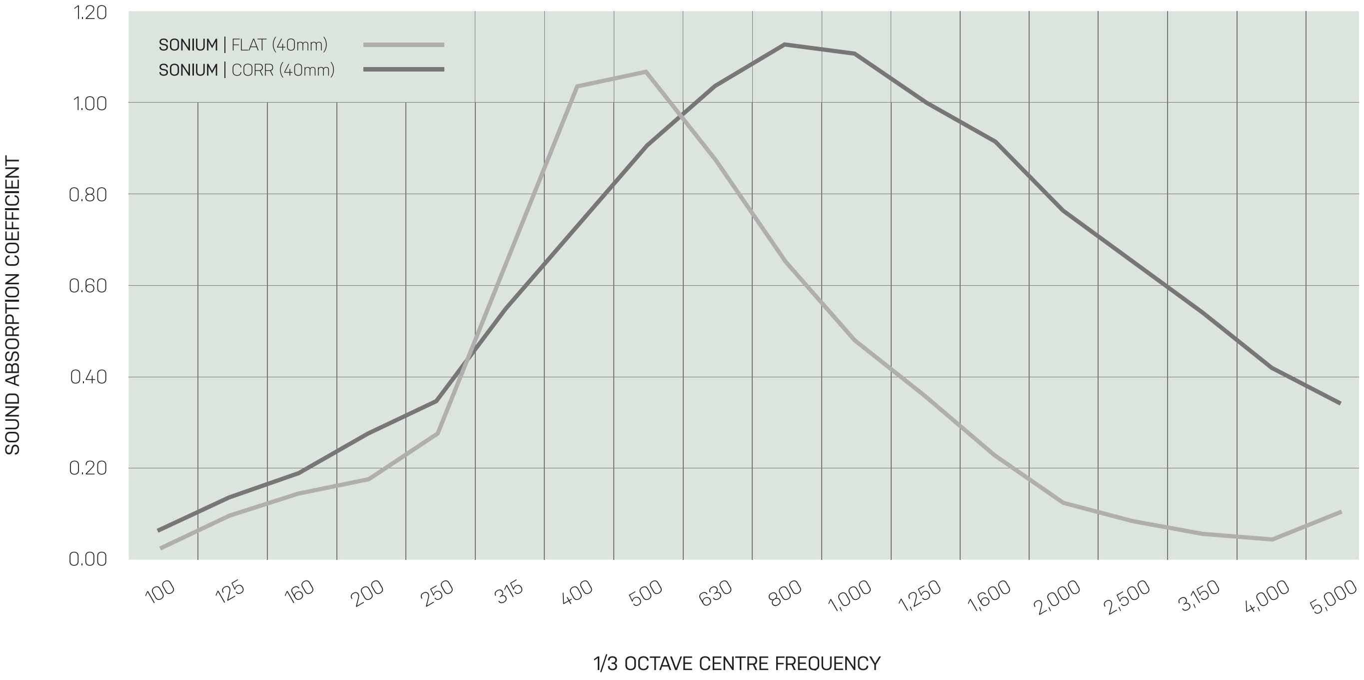
Geometrical set-up of a micro-perforated **SONIUM®** sound absorber panel

5.3 MEASUREMENT OF SOUND ABSORPTION

The measurement of sound absorption is carried out in a reverberation chamber. A reverberation chamber is a test laboratory room built with sound reflecting surfaces (usually concrete) and diffusing plates, for a high degree of sound scattering in the room.

An empty reverberation chamber has an extremely long reverberation time. By installing the material to be tested, the reverberation time will be lowered. The difference in reverberation time with and without the test material installed is then used to calculate the sound absorption at various frequencies (18 one-third octave bands between 100 Hz and 5000 Hz). The 1/3 octave band values are the basis for the calculation of single number ratings such as the Noise Reduction Coefficient (NRC), or the weighted sound absorption coefficient (αW).

The following plot shows the sound absorption of SONIUM microperforated panels at 40mm thickness.



5.4 SINGLE NUMBER RATINGS FOR SOUND ABSORPTION

For simplicity and ease of comparison between different products, single number ratings for sound absorption have been introduced.

The American standard ASTM C 423 defines the Noise Reduction Coefficient (NRC). This is the arithmetic average of four measured one-third octave band values at 250 Hz, 500 Hz, 1000 Hz and 2000 Hz,

Furthermore, ASTM C 423 describes the procedure to calculate the Sound Absorption Average (SAA) as the average value of sound absorption between 200 Hz and 2500 Hz.

International standard ISO 11654 describes the Weighted Sound Absorption Coefficient (W) which considers a wider frequency band (250-4000Hz) and involves a more complex calculation. ISO 11654 defines so-called sound absorption classes according to the value of αW.

Sound absorber class	αW - value
A	0,90 - 1,00
B	0,80 - 0,85
C	0,60 - 0,75
D	0,30 - 0,55
D	0,15 - 0,25
Not classified	0,00 - 0,10

Definition of sound absorber classes according to ISO 11654

For room acoustics it is not always appropriate to judge an acoustically effective material by its single number rating. ISO 11654 it states: "The rating is not suitable if the products should be used in a demanding environment that needs a careful acoustic outline. For such cases only the full frequency dependent sound absorption coefficients are suitable".

Nevertheless, single number ratings give a rough guide to the ability of a material to absorb sound. Detailed room acoustical planning needs the full set of one-third octave values from test results.

SONIUM

AYRES
Lightweight Panel Systems

Ayres Composite Panels Pty Ltd
25-27 Clune Street
Bayswater WA 6053
Australia

T: +61 (0) 8 9279 3426
justcurious@sonium.com.au

www.sonium.com.au