CEILING SYSTEMS

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CI/SfB (35) Xy

February 2007

ACOUSTICAL **GUIDE**

Role of ceilings in active acoustics

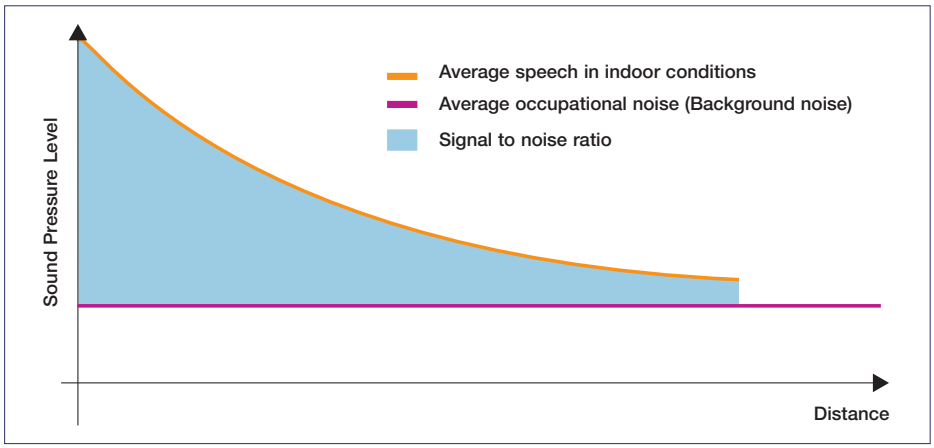
Armstrong

Why active acoustics are recommended

In a fully absorptive environment (no reflections/like in an open field) without any sound path barriers, sound levels decrease over distance at a rate of 6dB/doubling of distance (inverse square law).

The sound level decrease between a sound source and a listener is, in this case, only a function of distance (direct sound propagation path between source and receiver).

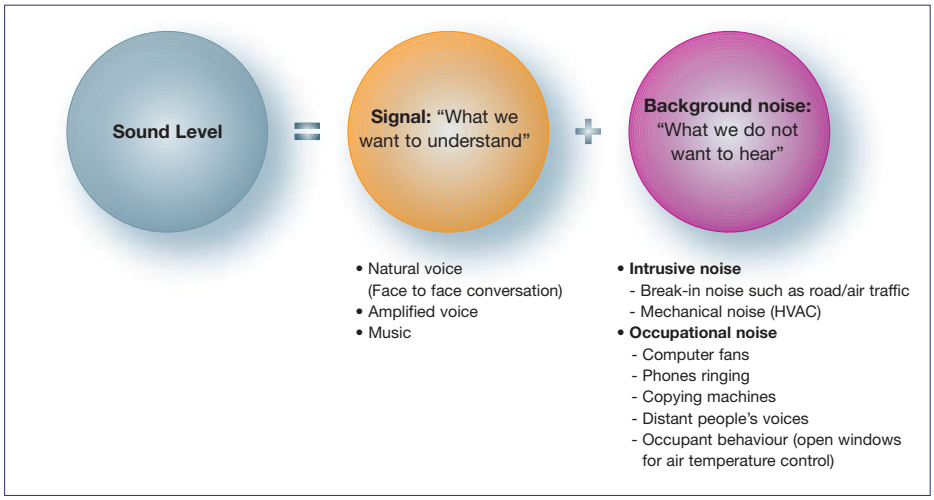
In enclosed spaces, sound can be reflected, absorbed and/or transmitted and sound level decrease is therefore not only a function of distance but also a function of the environment.



Sound & Signal to noise decay over distance in enclosed spaces

Passive acoustics address the needs to control reverberant and transmitted sound conditions in response to country, segment and application specific regulations.

At any listener's position, the sound level contributions may be composed as follows:



Sound level contributions in enclosed spaces

Building regulations are aimed at enhancing the signal while limiting the effect of background noise; however regulations do not set guidelines for acoustical system performances in '***functioning spaces***' (i.e fully occupied and with all noise sources taken into account) nor do they address the occupants' combined needs for intelligibility, privacy and concentration.

Functioning spaces introduce:

- Occupational noise, which contributes to the overall background noise level
- Absorption (any person present in the space absorbs sound).

'Occupational noise' and 'intrusive noise' are difficult to predict and their impact on the background noise level can vary significantly within a space. They increase the background noise level and therefore alter the signal to noise ratio. This may affect established levels of intelligibility, privacy and concentration.

Passive acoustic treatments alone (floors, partitions and ceilings) do not allow the end users' acoustical needs to be met, nor can they suit the occupants' future needs to adapt to activity change, occupational density change and space flexibility for reconfigurations.

The performance of passive systems as a whole (floor, ceilings, walls, furniture) is not always easy to predict. It depends not only on the performance of each individual element, but also on the quality of installation.

It is therefore recommended to address these constraints with active acoustics treatments.

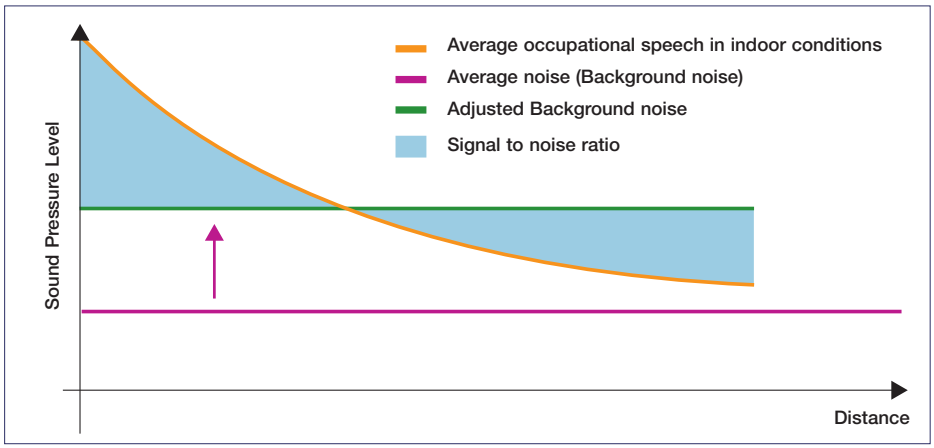
Actively managing the signal to noise ratio

Active ceilings integrate sound systems that actively manage signal to noise ratio by diffusing an amplified audio source through a loudspeaker network into the space below (active acoustics).
Active acoustics complement passive acoustic treatments to meet the occupants' immediate acoustical needs in functioning spaces (all sources taken into account) by introducing:

1 - Sound masking to overcome 'occupational factors'

Reduce the **signal to noise ratio** for improved privacy and concentration (reduce noise annoyance and mask distracting conversations).

Signal to noise ratio	Level of confidentiality
At least - 10 dB	Confidential privacy
- 5 dB	Good
5 dB - 10 dB	Marginal / poor
More than 10 dB	No privacy



Signal to noise reduction with sound masking

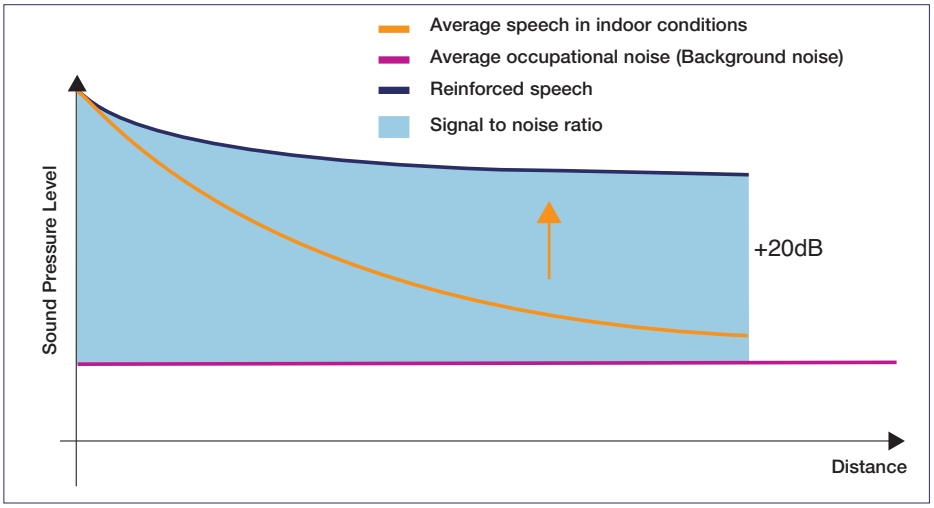
2 - Speech reinforcement to overcome distance and/or address large listener groups

Increase the signal to noise ratio for improved intelligibility.

To ensure excellent intelligibility, the signal to noise ration is recommended to be 10 - 15 dB minimum for people with good hearing and 20 – 30 dB for hearing impaired or users of head-sets (heard at the listener's position).

Indicative levels of speech intelligibility related to signal-to-noise ratio

People with good hearing	Signal-to-noise ratio	Hearing impaired or users of head-sets
-	30 dB	Excellent
-	20 dB	Good
Excellent	15 dB	Fair
Good	10 dB	Marginal
Fair	5 dB	Poor
Marginal	0 dB	No intelligibility
Poor	- 5 dB	-
No intelligibility	- 10 dB	-



Signal to noise increase with speech reinforcement

The graph above features sound decay over distance. When a space is in use, the occupational noise (background noise) introduced into a room can severely alter the optimal signal to noise ratio desired for speech intelligibility over distance (see general acoustics document). Introducing a speech reinforcement system 'lifts' the signal (voice) sufficiently above background noise to deliver an intelligible message throughout the room.

3 - Paging to address people from a remote location

Active acoustics may be used to diffuse a remote speaker's voice into a specific space. The amplified speech level is monitored to provide a strong enough signal to noise ratio in the targeted space while not disturbing adjacent rooms.

A good active acoustics system will allow each of the three 'criteria' listed above to be met both individually and in combination with each other.

Key criteria for active acoustics systems

Frequency response

Describes how much of the sources original frequency content the loudspeaker can reproduce.

Sensitivity

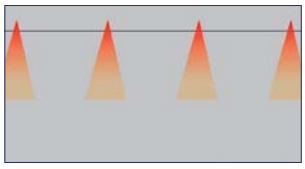
A measurement of the deliverable sound pressure level at 1W,1m. This criterion allows the selection of the loudspeaker type vs. the application.

Directivity

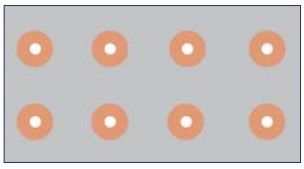
A measure of the angular dispersion of sound diffused by loudspeakers.
Low directivity at all frequencies is most desirable.
Over the full audible range (20Hz to 20,000Hz), frequencies may be divided into 3 groups:

- High frequencies (above 5,000Hz)
- Mid frequencies (300Hz to 5,000Hz)
- Low frequencies (below 300Hz)

With traditional loudspeaker systems (cone speakers), directivity increases with frequency.

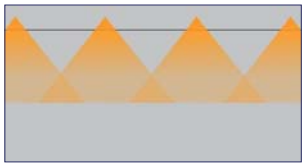


High directivity loudspeaker in section creating 'hot spots' and 'cold spots'

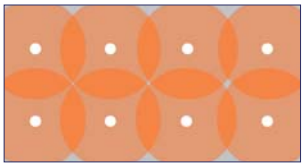


High directivity loudspeaker in plan

NXT technology based flat panel loudspeakers allow equal directivity to be achieved over the full frequency range.



Low directivity loudspeaker in section, for uniform coverage



Low directivity loudspeaker in plan

Low directivity in commercial, education and office environments is key to achieving good levels of intelligibility, privacy and concentration.

Sound coverage

Achieving uniform sound coverage across a room allows the production of a consistent signal to noise ratio at all listeners' positions.
The human ear is very sensitive to sound pressure level variations and uneven sound coverage creates 'hot spots' (focused areas of high sound pressure levels) and 'cold spots' (areas of low sound pressure levels) which are disturbing to occupants and counter productive in the case of speech privacy treatments in offices.
Sound coverage is a function of loudspeaker directivity as well as loudspeaker spacing.

Sound coverage guidelines for sound systems are as follows:
+/- 3dB 'good' (in-store music and marketing messages)
+/- 2dB 'better' (speech reinforcement in classrooms)
+/- 1dB 'best' (sound masking installation).

Benefits

- On-site levels of performance: Active acoustics take into account all sound and noise sources on-site to guarantee levels of **intelligibility**, **privacy** and **concentration**.
- In combination with passive acoustics treatments, create a **flexible environment** to meet current and future end users' needs.
- Active acoustics create more **communicative** spaces (intelligible commercial messages for increased levels of sales), more **productive** spaces (less noise distractions) and more **private** spaces (protection of data in retail banking, healthcare or office environments).

ARMSTRONG, undoubtedly the best acoustical provider with both active and passive treatments for all requirements.

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