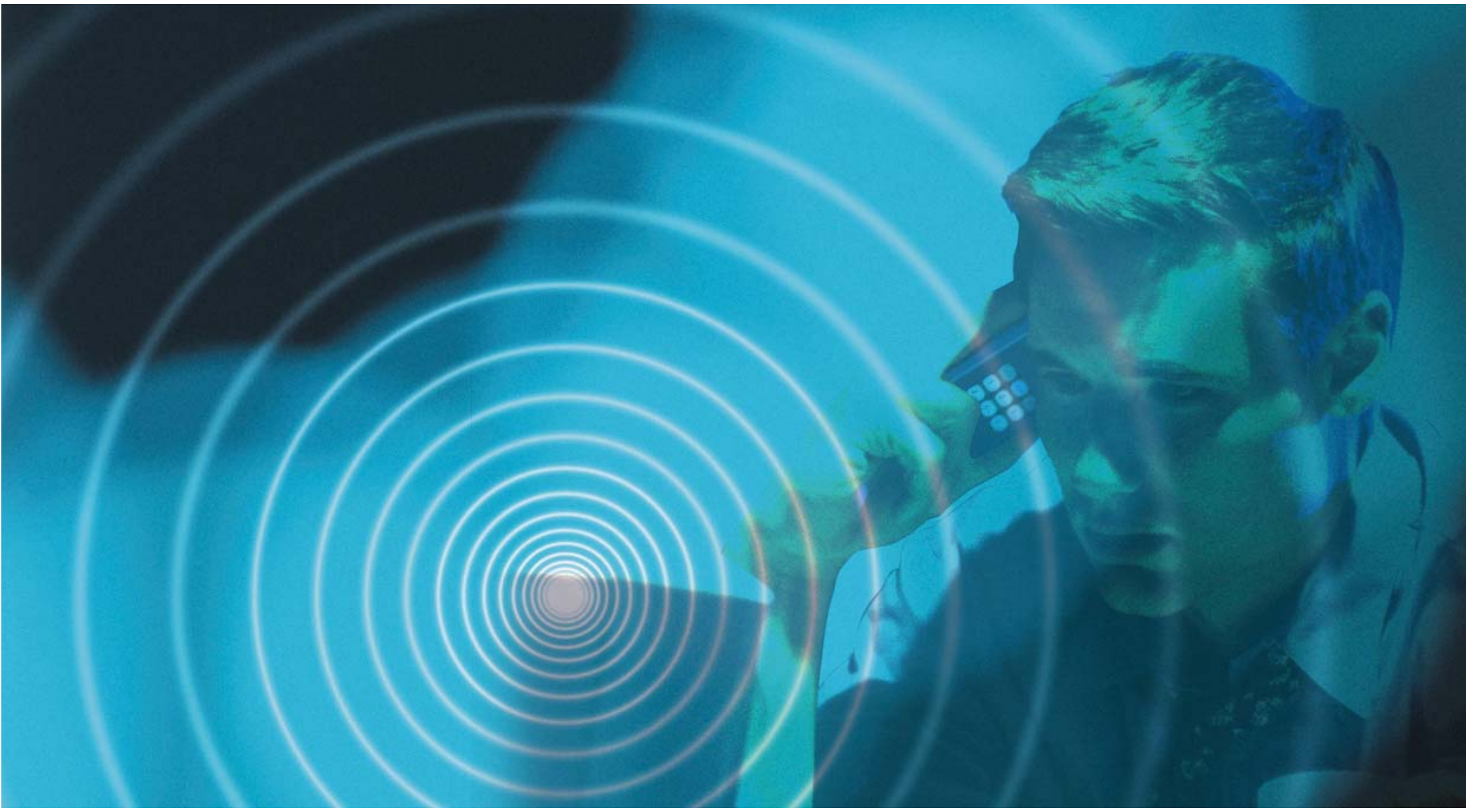
CI/SfB | | (35) | Xy | |
November 2006



THE ARMSTRONG **GUIDE**

to building acoustics

Armstrong®
CEILING SOLUTIONS

Introduction

Acoustics, no doubt like many of the other building technologies, is often seen by those who are not involved with the subject on a regular basis as being full of specialist and complex concepts, criteria and jargon. To some extent this is a valid criticism because the subject has become unnecessarily complicated in its use of technical terminology. This can often lead to misunderstandings, but worse the misapplication of suitable materials and constructions necessary to achieve good acoustic standards or solve troublesome acoustic problems.

As manufacturers of acoustic ceiling and wall lining systems, Armstrong World Industries and in particular the Technical Services Group of the Building Products Division has, over the years, received many enquiries from Architects, Designers, Engineers and Contractors who have been seeking acoustic advice. Interestingly though, these queries have been concerned with not only the acoustic performance of Armstrong's products but they have also covered a much wider range of acoustics issues.

So clearly the subject of building acoustics is still not well understood and, in addition, confusion often arises due to the different testing methods, units and criteria that are in use between Europe, North America and other parts of the world. This is a situation that now commonly occurs when major architectural practices and international building firms are able to undertake projects world-wide.

This acoustics guide has been produced in an attempt to help clarify the subject. It is intended as a readily accessible work of reference and has been structured in a dictionary format so that the meaning or definition of any unknown unit or term can be easily found and a simple and lucid explanation given. It is not intended as a technical treatise on the subject, for which there are many other good reference books available, but merely as an aid to better understanding and usage for non-acoustic specialists within the building design and construction teams. Throughout the text there are many cross-references to defined subjects that are italicised, and diagrams and tables have been introduced where they help to make the explanations clearer.

Also included at the end of the guide is a list of European, International and American standards covering most of the relevant requirements for testing, measurement and application of building acoustic performance and criteria. **However as new standards are regularly introduced and existing ones revised and updated, the latest version of any standard should be checked against the date of this publication.**

Comments on the content and presentation of this guide are always welcome so that future editions may be better tailored to suit user needs.

2006 - 1st revision

Since the original publication of this guide in 1999, Armstrong has further developed its business in acoustic products that now includes “active acoustic solutions” as well as its well proven range of “passive acoustics” ceilings. Known as “i-ceilings” active ceilings feature a range of flat panel loudspeakers which have the same appearance as many of the passive range of ceiling tiles, and as such can easily integrate with them without being visually intrusive and noticed.

i-ceilings provide active acoustics control that is used for sound masking (to aid with speech privacy), sound reinforcement (to aid speech intelligibility) as well as background music, public address and voice evacuation.

This guide has therefore been extended to add terms specifically related to electro acoustics and the 'Building Acoustics Reference Standards' section has been revised and extended to include all the latest relevant documents.

A

α — Alpha, see ***Sound Absorption Coefficient.***

α_p — Alpha p, see ***Practical Sound Absorption Coefficient.***

α_s — Alpha s, see ***Random Incidence Sound Absorption Coefficient.***

α_w — Alpha weighting, see ***Weighted Sound Absorption Coefficient.***

A — See ***Total Room Absorption.***

A-weighted decibel, dB(A)

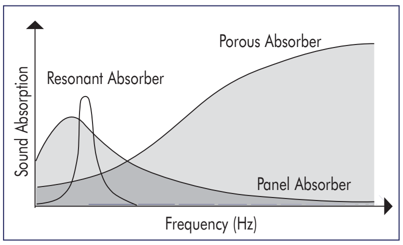
A single-number measurement of ***sound pressure level*** that approximates the subjective reaction to sounds with respect to frequencies.

The response of the human ear to sound is not linear to all values of ***frequency***. It is less sensitive to low (bass) frequencies than it is to middle and high frequencies (around 500 to 4000 Hz), and then it becomes gradually less sensitive again to very high frequencies. The A-weighting is a modification of the measured sound pressure level that approximates more closely to the response of the ear over the normal range of sound levels heard, and thus correlates reasonably well to the subjective reaction of ***loudness*** to sound.

The A-weighting response curve can be built into a ***sound level meter*** so that A-weighted sound levels can be directly measured. The resulting value is described as the sound level in dB(A) or L_{pA}, and can be used for the assessment of a wide range of sound sources such as transportation, leisure or industrial noise as well as building services noise.

However the main disadvantage in the use of dB(A) is that, as a single-number measure, it gives no indication of the spread of sound energy against frequency when detailed assessments are required. This is where ***Noise Rating (NR), Noise Criterion (NC) or Room Criterion (RC)*** curves can be more useful.
See ***Background Sound*** for recommended dB(A) limits.
See ***Sound Level*** for typical dB(A) examples of common sounds.

Absorber Response Curve



The measured ***sound absorption coefficients*** of materials will vary with frequency and these can be plotted as a curve on a graph to show their distribution.

Although materials of a similar type may exhibit different sound absorption coefficients depending upon their thickness, weight and structure, their absorption response curves will be of a similar (generic) shape. The different types of sound absorbers ie porous, membrane and resonant all have typical characteristic curves as seen on the following graph.

See ***Sound Absorption.***

Absorbtion

See ***Sound Absorption & Sound Absorption Coefficient.***

AC

See ***Articulation Class.***

Acoustic Correction

In churches, theatres, concert halls, or wherever people assemble to participate in speech or music, the treatment of the space should be such as to make the communication and listening conditions as ideal as possible for enjoyment, concentration and privacy. Acoustic correction is the term given to the materials and techniques adopted to optimise the room's acoustics.

Acoustic Faults

This term describes undesirable variations in audible sound level that can result from irregular reflections of sound.

Particular faults are:

Dead Spots which occur when the received sound level is significantly lower than is desirable for good audibility. Positions under very deep balcony overhangs in auditoria or similar shielded locations often exhibit such faults. Similar problems can occur when an ***electro acoustics*** system is used because the combination of sound waves diffused through a common set of loudspeakers may result in destructive interferences.

Echoes occur when sound reflections from distant surfaces are of sufficient magnitude and time delay after the ***direct*** (non-reflected) sound as to be distinguishable as a repetition of it. In effect the sound is heard at least twice within a short time period.

The expression “echoey” is often used by non-specialists to describe the ***sound field*** of an enclosed space which is particularly reverberant (see ***reverberation***). Strictly this is the wrong use of the term as - perhaps surprisingly - echoes are a relatively rare phenomenon in most buildings.

Flutter Echoes are multiple reflections of an impulsive sound along the same path between reflective parallel surfaces. They are heard as a distinct 'chattering' as the reflected sound decays more slowly than the local reverberant sound.

Focusing (or 'Hot Spots') occurs when reflections, (usually but not exclusively from curved surfaces), are concentrated at the listening position causing exceptional loudness and/or distortion of the received sound. Similar problems can occur due to incorrect layouts or settings of an ***electro acoustics*** system.

Acoustics

The science of sound concerned with its production, transmission, control and the sensation of ***hearing***.

The subject can be considered under various separate sub-headings such as:

Architectural - particularly the study and design of performance spaces.

Building - room acoustics, sound insulation and noise control in and around buildings.

Environmental - external noise from leisure, transportation and industry and its effect on people's lives and activities.

Industrial - noise and vibration control within industry and its effects on people's health, hearing and efficiency.

Medical - audiometry, deafness and occupational health.

Musical - the study of musical instruments and how they produce sound.

Transportation - noise and vibration from ground (including underground), air and water borne craft and vehicles.

Acoustic Screen

Generally this is a free standing and partial height divider used in ***open plan offices*** to sub-divide individual or group working areas and help to maximise the ***sound attenuation*** between them. Typically 1.2m to 1.8m in height, with similar dimensions in width, and perhaps 50mm to 80mm in thickness, they may be faced on one or both sides with sound absorptive material so as to provide local control of the build-up of ***reverberation*** and ***noise levels***. Sometimes screens may be built into office furniture (systems furniture) or mounted on desk tops.

Optimum acoustic performance between work zones can be achieved, provided that aesthetics and working efficiency are not otherwise compromised, by

1) Ensuring that screens are located as close to the noise source or the receiver as is possible and not by placing the screen democratically midway between the two.
2) Minimising the free height above screens and ensuring that a sound absorbing ceiling is located above them.
3) Avoiding or minimising gaps at their ends and between adjacent screens
4) Avoiding or minimising gaps beneath the screens and the use of a well carpeted floor under the screen will be of additional benefit.

Acoustic screens may also be used within industrial environments to control the noise output from machinery and processes and to shield operatives.

See ***Open Plan Office.***

Acoustics Laboratory

A private, academic or commercial facility designed and constructed specifically for the acoustic testing of materials, assemblies and products to national and international standards. Quality assurance can be established by third party accreditation schemes such as is available in most EU countries and the US.

Active Acoustics

This involves the use of ***electro acoustics*** to diffuse an amplified audio source via an active loudspeaker system as a means of improving the acoustic environment. Such a system may also be associated with microphones for real time sound pressure level monitoring and signal processed feedback.

Activity Noise

The intermittent and fluctuating noise resulting from the occupation of buildings, ie the noise due to people and their activities (also called ***occupational noise***) but which is distinguishable from ***background sound***.

AI

See Articulation Index.

Airborne Sound

Sound that is transmitted through the air as opposed to that which is transmitted through solids (structures) or liquids.

Alcons

Defined as the percentage **a**rticulation **l**oss of **cons**onants, this is an evaluation method by which the probable ***speech intelligibility*** of amplified sound from loudspeaker systems can be calculated taking into account the anticipated levels of ***direct*** to ***reverberant*** sound.

It is the consonants of speech that convey most of the information needed for its comprehension. Therefore, if they are significantly reduced, because of a weak speech signal or excessive reverberation or too high a level of background noise at the listener, then intelligibility will be reduced.

While the use of Alcons is a useful tool for prediction, it is the ***speech transmission index, (STI or RASTI)*** that is now more often used for the measurement of speech intelligibility.

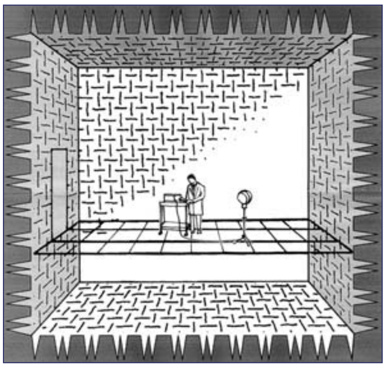
Alpha Weighting, α_w

See ***Weighted Sound Absorption Coefficient.***

Amplification

The increased intensity (and loudness) of sound by mechanical and/or electrical means. See ***Electro acoustics.***

Anechoic Chamber



A specialist room for acoustic measurements within an ***acoustics laboratory*** that is designed to provide ***free field*** conditions, ie without ***reverberation***, over the frequency range of interest. This is achieved by lining all the boundaries of the room with highly efficient sound absorbing material so that sound may propagate from the sound source without being reflected from any boundary surfaces. The sound absorbing linings are generally in the form of deep wedges made from man made mineral fibre (faced to prevent fibre erosion) or open cell fire retardant plastic foam The working floor plane is normally constructed of an acoustically transparent open steel mesh or grid with further sound absorbing material below.

Anechoic chambers are used particularly for ***audiometry*** studies or where ***sound power*** and ***directivity*** data is required for sound sources

Apparent Sound Reduction Index, R'

A measurement of ***sound reduction index*** but in the presence of ***flanking sound transmission***. Apparent sound reduction index can be established for either laboratory or ***field*** measurements in accordance with EN ISO 140-3 or 140-4.

See ***Weighted Apparent Sound Reduction Index, R'_W.***

Articulation Class, AC

Is a calculation and classification of ***sound attenuation*** that can have an influence on ***speech intelligibility***, eg between work zones in ***open plan offices***. Defined in ASTM E 1110, 'weighting factors' (each of which represents the relative contribution to the intelligibility of speech) are applied to the measurement of sound attenuation for each one-third octave band from 200 to 5000Hz. These are then summed together to give an overall measure. Similar in concept to ***Articulation Index*** but AC does not consider the influence of speech levels or background noise levels that AI does.

Articulation Index, AI

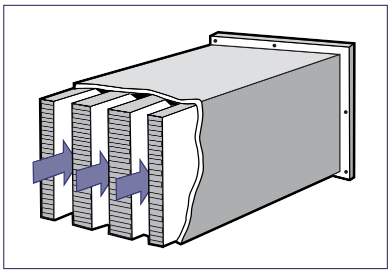
AI	Subjective Response
0.0 - 0.05	Confidential Privacy
0.05 - 0.20	Normal Privacy
0.20 - 0.35	Marginal Privacy
0.35 - 0.50	Fair Communication
0.50 - 0.65	Good Communication
0.65 - 1.00	Excellent Communication

A method for the calculation and classification of ***speech intelligibility*** or ***speech privacy*** that takes into account the influence of masking due to background noise on the level of speech signal received at the listening position. It is a formal procedure defined in ANSI S 3.5, that applies a 'weighting' to the difference between speech peaks and background sound, for each one-third octave band from 200 to 5000Hz, that are then summed together. Expressed as a value between 0 and 1.0, which represents the range from "unintelligibility" to "total intelligibility", AI can also be determined for open plan offices in accordance with ASTM E 1130.

See ***Articulation Class, Privacy Index, RASTI, Speech Interference Level, Speech Intelligibility and Speech Transmission Index.***

The table shown gives an indication of the likely subjective response for various values of AI.

Attenuator



A device introduced into ventilation systems for controlling fan noise, ***regenerated noise*** or ***cross-talk***, but while still allowing air to pass through. Attenuators are normally rectangular or circular in cross-section, constructed of sheet metal, and lined internally with a sound absorbing material such as man made mineral fibre (faced to prevent fibre erosion) or open cell plastic foam. Other names for an attenuator are **silencer** or, in North America, a **muffler**.

Audiometry

The procedure for the measurement of human hearing sensitivity and in particular ***hearing loss***. An 'Audiometer' is the instrument that is used for measurement.

Average Sound Reduction Index, R_m

The arithmetic average in decibels of sound reduction index over the sixteen one-third octave frequency bands from 100 - 3150Hz.

R_m is now less frequently used in favour of R_w ***(Weighted Sound Reduction Index).***

B

Background Sound (Noise)

	NR/NC Level	dB(A) Level
Larger auditoria > 500 seats,	15 - 25	25 - 35
Multi-purpose halls, smaller auditoria, sleeping rooms	20 - 30	30 - 40
Conference rooms, courtrooms, galleries, living rooms, private offices, teaching spaces	25 - 35	35 - 45
General offices, laboratories, libraries, restaurants	30 - 40	40 - 50
Canteens, dealing rooms, kitchens, leisure centres, retail areas, transportation waiting areas	35 - 45	45 - 55
Circulation, shopping malls, swimming pools, toilets, workshops	40 - 50	50 - 60
Car parks, storage	45 - 55	55 - 65

Background sound in buildings is that which is always present but is probably not so distinguishable as to be noticed by most occupants. It usually results from the servicing of, and activity within, a building and is due to sources such as ventilation equipment and terminals, heating and electrical services, office equipment such as computers, telephones and copying machines etc, as well as people's activities. However the ***break-in*** of sound into buildings from external transportation sources, particularly in urban areas, can also contribute.

The use of a room or space for a particular purpose will normally determine that a maximum tolerable background sound level should be present. For example, it is necessary to have quieter conditions in a theatre, where excellent ***speech intelligibility*** is essential, than in a restaurant, where masking, from the background sound, may be desirable for discreet conversations! Therefore the more acoustically critical the space, the lower the maximum background sound should be.

Limits for background sound are normally specified as ***Noise Rating (NR), Noise Criterion (NC) or Room Criterion (RC)*** curves or as ***dB(A)*** levels.

Typical recommended maximum levels for various spaces are given in the shown table.

Baffle — ***See Modular Absorber.***

Break-In — The transmission of sound from one area (possibly external) into an adjacent area, enclosure or building.
The term generally implies that the sound is unwanted ie it is noise.

Break-Out — The transmission of sound from an active source inside an enclosure, through its walls or boundaries, to the surrounding area.
Break-out is often associated with mechanical services noise control to describe the transfer from within a ventilation duct or plenum or fan enclosure.
The term generally implies that the sound is unwanted ie it is noise.

Broadband Sound — Sound whose energy is spread over a wide range of frequencies, none of which are particularly dominant.

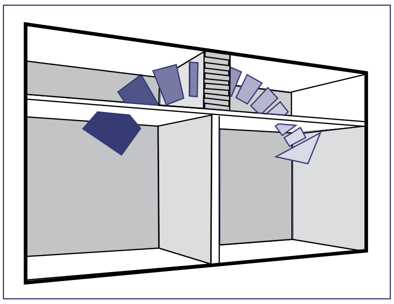
C

C and C_{tr} — See ***Spectrum Adaptation Terms.***

CAC — See ***Ceiling Attenuation Class.***

Cavity Absorber — See ***Resonant Absorber.***

Cavity Barrier — A material or element providing sound reduction that is used in the cavity of a suspended ceiling (or raised floor void) to enhance the ***room-to-room sound attenuation*** path. It should be noted that materials intended as fire barriers may not necessarily provide sufficient sound reduction.
Although there is no specific acoustic test for cavity barriers, they can be tested in conjunction with a suspended ceiling in accordance with EN 20140-9 or ASTM E 1414 but then the performance of the barrier would only relate to the particular ceiling included in the test.



Ceiling Attenuation, D_c — The laboratory measured difference in ***noise reduction*** (in specified one-third octave frequency bands) between two enclosed rooms sharing a common ceiling plenum, produced by one or more sound sources in one of the rooms.
Defined in ASTM 1414 as:

$D_c = L_s - L_r$ dB

where

D_c = measured ceiling attenuation

L_s = average one-third octave band sound pressure level in the source room dB

L_r = average one-third octave band sound pressure level in the receiving room dB

See ***Normalised Ceiling Attenuation $D_{n,c}$.***

Ceiling Attenuation Class, CAC

A single-number rating, expressed in decibels, of the laboratory measured frequency dependent room-to-room sound attenuation of a suspended ceiling sharing a common ceiling plenum above adjacent rooms.

It is determined by reference to ASTM E 413 from measurements of ***normalized ceiling attenuation*** made in accordance with ASTM E 1414 over the one-third octave band frequency range 125-4000Hz.

This USA based system is principally used in North America and Australia but references to it may also be seen in Europe.

CAC is similar to ***Weighted Suspended Ceiling Normalized Level Difference*** $D_{nc,w}$.

Cocktail Party Effect

This is an aural effect that may occur in any enclosed space where crowds of people congregate and talk to each other in small groups. The 'hubbub' produced by many different conversations results in individuals having to raise their voices to continue to make themselves heard by their companions above the ***activity noise*** caused by other groups. This gives rise to a gradual but significant transition from casual to normal to raised to almost shouting speech effort, and a consequential increase in the ***background sound***.

However despite this, it may still remain possible to become focused on the conversations within other groups and pick out the (more interesting) information content!

Coincidence Effect

In relation to the sound reduction through solid barriers, some materials exhibit a phenomenon called coincidence due to the way that certain (bending) waves transfer within them. This manifests itself as a pronounced loss or 'dip' in performance, below the level that may be expected due to the mass of the material, starting at a specific **critical frequency** and extending for an octave or so above.

The critical frequency is determined by the material's stiffness and thickness, and the coincidence effect tends to be more pronounced at higher frequencies for thin rigid materials such as glass, plasterboard or plywood etc.

Critical Distance

See ***Room Radius.***

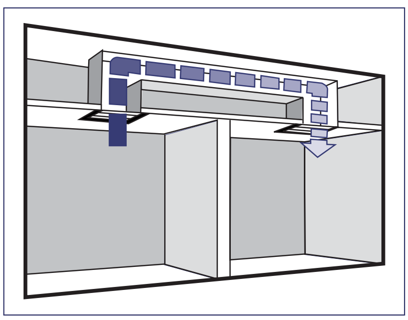
Critical Frequency

See ***Coincidence Effect.***

Cross-Talk

The unwanted sound transmission between one space and another via a ventilation duct or system irrespective of the direction of airflow. This may be controlled by the inclusion of a cross-talk ***attenuator.***

See ***Sound Leaks.***



D

ΔL, $\Delta L'$	Delta L, ***See Reduction of Impact Sound Pressure Level.***
ΔL_w	Delta $L_{w,}$ ***See Weighted Reduction of Impact Sound Pressure Level.***
dB	See ***Decibel.***
dB(A)	See ***A-Weighted decibel.***
D	See ***Level Difference.***
D_c	See ***Ceiling Attenuation.***
D_n	See ***Normalized Level Difference.***
D_{nc} or $D_{n,c}$	See ***Suspended Ceiling Normalized Level Difference and Normalised Ceiling Attenuation.***
$D_{n,w}$	See ***Weighted Normalized Level Difference.***
$D_{nc,w}$	See ***Weighted Suspended Ceiling Normalized Level Difference.***
D_{nT}	See ***Standardized Level Difference.***
$D_{nT,w}$	See ***Weighted Standardized Level Difference.***
D_w	See ***Weighted Level Difference.***

Dead Spots

See ***Acoustic Faults.***

Decibel, dB

A unit of magnitude for ***Sound Pressure, Sound Intensity, Sound Power*** and, in relation to ***Sound Insulation***, the measurement of level reduction. The dB is a logarithmic unit that compresses a wide range of values into a smaller scale and, in acoustics, is defined as ten times the logarithm (base 10) of the ratio of the measured sound level compared to a standard reference level.

See ***Loudness*** for the subjective impression of decibel changes.

Decibel Reduction

A reduction in ***sound pressure level*** expressed in decibels.

Diffuse Sound

The sound field within an enclosure is said to be diffuse when sound waves travel equally in all directions and the sound pressure level varies minimally throughout. Highly diffuse conditions are normally only achieved within a ***reverberation chamber*** of an ***acoustics laboratory.***

Diffraction

The tendency of sound waves to readily flow or bend around obstacles, that are small in comparison to the wavelength of the sound striking the obstacle.

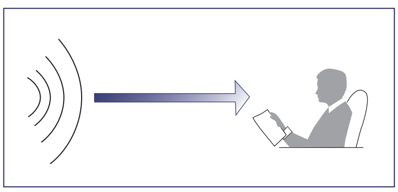
Directivity

Few sources radiate their sound energy equally in all directions. Most exhibit a directional radiation pattern whereby more sound is propagated in one or more specific directions in favour of others. For example, a conventional cone loudspeaker generally radiates more sound to the front with less to the sides and even less to the back. Also for any source its directivity will vary with frequency with high frequencies generally being more directional than the lower frequencies which tend to be omnidirectional in pattern. The exception to this being with new technology flat panel loudspeakers which usually have low directivity at all significant frequencies thus making them desirable for many audio applications.

The **Directivity Factor Q**(θ) for a source can be measured in an Anechoic Chamber or other free field environment and is defined as the ratio of the sound pressure level in the direction of interest to the sound pressure level averaged over all angles.

However for calculation purposes it is necessary to use the **Directivity Index** and this is defined as $10\log_{10} Q(\theta)$ where θ is the angle of interest.

Direct Sound



The component of a ***sound field*** that transmits directly from the source to the receiver without reflections, and therefore influence, from any obstacles or surrounding surfaces. Because it travels on the shortest path, the direct sound will arrive at the listener before any reflected (or ***reverberant***) sound.

See ***Inverse Square Law.***

Echoes

See ***Acoustic Faults.***

Electro acoustics

A science that deals with the transformation of electrical energy into acoustic energy or vice versa. Basic electro acoustics systems generally include:

- Input source: microphone/CD/DVD
- Audio signal processing equipment: power amplifier/equalizer
- Output equipment: loudspeaker(s)

See ***Amplification.***

Equivalent Continuous Sound Level, $L_{eq,T}$

An index for the assessment of overall noise exposure of a time varying sound. This is the notional steady level that would, over a given period of time, deliver the same sound energy as the actual fluctuating sound over the same period. Hence levels which fluctuate with time can be described in terms of a single figure level but the reference time period should always be stated. If used for A-weighted sound pressure levels then the descriptor will be $L_{Aeq,T.}$

Eyring Formula

This is a modification of the ***Sabine Formula*** that is likely to give more accurate predictions of ***reverberation*** time when the sound field is not totally diffuse. This situation occurs when the average sound absorption coefficient α is greater than about 0.25, and when the sound absorptive materials are not evenly distributed throughout the room. The equation is:

$$T = \frac{0.16V}{S\left(-\log_e (1-\alpha)\right)}$$

where:

T = Reverberation time in seconds

V = Room volume, m^3.

α = Average sound absorption coefficient of all surfaces

S = Area of all surfaces, m^2

F

f

See ***Frequency.***

Field Impact Insulation Class, FIIC

A single-number rating, expressed in decibels, of ***field*** measured frequency dependent ***impact sound*** insulation of a floor/ceiling assembly using a standardized ***tapping machine***.

It is determined by reference to ASTM E 989 from measurements of ***normalized impact sound pressure level*** made in accordance with ASTM E 1007 over the one-third octave frequency band range 100-3150Hz.

FIIC rates floor/ceiling structures in ascending degrees of impact sound insulation. Thus the larger the FIIC value, the higher is the degree of impact sound insulation.

FIIC values cannot be compared directly to ***Weighted Normalized Impact Sound Pressure Level*** $L'_{n,w}$ as with the latter method the larger the $L'_{n,w}$ value, the lower is the degree of impact sound insulation.

Field Measurements

These are the acoustic measurements of building elements or structures that are conducted outside the 'ideal' controlled conditions of an acoustics laboratory. Field measurements of ***airborne*** and ***impact sound insulation*** will normally include the effects of ***flanking sound*** and may also have ***sound leaks*** present.

Field Sound Transmission Class, FSTC

A single-number rating, expressed in decibels, of ***field*** measured frequency dependent airborne ***sound transmission loss***.

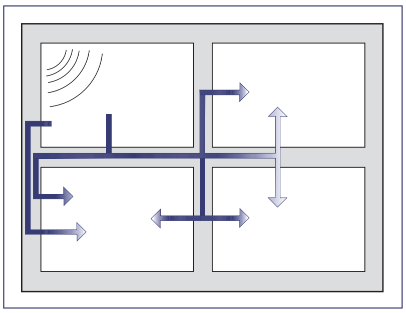
It is determined by reference to ASTM E 413 from measurements made in accordance with ASTM E 336 over the one-third octave frequency band range 125-4000Hz.

FSTC is similar to ***Weighted Apparent Sound Reduction Index***.

FIIC

See ***Field Impact Insulation Class.***

Flanking Sound

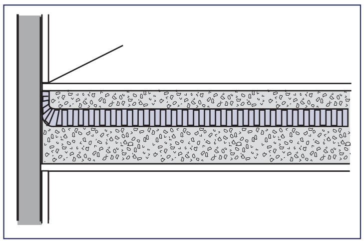


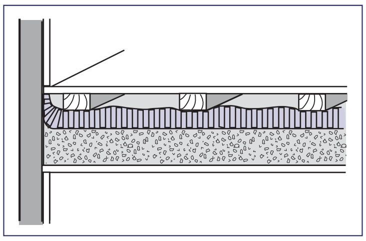
This is the ***structure borne*** transmission of sound between adjacent rooms or spaces but which bypass the obvious dividing barriers. Such transmission paths may include side walls, floor slabs, ceiling slabs etc.

The effect of flanking sound may be to lower the achieved ***sound insulation*** between adjacent areas below that which could be expected from the known performance of the identified dividing barriers. Because flanking sound is always present (other than within the 'ideal' confines of an acoustics laboratory), practical site performance between 'non-isolated' constructions will normally be limited to about R'_w 55 dB.

See ***Sound Leaks and Floating Floor.***

Floating Floor





A floating floor is part of a composite floor construction whereby the upper surface membrane (possibly a concrete screed or timber deck) is independently isolated (floated) from the lower structural floor by the use of a resilient underlay or an array of flexible pads or spring isolators. This separation results in better ***airborne*** and ***impact sound*** insulation than would be achieved by an equivalent solid floor of the same overall mass. However, in order to achieve this enhanced performance, it is essential that the 'isolation' is maintained throughout, with no rigid connections between the floating and structural floor, including around the edges of the floating floor.

Floating floors are typically used in music practice rooms, recording or broadcast studios, audiometry rooms, plant rooms located above occupied areas or similar spaces where very high levels of airborne sound reduction (eg R'_W or FSTC >55 dB) are required to adjacent rooms.

Flutter Echo

See ***Acoustic Faults.***

Focusing

See ***Acoustic Faults.***

Free Field

An external environment or an internal location such as an ***anechoic chamber*** in an ***acoustics laboratory***, where there are no surfaces or obstacles to reflect sound and which could otherwise influence the frequency range of the acoustic measurements being made

See ***Inverse Square Law.***

Frequency, f

The rate at which sound or ***vibration*** is generated by a source. The objective expression of frequency is synonymous with the subjective sensation of pitch.

The human audible frequency scale extends from approximately 20 Hz to 20,000 Hz. With such a potentially wide range of frequencies it is necessary, for practical use, to break them down into manageable groups or bands. In building acoustics, ***octave bands*** and ***one-third octaves bands*** are generally used.

Formerly expressed as cycles per second (cps), the unit of frequency now used is the ***Hertz*** (abbreviated Hz).

FSTC

See ***Field Sound Transmission Class.***

Functional Absorber

See ***Modular Absorber.***

H

Hearing

The subjective sensation of hearing sound involves three key perceptions:

Firstly sound has ***loudness*** which, objectively, we can also say as having amplitude or level, and we use ***decibels - dB*** to measure how much or little there is. ***See Sound Level for typical examples.***

Secondly we are also aware that, apart from how loud or quiet a sound is, it also has ***pitch*** or ***frequency***. We know that some sounds are "boomy" or "rumbly" and this is because the sound energy is concentrated at the lower (bass) end of the frequency spectrum. Alternatively we might say that a sound is "hissy" or "screeching" which indicates that most of its energy occurs at the upper (treble) end of the frequency range.

Thirdly it is also clear that sound can vary with time. Some sounds are continuous eg from ventilation grilles while others such as speech may be a series of separate events interspersed with longer breaks of silence.

In practice most sounds contain energy over a wide range of frequencies and it is the spread or distribution of energy level against frequency and time that gives a sound its character and enables us to recognise one sound from another.

Hearing Loss

An increase in the ***threshold of audibility*** whereby it becomes more difficult to hear quieter sounds or sounds with a particularly frequency content. This may occur naturally because of the ageing process or be brought about prematurely due to disease, injury or excessive and prolonged exposure to high levels of noise. The latter may occur in certain manufacturing industries, or from gunfire (eg target shooting without ear defenders), or with heavily amplified pop and disco music.

See ***Audiometry.***

Helmholtz Absorber (Resonator)

See ***Resonant Absorber.***

Hertz, Hz

The unit of ***frequency*** for a repetitive occurrence. One cycle per second is termed one Hertz. Named in memory of the German physicist Heinrich Rudolf Hertz (1857-1894).

Impact Insulation Class, IIC

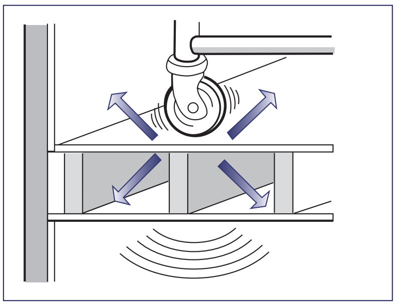
A single-number rating, expressed in decibels, of laboratory measured frequency dependent impact sound insulation of a floor/ceiling assembly using a standardized ***tapping machine.***

It is determined by reference to ASTM E 989 from measurements made in accordance with ASTM E 492 over the one-third octave frequency band range 100-3150Hz.

IIC rates floor/ceiling structures in ascending degrees of impact sound insulation. Thus the larger the IIC value, the higher is the degree of impact sound insulation.

IIC values cannot be compared directly to ***Weighted Normalized Impact Sound Pressure Level*** $L_{n,w}$ as with the latter method the larger the $L_{n,w}$ value, the lower is the degree of impact sound insulation.

Impact Sound



Is produced when short duration sources such as footsteps, wheeled trolleys, door slams etc, impact directly onto a structure. The sound will be heard as surface radiating ***airborne sound*** within the area containing the source but it may also be transmitted as ***structure borne*** sound to re-radiate as airborne sound in more remote locations.

Lightweight structures, such as timber or steel frames, are more likely to be excited by impact sound than those constructed from more massive masonry or dense concrete.

Impact Sound Pressure Level, L_i

This is the measurement of sound pressure levels in a receiving room when the floor/ceiling assembly under test, including the presence of a floor covering if applicable, is excited by a standardized ***tapping machine*** in the room above.

Laboratory measurements in accordance with ISO 140-6 or ISO 140-8, or field measurements in accordance with ISO 140-7, are made over the one-third octave band frequency range 100 - 3150Hz.

It should be noted that with impact sound pressure levels, the higher the resulting number, the lower is the performance of the structure and vice versa.

See ***Normalized Impact Sound Pressure Level*** and ***Standardized Impact Sound Pressure Level.***

ASTM E 492 for laboratory measurements and ASTM E 1007 for field measurements give very similar methods over the same frequency range.

Impact Sound Pressure Level Reduction, ΔL

See ***Reduction of Impact Sound Pressure Level.***

Impedance Tube

See ***Standing Wave Tube.***

Improvement of Impact Sound Pressure Level, ΔL

See ***Reduction of Impact Sound Pressure Level.***

Infrasound

These are pressure fluctuations that occur below the lower end of the audible frequency range ie < 20Hz.

See ***Ultrasound.***

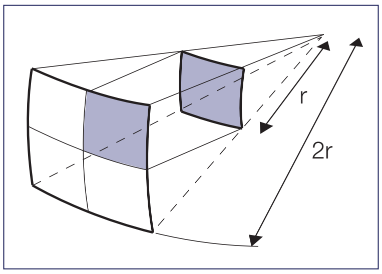
Insertion Loss

See ***Noise Reduction definition 2.***

Intrusive Noise

See ***Break-In***

Inverse Square Law



Under ***free field*** conditions sound spreads out from a source over a spherical wave front without reflection or encountering obstacles. Each time the distance from the source doubles the area of the wave front increases fourfold and this results in the ***sound pressure level*** at the wave front reducing by 6dB.

The sound pressure level at a specific distance can be predicted from the expression:

$L_p = L_w - 20 \log r - 11dB$

where:

L_p = sound pressure level at distance r

L_w = source sound power level

r = distance from the source, m

This decay rate will probably be affected within enclosures (***Anechoic Chambers*** excepted) due to the presence of reflected (***reverberant***) sound.

See ***Direct Sound.***

L

Level Difference, D

The difference in average sound pressure levels (in specified frequency bands) between two enclosed spaces produced by one or more sound sources in one of the spaces.

Defined in ISO 140-4 & 140-9, level difference is equivalent to ***Noise Reduction*** (definition 1). Measurements of Level Difference may also include the effects of ***Flanking Sound Transmission.***

See ***Suspended Ceiling Normalized Level Difference, Normalized Level Difference, Standardized Level Difference and Ceiling Attenuation.***

Loudness

Is the subjective impression of the magnitude or level of sound.

It is worth noting that for ***broadband sound*** a change of 2 to 3dB (up or down) is just perceptible. 5dB is clearly perceptible while 10dB corresponds to a doubling or halving of loudness. An increase or decrease of approximately 20dB would be considered very much louder or quieter.

See ***Phon and Sound Level.***

Loudspeaker

A loudspeaker or speaker is an electromechanical transducer which converts an electrical signal into an acoustic signal ie sound. A full range speaker is designed to have as wide a frequency response as possible, usually covering a minimum range of 70Hz to 19kHz.

See ***Electro acoustics.***

LA_{eq}	See ***Equivalent Continuous Sound Level.***
L_{eq}	See ***Equivalent Continuous Sound Level.***
L_i (subscript lowercase i for India)	See ***Impact Sound Pressure Level.***
L_I (subscript uppercase I for India)	See ***Sound Intensity Level.***
L_n	See ***Normalized Impact Sound Pressure Level.***
L'_{nT}	See ***Standardized Impact Sound Pressure Level.***
$L_{n,w}$	See ***Weighted Normalized Impact Sound Pressure Level (Laboratory).***
$L'_{n,w}$	See ***Weighted Normalized Impact Sound Pressure Level (Field).***
$L'_{nT,w}$	See ***Weighted Standardized Impact Sound Pressure Level.***
L'_p	See ***Sound Pressure Level.***
L_{pA}	See ***A-weighted decibel.***
L_{pr}	See ***Reverberant Sound Pressure Level.***
L_T	See ***Statistical Time Varying Sound Pressure Level.***
L_w	See ***Sound Power Level.***
L_1	See ***Statistical Time Varying Sound Pressure Level.***
L_{10}	See ***Statistical Time Varying Sound Pressure Level.***
L_{90}	See ***Statistical Time Varying Sound Pressure Level.***

M

Masking

Is the phenomenon whereby one sound can be used to interfere with (or mask) the perception of another sound. Sometimes this masking is undesirable such as the difficulties encountered when trying to use a telephone in a noisy environment lacking adequate control. Alternatively specially designed and introduced masking can be both desirable and beneficial and contribute to ***speech privacy.***

See ***Sound Masking.***

Mass Law

A relationship used to predict the approximate ***sound reduction index*** (SRI) or ***sound transmission loss*** (TL) of a uniform single-skin dividing barrier based upon its mass. The SRI (dB) may be found at a particular frequency from the expression:

$SRI(f) = 20 \log_{10} fm - 47dB$

where:

f = frequency of interest

m = mass of barrier kg/m^2

This relationship shows that the SRI increases by 6dB for each doubling of frequency for a given mass or for each doubling of the mass at a given frequency. However under field conditions a 5dB increase for each doubling of mass or frequency would be a more realistic estimate.

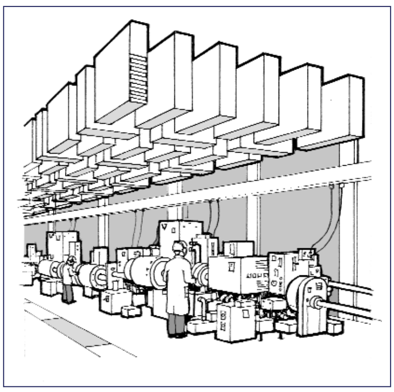
Mean Sound Reduction Index, R_m

See ***Average Sound Reduction Index.***

Membrane Absorber

See ***Panel Absorber.***

Modular Absorber



These are individual sound absorbing elements made from materials, such as man made mineral fibre (faced to prevent fibre erosion) or open cell plastic foam, that are suspended freely within an enclosure below a roof or ceiling structure. They are usually formed into rectangular, spherical or cylindrical shapes and the sound absorption achieved is dependent upon the size of each absorber and the number of units installed. They are normally used in spaces requiring significant sound absorption but where the more conventional treatment of boundary surface linings is not permissible nor appropriate, or where the boundary surfaces would be too far from the sound sources to be of benefit, eg in large factories, leisure centres etc.

Also referred to as ***Baffles*** or ***Functional Absorbers.***

Muffler

See ***Attenuator.***

N

NC See ***Noise Criteria Curves.***

NIC See ***Noise Isolation Class.***

NNIC See ***Normalized Noise Insulation Class.***

NNR See ***Normalized Noise Reduction.***

NR See ***Noise Rating Curves.***

Noise

Generally defined as unwanted sound because it can cause distraction, disturbance, interference with speech, stress, or damage to hearing. However noise can be very subjective and a specific noise that upsets one person may go totally unnoticed by another.

People can also acclimatise to noise, particularly if it is ***broadband*** and without rhythmic or impulsive components, so that it no longer appears offensive although underlying disturbance may still continue to occur.

Noise Criteria Curves, NC

A method of rating ***broadband sound*** against a set of standardized curves, that broadly equate to curves of equal loudness. These were first described in the USA in the late 1950's and were intended to be used for specifying ***background sound*** limits and for assessing the impact of mechanical and electrical plant and equipment services noise for internal spaces.

The shape and description of NC curves have undergone several revisions over the years because it was found that background sound levels that imitated the shape of the curves were not well balanced and were subjectively unacceptable. Preferred Noise Criterion (PNC), Balanced Noise Criterion (NCB) and Room Criterion (RC) curves have all been subsequently proposed and implemented. Now RC Mark II curves are also being considered.

See ***Background Sound*** for recommended NC limits.

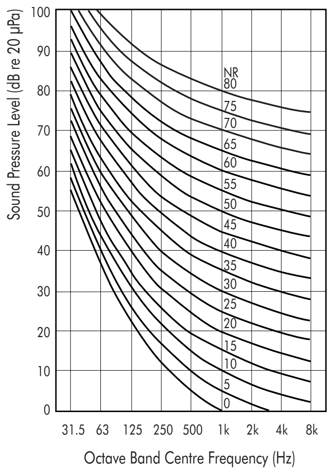
Noise Isolation Class, NIC

A single-number rating, expressed in decibels, of field measured frequency dependent ***noise reduction*** (def. 1).

It is calculated by reference to ASTM E 413 using measurements of noise reduction obtained in accordance with ASTM E 336 over the one-third octave band frequency range 125 - 4000Hz.

NIC is similar to ***Weighted Level Difference,*** D_{w}.

Noise Rating Curves, NR



A method of rating broadband sound against a set of standardized curves, that broadly equate to curves of equal loudness. These were first described in ISO/R1996: 1st Edition: May 1971 'Assessment of Noise with respect to community response', appendix Y. This method has found favour, particularly in Europe, for specifying background sound and/or assessing the impact of mechanical and electrical plant and equipment services noise of internal spaces.

See ***Background Sound*** for recommended NR limits.

Noise Reduction, NR

1. The dB difference in average sound pressure levels (in specified frequency bands) produced between two enclosed spaces by one or more sound sources in one of them. Defined in ASTM E 336, measurements of noise reduction could include the effects of ***Flanking Sound Transmission***. Noise Reduction is equivalent to ***Level Difference*** and, when referring to ASTM E 1414, ***Ceiling Attenuation.***
2. The dB difference in two noise levels resulting from the same source, measured before and after the implementation of noise control measures. May also be referred to as **Insertion Loss.**

Noise Reduction Coefficient, NRC

A single-number rating for ***random incidence sound absorption coefficients***. The term is defined in ASTM 423 as the arithmetical average of the measured sound absorption coefficients for the four one third octave band centre frequencies of 250, 500, 1,000 and 2,000 Hz, that is then rounded to the nearest 0.05. For example an averaged value of 0.62 would be rounded down to 0.60 while a value of 0.64 would be rounded up to 0.65.

This USA based system has also been used extensively in Europe and other parts of the world for many years but its popularity may now wane as the recently introduced ***Weighted Sound Absorption Coefficient***, α_w becomes more established and popular.

Normalized Ceiling Attenuation, $D_{n,c}$

The laboratory measured frequency dependent ***ceiling attenuation*** of a suspended ceiling sharing a common ceiling plenum above adjacent rooms that is corrected to take into account the sound absorption of the receiving room.

Defined in ASTM 1414 as:

$D_{n,c} = D_c - 10\log_{10}(A/A_0)$ dB

where

D_c = measured ceiling attenuation
A = total sound absorption in the receiving room in m^2
A_o = reference sound absorption (normally taken as $12m^2$)
Therefore the normalized ceiling attenuation is that which exists if the sound absorption of the receiving room is $12m^2$.

Normalized Ceiling Attenuation is similar to ***Suspended Ceiling Normalized Level Difference***.

Normalized Impact Sound Pressure Level, L_n

The corrected measurement of ***impact sound pressure level***, to take into account the sound absorption of the receiving room.

Defined in EN ISO 140-6, 140-8 or 140-11 and ASTM E 492 for laboratory measurements and EN ISO 140-7 and ASTM E 1007 for field measurements as:

$L_n = L_i + 10\log_{10} (A/A_0)$ dB

where

L_i = measured impact sound pressure level
A = total sound absorption in the receiving room in m^2
A_o = reference sound absorption (normally taken as $10m^2$)

Therefore the normalized impact sound pressure level is that which exists if the sound absorption of the receiving room is $10m^2$.

Normalized Level Difference, D_n

The corrected value of field measured ***level difference*** between two rooms, to take into account the sound absorption of the receiving room.

Defined in EN ISO 140-4 as:

$D_n = D - 10\log_{10} (A/A_0)$ dB

where

D = measured level difference
A = total sound absorption in the receiving room in m^2
A_o = reference sound absorption (normally taken as $10m^2$)

Therefore the normalized level difference is that which exists if the sound absorption of the receiving room is $10m^2$.

Normalized Noise Insulation Class, NNIC

A single-number rating, expressed in decibels, of field measured frequency dependent ***normalized noise reduction.***

It is determined by reference to ASTM E 413 using measurements obtained in accordance with ASTM E 336 over the one-third octave band frequency range 125 - 4000Hz

NNIC is similar to ***Weighted Normalized Level Difference, $D_{n,w}$***.

Normalized Noise Reduction, NNR

The corrected value of field measured ***noise reduction*** between two rooms, to take into account the reverberation time of the receiving room.

Defined in ASTM E 336 as:

$NNR = NR + 10\log_{10} (T/T_0)$ dB

where

NR = measured noise reduction
T = reverberation time in the receiving room in seconds
T_o = reference reverberation time of 0.5 seconds

Therefore the normalized noise reduction is that which exists if the ***reverberation time*** of the receiving room is 0.5 seconds.

Equivalent to ***Standardized Level Difference.***

See ***Normalized Noise Insulation Class, NNIC.***

NR See ***Noise Rating Curves.***

NRC See ***Noise Reduction Coefficient.***

NVLAP **N**ational **V**oluntary **L**aboratory **A**ccreditation **P**rogram administered by the US Department of Commerce that provides third party guidance for laboratory measurement procedures and instrumentation quality control.

O

Occupational Noise

See Activity Noise

Octave Band

A group of adjoining frequencies where the value of the upper limiting frequency is twice that of the lower limiting value. Each octave band is identified by its centre (geometric mean) frequency. In building acoustics the six bands with the frequency values 125Hz, 250Hz, 500Hz, 1000Hz, 2000Hz and 4000Hz are normally used for measurements, calculation and assessment.

Octave Band Centre Frequency, Hz	One-Third Octave Band Centre Frequency, Hz
	100
125	125
	160
	200
250	250
	315
	400
500	500
	630
	800
1000	1000
	1250
	1600
2000	2000
	2500
	3150
4000	4000
	5000

One-Third Octave Band

A group of adjoining frequencies (formed by dividing each ***octave band*** into three) that are used when more detailed information is required than is available from octave band spectra. Each one-third octave band is described by its centre (geometric mean) frequency and in building acoustics the eighteen bands with the frequency values 100Hz, 125Hz, 160Hz, 200Hz, 250Hz, 315Hz, 400Hz, 500Hz, 630Hz, 800Hz, 1000Hz, 1250Hz, 1600Hz, 2000Hz, 2500Hz, 3150Hz, 4000Hz and 5000Hz, are normally used for measurements, calculation and assessment.

However if low frequency sound or vibration analysis is involved then frequency bands well below 100Hz would be appropriate.

Open Plan Office

A multiple occupancy office, in which there is an absence of full-height partitions to sub-divide it, and where ***speech privacy*** and freedom from noise distraction become important acoustical considerations. Partial height space dividers ***(acoustic screens)*** and furniture may be used to form work zones and meeting areas, and the use of efficient sound absorbing ceilings can help control the transmission of noise between such spaces. ***Sound Masking*** may also be used to enhance speech privacy and minimise distraction problems.

See ***Articulation Class.***

Open Window Unit (OWU)

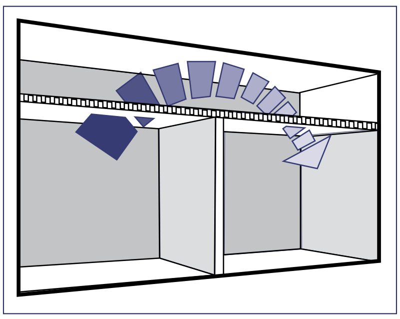
See ***Sabine.***

Optimum Reverberation Time

The reverberation time that will help to establish good acoustical conditions for a room or area taking into account its intended use, occupancy and volume. Optimum reverberation times may need to vary with frequency, depending upon the activity, but typical values at 500 -1000 Hz for empty spaces are as shown in the table.

Activity	Reverberation Time, T, secs	Application
Broadcast & Recording	0.25 - 0.9	Studios and Control Rooms depending upon size and usage
Speech Only	0.5 - 1.2	Education, Council Chambers, Law Courts, Lecture Theatres, Conference Halls
Reproduced Sound	0.8 - 1.2	Cinemas
Music Practice	0.8 - 1.5	Education
Trained Speakers with Incidental Music	1.0 - 1.4	Theatres, Stage Shows, Variety
Multi-Purpose	1.0 - 1.5	School Halls, Community Halls, Leisure Centres
Opera	1.0 - 1.6	Opera Houses
Solo Instruments & Small Groups	1.2 - 1.6	Salons, Recitals and Chamber Music Performance
Orchestral Music	1.6 - 2.4	Large Recital and Concert Halls
Organ and Choir Music	2.0 - 4.0	Large Concert Halls, Churches and Cathedrals

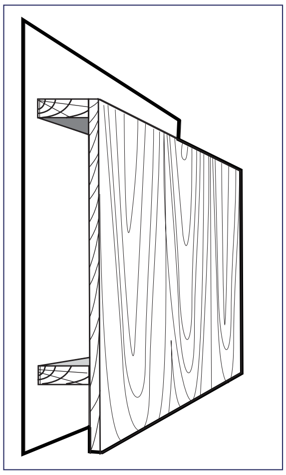
Overlay



A material that is laid onto the back of a suspended ceiling in order to enhance its sound insulation. However overlay materials must be considered and installed with care so as not to overload the ceiling and its suspension system (thus causing unacceptable deflection or possibly even collapse!), or to compromise the ceiling's fire protection performance if applicable. Plasterboard or metal sheets and man made mineral fibre layers are all commonly used as overlays and the latter may also provide additional thermal insulation.

P

Panel Absorber



Is typified by a thin rigid panel or membrane that is mounted over an enclosed airspace and set into ***vibration*** by incident sound waves. Flexing of the panel causes sound energy to be dissipated by friction, and hence conversion into heat, within the material and at its constrained edges.

Maximum ***sound absorption*** occurs at the resonant frequency of the panel (normally <500Hz), and it is the panel's mass, stiffness and the depth of the enclosed airspace behind it that will determine this.

Panel absorbers are typified by common materials such as:

- Thin wood-based panels or sheets such as plywood, blockboard and chipboard.
- MDF (medium density fibreboard).
- Plasterboard.
- Fire protecting building boards (calcium silicate or similar).
- Hollow Timber Floors.
- Furniture Panels.
- Hollow Core Doors.
- Glazing.
- Large Sheet Metal Ducts.
- Wet felt/Metal Ceilings

See ***Absorber Response Curve.***

Percentile Level

See ***Statistical Time Varying Sound Pressure Level.***

Phon

A unit of loudness level of a sound equal to the sound pressure level of a 1,000 Hz tone judged to be as loud. Originally devised in the late 1930's the phon is now less commonly used in building acoustics due to the more universal use of ***dB(A).***

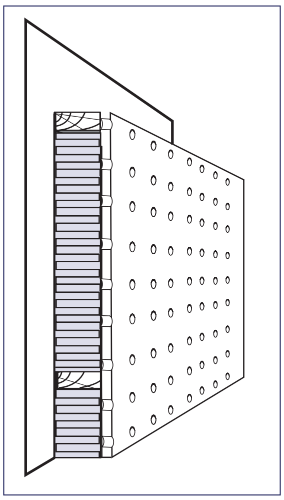
Pink Noise

Broadband (electronically generated) noise, whose energy content is equal per frequency bandwidth, that is often used as a sound source for acoustic measurements.

Pitch

The subjective auditory sensation in response to the ***frequency*** of sounds on a scale from low to high. The higher the frequency the higher the pitch and when a frequency is doubled the corresponding pitch is raised by one octave.

Porous Absorber



A particular form of sound absorber typified by an open structured material with interconnected voids that allows, but presents resistance to, the flow of sound waves through it. The incident sound waves cause motion of the air within the material's pores, and hence frictional losses that result in dissipation of sound energy by conversion into heat.

Porous absorbers are more effective at middle to high frequencies (>500Hz) and their efficiency is determined by thickness, porosity and flow resistance. They are typified by common materials such as:

- Carpets.
- Draped Curtains.
- Man Made Mineral Fibre Quilts and Slabs.
- Open Cell Plastic Foams.
- People (clothes).
- Open weave fabric upholstered furniture.
- Mineral Fibre Ceilings.

Porous absorbers tend not to be very durable and, in the case of mineral fibre layers or plastic foams, not very attractive or easily maintained. When used as wall linings or in similar exposed locations, where they may be subject to wear and tear, these materials may need to be protected with more durable but still acoustically transparent facings. Suitably detailed treatments such as open weave fabrics, perforated metal or wood based sheets, expanded metal lath, timber slats, or similar open faced coverings may provide acceptable protection while still allowing maximum sound absorption.

See ***Absorber Response Curve.***

Practical Sound Absorption Coefficient, α_p

See ***Weighted Sound Absorption Coefficient.***

Privacy Index, PI

This is another useful measure for ***speech privacy*** and is expressed as a percentage value which can be calculated from the ***Articulation Index (AI)*** as follows:

PI = (1 - AI) x 100%

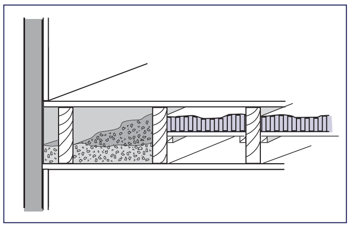
Defined in ASTM E 1130, PI values of 95% or more provide confidential speech privacy while normal speech privacy corresponds to PI values of between 80 and 95%.

Public Address

An electronic amplification system installed and used for broadcasting voice messages (and possibly background music) in public areas.

See ***Electro acoustics.***

Pugging



A loose-fill material inserted into the joist cavity of a lightweight timber floor in order to improve its sound reduction properties. Dry sand, gravel, ash or dense granular man made mineral fibre have been used and the material is either laid onto the rear of the ceiling or supported on boards fixed between the joists. Performance tends to increase with mass but care must taken in order to ensure that the floor/ceiling structure is not weakened or overloaded by the material chosen or that a subsequent accidental ingress of water or moisture may be absorbed by it.

Pure Tone

A sound generated at one particular frequency only.

PWL

See ***Sound Power Level.***

R

R

See ***Sound Reduction Index.***

R_m

See ***Mean or Average Sound Reduction Index.***

R_w

See ***Weighted Sound Reduction Index.***

R'_w

See ***Weighted Apparent Sound Reduction Index.***

Random Incidence Sound Absorption Coefficient, α_s

A measure of ***sound absorption*** derived from tests undertaken in a ***reverberation chamber*** of an ***acoustics laboratory***, over the one-third octave frequency bands 100-5000Hz, in accordance with EN ISO 354 or ASTM C 423. These are obtained under ***diffuse field*** conditions where sound is striking the test specimen from all (random) directions and are the coefficients that are used for calculations and assessments in architectural and building acoustics.

Random Incidence Sound Scattering Coefficient, s

A measure of sound scattering (sound which is not specularly reflected) derived from tests undertaken in a reverberation chamber of an acoustics laboratory, over the one-third octave frequency bands 100-5000Hz, in accordance with ISO 17497. These are obtained under diffuse field conditions where sound is striking the test specimen from all (random) directions and define the fraction of scattered sound energy that is uniformly diffused. They can be useful in room acoustic calculations, simulations and prediction models.

RASTI

Rapid **S**peech **T**ransmission **I**ndex - RASTI is a computer based method for relatively easily determining the ***speech transmission index (STI)*** that is used to assess the speech intelligibility within an enclosure particularly from public address (PA) or other sound reinforcement systems. Using dedicated transmitting and receiving instrumentation, RASTI measurements are made at 500Hz and 2000Hz and take into account the ***background sound*** and ***reverberant sound*** components present.

Speech Transmission Index	Perceived Intelligibility
0.00 - 0.30	Bad
0.30 - 0.45	Poor
0.45 - 0.60	Fair
0.60 - 0.75	Good
0.75 - 1.00	Excellent

There is a correlation between speech transmission index and perceived intelligibility as in the shown table.

Rating of Sound Absorption

See ***Weighted Sound Absorption Coefficient.***

Rating of Sound Insulation

Most measurements of airborne or impact sound insulation, whether ***field*** or laboratory, are conducted over a range of frequencies so as to obtain a detailed picture of performance. If these are made in accordance with national or international standards then at least 18 individual ***one-third octave band*** measurements over the range 100-5000 Hz should be obtained.

For specifiers, who are trying to compare the performance of alternative building products, or for suppliers of product data, such a large range of values can be too cumbersome and make comparisons awkward. A single-number rating (that distils the wide range of measurement results into a single value) is therefore more appealing and easily handled.

A simple arithmetic average (adding up all the values in the range and dividing by the number in the range) has been used, see ***Average Sound Reduction Index,*** but the final result can be misleading in that it takes no account of the shape of the ***frequency*** spectrum. Using this averaging method, three entirely different shaped spectra could all have the same average value.

Consequently specific rating methods have been devised and introduced that do take into account the spread of measurements, against frequency, by comparing them with a standard curve. Also, as the standard curves adopted are chosen so as to broadly simulate the human response to sound, the values obtained generally correlate well with the subjective impression of common internal noise sources.

See EN ISO 717-1 & 717-2 and ASTM E413 & E989 for further details of the rating methods and procedures.

RC

See ***Room Criterion Curves.***

Reduction of Impact Sound Pressure Level, ΔL, ΔL’

For any given one-third octave band, this is the reduction in ***normalized impact sound pressure level,*** resulting from the installation of a test floor covering. It is determined in accordance with EN ISO 140-8 or 140-11 for laboratory measurements (ΔL) and EN ISO 140-7 for ***field*** measurements (ΔL').

Resilient floor coverings such as carpets and sheet vinyl with a foam underlayer (the thicker the better) or ***floating floors*** can help to reduce the transmission of impact sound.

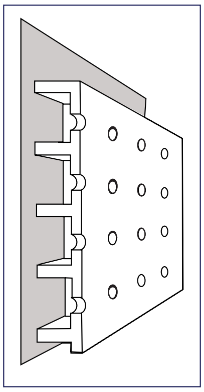
Reflection Coefficient

The fraction of sound energy returned into a room after a sound wave strikes a boundary surface. The fraction not returned to the room is the ***sound absorption coefficient.***

Regenerated Noise

Is the noise generated, within ventilation system ductwork or terminals, by the action of high velocity turbulent airflow (normally at bends, constrictions or obstructions), as distinct from the noise that is generated by the prime sound source fan(s).

Resonant Absorber



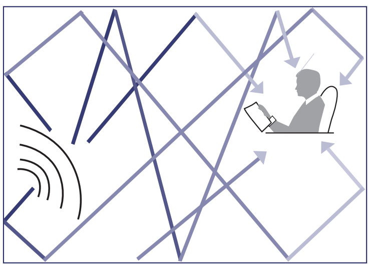
An enclosed cavity, connected by a narrow opening to a space containing a sound source, can be caused to resonate over a narrow range of frequencies by sound that is incident upon it. Oscillations in the neck of the opening cause sound energy to be dissipated into heat by frictional losses and hence sound absorption results. If porous absorbent (damping) material is included in the cavity, the range of absorbing frequencies can be broadened although the peak level of the absorption achieved will be reduced.

Resonant absorption often occurs as a consequence of using perforated plates as facings to ceiling and wall lining products although it is rare for purpose designed resonant absorbers to be included specifically in acoustic design solutions.

Resonant absorbers may also be called **Cavity** or **Helmholtz** absorbers.

See ***Absorber Response Curve.***

Reverberant Sound (Pressure Level)



The component of a ***sound field*** due to the continued reflections of sound from the surfaces or obstacles of an enclosure. In most internal spaces reverberant sound is more dominant spatially than ***direct sound*** and hence can be controlled by sound absorption.

An approximate indication of the reverberant sound pressure level (frequency dependent) can be determined from the expression:

$L_{pr} = L_w - 10 \log_{10} A + 6dB$

However if the room volume and reverberation time are known, this expression translates to:

$L_{pr} = L_w - 10 \log_{10} V + 10 \log_{10} T + 14dB$

where:

L_{pr} = reverberant sound pressure level
L_w = source sound power level
A = total room sound absorption, m^2
V = room volume m^3
T = reverberation time, seconds

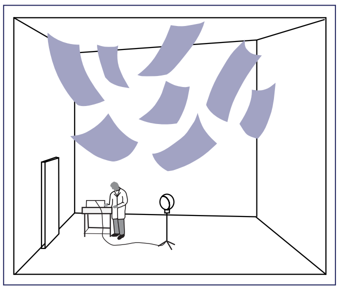
Reverbertion

The persistence of sound in an enclosure, due to its continued reflection or scattering from surfaces or objects, after the sound source has ceased. Reverberation is heard as a blend of all the reflected sounds occurring within the first 35 - 40 milliseconds or so which the ear and brain does not discriminate from the ***direct sound.*** This should not be confused with echoes which are discrete late arrival (>70 milliseconds) sounds which are heard distinctly and separately from the direct sound.

Reverberation is of significance in determining the quality and level of sound in an enclosure.

See ***Reverberation Time and Acoustic Faults.***

Reverberation Chamber



A room within an ***acoustics laboratory*** that is designed to provide a highly ***diffuse sound*** field over the frequency range of interest and is characterised by being highly ***reverberant.*** This is ideally achieved by designing the room with an irregular plan so that no two opposite walls are parallel to each other and by ensuring that all of the room boundary surfaces are highly reflective to sound. In addition diffusing elements, that help to randomly scatter the reflected sound, may be suspended from the ceiling (like floating clouds) or fixed to the walls.

Reverberation Time, T

This is the time, in seconds, required for reflecting or reverberant sound in an enclosure to decay to one-millionth (equivalent to a drop of 60dB) of its original energy level after the cessation of the sound source.

It is the most common (and easily obtained) measurement or predictor of a room's potential sound quality. The reverberation time for rooms intended primarily for speech needs to be reasonably short otherwise successive speech sounds will overlap with a consequential loss of intelligibility. However when music is played, particularly of the classical type with unamplified instruments, then the room will benefit from a longer reverberation time with a blending of successive notes and the resulting fullness of tone.

T is frequency dependent and is normally measured in ***one-third octave*** or ***octave bands***. It can also be predicted using the ***Sabine*** or ***Eyring Formulae***.

The symbols RT or T_{60} are also in common usage to designate reverberation time.

See ***Optimum Reverberation Time*** for recommended values.

Room Criterion Curves, RC

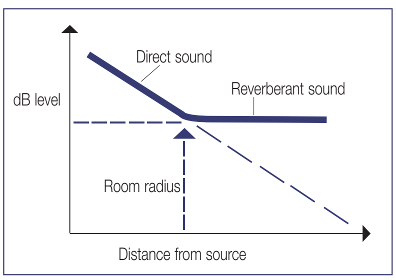
See ***Noise Criterion Curves.***

Room Radius, r

Within an enclosure, this is the distance from the sound source where the ***direct and reverberant sounds*** are of equal ***sound pressure level.*** It may also be known as the **Critical Distance**.

Closer to the source than the room radius, the direct sound will dominate, while further from the room radius the reverberant sound will be more significant. Therefore if sound absorptive treatments are to be introduced to control noise levels, they should be placed in the reverberant field so as to achieve maximum effect.

An approximate indication of the room radius can be found from the expression:



$$r = \sqrt{\frac{A}{16\pi}}$$

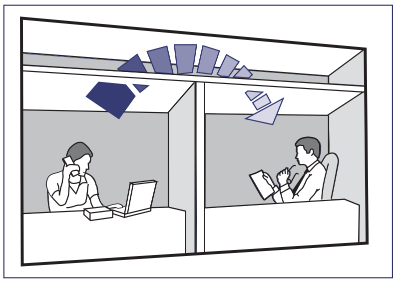
where:

r = room radius, metres

A = total room sound absorption in m^2

See ***Sound Field.***

Room-to-Room Sound Insulation



The term normally used to describe the ***level difference, noise reduction or ceiling attenuation*** between adjacent rooms via the suspended ceilings and common void above them. It could also be applied to the transmission process via a raised floor and the common void beneath.

RT

See ***Reverberation Time.***

S

Sabin (Sabine)

A measure of sound absorption of a material that is the product of its surface area S, multiplied by its ***random incidence sound absorption coefficient*** α_s.
One metric Sabin unit is equal to 1 m^2 of a surface having an absorption coefficient of 1.0, ie, perfect absorption. However in North America, where Imperial measurements are still used, a Sabin may be equivalent to 1ft^2 of a surface having an absorption coefficient of 1.0.

A Sabine (ending e) appears to be in usage as the metric unit, probably so as to differentiate it from the imperial unit Sabin.

Originally called ***"open window unit"***, because an open window absorbs all sound incident upon it and hence has a coefficient of 1.0, it was subsequently renamed in memory of W C Sabine (***see Sabine Equation***).

Sabine Equation

This is a relationship between the volume of a room and the ***total room absorption*** present, to its ***reverberation time*** and is defined as:

$$T = \frac{0.16V}{A}$$

where:

T = reverberation time in seconds

V = room volume in m^3.

A = total room absorption in m^2

or:

$$T = \frac{0.05V}{A}$$

where:

T = reverberation time in seconds

V = room volume in ft^3.

A = total room absorption in ft^2

In other technical references the constants in these equations may sometimes be expressed as 0.161 or 0.163 (metric) or 0.049 (imperial). However for practical Building acoustics such precision may be considered unnecessarily pedantic when it is realised that the hearing acuity for normal people cannot differentiate reverberation times or sound levels in fractions of seconds or tenths of decibels.

Implicit in the derivation and use of this formula is the assumption that a diffuse sound field is present, which in effect means that the average sound absorption coefficient is small compared with unity (typically ≤0.25), and that the sound absorptive materials are evenly distributed throughout the room. This is not always the case and therefore in circumstances that exceed these limitations, an alternative reverberation time prediction method is necessary such as the ***Eyring*** equation.

However because of its simplicity for calculations, the Sabine equation is the one most commonly used, accepting that there is a limitation to its accuracy for some applications.

The equation was first derived by Wallace Clement Sabine (1868-1919), an American Physicist and Acoustician, who is undoubtedly considered as the father of modern Architectural Acoustics.

Scattering Coefficient

See ***Random Incidence Sound Scattering Coefficient***

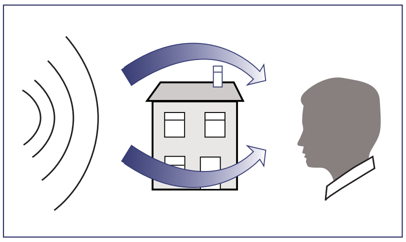
Shape Indicators (L, M or H)

See ***Weighted Sound Absorption Coefficient.***

Silencer

See ***Attenuator.***

Sound



Sound is a form of energy that radiates out from a source as a series of multiple pressure variations through air or other elastic medium. If the pressure variations are of sufficient amplitude and frequency when they reach and stimulate our ears, we experience the sensation of hearing.

We may also be familiar with changes of air pressure, and its effect on weather patterns, every time that we look at a barometer. However these variations are far too slow for the human ear to detect and hence would not be defined as sound.

Sound energy can also transmit through structures in the form of ***vibration***, that we may be able to feel, and then can become a further source of radiating sound that is subsequently heard.

For sound to exist, three essential components are necessary:

1. A radiating source
2. An elastic transmitting medium
3. A listener or receiver

Therefore any attempt at the control of sound must address the reduction or isolation of one or more of these components.

See ***Hearing.***

Sound Absorption

Is the loss of sound energy when striking or transmitting into a boundary surface material or obstacle or when causing a volume of air to resonate. The reduction of energy is generally due to dissipation into heat by friction but it may also be lost when sound passes into adjacent areas, or to the outside through an opening, and does not return.

Most materials absorb sound to a greater or lesser extent and the more common forms of sound absorbers can be conveniently classified into three main types such as:

Porous or dissipative.

Panel or membrane.

Resonant or Helmholtz or Cavity

More recently new forms of engineered sound absorbers, using thin micro-perforated plates and films, and thin non-woven porous tissues, have become available. Their performance can optimised by selecting specific values for their flow resistance, and spacing in front of reflective surfaces.

Additionally sound can also be absorbed within air although this is only significant at high frequencies and is dependent upon temperature and humidity.

Increasing the sound absorption within an enclosure will result in a reduction of the (frequency dependent) reverberant sound pressure level and reverberation time. Conversely reducing the sound absorption will result in an increase in the reverberant sound pressure level and reverberation time. The change can be calculated from the expression:

$\Delta L_p = 10\log_{10} (A_2 / A_1)$ dB or $\approx 10\log_{10} (T_2 / T_1)$ dB

where

ΔL_p = sound pressure level change
A_2 = total room sound absorption after treatment
A_1 = total room sound absorption before treatment

or

T_2 = reverberation time after treatment
T_1 = reverberation time before treatment

Effectively this shows that doubling or halving the ***total room absorption***, or the reverberation time, will result in a 3dB change in the ***reverberant sound pressure level***. See ***Sabin, Sound Absorption Coefficient.***

Sound Absorption Class (A to E)

See ***Weighted Sound Absorption Coefficient.***

Sound Absorption Coefficient, α

For a given material, this is the fraction of incident sound energy that is absorbed at its surface. Expressed as a value between 1.0 (perfect absorption or no reflection) and zero (total reflection or no absorption), **α** varies with frequency and the angle of incidence.

See ***random incidence sound absorption coefficient.***

Sound Absorption Unit

See ***Sabine.***

Sound Attenuation

1. A term used in relation to the room-to-room transmission of sound via a common ceiling plenum. See ***Suspended Ceiling Normalized Level Difference***, EN 20140-9 & ASTM E 1414.

2. A general term relating to the reduction in transmission of sound pressure levels between one internal area or location and another. Equivalent to ***level difference*** or ***noise reduction***.

3. The reduction of noise levels associated with airflow within ventilation equipment and ductwork systems.

Sound Conditioning

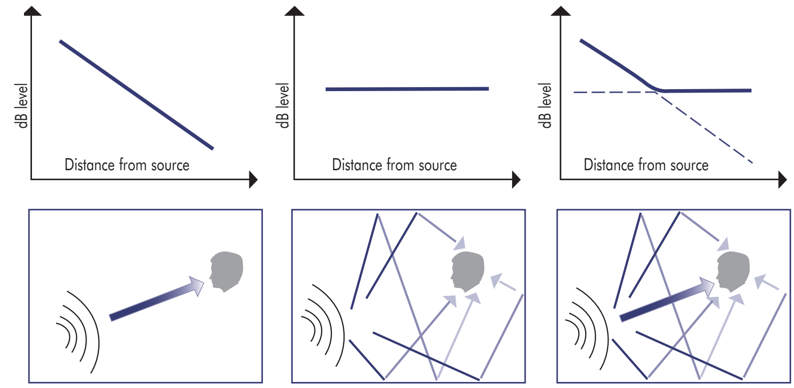
See ***Sound Masking.***

Sound Field

The sound field, due to a source within an enclosure, consists of ***direct sound*** and ***reverberant sound*** and the ***sound pressure level*** at any point will be the sum in decibels of both components.

Close to the source the direct field is likely to be the more dominant but this will reduce in level with increasing distance from the source. However the reverberant field, which is determined by the room volume and the amount and distribution of sound absorbing finishes present, remains relatively constant throughout the space. The distance at which both the direct and reverberant sound fields are of equal level is termed the ***room radius***.

'Soundfield' is also a term used to describe speech reinforcement systems, used particularly in teaching spaces, to enhance ***speech intelligibility***.



Direct sound | Reverberant sound | Combined sound

Sound Insulation

A general term describing the reduction of airborne and structure borne sound between separate spaces.

Sound Intensity

The sound intensity due to a source is the mean rate of acoustic energy flow, through unit area, perpendicular to the direction of propagation.

In building acoustics the practical use of sound intensity has traditionally had less significance than ***sound power*** (the acoustic energy that a source produces) or ***sound pressure*** (what we hear or measure). However more recently techniques and instrumentation have been developed which enable more accurate on-site determination of the sound reduction of building barriers by the use of sound intensity measurements. See ISO 15186-2 for field measurement procedure.

Sound Intensity Level, L_I

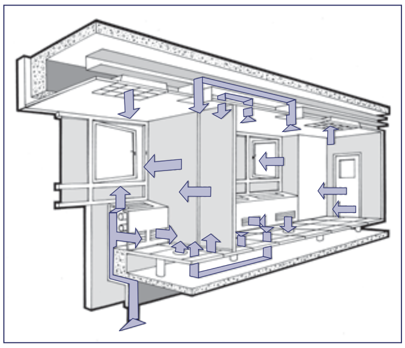
The sound intensity level (decibels) is 10 times the logarithm, to the base ten, of the ratio of a given sound intensity to a reference sound intensity The reference level is 10^{-12} Watts/m^2.

Sound Leaks

This is the ***airborne sound*** transmission via gaps or cracks around or through building elements and services that allow sound to escape from one area to another adjacent area, and thus lower the element's potential sound reduction.

Typical (although not the only) sound leak paths include:

- Through key holes or air vents within doors, or around their edges if good frame and threshold acoustic seals are absent.



- Poorly sealed openings within walls or floors through which pipes, ducts, wiring or similar distribution services pass.
- Junctions at the perimeter, and joints between the modular elements, of partitions, ceilings and raised floors which are not adequately sealed.
- Recessed air-handling luminaires within the suspended ceiling to a common ceiling plenum above adjacent areas.
- Recessed continuous lighting troughs or linear air diffusers, within the suspended ceiling, that span across a common partition.
- Ventilation grilles or diffusers that share common ductwork systems or are connected to each other via a common ceiling or raised floor air moving plenum (***cross-talk***).
- Continuous perimeter piped heating or power/data cable conduit systems which run behind partitions.
- Continuous perimeter curtain walling and internal lining systems.

See ***Flanking Sound.***

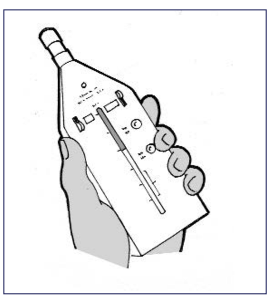
Sound level

A value of ***sound pressure level*** determined by measurement with a ***sound level meter*** or by calculation, with a standard frequency weighting such as the ***A-weighting*** applied.

Typical dB(A) sound levels for various environments together with an indication of possible subjective reaction and values of sound pressure and relative energy are given in the following table:

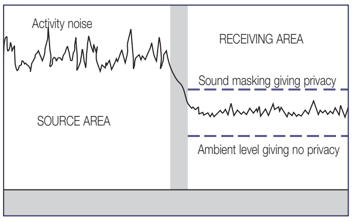
Subjective Reaction	Sound Level dB(A)	Relative Energy	Sound Pressure, Pa	Typical Experience
	140	100,000,000,000,000	200	Threshold of Pain
Intolerable	130	10,000,000,000,000	63	Concorde take-off - 100m
	120	1,000,000,000,000	20	Unsilenced Pneumatic Drill - 1m
Deafening	110	100,000,000,000	6.3	Discotheque Dance Floor
	100	10,000,000,000	2	Inside a Tube Train
Very Loud	90	1,000,000,000	.63	Inside a Bus
	80	100,000,000	0.2	Kerbside of Urban High Road
Loud	70	10,000,000	0.063	TV - Normal Listening Level
	60	1,000,000	0.02	Conversational Speech - 1m
Moderate	50	100,000	0.0063	Library Background
	40	10,000	0.002	Theatre Background
Quiet	30	1,000	0.00063	Concert Hall Background
	20	100	0.0002	Audiometry Room Background
Very Quiet	10	10	0.000063	Threshold of Audibility
	0	1	0.00002	

Sound level Meter

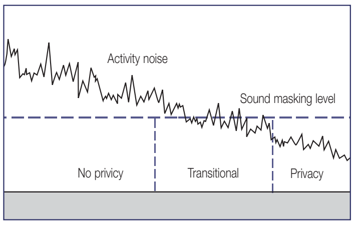


An electronic instrument that measures the amplitude level of sounds in decibels and, via an electronic filter, weighted values such as ***dB(A)***. Some instruments can also measure the frequency of sound in ***one-third octave*** and/or ***octave bands*** while others can also determine the time varying characteristics of sound.

Sound Masking



Cellular office



Open plan office

Internal multi-occupancy spaces like open plan offices, or cellular offices with low sound insulation between them, often suffer from poor acoustic conditions. This results in disturbance due to the persistence of fluctuating activity noise, and also because of poor ***speech privacy*** (high levels of unwanted ***speech intelligibility***) between working zones. Such problems may be mitigated by the use of sound masking.

This term describes electronically generated sound, of a specified level and frequency content, that is beneficially introduced into such environments (normally by an array of loudspeakers concealed in the ceiling void or within the ceiling plane) to provide ***masking*** of the fluctuating noise and to enhance ***speech privacy***.

Occasionally mechanically generated sound from ventilation system grilles may be used to provide masking, but these sources tend to be unreliable as the level and frequency content of the sound cannot usually be adequately (and consistently) controlled.

Often incorrectly referred to as ***White Noise***, Sound Masking may be also termed **Sound Conditioning.**

Sound Power

The sound power of a source is the rate at which acoustic energy is transferred from a vibrating source to an elastic medium. The greater the sound power of a source the higher will be the sound pressure measured at a specific distance from the source.

Sound Power Level, L_w

The sound power level (decibels) is 10 times the logarithm, to the base ten, of the ratio of a given sound power to a reference sound power. The reference level is 10^{-12} Watts.

Sound Pressure

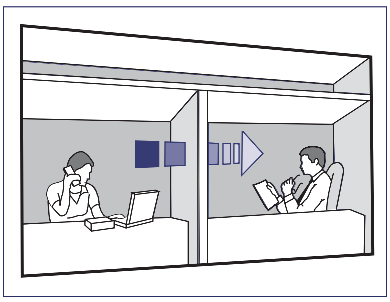
The sound pressure due to a source is the amplitude of the pressure variations in a ***sound wave.***

Sound Pressure Level, L_p

The sound pressure level (decibels) is 10 times the logarithm, to the base ten, of the square of the ratio of a given sound pressure to a reference sound pressure. The reference level is 20 μPa.

See ***Sound Level*** for typical values.

Sound Reduction Index, SRI or R



The property of a dividing barrier (wall, partition, door, window or floor etc) that characterises its ability to reduce the level of sound transmitting through it.

It is determined from acoustic laboratory measurements made in accordance with EN ISO 140-3, when the barrier is mounted between two reverberant chambers, using the expression:

SRI = $L_1 - L_2 + 10 \log S - 10 \log A$ dB

where:

L_1 = average sound pressure level in the source room

L_2 = average sound pressure level in the receiving room

S = area of the barrier common to both rooms, m^2

A = total receiving room absorption with the barrier in place, m^2

Since SRI is a function of frequency, it is desirable that the measurements are made over the one-third octave frequency bands 100-5000Hz.

Equivalent to ***Sound Transmission Loss.***

Sound Transmission Class, STC

A single-number rating, expressed in decibels, of laboratory measured frequency dependent airborne sound insulation properties of a dividing barrier.

It is determined by reference to ASTM E 413 from measurements of ***sound transmission loss*** made in accordance with ASTM E 90 over the one-third octave frequency band range 125-4000Hz.

This USA based system is principally used in North America and Australia but references to it may also be seen in Europe and the Far East.

STC is similar to ***Weighted Sound Reduction Index, R_w.***

Sound Transmission Loss, TL

The property of a dividing barrier (wall, partition, door, window or floor etc) that characterises its ability to reduce the level of sound transmitting through it.

It is determined from acoustic laboratory measurements made in accordance with ASTM E 90, when the barrier is mounted between two reverberant chambers, using the expression:

$TL = L_1 - L_2 + 10 \log S - 10 \log A$ dB

where:

L_1 = average sound pressure level in the source room
L_2 = average sound pressure level in the receiving room
S = area of the barrier common to both rooms, m^2
A = total receiving room absorption with the barrier in place, m^2

Since TL is a function of frequency, it is desirable that the measurements are made over the one-third octave frequency bands 100-5000Hz.

Equivalent to ***Sound Reduction Index.***

Sound Wave

A pressure disturbance in air transmitting at a finite velocity, (approximately 345m/sec at 21°C) that results from the activity of a sound source. Continuous ***broadband sound*** consists of a consecutive series of waves of many frequencies.

Spectrum Adaptation Terms, C and C_{tr}

The single-number rating method defined in EN ISO 717-1 uses a standard reference curve to determine the weighted value of airborne sound insulation. In addition, the spectrum adaptation terms C and C_{tr} can also be evaluated to take into account different source spectra as indicated in annex A of EN ISO 717-1.

C is an A-weighted ***pink noise*** spectrum, while Ctr is an A-weighted urban traffic noise spectrum.

Speech Intelligibility

This is a general term that characterises the comprehension of verbal communication, whether naturally spoken or broadcast by an electronic amplified system, that is based upon the identification and understanding of words and phrases and the vowels and consonants that they contain. Generally it is the consonants of speech that contain the information while the vowels contribute more to the power of the sound.

The most important aspects that affect speech intelligibility (or ***speech privacy***) are:

1. The loudness of the speech signal.

2. The level of the background sound at the listening position (because it may ***mask*** the received speech level).

3. The reverberation time at the listening position (because, if it is too long, intelligibility will be reduced).

Other factors such as the articulation of the speaker, familiarity that the listener may have with the received message, the hearing acuity of the listener, and any emotional effect that the message may invoke can also be relevant. Also, in the case of direct (face-to-face) communication, facial expressions and body gestures can also reinforce the message.

The calculation or measurement of speech intelligibility can be determined by a number of different methods including ***Alcons, Articulation Class, Articulation Index, RASTI, Speech Interference Level and Speech Transmission Index.***

See ***Articulation Index*** for a table of speech intelligibility values.

Speech Interference Level, SIL

	Maximum distance at which conversation is considered to be satisfactorily intelligible	
Speech Interference Level dB	**Normal Voice meters**	**Raised Voice meters**
35	7.5	15
40	4.2	8.4
45	2.3	4.6
50	1.3	2.6
55	0.75	1.5
60	0.42	0.85
65	0.25	0.50
70	0.13	0.26

This is an evaluation method, which may be considered as a simplified alternative to ***Articulation Index***, for assessing the interfering (***masking***) effects of noise on speech. SIL is derived by calculating the arithmetic average of the four ***octave band*** sound pressure levels of the noise at the frequencies 500, 1000, 2000 and 4000Hz. The probable effect of SIL can be evaluated as in the shown table.

Speech Levels

Vocal Effort	Male, dB(A)	Female, dB(A)
Casual	53	50
Normal	58	55
Raised	65	62
Loud	75	71
Shouting	88	82

Speech is a continuously changing pattern of sound waves that vary widely in terms of both sound pressure level and frequency content. In addition, the occurrence of the speech sounds will fluctuate depending upon the nature and content of the spoken dialogue.

However studies, using measured values for male and female speakers in quiet free field conditions, show A-weighted (LA_{eq}) sound levels at 1 metre in front of the speaker for different vocal efforts as shown.

For detailed speech spectra which can be used in the calculation of the ***Articulation Index*** **see ASTM E1330**

Speech Privacy

In effect this is the reverse of ***Speech Intelligibility*** and describes the situation where someone speaking does not wish to be overheard by those around them. Hence high levels of sound reduction afforded by barriers and/or the use of ***Sound Masking***, are desirable.

Speech privacy (which implies low levels of speech intelligibility) should be considered between adjacent spaces such as executive offices, medical consulting rooms, personnel meeting rooms etc, and may be necessary between cellular offices, open plan office work zones and similar situations.

Speech Transmission Index, STI

Is a complex method for measuring speech intelligibility, primarily from a speech reinforcement system, over a wide range of frequencies. Because of its complexity and the large amount of data processing necessary to obtain the information required, a more simplified procedure known as ***RASTI*** (rapid speech transmission index) is more often used.

Speech of Sound, c

The speed of sound waves in air is dependent upon temperature and can be determined using the formula:

c (metres per second) = 332 + 0.6 (temperature °C)

Therefore at a temperature of 21°C the speed of sound in air is approximately 345 metres per second (1240 kph or 770 mph).

In solids, waves transmit at speeds of about ten to fifteen times greater than in air but this does vary between materials.

SPL

See ***Sound Pressure Level.***

SRI

See ***Sound Reduction Index.***

Standardized Impact Sound Pressure Level, L'_{nT}

This is the corrected value of ***field measured impact sound pressure level*** to take into account the sound absorption of the receiving room

Defined in EN ISO 140-7 as:

$L'_{nT} = L_i - 10\log_{10} (T/T_0)$ dB

where

L_i = measured impact sound pressure level
T = reverberation time in the receiving room
T_0 = reference reverberation time (normally taken as 0.5 seconds)

Therefore the standardized impact sound pressure level is that which exists if the ***reverberation time*** in the receiving room is 0.5 seconds.

Standardized Level Difference, D_{nT}

The corrected value of field measured ***level difference*** between two rooms, to take into account the reverberation time of the receiving room.

Defined in EN ISO 140-4 as:

$$D_{nT}=D+10\log_{10}\frac{T}{T_0} \text{ dB}$$

where

D = measured level difference
T = reverberation time in the receiving room
T_o = reference reverberation time (normally taken as 0.5 seconds)

Therefore the standardized level difference is that which exists if the ***reverberation time*** in the receiving room is 0.5 seconds.

Standing Wave Tube

This is a bench-top apparatus (defined in EN ISO 10534 & ASTM C 384) that provides a method for measuring sound absorption coefficients of small (typically up to 100mm diameter) material samples. However the values obtained using this method are determined at a specific angle of incidence (normally 90°) to the sample and therefore these results cannot be used for direct comparison with ***random incidence sound absorption coefficients*** that are obtained in a ***reverberation chamber*** and described in EN ISO 354 or ASTM C 423.

A standing wave tube may also be termed an **Impedance Tube**.

Statistical Time Varying Sound Pressure Level, L_T

For noise levels that may vary widely with time, for example road traffic noise or environmental noise, it is necessary to employ an index that takes into account such temporal variations. The $L_{10,}$ the level exceeded for ten per cent of the time period under consideration, may be considered to represent an "average maximum level" and is often used for the assessment of road traffic noise. The $L_{90,}$ the level exceeded for ninety per cent of the time, is normally used to represent the background sound level. The $L_{1,}$ the level exceeded for one per cent of the time, is representative of the maximum levels recorded during the sample period. These indices may be applied to the A-weighted dB (L_{AT}) or to sound pressure, eg octave band, dB levels.

STC

See ***Sound Transmission Class.***

STI

See ***Speech Transmission Index and RASTI.***

Structure Borne Sound

Sound energy that is transmitted through structures as opposed to that which transmits through the gases (air) or fluids.

See ***Vibration.***

Suspended Ceiling Normalized Level Difference, D_{nc}

The laboratory measured frequency dependent ***level difference*** of a suspended ceiling sharing a common ceiling plenum above adjacent rooms that is corrected to take into account the sound absorption of the receiving room.

Defined in EN 20140-9 as:

$D_{nc} = D - 10\log_{10} (A/A_0)$ dB

where

D = measured level difference
A = total sound absorption in the receiving room in m^2
A_o = reference sound absorption (normally taken as $10m^2$)

Therefore the normalized level difference is that which exists if the sound absorption in the receiving room is $10m^2$.

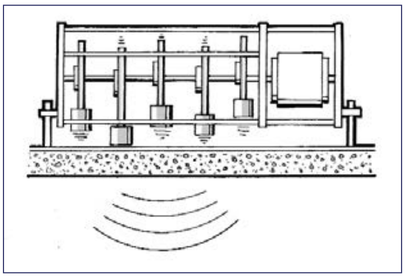
D_{nc} is similar to ***Normalized Ceiling Attenuation***.

T

T or T_{60}

See ***Reverberation Time.***

Tapping Machine



This is a portable electro-mechanical device used as a standardized impact sound source to rate the ***normalized sound pressure levels*** or ***impact noise insulation*** of floors. The machine has five reciprocating steel or brass hammers that are successively dropped from a height of 40mm to strike the floor surface at a rate of 10 impacts per second. The equipment is described fully in EN ISO 140-6, 140-7 or 140-8.

Threshold of Audibility

The minimum sound pressure level that will stimulate the sensation of hearing for a given listener at a particular frequency. Any sound below this level would therefore be inaudible.

Threshold of Pain

The minimum sound pressure level that will stimulate a sensation of pain for a given listener.

Total Room Absorption, A

The sound absorption within a room used in ***reverberation time, level difference and sound pressure level*** calculations.

It is obtained by multiplying each room surface or object by its ***random incidence sound absorption coefficient*** for each frequency band of interest together with air absorption if significant, ie:

$A = S(S_1 \times \alpha_1)+(S_2 \times \alpha_2)+(S_3 \times \alpha_3)+(O_1 \times \alpha_1)+ (V\alpha)$ etc

where:

S = surface area m^2

α = frequency dependent sound absorption coefficient

$O\alpha$ = object sound absorption

$V\alpha$ = volume dependent air absorption

Transmission Loss

See ***Sound Transmission Loss.***

Transmission Suite

A pair of rooms (either horizontally or vertically located) within an ***Acoustics Laboratory*** designed for the measurement of ***airborne*** and ***impact sound*** reduction of building elements to national and international standards.

The rooms will usually have ***reverberant*** conditions and be isolated from each other by incorporating structural details so as to reduce the effects of ***flanking sound*** transmission to insignificant levels.

UV

UKAS

The **U**nited **K**ingdom **A**ccreditation **S**ervice is recognised by government to assess, against internationally agreed standards, organisations that provide certification, testing, inspection and calibration services.

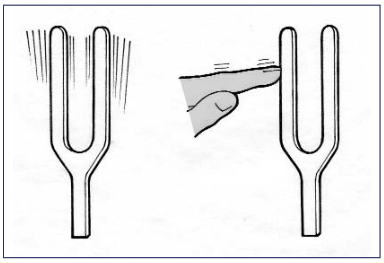
Similar third party accreditation schemes exist in other European and International countries.

Ultrasound

These are the pressure fluctuations that occur above the upper end of the audible frequency range ie > 20000 Hz.

See ***Infrasound.***

Vibration



Is the oscillatory (backwards and forwards) movement of a solid body about a reference position. If the movements are of sufficient amplitude and ***frequency*** then sound will be generated.

Vibrations can often be felt and sometimes seen. For example, a tuning fork, when struck, generates sound while the prongs can be seen to vibrate rapidly. Even when the vibrations are no longer visible, they can still be felt by placing a finger close to the prongs. Vibration transmitted through structures may be termed ***structure borne***.

Vibration Isolation

The use of devices such as steel springs, rubber mounts or similar resilient materials used to support a vibrating source or structure and thus minimise the transmission of its vibration energy into the surrounding structure.

Vibration Isolator

A device or material that provides ***vibration isolation***.

Voice Alarm (VA)

May also be termed voice evacuation and is an ***electro acoustics*** system which alerts people to an emergency (fire, terrorist threat etc) in a clear and unambiguous manner with the minimum of delay. Studies have shown that VA messages result in quicker recognition times and less stress than when bells or sirens are used, and that live announcements result in faster response than those from recordings.

W

Wavelength, λ

The distance that a ***sound wave*** travels in one cycle. This is equal to the speed of sound in the medium (345 metres per second in air at 21oC) divided by the frequency, ie

$$\lambda = \frac{c}{f} = \frac{\text{speed of sound}}{\text{frequency (Hz)}}$$

As examples, the wavelengths for various frequencies are:

100Hz = 3.45m

1000Hz = 345mm

10000Hz = 34.5mm

Weighted Apparent Sound Reduction Index, R'_w

A single-number rating, expressed in decibels, of the laboratory or field frequency dependent measurement of airborne sound insulation between rooms, that may include the influence of ***flanking sound***.

It is determined by reference to EN ISO 717-1 from measurements of apparent sound reduction index made in accordance with EN ISO 140-3 or 140-4 over the third-octave band frequency range 100-3150Hz.

R'_w is similar to ***Field Sound Transmission Class, FSTC***.

Weighted Level Difference, D_w

A single-number rating, expressed in decibels, of the field measurement of frequency dependent airborne sound insulation between rooms.

It is determined by reference to EN ISO 717-1 from measurements of ***level difference*** made in accordance with EN ISO 140-4 over the third-octave band frequency range 100-3150Hz

D_w is similar to ***Noise Insulation Class, NIC.***

Weighted Reduction of Impact Sound Pressure Level, ΔL_w

A single number rating, expressed in decibels, of the difference between the ***weighted normalized impact sound pressure levels*** of a reference floor with and without a floor covering.

It is determined by reference to EN ISO 717-2 from measurements of ***normalized impact sound pressure level*** made in accordance with EN ISO 140-7 or 140-8 over the third-octave band frequency range 100-3150Hz.

This rating can be considered as an indication of the impact insulation value of the floor covering, the higher the rating, the better is its performance.

Weighted Normalized Impact Sound Pressure Level $L_{n,w}$ (laboratory)

A single-number rating, expressed in decibels, of laboratory measured frequency dependent impact sound insulation of a floor/ceiling assembly using a standardized ***tapping machine***.

It is determined by reference to EN ISO 717-2 from measurements of ***normalized impact sound pressure level*** made in accordance with EN ISO 140-6 over the third-octave band frequency range 100-3150Hz.

It should be noted that with impact sound pressure levels, the higher the resulting number, the lower is the sound insulation performance of the structure, and vice versa.

$L_{n,w}$ values cannot be compared directly to ***Impact Insulation Class IIC*** as with the latter method the larger the IIC value, the higher is the degree of impact sound insulation performance.

Weighted Normalized Impact Sound Pressure Level $L'_{n,w}$ (field)

A single-number rating, expressed in decibels, of ***field*** measured frequency dependent ***impact sound*** insulation, between rooms in buildings, of a floor/ceiling assembly using a standardized ***tapping machine***.

It is determined by reference to EN ISO 717-2 from measurements of ***normalized impact sound pressure level*** made in accordance with EN ISO 140-7 over the third-octave band frequency range 100-3150Hz.

It should be noted that with impact sound pressure levels, the higher the resulting number, the lower is the sound insulation performance of the structure, and vice versa

$L'_{n,w}$ values cannot be compared directly to ***Field Impact Insulation Class FIIC*** as with the latter method the larger the FIIC value, the higher is the degree of impact sound insulation performance.

Weighted Normalized Level Difference, $D_{n,w}$

A single-number rating, expressed in decibels, of the field measurement of frequency dependent airborne sound insulation between rooms.

It is determined by reference to EN ISO 717-1 from measurements of ***normalized level difference*** made in accordance with EN ISO 140-4 over the third-octave band frequency range 100-3150Hz.

$D_{n,w}$ is similar to ***Normalised Noise Insulation Class, NNIC.***

Weighted Sound Absorption Coefficient, α_w

A single-number rating for ***random incidence sound absorption coefficients*** αs calculated by reference to EN ISO 11654. This may be considered as an alternative to ***Noise Reduction Coefficient***.

With this method, ***one-third octave band*** values of sound absorption, measured in accordance with EN 20354 or ISO 354, are arithmetically converted into ***octave bands*** at 250, 500, 1000, 2000 and 4000Hz (termed practical sound absorption coefficients α_p), and these are plotted onto a graph. A standard reference curve is then shifted towards the measured values in steps of 0.05 until the sum of the unfavourable deviations (the values of α_p below the reference curve) are less than or equal to 0.10. At this point the practical sound absorption coefficient value of the reference curve which intersects a vertical line at 500 Hz is deemed the 'weighted sound absorption coefficient, α_w'. (See EN ISO 11654 for full details). The derived value of α_w will vary between 0.00 and 1.00 but is only expressed in multiples of 0.05, eg α_w can equal 0.65 or 0.70 but **not** 0.68.

If a practical sound absorption coefficient exceeds the reference curve value by 0.25 or more, at one or more frequencies, then a "shape indicator" is applied to the weighted sound absorption coefficient. If the excess occurs at 250Hz, the notation **(L)** is used. For excesses at 500Hz or 1000Hz **(M)** is used and for 2000Hz or 4000Hz **(H)** is used. So, for example, a weighted sound absorption with an excess at 500 Hz could be described as α_w = 0.65(M).

It should be noted that the weighted sound absorption coefficient is only intended to be used for routine applications in normal offices, corridors, classrooms, hospitals etc. It is not appropriate for specialist environments requiring expert acoustic design nor for non-plane items such as chairs, screens etc. Also as the lower limit for the reference curve is 250Hz, the rating method is not suitable for products that principally exhibit low frequency sound absorption below this frequency, eg ***panel or resonant*** absorbers.

In addition, and depending upon the calculated value of the weighted sound absorption coefficient, a "Sound Absorption Class" (A to E) may also be assigned to describe the performance and such classification can be useful for easy comparison between alternative materials.

Weighted Sound Reduction Index, R_w

A single-number rating, expressed in decibels, of laboratory measured frequency dependent airborne sound insulation properties of a building element or material.

It is determined by reference to EN ISO 717-1 from measurements of ***sound reduction index*** made in accordance with EN ISO 140-3 over the third-octave band frequency range 100-3150Hz.

R_w is similar to ***Sound Transmission Class, STC***.

Weighted Suspended Ceiling Normalized Level Difference, $D_{nc,w}$

A single-number rating, expressed in decibels, of the laboratory measured frequency dependent room-to-room sound attenuation of a suspended ceiling sharing a common ceiling plenum above adjacent rooms.

It is determined by reference to EN ISO 717-1 from measurements made in accordance with EN 20140-9 over the third-octave band frequency range 100-3150Hz.

$D_{nc,w}$ is similar to ***Ceiling Attenuation Class, CAC.***

Weighted Standardized Impact Sound Pressure Level $L'_{nT,w}$

A single-number rating, expressed in decibels, of the field measurement of frequency dependent impact sound insulation between rooms in buildings.

It is determined by reference to EN ISO 717-2 from measurements of ***standardized impact sound pressure level*** made in accordance with EN ISO 140-7 over the third-octave band frequency range 100-3150Hz.

Weighted Standardized Level Difference, $D_{nT,w}$

A single-number rating, expressed in decibels, of the field measurement of frequency dependent airborne sound insulation between rooms.

It is determined by reference to EN ISO 717-1 from measurements of ***standardized level difference*** made in accordance with EN ISO 140-4 over the third-octave band frequency range 100-3150Hz.

White Noise

Broadband (electronically generated) noise, whose energy content is equal per unit of frequency, which is often used as a sound source for acoustic measurements. White noise may be associated with ***Sound Masking*** but it is not subjectively suitable for this purpose.

BUILDING ACOUSTICS REFERENCE STANDARDS

The following is a list of EN, ISO, ASTM and ANSI standards relating to building acoustics, some of which have been referred to in the preceding text. It is by no means comprehensive and does not represent all those that are available on the subjects of sound and vibration.

Many ISO standards have been adopted by CEN (the European Committee for Standardization) who are responsible for publishing each European Standard (EN). Joint standards are noted and cross references given.

When an EN is published, member countries are obliged to adopt the EN as a national standard and at the same time withdraw any conflicting existing national standards. The current member countries of CEN are:

Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

EUROPEAN STANDARDS

EN 12345-1: 2000
Building Acoustics - Estimation of acoustic performance of buildings from the performance of elements - Part 1: Airborne sound insulation between rooms

EN 12345-2: 2000
Building Acoustics - Estimation of acoustic performance of buildings from the performance of elements - Part 2: Impact sound insulation between rooms

EN 12345-3: 2000
Building Acoustics - Estimation of acoustic performance of buildings from the performance of elements - Part 3: Airborne sound insulation against outdoor sound

EN 12345-4: 2000
Building Acoustics - Estimation of acoustic performance of buildings from the performance of elements - Part 4: Transmission of indoor sound to the outside

EN 12345-6: 2000
Building Acoustics - Estimation of acoustic performance of buildings from the performance of elements - Part 6: Sound absorption in enclosed spaces

EN 20140-2: 1993 - Identical to ISO 140-2:1991
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 2: Determination, verification and application of precision data

EN 20140-9: 1993 - Identical to ISO 140-9:1985
Acoustics - Measurement of sound insulation in buildings and of building elements - Part 9: Laboratory measurements of room-to-room airborne sound insulation of a suspended ceiling with a plenum above it

EN 20140-10: 1992 - Identical to ISO 140-10:1991
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 10: Laboratory measurements of airborne sound insulation of small building elements

EN 21683:1994 - Identical to ISO 1683:1983
Acoustics. Preferred reference quantities for acoustic levels

EN 29052-1:1992 - Identical to ISO 9052-1:1989
Acoustics. Method for the determination of dynamic stiffness
Part 1: Materials used under floating floors in dwellings

EN 29053:1993 - Identical to ISO 9053:1991

Acoustics. Materials for acoustical applications. Determination of airflow resistance

COMBINED EUROPEAN / INTERNATIONAL STANDARDS

EN ISO 140-1: 1997
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 1: Requirements for laboratory test facilities with suppressed flanking transmission

EN ISO 140-3: 1995
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 3: Laboratory measurements of airborne sound insulation of building elements

EN ISO 140-4: 1998
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 4: Field measurements of airborne sound insulation between rooms

EN ISO 140-5: 1998
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 5: Field measurements of airborne sound insulation of facade elements and facades

EN ISO 140-6: 1998
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 6: Laboratory measurements of impact sound insulation of floors

EN ISO 140-7: 1998
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 7: Field measurements of impact sound insulation of floors

EN ISO 140-8: 1997
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 8: Laboratory measurements of the reduction of transmitted impact noise by floor coverings on a heavyweight standard floor

EN ISO 140-11: 2005
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 11: Laboratory measurements of the reduction of transmitted impact noise by floor coverings on lightweight reference floors

EN ISO 140-12: 2000
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 12: Laboratory measurements of room-to-room airborne and impact sound insulation of an access floor

EN ISO 140-14: 2004
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 14: Guidelines for special situations in the field

EN ISO 140-16: 2006
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 16: Laboratory measurement of the sound reduction index improvement by additional lining

EN ISO 354: 2003
Acoustics - Measurement of sound absorption in a reverberation room

EN ISO 717-1: 1996
Acoustics - Rating of sound insulation in buildings and of building elements
Part 1. Airborne sound insulation

EN ISO 717-2: 1996
Acoustics - Rating of sound insulation in buildings and of building elements
Part 2. Impact sound insulation

EN ISO 3382: 2000
Acoustics - Measurements of reverberation time of rooms with reference to other acoustical parameters

EN ISO 10534-1: 2001
Acoustics - Determination of sound absorption coefficient and impedance in impedance tubes
Part 1: Method using standing wave ratio

EN ISO 10534-2: 2001
Acoustics - Determination of sound absorption coefficient and impedance in impedance tubes
Part 2: Transfer-function method

EN ISO 10848-1: 2006
Acoustics - Laboratory measurements of the flanking transmission of airborne and impact sound between adjoining rooms
Part 1: Frame document

EN ISO 10848-2: 2006
Acoustics - Laboratory measurements of the flanking transmission of airborne and impact sound between adjoining rooms
Part 2: Applications to light elements when the junction has a small influence

EN ISO 10848-3: 2006
Acoustics - Laboratory measurements of the flanking transmission of airborne and impact sound between adjoining rooms
Part 3: Applications to light elements when the junction has a substantial influence

EN ISO 11654: 1997
Acoustics - Sound absorbers for use in buildings - Rating of sound absorption

EN ISO 11821: 1997
Acoustics - Measurement of the in-situ sound attenuation of a removable screen

EN ISO 15186-1: 2003
Acoustics - Measurement of sound insulation in buildings and of building elements using sound intensity
Part 1: Laboratory measurements

EN ISO 17624: 2004
Acoustics - Guidelines for noise control in offices and workrooms by means of acoustical screens

EN ISO 18233: 2006
Acoustics - Application of new measurement methods in building and room acoustics

INTERNATIONAL STANDARDS

ISO 140-2: 1991 - Identical to EN 20140-2:1993
Acoustics - Measurement of sound insulation in buildings and of building elements -Part 2: Determination, verification and application of precision data

ISO 140-9: 1985 - Identical to EN 20140-9:1994
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 9: Laboratory measurements of room-to-room airborne sound insulation of a suspended ceiling with a plenum above it

ISO 140-10: 1991 - Identical to EN 20140-10:1992
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 10: Laboratory measurements of airborne sound insulation of small building elements

ISO/TR 140-13: 1997
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 13: Guidelines

ISO/FDIS 140-18:
Acoustics - Measurement of sound insulation in buildings and of building elements -
Part 18: Laboratory measurements of sound generated by rainfall on building elements

ISO 717-1: 1996/Amd 1:2006
Rounding rules related to single number ratings and single number quantities

ISO 717-2: 1996/Amd 1:2006
Rounding rules related to single number ratings and single number quantities

ISO/TR 3352: 1974
Acoustics - Assessment of noise with respect to its effect on the intelligibility of speech

ISO/CD 3382-1:
Acoustics - Measurements of room acoustic parameters
Part 1: Performance rooms

ISO/DIS 3382-2:
Acoustics - Measurements of room acoustic parameters
Part 2: Reverberation time in ordinary rooms

ISO 9052-1:1989 - Identical to EN 29052-1:1992
Acoustics - Method for the determination of dynamic stiffness
Part 1: Materials used under floating floors in dwellings

ISO 9053:1989 - Identical to EN 29053:1993
Acoustics - Materials for acoustical applications. Determination of airflow resistance

ISO 9921:2003
Ergonomics - Assessment of speech communication

ISO 15186-2: 2003
Acoustics - Measurement of sound insulation in buildings and of building elements using sound intensity
Part 2: Field measurements (available in English only)

ISO 15186-3: 2002
Acoustics - Measurement of sound insulation in buildings and of building elements using sound intensity
Part 3: Laboratory measurements at low frequencies

ISO 15712-1: 2005
Building acoustics - Estimation of acoustic performance of buildings from the performance elements
Part 1: Airborne sound insulation between rooms

ISO 15712-2: 2005
Building acoustics - Estimation of acoustic performance of buildings from the performance elements
Part 2: Impact sound insulation between rooms

ISO 15712-3: 2005
Building acoustics - Estimation of acoustic performance of buildings from the performance elements
Part 2: Airborne sound insulation against outdoor sounds

ISO 17497-1:2004
Acoustics. Sound scattering properties of surfaces
Part 1: Measurement of the random-incidence scattering coefficient in a reverberation room

INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC 60268-16 Ed. 3.0 en: 2003
Sound system equipment
Part 16: Objective rating of speech intelligibility by speech transmission index

IEC 60849 Ed. 2.0 b:1998
Sound systems for emergency purposes

AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM E 90-04
Standard Test Method for:
Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions & Elements

ASTM C 336-05
Standard Test Method for:
Measurement of Airborne Sound Insulation in Buildings

ASTM C 384-04
Standard Test Method for:
Impedance and Absorption of Acoustical Materials by the Impedance Tube Method

ASTM C 413-04
Classification for Rating Sound Insulation

ASTM C 423-02ae1
Standard Test Method for:
Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method

ASTM C 492-04
Standard Test Method for:
Laboratory Measurement of Impact Sound Transmission Through Floors-Ceiling Assemblies Using the Tapping Machine

ASTM C 522-03
Standard Test Method for:
Airflow Resistance of Acoustical Materials

ASTM E 596-96 (2002)e1
Standard Test Method for:
Laboratory Measurement of Noise Reduction of Sound-Isolating Enclosures

ASTM E 795-05
Standard Practices for:
Mounting Test Specimens During Sound Absorption Tests

ASTM E 966-04
Standard Guide for:
Field Measurement of Airborne Sound Insulation of Building Facades and Facade Elements

ASTM E 989-06
Standard Classification for:
Determination of Impact Insulation Class (IIC)

ASTM E 1007-04e1
Standard Test Method for:
Field Measurement of Tapping Machine Impact Sound Transmission Through Floor-Ceiling Assemblies and Associated Support Structures

ASTM E 1110-01
Standard Classification for:
Determination of Articulation Class

ASTM E 1111-05
Standard Test Method for:
Measuring the Interzone Attenuation of Open Office Components

ASTM E 1130-02e1
Standard Test Method for:
Objective Measurement of Speech Privacy in Open Offices Using Articulation Index

ASTM E 1374-06
Standard Guide for Open office Acoustics and Applicable ASTM Standards

ASTM E 1408-91 (2000)
Standard Test Method for:
Laboratory Measurement of the Sound Transmission Loss of Door Panels and Door Systems

ASTM E 1414-00a
Standard Test Method for:
Airborne Sound Attenuation Between Rooms Sharing a Common Ceiling Plenum

ASTM E 1573-02
Standard Test Method for:
Evaluating Masking Sound in Open Offices Using A-Weighted and One-Third Octave Band Sound Pressure Levels

AMERICAN NATIONAL STANDARDS INSTITUTE

ANSI S3.2: 1989 (R1999)

Methods for Measuring the Intelligibility of Speech over Communications System

ANSI S3.5: 1997 (R2002)

Methods for the Calculation of the Articulation Index

Western Europe

België & Luxemburg
Armstrong Building Products B.V.
Office Building Quadrium
Claudius Prinsenlaan 126
4818 CP Breda
Nederland
Tel: (+32) 02 223 0072
Fax: (+31) 076 521 0407

Deutschland
Schweiz/Suisse/Svizzera
Armstrong Building Products GmbH
Office Building Quadrium
Claudius Prinsenlaan 126
4818 CP Breda
Niederlande
Tel: (+49) 0251 7603 210
Fax: (+49) 0251 7603 593

España & Portugal
Armstrong Building Products
Immeuble Paryseine
3 allée de la Seine
94854 Ivry-sur-Seine
Francia
Servicio Informacion Techos
Tel: (+34) 91 642 04 99
LLAMADA GRATIUTA 00 800 90 21 03 68
Fax: (+33) 1 4521 0411

France
Afrique Francophone
Armstrong Building Products
Immeuble Paryseine
3 allée de la Seine
94854 Ivry-sur-Seine
Service Information Plafonds
APPEL GRATUIT 0800 413643
Fax: (+33) 01 4521 0411

Italia
Armstrong Building Products
Ufficio commerciale
Immeuble Paryseine
3 allée de la Seine
94854 Ivry-sur-Seine
Francia
Tel: (+39) 02 66 22 76 50
Fax: (+39) 02 66 20 14 27

Nederland
Armstrong Building Products B.V.
Verkoopkantoor Nederland
Office Building Quadrium
Claudius Prinsenlaan 126
4818 CP Breda
Nederland
Tel: (+31) 076 521 7733
Fax: (+31) 076 521 0407

United Kingdom
Republic of Ireland
Building Products Division
Armstrong House
38 Market Square
Uxbridge
Middx UB8 1NG
FREEFONE 0800 371849 (UK)
FREEFONE 1800 409002 (ROI)
Fax: (+44) 01895 274287

Central Europe

(PL/CZ/SK/H/MAK/HR/SLO/YU/
RO/BG/AL/TR/EW/LV/LT)
Armstrong Building Products B.V.
Sp.z.o.o. Oddzial w Polsce
ul. Domaniewska 37
02-672 Warszawa
Poland
Tel: (+48) 0 22 337 86 10/ 86 11
Fax: (+48) 0 22 337 86 12

Eastern Europe

C.I.S.
Armstrong Moscow GmbH
Park Place, office E502
113/1, leninsky Prospekt
Moscow 117198
Russia
Tel: (+7) 095 956 5100
Fax: (+7) 095 956 5101

Africa & Middle East

Armstrong World Industries Ltd
Africa & Middle East Division
Armstrong House
38 Market Square
Uxbridge, Middx UB8 1NG
England
Tel: (+44) 01895 251122
Telefax: (+44) 01895 272928

www.armstrongceilings.eu

Job No. 12576 Produced by The Design Quorum, Gerrards Cross, Bucks UK. Tel: 01753 891707 Printed on chlorine free paper

Armstrong
CEILING SOLUTIONS