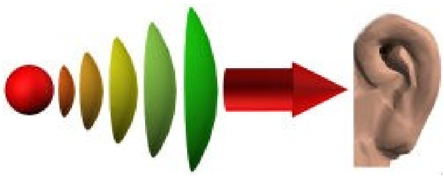
ACOUSTIC ADVISORY NOTE 0 AA/BG/081895/1

GENERAL INFORMATION

EMISSION – TRANSMISSION - RECEPTION



Sound is the result of vibrations in the air around us, given off by the noise source - this is called **EMISSION.**
These vibrations transfer their energy into the surrounding environment - this is **TRANSMISSION.**
They reach the ear and ear drum which transmit them along an internal chain and are interpreted as sensations - this is **RECEPTION**.

NOISE CHARACTERISTICS

Figure 1

dB	Noise Source	Conversation
0	Audibility threshold	
10 20 30 40	Quiet countryside Quiet working conditions	Whispers
50 60	Normal conversation	Normal voice
70 80	A busy street	Loud voice
90 100	Factory workshop Noisy machines	Shouting
110 120 130 140	Presses, planers Industrial boilers Pain threshold Jet engines Ear is destroyed	Impossible

A noise is characterised by:

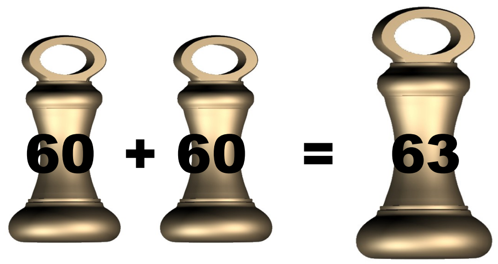
- Its **FREQUENCY** which identifies its tone: low-pitched, medium- or high-pitched noise, measured in **HERTZ** (Hz).

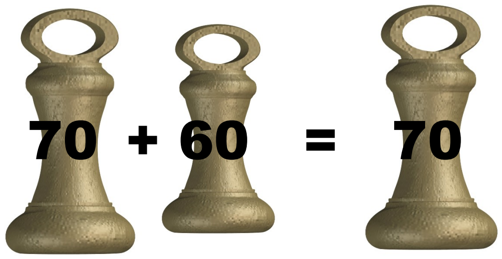
  The human ear can pick up noise between 20 and 20,000 Hz but a conversation is pitched at between 500 to 4000 Hz. In construction it is usual to consider the range between 125 and 4000 Hz.

from 125 to 250 Hz	low frequencies
from 500 to 1000 Hz	medium frequencies
from 2000 to 4000 Hz	high frequencies

- Its **LEVEL** of pressure which defines its amplitude measured against a certain level. Unit: **DECIBEL** (dB).
  (Examples of level types are given in Figure 1).

The corresponding curve tracing the pressure levels measured according to frequencies, is called the **Spectrum.** This is vital to any acoustic analysis in order to adapt the acoustic system to the nature of the noise.





The ear is less sensitive to low frequencies than to medium- and high-pitched ones. A frequency correction is often applied before combining them to obtain a single value expressed in dB(A). This is more representative of the actual sensation detected by the ear.

When combining noise from two sources with similar noise levels the dB(A) are not added together arithmetically but logarithmically.

For instance 60 + 60 = 63 dB(A).

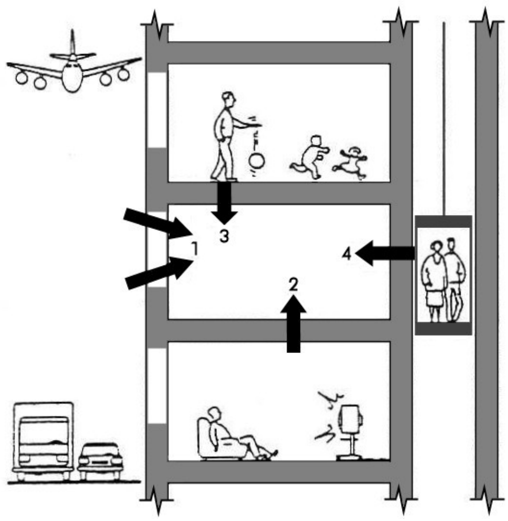
Conversely if a level is reduced by 3 dB(A), the energy is effectively cut by half. For example, in a workshop where identical machines operate, a reduction in the general level of 3 dB(A) will be the equivalent of stopping half the machines.

When there is a difference in level between two sounds of 1 0 dB(A) or more, the weaker will be hidden by the stronger.

Thus, 60 + 70 = 70 dB(A).

DIFFERENT TYPES OF NOISE

Figure 3



(Illustration Figure 3)

- **Airborne Noise:**

  These are noises transmitted through air. They can be external (→1) - plane, road, train... - or internal (→2) - conversations, music, television...

- **Impact Sounds:**

  These are created by an object falling on to the ground, by a person's footsteps or, for example, by a hammer knocking on a wall (→3).

- **Noise from Equipment:**

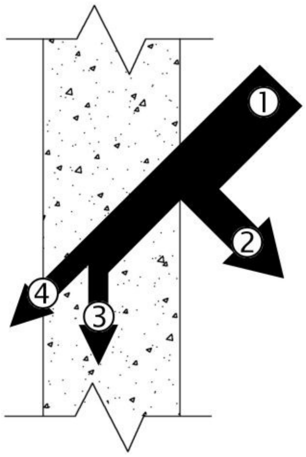
  These are sounds made by air-conditioning systems, plumbing, lifts, etc. (→4).

AXTER ACOUSTICS are concerned with the protection of the building envelope. The acoustic solutions offered control the effects of airborne noise.

It is this aspect only which is covered by the AXTER ACOUSTIC ADVISORY NOTES.

INSULATION - ABSORPTION

Figure 4



When a sound wave (1) hits a partition, the energy it is carrying is:
- partly reflected (2)
- partly absorbed by the partition (3)
- partly transmitted to the other side of the partition (4).

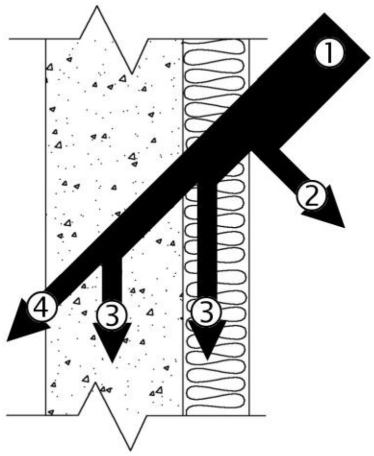
(See Figure 4)

Sound insulation of a partition (wall, roof...) is characterised by the difference between elements (1) and (4).

The **sound absorption** of a partition (wall, roof...) is characterised by the difference between elements (1) and (2).

DO NOT CONFUSE SOUND INSULATION AND ABSORPTION

Figure 5



They are two different elements.

Installing an absorbent material on a partition reduces the reflected element (2) and increases the amount absorbed (3) but has little effect on the amount transmitted (4). *(See Figure 5).*

The installation of an absorbent material on an internal partition does not improve its sound insulation.

N.B. A good thermal insulation does not necessarily make a good acoustic insulation material.

CHARACTERISTICS OF ACOUSTIC INSULATION

Laboratory Measurements

Airborne sound insulation involves separating by a physical barrier the space to be protected from the space containing the noise source. Sound waves will impinge on the partition causing it to vibrate and then radiate sound into the receiving space. The proportion of the reduction between the incident and transmitted sound intensity is known as the **Sound Reduction Index**. It is an intrinsic characteristic of a material or of a partition and is a value which can be measured only under special laboratory conditions.

It is noted as **R** in dB. The value for **R** will vary with frequency and when expressed as a global value (average, mean) it is measured in dB(A). The higher the value of **R**, the better the absorption of the partition.

It characterises the acoustic level of performance of a partition and enables a comparison to be made between several different partitions.

The Sound Reduction Index is often expressed as a single value and today there are three commonly used indicators: R pink, R traffic & Rw.

In-Situ Measurements

The Sound Reduction Index is an intrinsic property of a partition. The sound level difference between two spaces separated by the partition depends upon the value of the Sound Reduction Index, the area of the partition, the nature of the other walls or partitions, the volume and shape of the building and the acoustic properties of the spaces concerned. When measured in-situ it is referred to as the sound level difference **D** in dB. The greater the value of **D**, the more effective the partition.

D can usually only be measured on site but today sophisticated computer simulation programs can produce reliable estimates.

The global insulating qualities provided by a partition are particularly affected by weak points in the partition. For example, cladding is installed to insulate a façade but doors, windows, draughts, etc., all play a part.

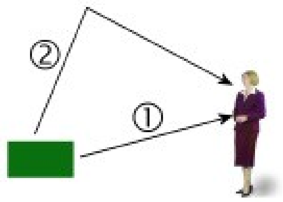
The acoustic treatment must be adapted to the type of noise. For example, if the noise to be treated is composed principally of high frequencies, the partitions to be installed must be particularly effective against these frequencies.

In general the value of **D** is less than the value of **R**.

DO NOT CONFUSE **D** (measured in-situ) WITH **R** (measured in laboratory conditions).

CHARACTERISTICS OF SOUND ABSORPTION

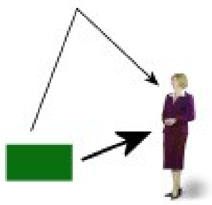
Figure 8



When a sound travels from a source in an untreated building *(Figure 8),* an observer close to the source first of all hears the sound coming direct from it (→1), (direct field), then receives the sound reflected by all the other sources (→2), (reverberated field).

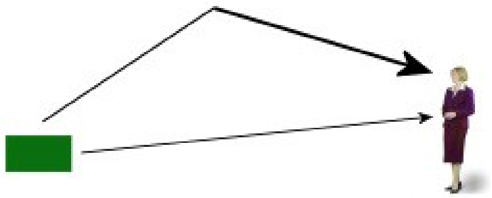
If this observer is close to the source the direct field is dominant (*Figure 9).*

Figure 9



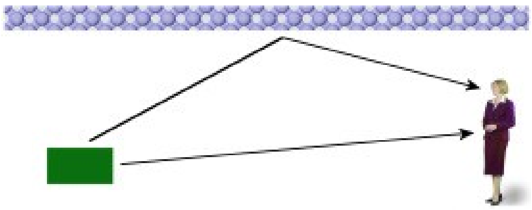
When the observer moves away from the source, the direct field becomes less significant and the reverberated field becomes dominant *(Figure 10).*

Figure 10



The installation of an absorbent material will only have an effect on the reverberated sound. So if the gains are minimal for the observer close to the sound source, they will be much more significant for the observer who is further away *(Figure 11).*

Figure 11



Measured under Laboratory Conditions

All materials can to a greater or lesser extent absorb sound, that is, they convert mechanical energy of molecular vibration into heat. The performance of a material is usually quantified in terms of its sound absorption coefficient α which is defined as the sound energy not reflected from the material divided by the sound energy incident upon the material.

α, alpha Sabine, can be measured under laboratory conditions in accordance with a standard procedure. It is a non-unit value varying between 0 and 1 and is usually given for each frequency band.

The bigger the value of α, the greater the quantity of absorbed energy.

α close to 0 = non-absorbent materials such as marble, concrete, tiles.

α close to 1 = very absorbent materials such as mineral wool.

In-Situ Measurements

In-situ measurements are taken of the reverberation time or of the sound level reduction when the distance from the source is doubled, according to the type of building.

Reverberation Time:

If a noise is made inside a building and then suddenly stopped, the noise level will diminish or decay with time. The time in seconds taken by the resonant energy to reduce by 60 dB once the sound source has stopped, is called the **reverberation time**. It is expressed in seconds and described as Tr.

It is a characteristic peculiar to each building dependent on shape, volume, the type of constituent products and the absorption coefficient of these materials.

The reverberation time is used to classify the acoustic comfort in classrooms, lecture halls, sports halls, theatres, auditoria, swimming pools, etc.

Sound Level Reduction by Doubling Distance:

Another method of classifying a building is by analysing the reduction in sound level when the distance from the noise source is doubled.

When an observer is in a building where a noise is being made, he hears a certain level of sound which is the sum of the sound levels from all sources operating within the room. As he moves further away from the source, the level of sound diminishes.

The levels of acoustic pressure can be measured at points along the same axis whose origin is the sound source. Each point is placed at double the distance from the source of the previous point (e.g. 2, 4, 8, 16 and 32m). These measurements are then noted by plotting the recorded sound levels against distance. When plotted on a logarithmic scale the resultant graph is a straight line and it is the slope of this line which is referred to as the **SOUND LEVEL REDUCTION BY DOUBLING DISTANCE**. It is described as **DL** and is expressed in units of dB(A).

It can usually only be measured on site but today sophisticated computer simulation programs can produce reliable estimates.

If a building reverberates, the level of sound diminishes very little as the observer moves away. In this case **DL** will be close to 1dB(A), corresponding to a reverberating, untreated building. Conversely, in a building treated with absorbent materials (with no internal partitions), the **DL** will be close to 6dB(A).

This classification is used in particular for working or factory environments.

EQUIVALENT CONTINUOUS SOUND LEVEL

Hearing damage can occur through rupture of the ear-drum in cases of extreme over-pressure but more normally through damage to the delicate hair cells in the inner ear. This will occur through steady and continuous exposure to certain noise sources. In order to assess the average noise level over a period of time it is usual to calculate or measure in-situ the 'equivalent continuous sound level' over a set period of time. This is defined as the level of a notional steady sound which, at a given position and over a defined period of time, would have the same A weighted acoustic energy as the fluctuating noise. It is usually denoted by $L_{EQ,t}$. Templeton and Saunders give the following example of activity on a construction site:

Plant	Average sound level dB(A)	Typical on time in an 8-hour period (hrs)
Cement mixer	75	5
Dumper truck	68	3
Power saw	82	1
Generator	65	8

Using standard techniques these figures can be corrected to an 8-hour $L_{EQ,8}$.

In this example the $L_{EQ,8}$. = 76.6 dB(A)

The Noise at Work Regulations 1989 require action to be taken where the noise is above any of three action levels:

First Action Level - a daily personal exposure ($L_{EQ,d}$) of 85 dB(A)
Second Action Level - a daily personal exposure ($L_{EQ,d}$) of 90 dB(A)
Peak Action Level - a peak sound pressure of 200 pascals (140 dB re 2OμPa)

Many buildings, libraries, theatres, schools, etc. require an $L_{EQ,d}$ considerably less than those defined in the Noise at Work Regulations. BS823 : 1987 and Building Bulletin 51 of the Department for Education, amongst others, give ideal figures for many such buildings. In some cases these refer to background figures before taking account of the activity within the building, important for cinemas and theatres and in others, such as swimming pools and sport halls, to the activities themselves. Each building has a different requirement and this needs to be taken into consideration in any acoustic analysis.

Bibliography

1. Noise at Work Regulations 1989
2. Templeton, D W and Saunders D - Acoustic Design - Architectural Press
3. Department for Education - Building Bulletin 51 (draft) - Acoustics in Education Buildings
4. BS 8233 :1987 - British Standard Code of practice for' Sound insulation and noise reduction for buildings'

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