interstuhl

WHITEPAPER

ACOUSTICS IN SPACES – **AN IMPORTANT FACTOR FOR COMFORT AND PRODUCTIVITY**

ENJOY SEATING PERFORMANCE.

INTRODUCTION

Acoustics play an important role for people when it comes to work environments. The acoustic conditions are a particular point of focus in open work spaces and open-plan offices. Nearly half of all employees in offices regularly feel bothered by noise.[1] How people experience noise disruptions can often be very subjective. However, there are acoustic factors that have been proven to negatively affect people and their work. Noise is omnipresent and can be a disturbance in many situations. Colleagues talking to each other or on the phone, printers and copiers, the coffee machine – there are various sources of noise. This makes acoustic solutions that stop the propagation of sound in a room all the more important. But what actually is sound? What does acoustics mean? How is noise created? How does it behave in spaces and how can it be reduced? These are the questions we will investigate in this white paper, as well as examining the issue of acoustics in space from several angles, particularly in office environments.

[1] bso study 2015 "Status quo of office workspaces in Germany"

SOURCES OF NOISE IN OFFICES...

There are many situations in our daily lives where there is a lot of noise, but we are often unaware of its existence and impact. In working environments – and not just at loud industrial production sites – noise is an important topic. Noise is also considered to be one of the major sources of disturbance in office spaces.[1]

There are plenty of sources for noise in offices: Talking colleagues, printers and copiers, video conferences, the air conditioning and many other things are driving up the sound level.[2] The biggest disruptive factors are conversations and ringing phones. Noises like these contain information and are impulsive, making it harder for employees to block out this type of stimulus.[3] Each person experiences acoustic interferences with varying levels of intensity and disturbance, since this perception is subjective and dependent on many factors (e.g. personal well-being, sympathies for the persons causing the disturbance, current activity and stress level).

[1] Statista, 2011 "Disturbing factors in office workspaces"

[2] DGUV Information 2021 "Acoustics in office spaces"

[3] iba online "Acoustics"

… AND THEIR CONSEQUENCES

Health

At a higher intensity, noise can impair hearing in the long term and lead to irreparable damage to the hearing organs. This level of intensity is not usually present in offices. A high noise level in offices can nevertheless also negatively impact human health. It can lead to headaches, high blood pressure, trouble sleeping and especially stress reactions.[1]

Concentration

Another reason for improving the acoustics in a space is that noise can negatively impact the ability to concentrate and focus. Studies have found that loud environments directly impact the processing time for tasks, increase the error frequency and lower the efficiency of performance.[2] The degree to which employees consider a noisy background to be disturbing also depends on the complexity of their tasks. A high noise level has a bigger impact on complex tasks that require a high level of concentration than on simpler tasks.[1]

Communication

Sending and receiving messages requires an environment free from disturbances. Ambient noise makes it harder to understand what a conversational partner is saying, increasing the stress level. The high noise level also leads to misunderstandings during communication itself.[1]

Our days at the office are accompanied by many acoustic influences. These can often hinder communication by making it more difficult to understand what is being said, reduce employees' ability to concentrate and negatively impact health, for example by increasing stress levels.

[1] DGUV Information 2021 "Acoustics in office spaces"

[2] BauA 1996 "Noise assessment – office workspaces"

ACOUSTICS, SOUND, REVERBERATION, VOLUME & CO.

We will now briefly explain the most important terms relating to acoustics in a space.

The term **acoustics** describes the perception and effect of **sound** as well as its creation and propagation.[1] Sound refers to vibrations in an elastic medium (gas, liquids, solid bodies). The resulting sound waves can be perceived by the human ear. However, humans can only perceive sound in a **frequency range** of 16 Hz (Hertz = measuring unit) to 20,000 Hz. The frequency indicates how many vibrations there are per second. This determines whether we hear sounds at a high or low pitch.[2]

The **volume** of a sound is described by the **sound pressure p**. The sound pressure range perceived by the human ear is very broad. It starts at the auditory threshold, the lowest sound pressure that can be perceived by humans, and ends at the pain threshold. The pain threshold is around a million times higher than the auditory threshold. That is why a special measurement is used for this large range of values: decibel (dB).[2] The auditory threshold has been set at 0 dB, while the pain threshold is at around 120 dB. Hearing damage can occur starting at a daily noise exposure of 85 dB.[3] Since the volume also depends on the frequency and our ears perceive low-pitched and high-pitched sounds differently, an A weighting is used to evaluate the sound pressure level. That is why values are usually given in dB(A).[2]

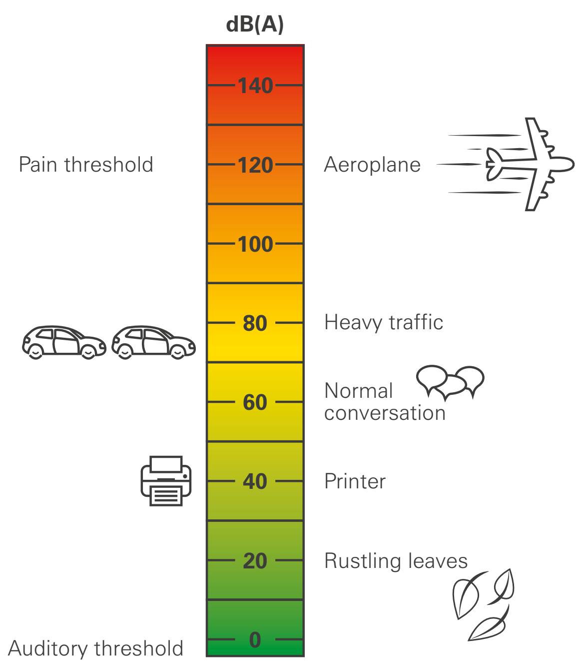


Fig. 1: Typical sound pressure levels for sources of sound[2]

[1] German Environment Agency 2018 "Basic principles of acoustics"

[2] DGUV Information 2021 "Acoustics in office spaces"

[3] German Noise and Vibrations Occupational Safety and Health Ordinance

The noise reduction target of 55 dB(A) for complex office work and 70 dB(A) for routine work should not be exceeded.[1]

To give an example: A normal conversation already comes to 65 dB(A).[2] This shows how difficult it can be to keep to the recommended noise level.

The **reverberation time** is the duration during which the sound pressure decreases by 60 dB following sound transmission. It is the most important criterion for assessing the acoustic quality of a space. The reverberation time is directly dependent on the size of the space and geometry, the sound-absorbing properties of the surfaces and the furnishings. A long reverberation time provides a "reverberant" perception of the space – the sound pressure level in the room is higher and may, for example, lead to disturbances in workspaces such as open-plan offices. Therefore, the quicker a sound signal (e.g. an interfering noise) fades away in a space, the less troublesome it is for people to work and communicate in this space.[3] Long reverberation times make it difficult to understand what is being said and cause sounds to layer. Offices should therefore have a reverberation time of 0.5 to 0.8 seconds.[2]

The reverberation time can be reduced by encouraging **sound absorption**. Sound absorption describes the reduction of sound energy in a space. This occurs by converting the sound energy, preferably into heat or another type of energy, when the sound hits a boundary area. The sound absorption coefficient α is used to indicate the sound-absorbing properties of materials. It describes the ratio between the sound energy hitting the material and the sound energy being absorbed ($\alpha = 0$: sound is not absorbed; $\alpha = 1$: sound is completely absorbed). The higher the sound absorption coefficient of a material is, the more it reduces the reverberation time in a space.

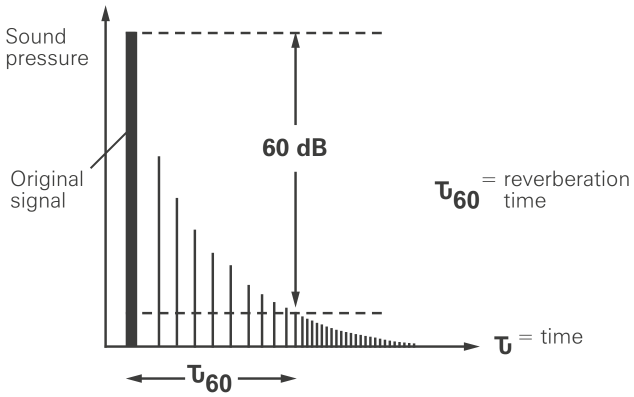


Fig. 2: Determining reverberation time[3]

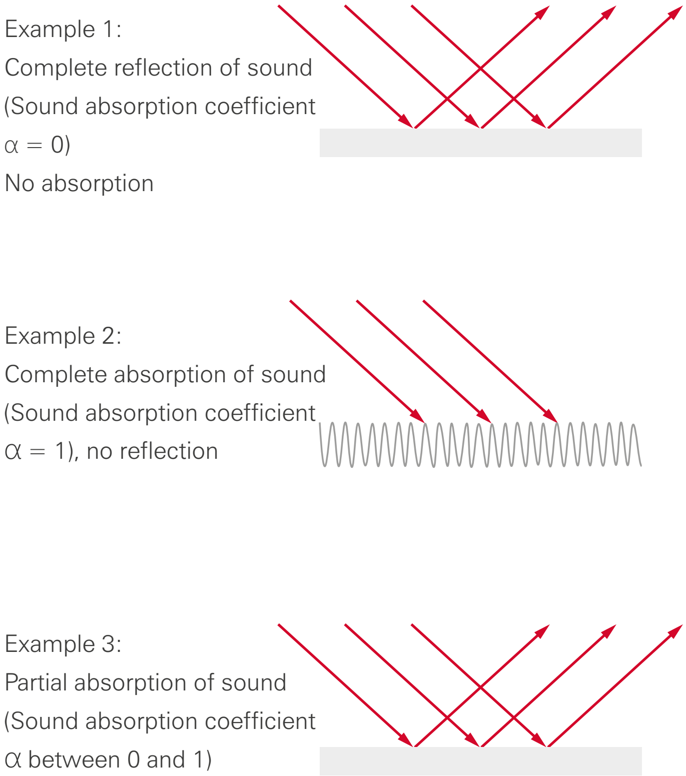


Fig. 3: Sound absorption coefficient of different surfaces[1]

[1] Technical Rules for Workplaces ASR A3.7

[2] DGUV Information 2021 "Acoustics in office spaces"

[3] iba magazine 2016 "Effectively designing acoustic conditions in workspaces"

It is not only the material itself that is important for sound absorption, but also the material surface area. That is why the sound absorption coefficient is suitable for calculating surface materials (floor, ceiling, wall), but not for calculating the actual reverberation time in the room. This is because it matters how and to what extent the area in a room is covered by solid and free-standing elements. A highly-absorbent partition only achieves the desired effect, for example, when several are position vertically next to each other between the workstations. As a result, the size of the **equivalent sound absorption surface** is required to truly measure the sound-absorbing effect of an absorber in a space. This is calculated by multiplying the area S of the absorber with its sound absorption coefficient α. The larger the equivalent sound absorption surface of a space is, the more sound-absorbing and quiet it is.[1] In order to achieve a high level of sound absorption in offices, sound-absorbing cladding can be applied to ceilings, walls, floors and window areas or sound-absorbing furnishing can be used. A mean sound absorption coefficient of 0.35 over the room area is recommended for office spaces. This means that 35% of the surfaces in the space are 100% absorbent.[2]

Several related values are important for evaluating the acoustics in a space: The reverberation time is the duration during which the sound pressure decreases by 60 dB following sound transmission. In order to reduce the reverberation time in a space, the sound absorption should be increased with acoustically effective surfaces on the room elements used. The relevant value for free-standing products is the equivalent sound absorption surface. The bigger the absorption area, the better the sound absorption in the room.

[1] iba magazine 2016 "Effectively designing acoustic conditions in workspaces"

[2] DGUV Information 2021 "Acoustics in office spaces"

EXCURSUS: STANDARDS AND REGULATIONS

Standards and regulations concerning the acoustics in a space are of great importance to the responsible planning office when designing office buildings. There are countless standards that specify how, where and what needs to be measured, and many different requirements. In Germany, for example, the limit value specifications are covered by the Occupational Safety and Health Ordinance and the corresponding requirements further detailed in the Technical Rules for Workplaces ASR A3.7 "Noise". There are two general methods for testing the acoustics of a space: One method tests the sound absorption coefficient of individual materials used for the ceilings or walls, or the equivalent sound absorption surface of individual objects in reverberating rooms (DIN ISO 354). Another method focuses on the (furnished) room and its reverberation time (DIN 18041). There are other standards, for example those dealing with measuring acoustic parameters in different rooms such as event spaces or open-plan offices (DIN EN ISO 3382).

There are two general testing methods for acoustics: Evaluating the absorption behaviour of individual materials and furniture in an empty space, or measuring the reverberation time of a furnished space.

ACOUSTICS IN PROPERTY PLANNING

The issue of acoustics is one of the most important aspects when planning new buildings and conversions. An ideal room concept includes acoustic solutions that visually integrate into the furnishings extremely well.

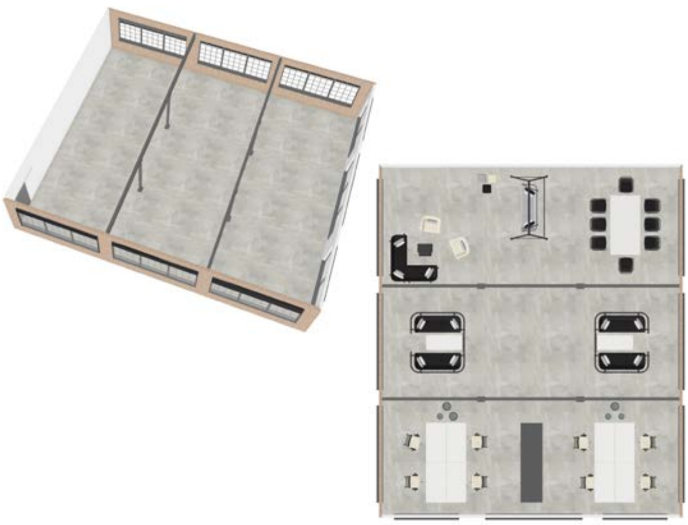
We will give you an overview of the different planning steps below, taking into account acoustic requirements.[1]

1. Establishing a foundation

During this phase, it is important to record the requirements and objectives as well as the conditions on-site. Questions to be answered include: How big are the rooms? What activities will take place in the rooms? How will people work together? How many people will work in which areas in the room (open space, individual offices, open-plan office, etc.)? A distinction is made between rooms of type A (good conditions for listening in the entire room, e.g. seminar and meeting rooms) and rooms of type B (conversations are understood only over short distances, e.g. open spaces).[2]

2. Drafting phase

During this phase, the planning office creates a first design draft while taking into consideration the acoustic conditions. This concept is based on experience as well as manufacturer specifications for the materials and furniture likely to be used. Specifications used here include the sound absorption coefficient and the furniture dimensions.

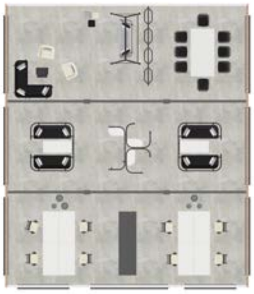


[1] Maren Witopil, Interior Designer

[2] DIN 18041:2016-03

3. Integrating acoustic planning

Involving specialised acoustic planners is particularly recommended for meeting and event spaces as well as open spaces. These experts will evaluate the previously created design draft (surfaces, selection of fabrics, room division), give specific recommendations and compile calculations in an acoustics concept (e.g use and site of acoustic elements/baffles).



4. Revising and finalising

The planners revise their design based on the acoustics concept. Not everything that looks nice and practical is actually a sensible choice when considering acoustics. The planners also integrate elements that may not have previously been considered, for example soundproofing for printers or projectors.

It is also possible to plan room acoustics with the acoustics plug-in, a further development of the pCon.planner. With this application, expanded OFML data can be used to export relevant information about the room volume, surface data and absorption surfaces directly from the furnishing plan.[1]

The aim of an acoustics concept is for the people who work in the space to feel comfortable and to be able to complete their tasks productively. To achieve this, it is important to keep in mind that volume and sounds are perceived differently by everyone. A lack of sound absorption is not the only reason why people are disturbed by noise. Some people also find it uncomfortable if sound is absorbed too well. And no matter how good the planning and acoustics concept are – discipline and respectful conduct among colleagues are also required.[2]

Acoustics are considered as a factor in property planning. In a first step, all requirements and on-site conditions for the space to be planned are considered and a design draft is created. Ideally, an acoustics planner will be involved to give a professional evaluation of the concept. Based on this evaluation, a finalised design with all additional acoustic elements is created.

[1] pCon.planner acoustics plug-in

[2] Maren Witopil, Interior Designer

OPTIONS TO REDUCE SOUND IN ROOMS

An acoustically well designed work environment is essential for focused work without disturbances. This not only protects employee health, but also promotes productivity. Employee well-being improves and with it the motivation to perform well.[1]

In order to understand the effect of acoustic solutions, sound propagation first needs to be scrutinised. Direct sound, which is received at the listening position, is issued from the source of a sound. There is also reflected sound, where a part of the sound is reflected back into the room depending on the ceiling and wall materials.[2] Sound absorption products are used to reduce this kind of sound as much as possible.

Sound-absorbing ceilings, walls and floors can be used, for example.[2]

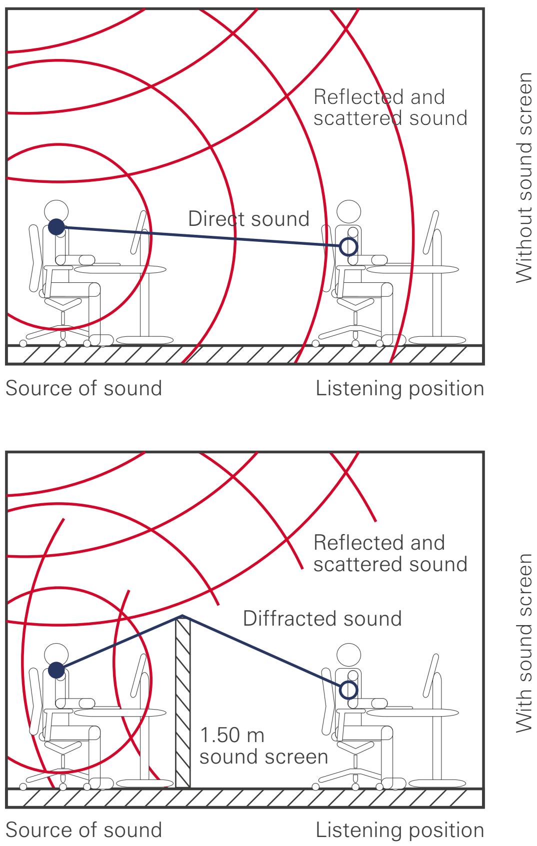


Fig. 4: Schematic representation of sound propagation in a room[2]

[1] DGUV Information 2021 "Acoustics in office spaces"

[2] iba magazine 2016 "Effectively designing acoustic conditions in workspaces"

Ceilings:

Acoustic ceilings:
Thanks to their large surface area and their sound-absorbing properties, acoustic ceilings are well suited to reducing noise. They do so with perforated gypsum boards in the suspended ceiling or with a special acoustic plaster that breaks the sound.

Baffle ceilings:
Baffle ceilings are comprised of several elements that are suspended vertically from the ceiling closely next to each other. They are especially suited to large rooms with high ceilings that require a large sound absorption surface.

Ceiling panels:
Ceiling panels are individual elements that are usually attached to the ceiling horizontally at different heights and in different sizes. They are positioned freely in the room and are often installed above workstations with integrated lighting.

Walls:

Wall cladding:
Existing walls can be covered with slotted or perforated panels. These are usually backed with sound-absorbing materials.

Sound-absorbing partitions:
Floor-to-ceiling partitions can absorb sound between different areas.

Floors:

Footfall sound insulation:
Sound-absorbing materials inserted between the substrate and floor covering can help to significantly reduce noise. Floating screed is usually placed on a sound-absorbing layer.

Carpet or vinyl:
Textile floor coverings are porous and therefore reduce the sound produced by walking in particular.

Floor superstructures:
Elevated floor systems create a hollow space or raised floor.

Sound-absorbing furnishings can be used as an alternative.[2]

Furnishings:

Sound-absorbing furniture surfaces:
Perforated or slotted surfaces are frequently used for sound absorption on cabinet doors, blinds, sliding doors, etc.

Seating:
Large lounge furniture like sofas and similar items act like sound screens.

Partitions:
Free-standing and mostly movable elements can be upholstered with a textile, sound-absorbing material. The larger the surface of a partition is, the more sound it absorbs.

Decorative acoustic elements:
Today there are many sound-absorbing pictures or felt elements that can contribute to a room's design.

There are different ways of integrating sound absorbers to reduce sound propagation in a room. On the one hand, ceilings, walls and floors with sound-absorbing properties such as perforation or textile surfaces can be installed permanently. On the other hand, free-standing furnishing like partitions can be used.

[2] DIN 18041:2016-03

ACOUSTIC SOLUTIONS FROM INTERSTUHL

Interstuhl has also spent a lot of time thinking about acoustics so that the company can offer people a healthy and productive work environment. In doing so, we primarily develop solutions intended to reduce or prevent the unhindered propagation of sound. Our HUB system in particular is suitable for many different acoustic applications.

Different types of partitions, like the HUB screens or the moving HUB boards, make it possible to create separate areas and quiet zones in a flexible manner. With its three walls and a standing table top, the HUB booth enables undisturbed phone calls, for example in open-plan offices and open spaces. The HUB pod goes beyond this and creates an almost completely enclosed meeting or work space for maximum concentration and quiet. Together with seating solutions like the HUB bench, this makes it possible to flexibly create any number of zones. Some HUB products can also be equipped with an acoustic performance material of absorber class B.

The versatile HUB furniture and space-structuring system from Interstuhl offers many acoustically effective applications. Separate quiet zones for focused working can be created with its flexible partitions, telephone booths or meeting pods.

[1] Maren Witopil, Interior Designer

[2] DIN 18041:2016-03

SUMMARY

Our days at the office are accompanied by many acoustic influences. These can often hinder communication by making it more difficult to understand what is being said, reduce employees' ability to concentrate and negatively impact health, for example by increasing stress levels.

Several related values are important for evaluating the acoustics in a space: The reverberation time is the duration during which the sound pressure decreases by 60 dB following sound transmission. In order to reduce the reverberation time in a space, the sound absorption should be increased with acoustically effective surfaces on the room elements used. The relevant value for free-standing products is the equivalent sound absorption surface. The bigger the absorption area, the better the sound absorption in the room.

There are two general testing methods for acoustics: Evaluating the absorption behaviour of individual materials and furniture in an empty space, or measuring the reverberation time of a furnished space.

Acoustics are considered as a factor in property planning. In a first step, all requirements and on-site conditions for the space to be planned are considered and a design draft is created. Ideally, an acoustics planner will be involved to give a professional evaluation of the concept. Based on this evaluation, a finalised design with all additional acoustic elements is created.

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FAQS

Why is the topic of acoustics so important for offices?
Permanently high noise levels negatively affect the health of the people working in this environment. If it is too loud, our ability to concentrate and perform also suffers. What's more, sources of sound make it difficult to communicate.

01

Which values need to be considered to evaluate the sound absorption of an acoustic solution?
The sound absorption coefficient is used for surface materials. The higher the sound absorption coefficient of a material is, the more it reduces the reverberation time in a space. For free-standing products in the room, it is the equivalent sound absorption surface that is important.

02

Which values should not be exceeded in an office?
The sound pressure level at office workplaces should not exceed 55 dB(A). A sound absorption coefficient of 0.35 is recommended, meaning that 35% of the office space is 100% absorbent.

03

How can I make my office "quieter"?

A significant level of sound absorption can be achieved by using acoustic ceilings, wall cladding, footfall sound insulation, partitions or seating. The floor plan (e.g. dividing large spaces) also plays an important role.

04

Who can I contact at Interstuhl if I have questions about room acoustics?
Please contact us by e-mail at e.walter@interstuhl.de or by phone at +49 (0) 7436 871 335.

We will respond to you as soon as possible to deal with your enquiry.

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