INT&RIOR SYSTEMS

creating quality ambient spaces

Acoustic Solutions

Office Acoustics

This eBook:

Design Considerations for Offices
Reducing Sound Distraction
Creating Privacy in the Workplace
Sound Masking
Design Guidelines

NEW ZEALAND INSTITUTE OF ARCHITECTS INCORPORATED
APPROVED CPD PROVIDER

ADNZ ARCHITECTURAL DESIGNERS NZ

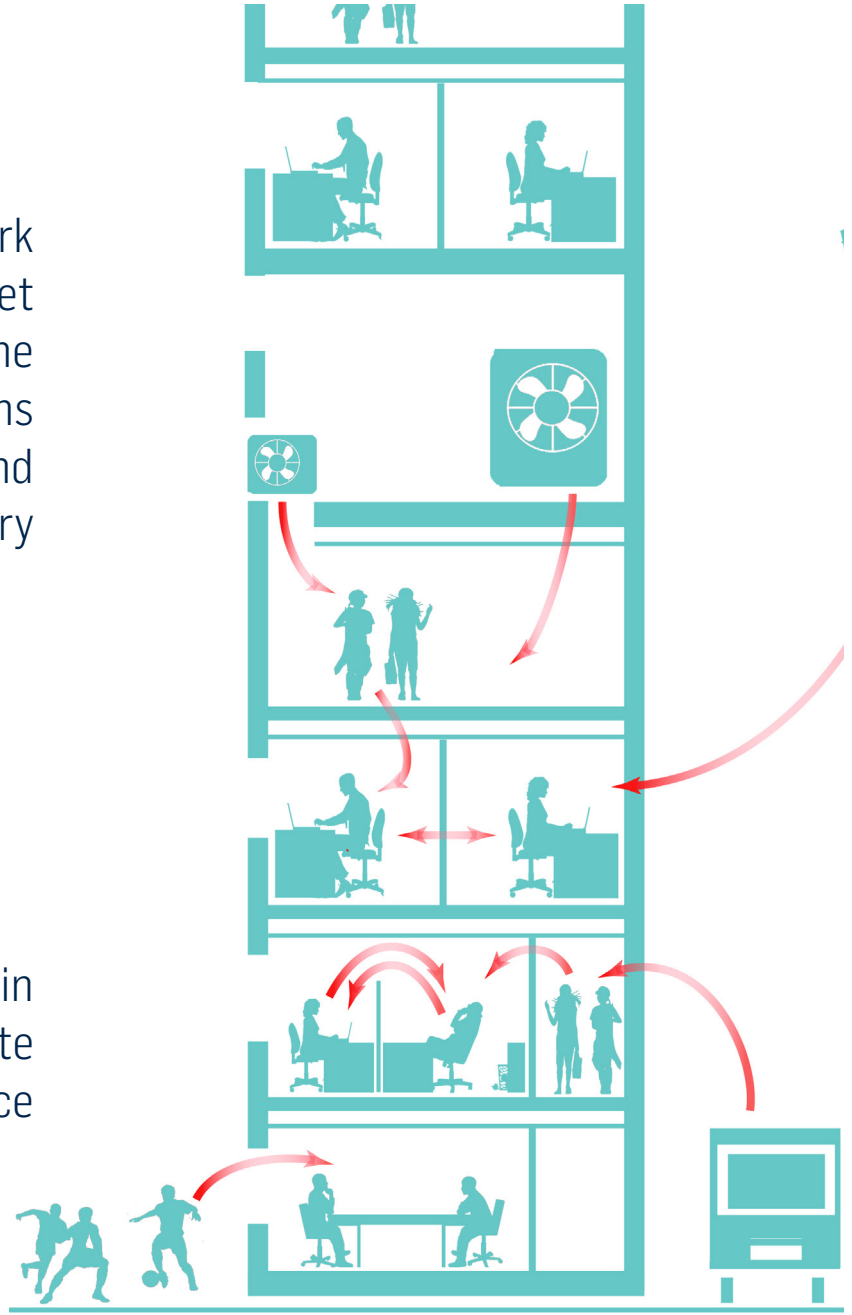
Contents

Introduction

Good office acoustics are a key contributor to work performance and well-being. The ability to find quiet places is essential to support focused work, while the ability to have planned or spontaneous interactions without disturbing others is necessary for team work and relationship development. Speech privacy is necessary for confidential interactions and work processes.

"Acoustic comfort" is achieved when the workplace provides appropriate acoustical support for Collaboration, Confidentiality, Concentration and Relaxation.

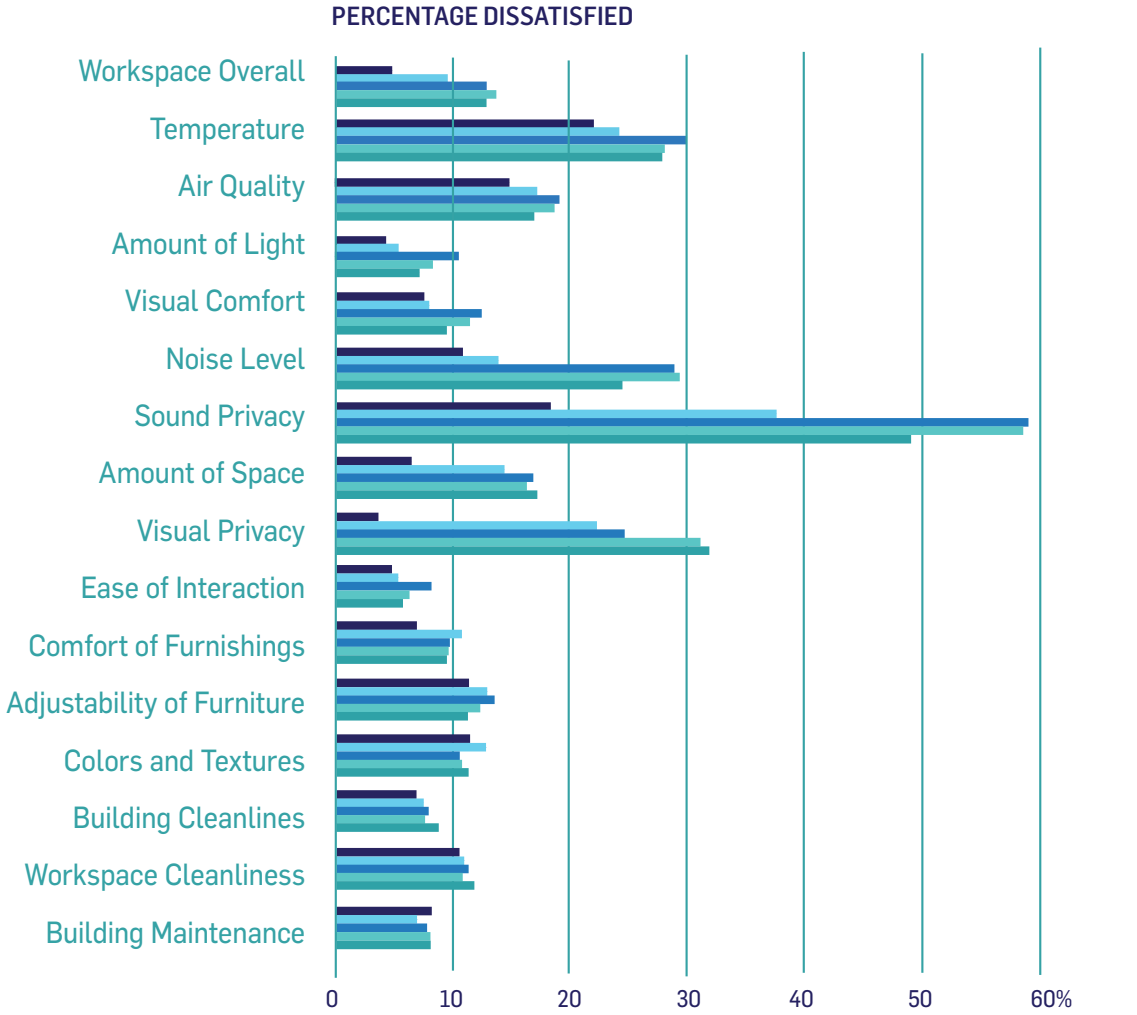
A basic understanding of how sound energy behaves in an interior space and how to control it will help to create the most functional acoustical environment in office spaces.



Productivity in the Workplace

A room and its acoustic quality should be a support for people and the activities in the space. To create the correct acoustic conditions is to create Room Acoustic Comfort

Worker productivity is the relationship between "inputs" (information, materials, instructions, etc.) and "outputs" (tasks, decisions, etc.). Anything that affects work conditions will have some impact on workers' ability to work productively.

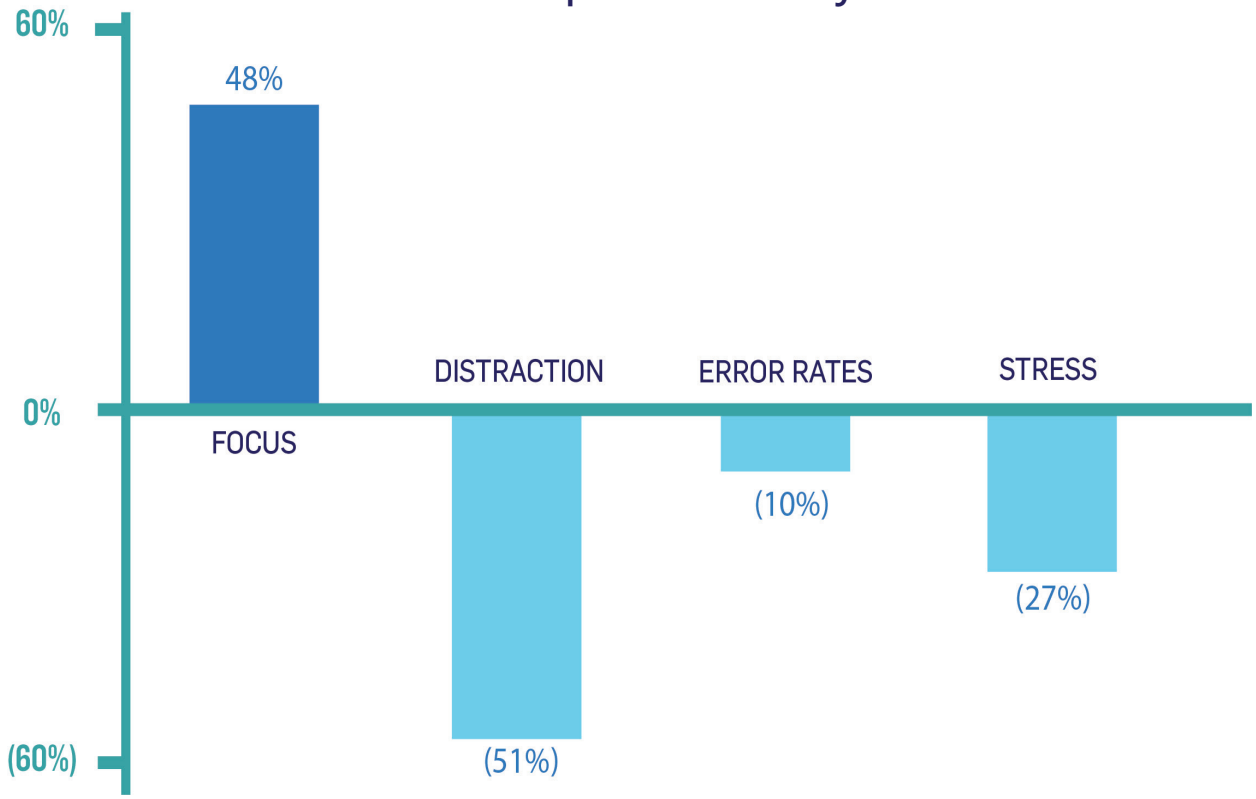


Source: Analysis of data from the center on the built environment by Jungsoo Kim and Richard de Dear, University of Sydney (hbr.org)

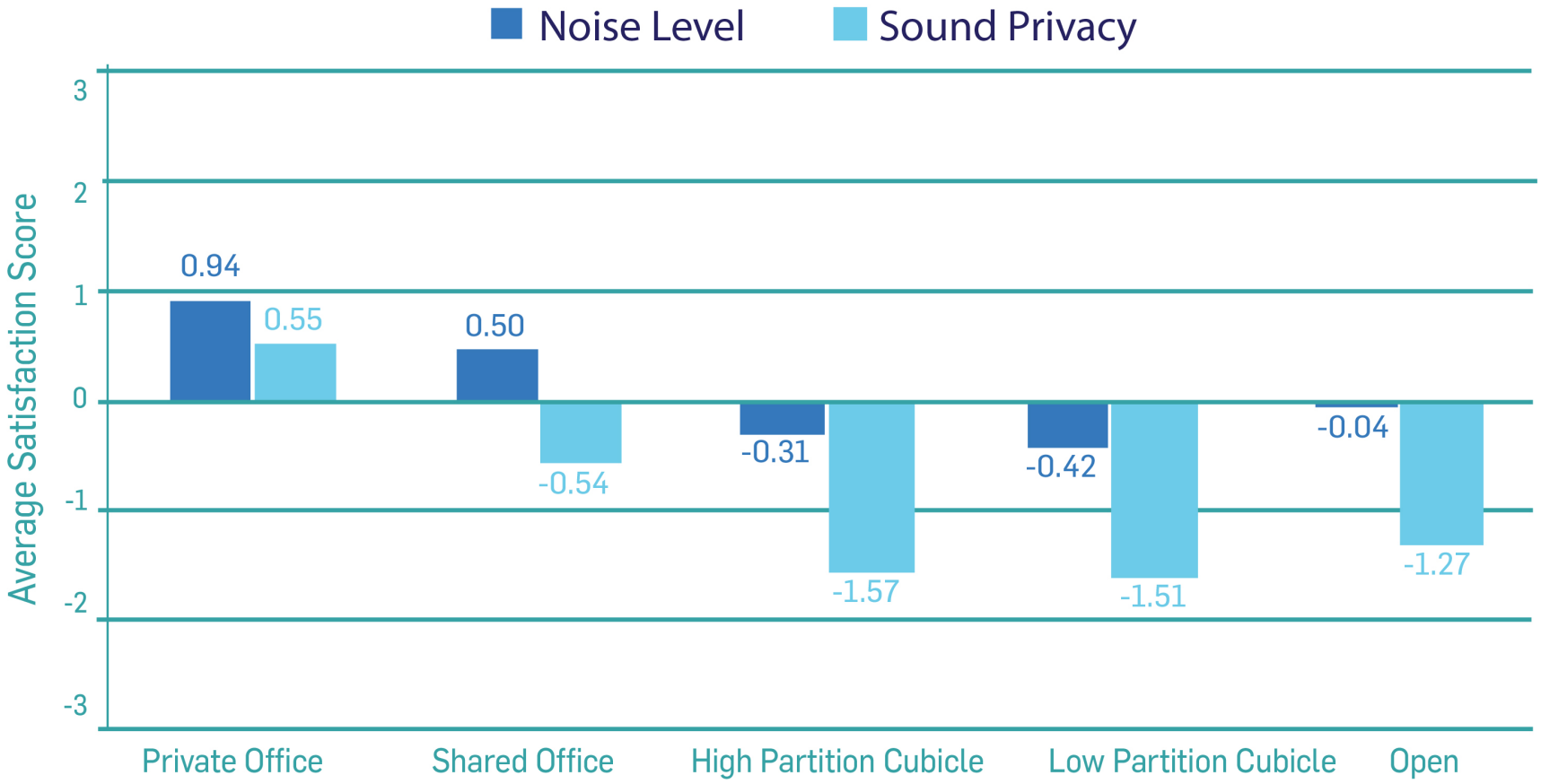
Noise is the number one obstruction to productivity.

Beyond productivity, office acoustics also affect employee health and safety. Many studies recognise that noise (even at low levels) is a cause of stress, which in turn can cause health problems such as high blood pressure, digestive disorders, headaches, hypertension, and ulcers.

Improvements Resulting from Increased Speech Privacy



How Acoustics Affect Human Productivity, David M. Sykes



As many offices transition to greater density and less private enclosure for economic and organisational reasons, acoustic performance is an increasingly important issue. An open workspace creates the unique problem of distractions from unwanted noise. Numerous studies convincingly demonstrate that noise is the number one contributor to lack of productivity in the workplace as it is difficult, if not impossible, concentrate while distracting noises are prevalent.

Theory

Common Acoustic Terms

Articulation Index (AI) is a measure of rating speech intelligibility
AI < 0.05 is representative of very poor speech intelligibility.
AI > 0.80 represents good speech intelligibility.
It can losely be described as the number of random words (out of 100) that can be clearly understood

Speech Privacy Index (PI) is derived from the Articulation Index. the AI and PI add up to 100%.

Articulation Class (AC) is a measure of rating the speech privacy performance of a ceiling in an open plan environment where sound is reflected off the ceiling between two adjacent spaces divided by partial-height partitions. It refers to the distance at which the sound level drops by 10dB.
AC < 150 is low performance
AC ≥ 180 is high performance.

Reverberation Time is the time required for a steady-state sound to decrease 60dB once it is stoppped.

Privacy Index

The Privacy Index is a percentage rating that incorporates all known acoustical factors into a highly precise measure of Acoustical Privacy. It is a rating for both speech and noise and is expressed as a percentage.

PRIVACY LEVEL	No Privacy	Transitional Privacy	Normal Privacy	Confidential Privacy
PRIVACY INDEX	0 - 69	70 - 79	80 - 94	95 - 100
	•Lectures or Seminars •Office Meetings •Social Activities		•Managers •Programmers •Persons writing or reading difficult materials •Self-learning situations •Sales Staff •Purchasing Staff •Administrative Assistants •Executive Secretaries •Draftsmen and Designers •Customer Service Staff-Telephone	•Executives •HR Department •Conference Rooms •Classified Conversations •Classified Material •Handling •Board Room Discussions •Strategic Planning Discussions •Research and Development Activities

0-69%

No Privacy

When two people have No Privacy from each other, their conversations are well understood and distracting to others.

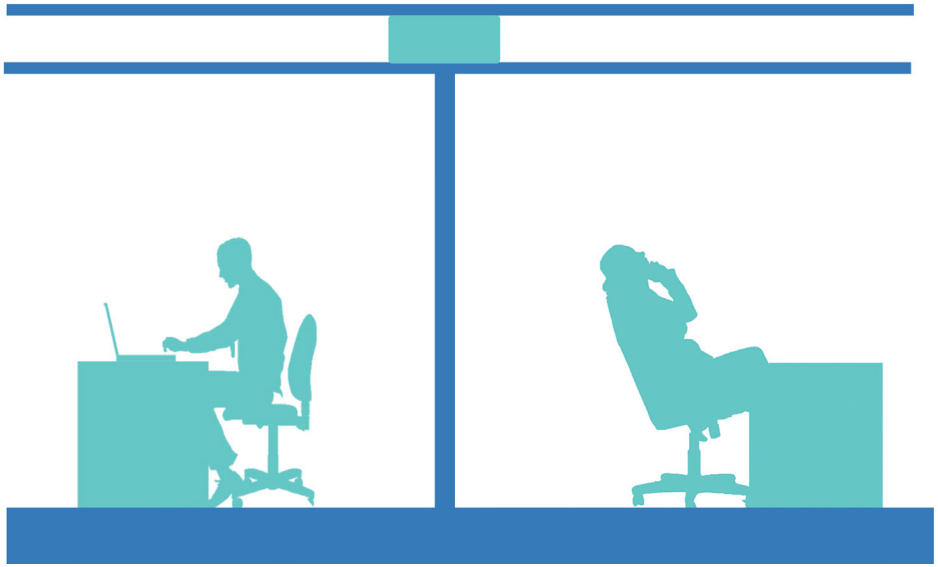
Articulation Index: 31-100%

This is the design goal for boardrooms and closed offices.

70-79%

Transitional Privacy

When two people have Transitional Privacy from each other, their conversations will distract others occasionally.



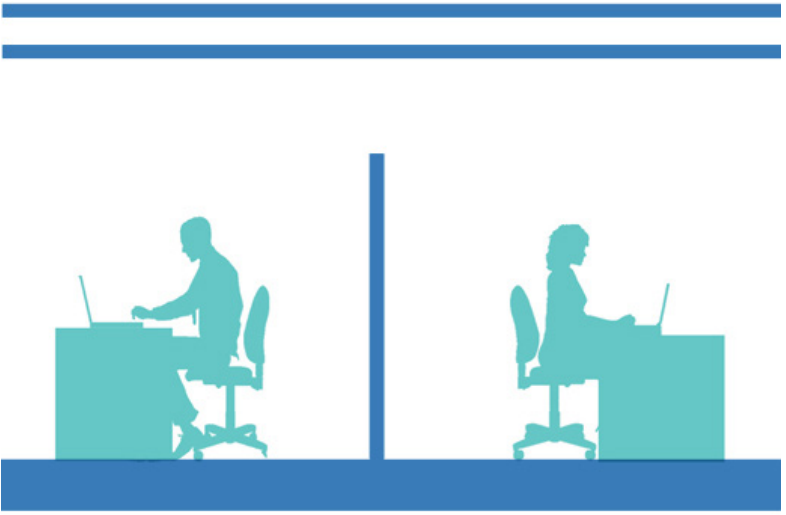
Articulation Index: 31-40%

Some words are understood.

80-94%

Normal Privacy

When two people have Normal Privacy from each other, their conversations do not distract each other, although the conversations are partially understood.



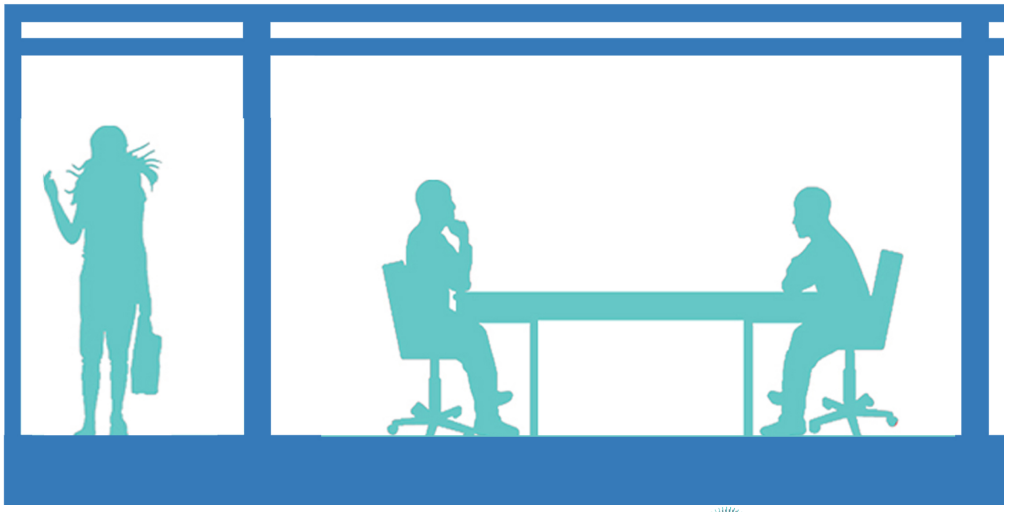
Articulation Index: 5-20%

The talker is heard but little is understood

95-100%

Confidential Privacy

When two people have Confidential Privacy from each other, their conversations are not intelligible to each other. Complete conversational privacy is achieved.



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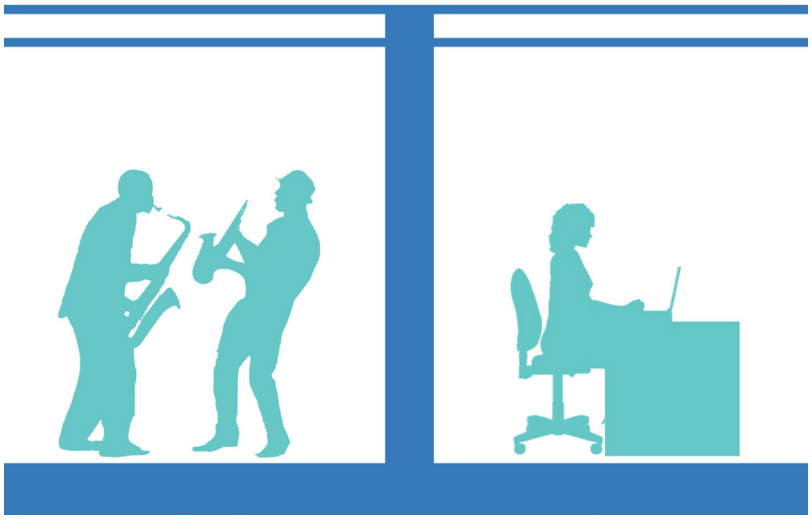
Articulation Index: 1-5%

Can barely understand anything across a partition system. The talker may be HEARD but not UNDERSTOOD.

100%

Secret Privacy

This degree of privacy is achieved when Confidentiality is assured and an outside listener will usually not be aware that a conversation is being held.



Articulation Index: 0%

Can't understand anything across a partition system

AI	SII	PI	PRIVACY CONDITION	OFFICE ENVIRONMENT
> 0.65	> 0.75	< 35%	Good Communication	Necessary when communication is desirable (conference rooms, classrooms, auditoriums, etc.)
> 0.40	> 0.45	< 60%	No Privacy	Clear intelligibility of conversations and distractions
0.35	0.45	65%	Freedom from Distraction	Reasonable work conditions not requiring heavy concentration or speech privacy; can hear and understand neighbouring conversations
0.20	0.27	80%	Normal Speech Privacy	Only occasional intelligibility from a neighbour's conversation; work patterns not interrupted
< 0.05	< 0.10	> 95%	Confidential Speech Privacy	Aware of neighbour's conversation but it is not intelligible

AI Articulation Index
SII Speech Intelligibility Index
PI Privacy Index

Design Guidelines

Open Plan Offices

Private Offices and Boardrooms

Open Plan Offices

Introduction

Sound Paths

Acoustic ABCs

Layout Design

Summary

Introduction

Over 60 percent of occupants in open plan offices felt that acoustic conditions interfered with their ability to get their job done.

The Center for the Built Environment at U C Berkeley conducted post-occupancy evaluation with 4,096 respondents from a variety of office configurations.

Open plan office environments provide greater flexibility than enclosed offices but acoustic problems are very prevalent with this model. Poor acoustics can cause distraction, stress, and interference with conversations and normal work routine.

In an open office it is essential that the sound propagation is restricted (spatial decay) in order to minimise disturbance, mainly between different work groups. In other words, it is important that the sound level falls quickly with distance.

The reality in open plan offices is that normal privacy can be achieved only when :

- voices are low
- relatively high levels of background sound levels are continuously present
- sound absorbing material has been applied to most surfaces above, behind and around the talkers so that conversation is not reflected into surrounding spaces.

The acoustic planning of an open-plan area requires that a number of factors are considered;

- Location of work stations
- Choice of sound absorbent ceiling
- Design of furnishings (furniture, screens, wall absorbers)
- Silent work areas
- Floor surface
- Background noise

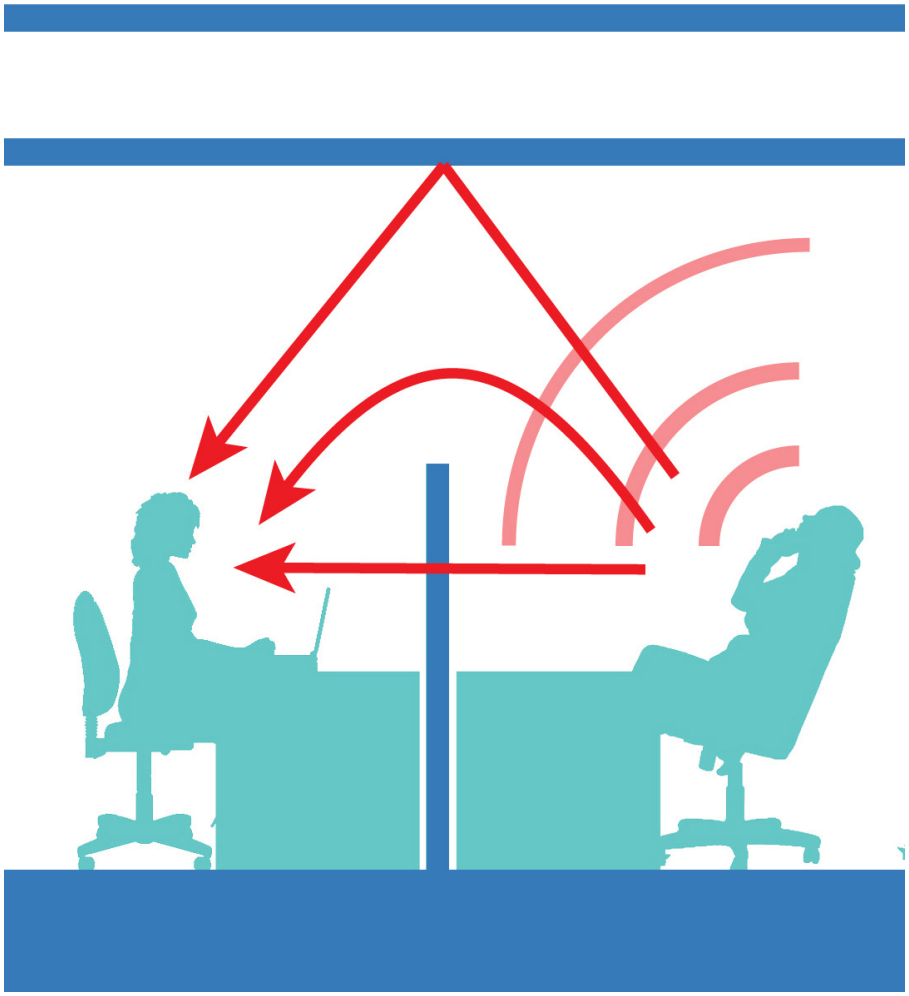
Open Plan acoustic design has its limitations: If a conversation is truly intended to be confidential, it should take place in a fully enclosed room.

In considering what is and what is not good open plan acoustics, it is important to appreciate the difference between “hearing” and “understanding”. The sounds from an adjacent workspace generally are not as distracting if they cannot be understood. Once they cannot be understood, speech privacy is created even though some degree of distraction may exist. Because of this, the overall ambient sound level is of high importance.

Sound Paths

In an Open Plan Office environment, there are three paths by which sound travels:

1. A direct path: which is the straight line between the source and receiver
2. A reflected path: which occurs as sound bounces off various surfaces
3. A defracted path: which involves sound bending over the top and around the sides of partitions



To achieve Speech Privacy in a commercial office environment, these paths must be considered. Acoustic control can be summarised by the Acoustic ABCs.

ABSORB **BLOCK** **COVER**

Acoustic ABCs

ABSORB

Recommended reverberation time is 0.75 seconds.
Absorptive wall partitions, ceiling tile and wall treatments will be necessary to achieve this reverberation time.

BLOCK

Avoid direct sound pathways between source and receiver
Separate cubicles by proper placement of wall partitions: Without controlling reflections off the ceiling and perimeter walls, partitions can be ineffective.
Reasonable precautions should be taken to insulate against noise from adjacent rooms, machinery, ducts and external noise sources.

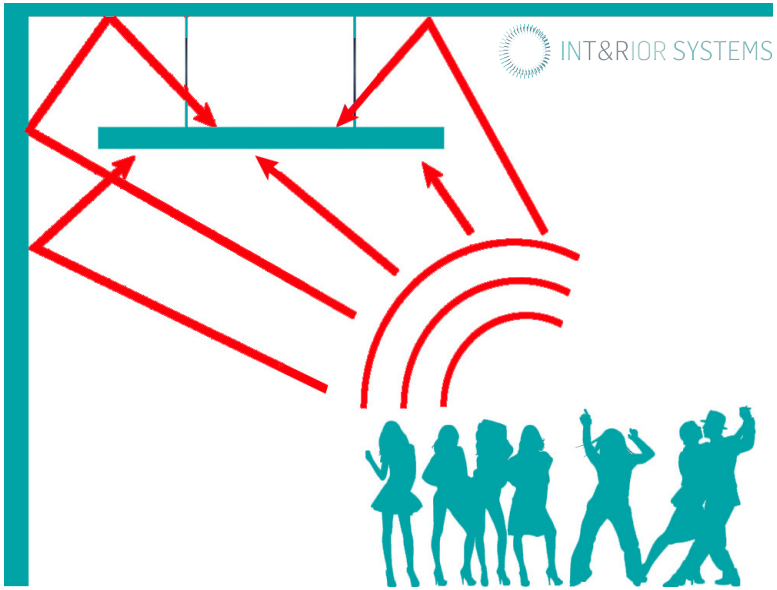
COVER

It's almost impossible to achieve speech privacy in an open office environment without installing an electronic masking system.

ABSORB

Human ears are more sensitive to certain frequencies and these frequencies are the same as those in human speech. It is the higher frequencies of human speech (1,000 Hz through 3,000 Hz) that provide intelligibility. These frequencies must be closely considered in developing an acceptable open plan environment.

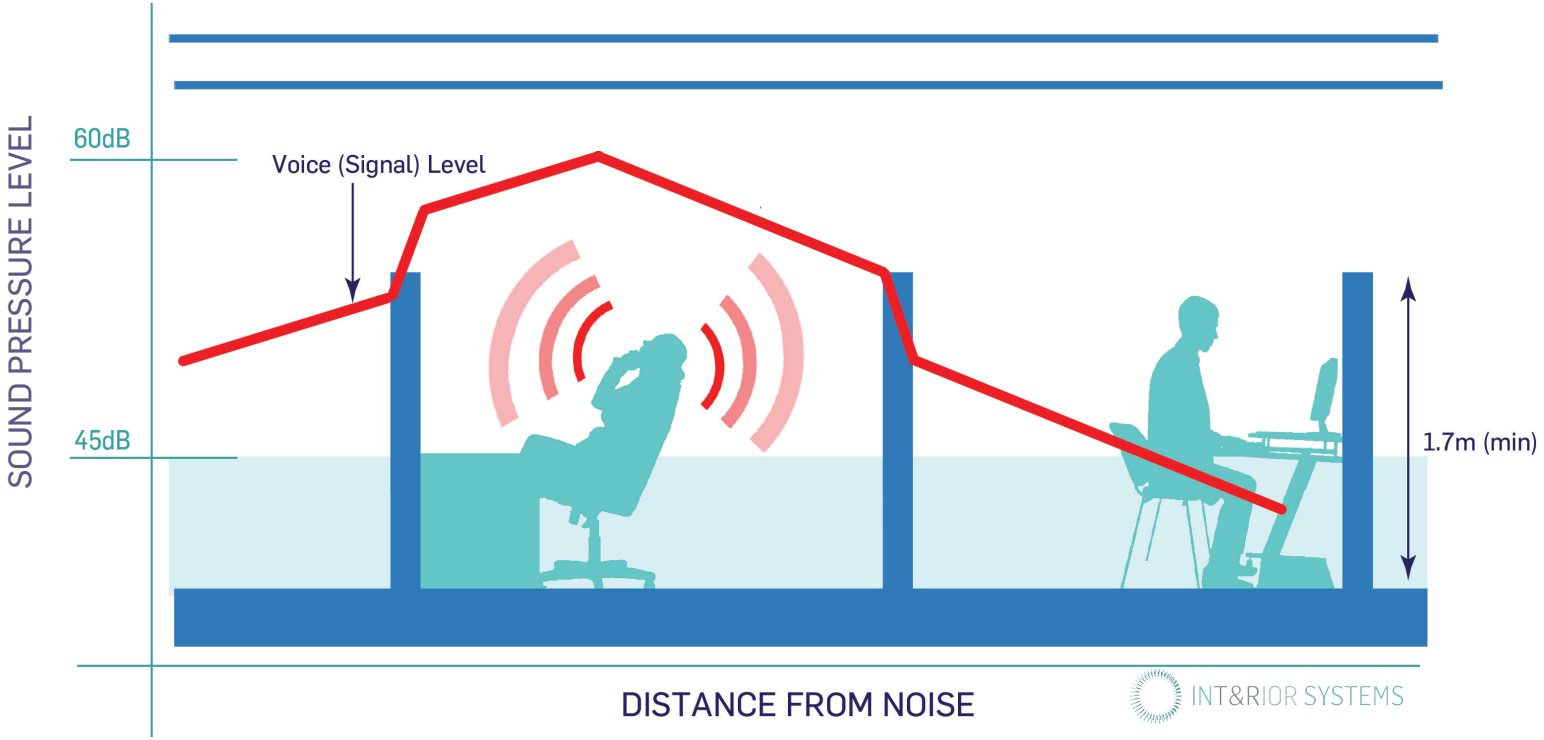
In evaluating an NRC rating for open plan acoustics, it is important that the higher absorption coefficients are at the higher frequencies (the articulate frequencies of human speech). Different materials may have the same NRC, however the one which absorbs more of the intelligible (higher) speech frequencies is a more effective material for controlling sound in an office environment. In fact, the reflection of low frequencies may be an advantage in that it generates an ambient sound level that can reinforce the background masking sound.



BLOCK

Spacing between people is important and should be maximised with the layout of the office. “Lines of sight” between people should be minimised in order to deal with the direct path of sound.

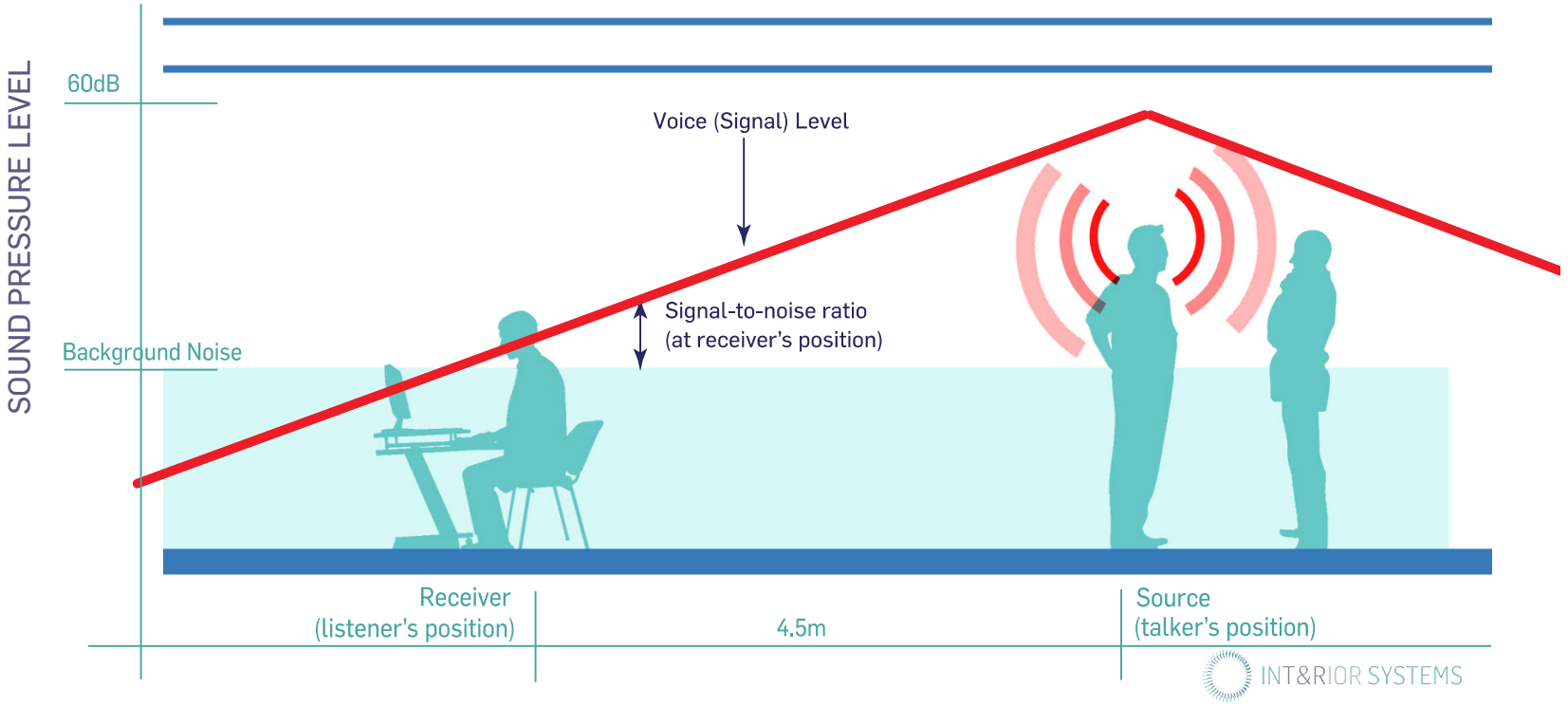
To stop the direct path of sound, erect barriers between workstations to stop sound from passing through such as furniture and half-height partitions. A partition with an STC of 20 is recommended. Because sound energy will still travel over the partition, an STC of more than 20 is not generally an advantage.



Furthermore, arrange like activities together, and separate noisy areas from quiet ones.

COVER

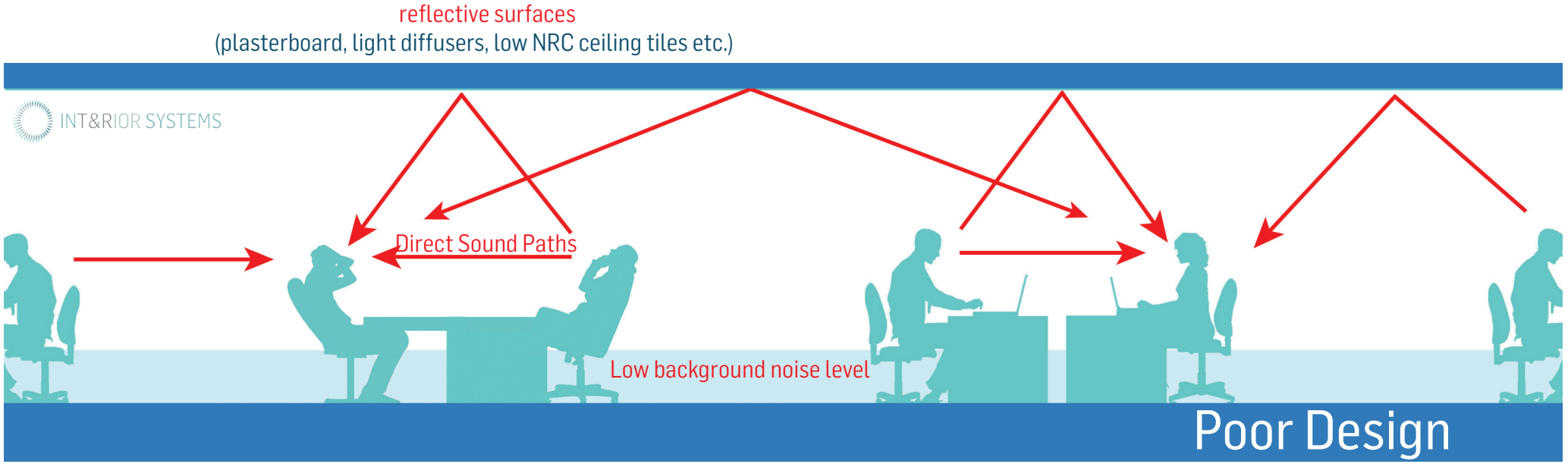
It is important to have a certain level of background noise to cover the sound energy which is not blocked or absorbed by acoustical panels. That sound may be present in a space naturally or can be created artificially with electronically produced sound evenly distributed throughout a space, usually through speakers below or in the ceiling.



Layout Design

- Group like-activities together and separate noisy and quiet areas
- Avoid placing reflective surfaces (such as lighting fixtures) where they can reflect sound to the adjacent workspace.
- Have a separate room for servers, copiers and printers to reduce bassy background noise
- Minimise direct sound paths between staff in close proximity

If the overall office Background sound level is too low, noise masking systems can be introduced.



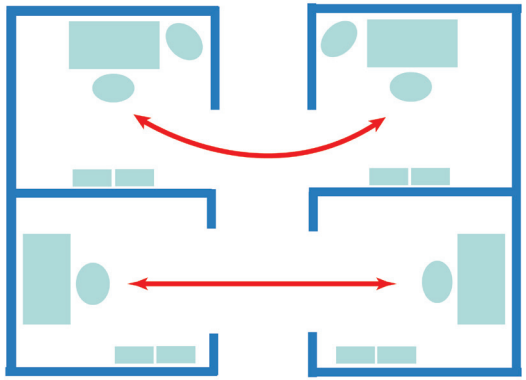
Myth: High cubicle partitions mean less noise, more privacy, and fewer distractions.

Unfortunately, instead high cubicles may lead to less privacy and more disruption.

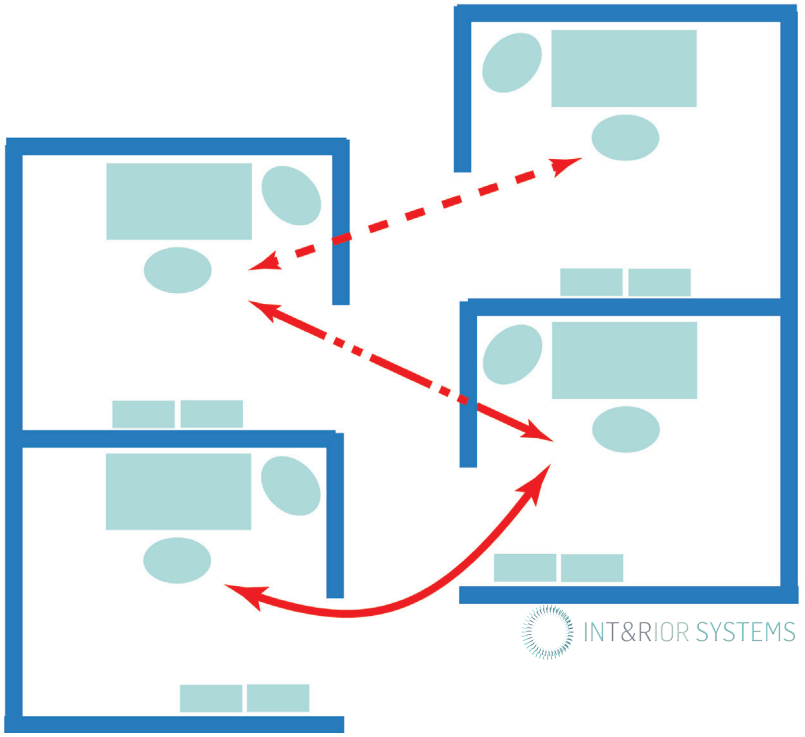
Research shows that higher cubicle partitions block line of sight but only provide small amounts of additional acoustical shielding. The increased 'visual privacy' may encourage people to talk louder because they think they have more privacy.

Partition Layout

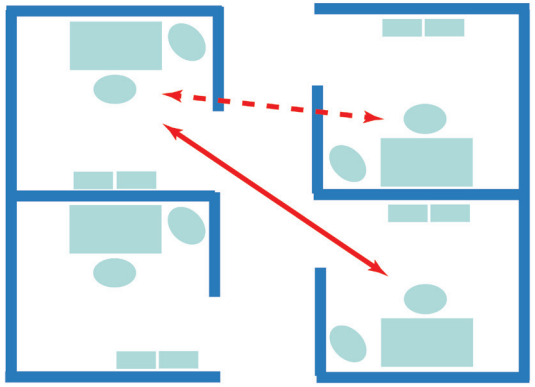
Poor Effectiveness



Preferred Effectiveness



Moderate Effectiveness



The highest sound reduction that can be expected between workstations is roughly 20 decibels, because sound energy will defract over the top and around the side of partial height partitions. An STC of more than 20 is not generally an advantage.

Summary

Recommended Design Parameters - Open Plan

Ceilings	NRC 0.90 or higher
Floor (Carpeted)	NRC 0.15
Half Height Partitions	NRC 0.40 or higher STC 20
Walls	NRC 0.40
Optimal Background Noise Level	45 - 50 dBA

Private Offices & Meeting Rooms

Introduction

Most workplace environments should have quiet areas—places where private conversations can occur without being heard in adjacent rooms or passageways for employee matters, contract negotiations, classified discussions, etc.

Although meeting rooms and private offices generally have partition walls from the floor to the suspended ceiling, acoustical problems can still occur. Rooms with closed doors can keep conversations private only if adequate measures have been taken in construction to prevent sound from leaking around and under doors, through walls, across the ceiling plenum, through ducting, etc.

The acceptable background noise level in these rooms is lower than for the open plan offices, due to the need for an effective Signal to Noise Ratio. (The speakers voices must be louder than the background noise even at a distance from the speaker.

Poor acoustic design of meeting rooms leads to problems such as an inability to have private discussions, problems with flutter echo and the ability to hear unwanted sounds.

Private Office

In private offices the main acoustic concern is:
Noise transfer through and across wall and ceiling systems

Awareness of activity in adjacent spaces is typical in most offices. However, if the transmitted speech is intelligible, it becomes far more distracting. In certain types of offices activities, confidentiality and speech privacy are a serious concern.

If Confidentiality is important it is paramount that the sound paths across partitions are properly addressed.

Although the volume of an office is generally not enough to cause reverberation issues, in larger offices with parallel blank walls, flutter echo issues can be prevalent.

For specific office design it comes down to the room and its function. Depending on the intended use, different acoustic treatments are appropriate.

It is therefore important to consider the activity and use of a space in order to design wall, ceiling and door systems of a rooam.

Recommended Acoustic Separation

Sensitive Areas:	60 STC
Private Offices:	45 - 50 STC
Standard Offices	40 - 45 STC
Offices to Corridors:	40 STC

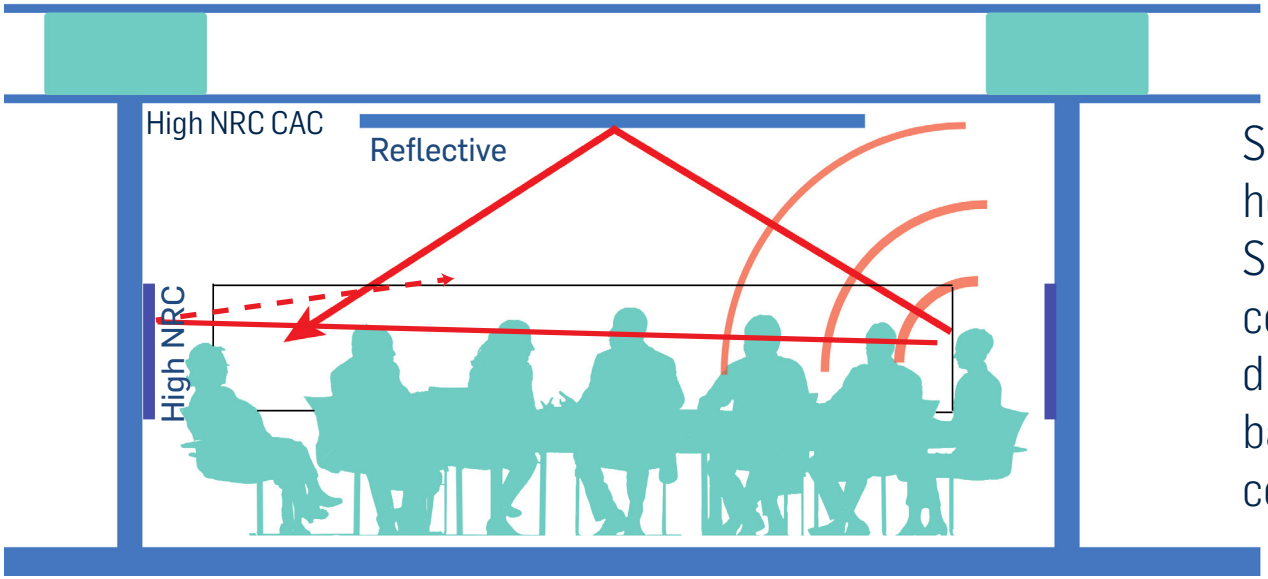
Boardroom Design

In Boardrooms there are three main acoustic concerns:

- Noise transfer through and across wall and ceiling systems
- Ability to understand speakers across the boardroom table
- Flutter echoes between parallel surfaces

Boardroom design must maximise the signal to noise ratio; the speakers voice must be clearly heard above the background noise. At the same time, the reverberation must be controlled to prevent buildup of sound energy in the space. This requires careful placement of absorptive and reflective materials. As a general rule, the reflection should be placed along the boardroom table ceiling whereas the remaining ceiling, and the wall at head height should be covered in absorptive materials.

Flutter Echo (where sound bounces back and forth) can be a problem in many boardrooms. Always place absorption on the majority of two adjacent walls in a rectangular room to prevent sound energy 'bouncing' between two parallel refective surfaces. This absorption should be placed at head (talking) height.



Sound paths through and across ceiling height partitions should be considered. Solutions may include using high CAC ceiling tiles, plasterboard ceilings with direct fix absorption, polyester or glasswool baffle block or wavebar above the wall in the ceiling .

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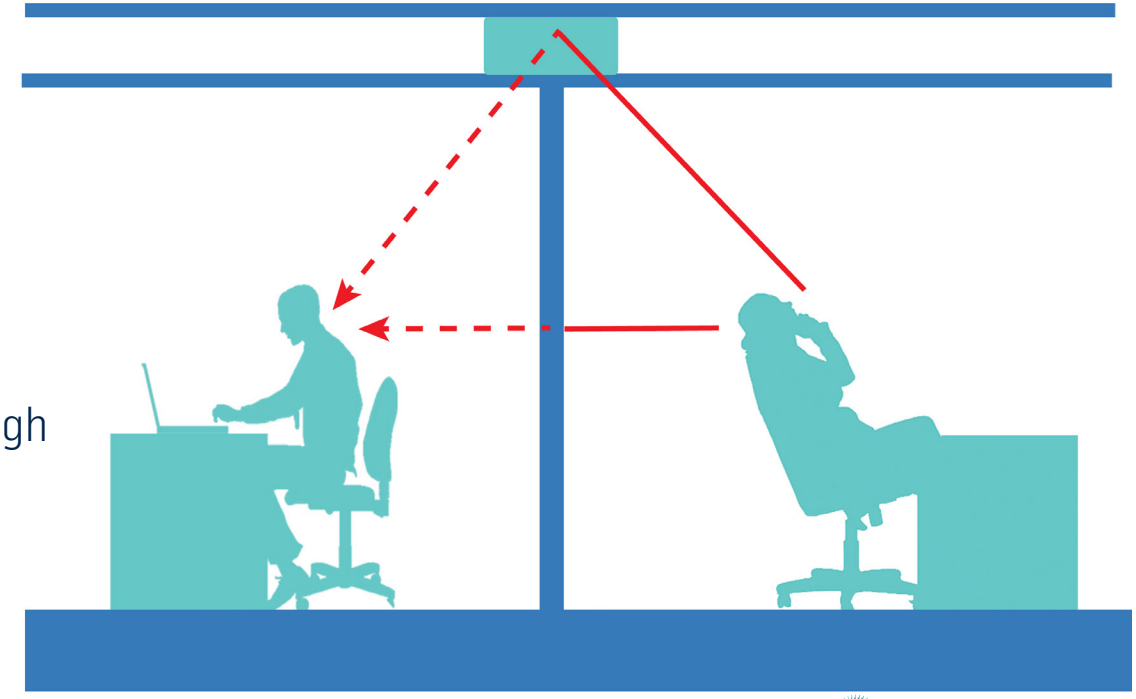
Noise Transfer

Noise transfer between offices is due to the isolation quality of a wall and ceiling assembly, as well as any potential flanking paths. The weakest point of an assembly largely determines the isolation quality of an assembly. Even if the assembly has a high STC rating, a variety of flanking paths can allow noise transmission and speech to be understood between spaces. Some of the sound paths that can contribute to potential noise transfer are:

- Wall Assembly
- Door Assembly
- Penetrations (light switches and power outlets)
- Air-Gap between wall and window mullion
- Flanking over the wall/through the ceiling through the ductwork.



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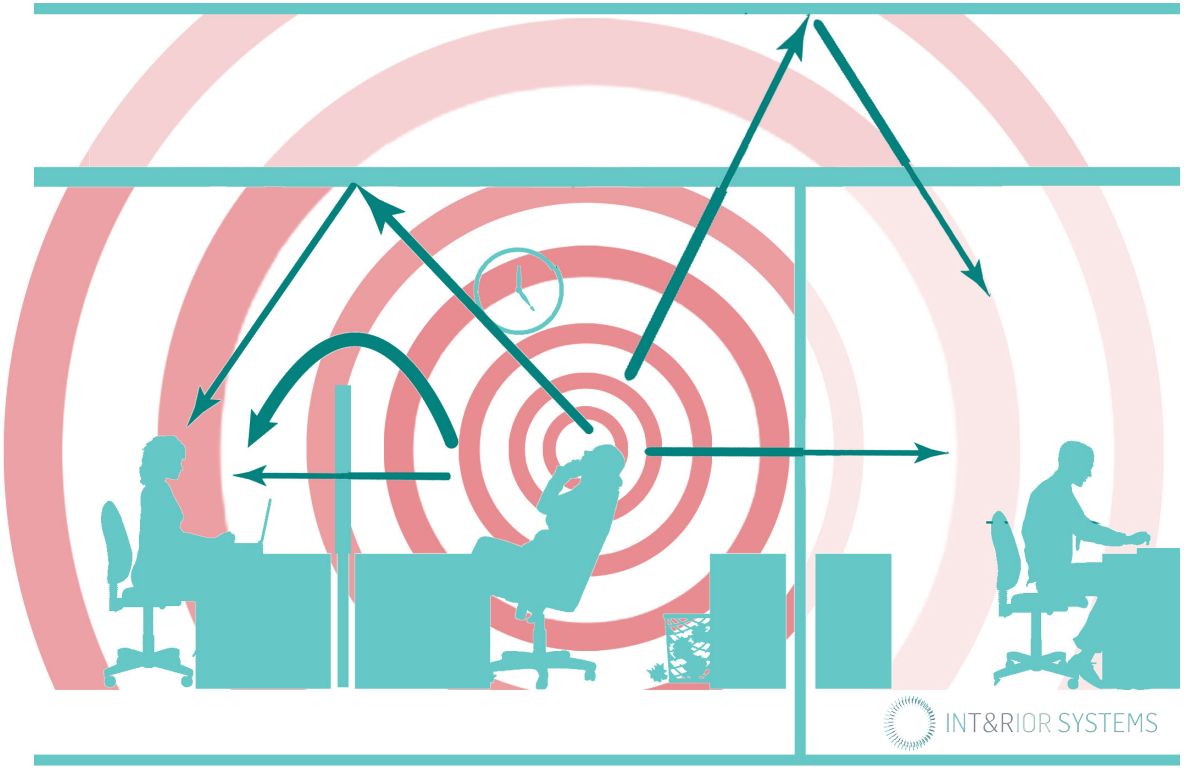
Attenuation - STC

30 dB has little sound-control effectiveness
35 dB allows normal conversation to be heard through the wall
40 dB allows loud conversation to be heard through the wall
50 dB will prevent loud conversation from being heard through the wall.
60 dB provides a decent level of confidentiality
65 dB will block most everyday noise.



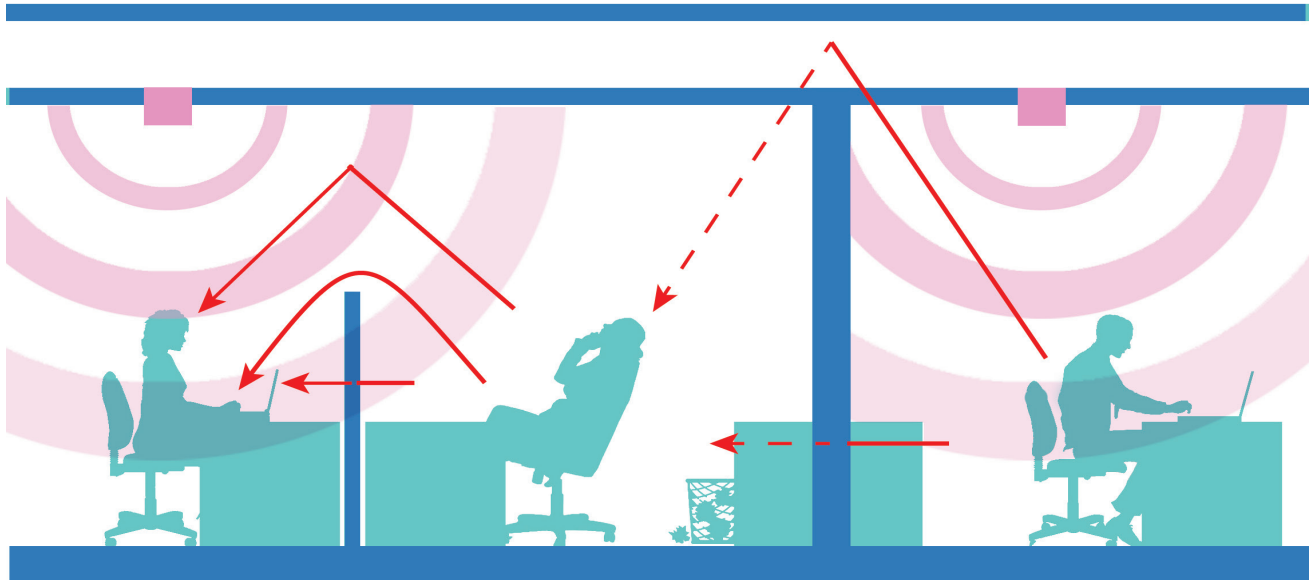
Summary

Recommended Design Parameters - Enclosed Spaces

Ceilings		NRC 0.70 OR NRC 0.90 and reflective panels
Floor		NRC 0.15
Wall/ceiling Attenuation:		
	Sensitive Areas	60 STC and CAC
	Adjacent Offices	45 - 50 STC and CAC
	Walls to Corridors	40 STC and CAC
Optimal Background Noise Levels	Private Offices	40 - 45 dBA
	Conference Rooms	35 - 40 dBA

Sound Masking

Effective Sound Masking



- It is uniform throughout the space – no 'hot' or 'dead' spots.
- It is the correct volume – louder than what it is covering, but not so loud as to interfere with conversations. One should never feel compelled to speak over it or strain to listen.
- It has the correct tonal qualities. A "hum" not a "hiss."

It is not noticed when it is on but, is missed if turned off . Background music is generally not effective as masking. It is another specific signal which may or may not be a distraction – depending on the individual and /or the task.

Optimal Background Noise Levels

Conference rooms	35-40dB
Private	40-45dB
Open-plan areas	45-50dB
Business machines	50-55dB

Product Solutions

Summary

Summary

Ceilings	NRC 0.90 or higher	Glasswool Suspended Ceiling (C Max Absorb Ceiling Tiles)
Floor	NRC 0.15	Carpet
Half Height Partitions	NRC 0.40 or higher STC 20	Perforated ply/plaster/metal or polyester wall covering
Walls	NRC 0.40	Polyester wall covering or Sound Cloud Panels
Ceilings	NRC 0.70 or higher	High NRC Mineral Fibre suspended Ceiling (Venus Max) C Max Direct Fix over plasterboard
Ceilings (high spec)	NRC 0.90 and reflective panels	C Max Absorb/ Sound Cloud Panels C Max Reflect or dropped ceiling in Ply/MDF etc
Floor	NRC 0.15	Carpet
Wall/Ceiling Attenuation:		
Sensitive Areas	60 STC and CAC	Careful selection of sound attenuating systems. Could include a mixture of Acoustic separation clips, baffleblock, high CAC tiles, solid core doors, double glazing, double layers of plasterboard, insulation, Whisper Stud etc.
Adjacent Offices	45 - 50 STC and CAC	
Walls to Corridors	40 STC and CAC	

T & R Interior Systems Ltd.
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