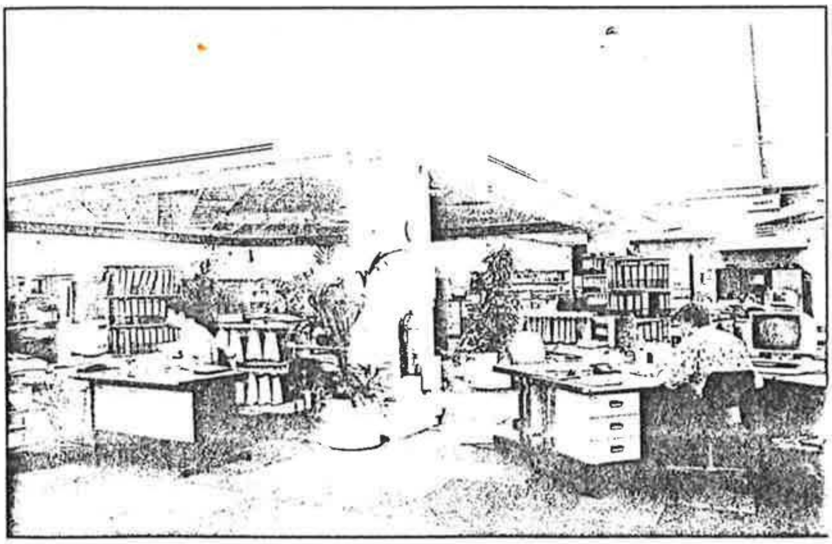
When quieter is not better at the office

Office noise affects the productivity of every person in every office. Companies have woken up to the detrimental effects on productivity of stale air pumped out by air-conditioning systems, and they are replacing these with natural ventilation systems. However, air-conditioning provides a useful by-product: the steady masking of background noise. Tom Dawn considers the options for creating a better acoustical environment.

Evidence shows that there is a pay-off in the balance between the sounds we need to hear and those that cause distraction. New approaches to office building design threaten to tip the noise balance in the wrong direction in their efforts to improve other aspects of the indoor climate.

The popular direction for improved building design in recent years has been defined by so-called "sick" buildings, in which workers are repeatedly absent as a result of one illness or another, often related to their lungs. A second important factor has been the increasing drive for energy efficiency.

Figure 1: Open-plan offices work on the principle of keeping functionally related work groups together. Background noise contributes to acoustic privacy.



The results of these efforts have been an increasing tendency towards using natural ventilation, natural lighting and passive heat control. Natural noise, however, is not so effective in its role of providing the ambient sound conditions that optimize our productivity.

Until now background noise in offices has been created by a combination of forced ventilation and outdoor traffic noise, typically providing levels of 35–40 dB(A). In contrast an office ventilated by a displacement vent system typically has background noise of 20–25 dB(A).

The installation of displacement ventilation with static cooling will become more common in the UK in the next few years. These systems are already well established in Scandinavia and Switzerland, and other continental European countries are following their lead.

Designers will thus be faced increasingly with a choice between providing active background noise sources to create the masking effect or much improved sound insulation within offices. This is an economic choice, an example of which is provided in the case study (p13).

Productivity and privacy

Research at Heriot-Watt University by C & R Mackenzie demonstrated that "interesting" background speech causes a dip in productivity of over 10% in tests similar to office clerical tasks. The distraction was overcome by applying a masking noise of approximately 4 dB above the level of background speech. The results indicated that the precise spectrum of broadband masking noise was largely irrelevant. Mackenzie's research supported evidence from as early as the 1950s that identified noise as a cause of lower productivity in banking halls.

The open-plan office concept works on the principle that functionally related workgroups are able to hear each other clearly but are shielded from intelligible sounds from other groups. In the right circumstances this controlled contact undoubtedly provides motivation and helps communication.

For individuals such as managers who need uninterrupted periods of concentration, an increased level of privacy is necessary and, in some cases, a high level of sound insulation is required for confidentiality. This is often achieved by providing cellular offices for managers.

In contrast with the office environment, research conducted in industry – the pressing shop of a car factory – by Dr David Wyon in South Africa concluded that noise and temperature do not affect performance. Wyon studied the combined effects of heat and noise on parameters like reaction, aim, vigilance and motor judgement. His study included temperatures of 22 °C and 30 °C, and a noise rating of 85 dB(A).

CIBSE office noise ratings

In its 1986 guide, the Chartered Institution of Building Services Engineers recommends noise ratings (a weighted sound pressure level measurement, allowing for our lesser tolerance of high-frequency noise) for various locations (see table). It should be remembered that, in a typical office, the actual levels may vary by ~5 dB(A).

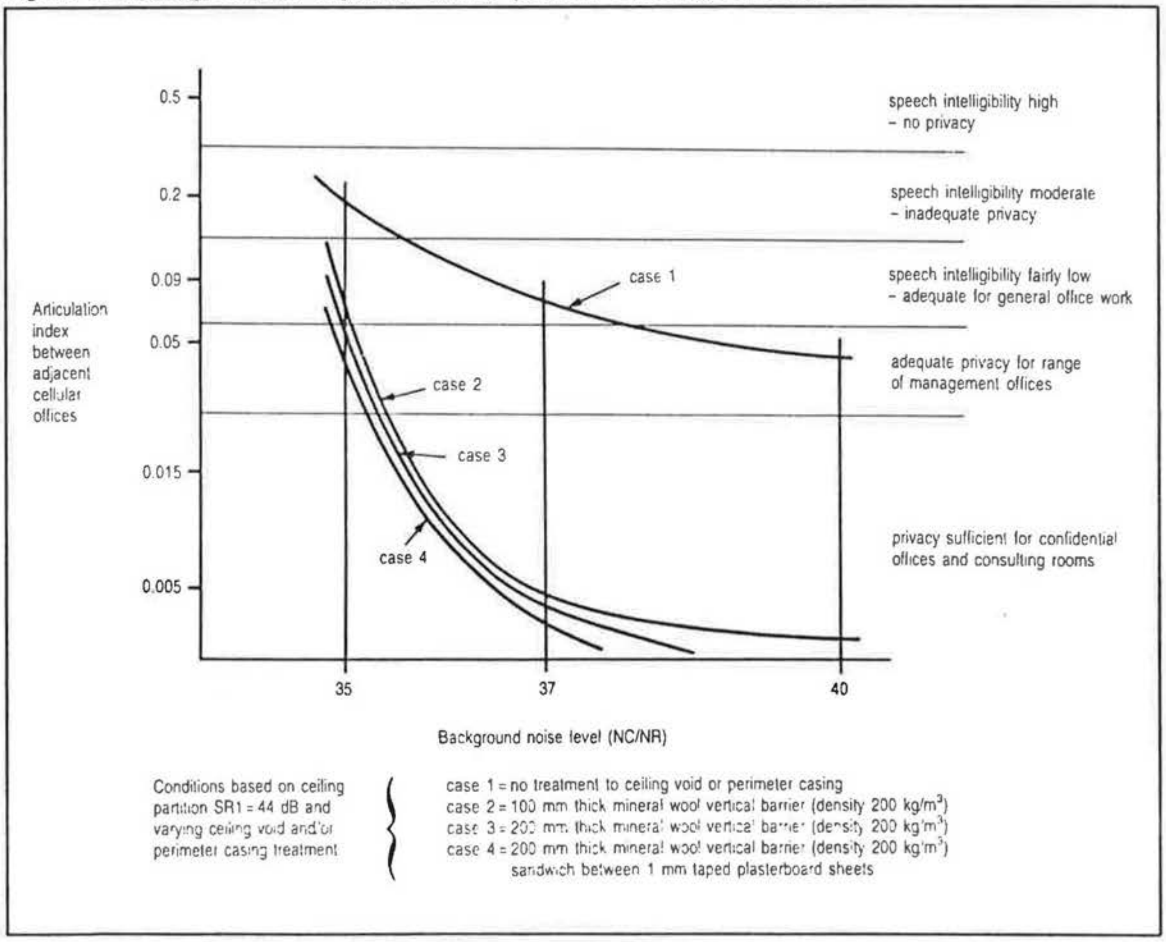
With a background noise rating of 40 dB(A), the typical maximum distance at which normal speech is intelligible is 7 m. This hearing range can be reduced by the installation of sound-reducing partitions. However, these barriers will not close the path for sound reflected off the ceiling, which must therefore also be made of absorbent material. For instance, ceiling material with a sound absorption coefficient of 0.9 reduces reflected sound by 10 dB. The space above suspended ceilings or within perimeter casings may provide additional sound paths, which are difficult to deal with because of access.

Examples of the balance between background noise and sound insulation above suspended ceilings is illustrated by the graph (figure 2) indicating levels of privacy, based on the experience of Stuart Morgan of acoustic consultants Hann Tucker Associates.

Table: CIBSE's recommended noise ratings

Location	Rating dB(A)
top management offices	30
middle management offices and small conference rooms	35
common areas of offices	40
landscaped offices	45

Figure 2: Privacy between adjacent offices (source: Building Services*).*



Sound conditioning versus sound insulation

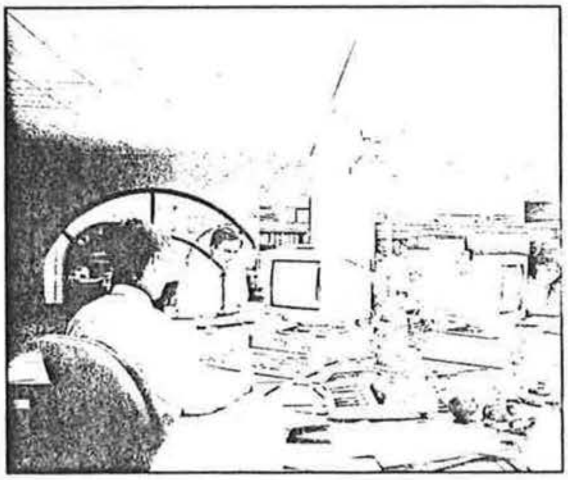
The sound-masking benefit of air-conditioning has been recognized since open-plan offices were introduced in the 1950s, to the extent that it has been taken for granted. Specific sound-control systems were developed to protect security services from snoopers or for other specialized applications. General sound control is only now becoming an issue that building designers have to face as air-conditioning systems are replaced by natural ventilation or displacement ventilation, and as atriums increase the number of "outside" walls in a building, and thus insulation from outside sounds.

Many companies are still unconvinced of the need to invest in specific noise-control systems. The expense has often been justified in terms of secondary benefits, such as providing a public address system. Because of this reluctance to invest, only larger building designers and specialist consultants are likely to promote sound control.

Both natural and displacement ventilation systems are quieter than air-conditioning. The former involves opening windows, which lets in traffic noise. This can provide sound masking, but is often irregular and can itself be a distraction. Although natural noise sources, such as office equipment (figure 3), normal office activity and outside traffic noise, can make a positive contribution to background noise, they are not controlled and are therefore not guaranteed.

However, new products are coming on the market that offer a wider range of options for outside noise control. For example Colt International's interactive window system allows natural ventilation through an open window without letting in outside noise (figure 4). The system uses an upper opening light to allow good air exchange and daylight, external horizontal louvres for solar protection, a sound baffle for acoustic attenuation, internal blind options for solar glare protection, and an internal daylight shelf to assist daylight dispersal and prevent solar and sky glare.

Figure 3: PCs and photocopiers help to provide background noise, but forced ventilation systems contribute most.



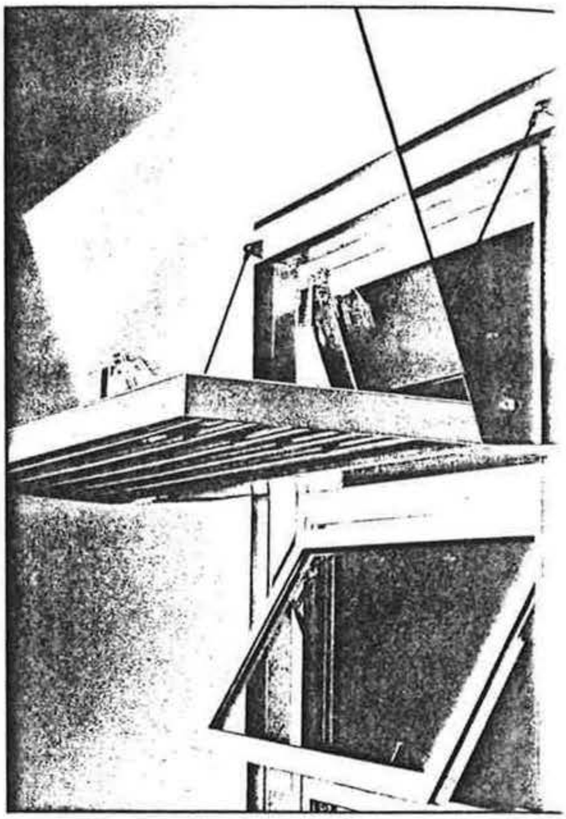


Figure 4: Colt's Interactive Window. Baffles keep out unwanted traffic noise.

Sound-insulating partitions provide a solution to distracting noises for cellularized offices and, to a limited extent, open-plan areas. In addition regular sounds, which mask irregular and distracting sounds, can be generated by placing broadband sound sources in suspended ceilings. Solutions must be tailored to the individual environment. For example the Staines-based consultancy, Applied Acoustic Design, recently used a sound-masking system to counter the effect of cross-talk between two adjacent conference rooms.

The effect was perceived as an annoying distraction by people on both sides of the wall. On testing the level of sound insulation between the two rooms, no single weak spot could be identified, and general levels of sound insulation were reasonably high. The problem was attributed to the unusually quiet situation of the conference rooms. The cost-effective solution (which also minimized disturbance) was to install a sound-masking system, allowing precise background noise to be set for the specific space.

Case study: When sound conditioning is the economic choice

Consultants Hoare Lee & Partners were commissioned to design a new headquarters office development for a large financial institution as part of its plans for relocation. The total office area was to be 35 000 m^2.

The decision to ventilate and cool the office development with a displacement ventilation-chilled beam system was expected to reduce background noise levels. These were likely to drop to around noise rating NR25 (30 dB(A)), compared with the value of NR35 typically associated with traditional forced ventilation.

The client's requirements included good open-plan office acoustics and a good standard of speech privacy in most cellularized offices, meeting rooms and other areas. Open-plan office acoustics rely on a minimum level of continuous background masking noise, which is not provided by a displacement ventilation-chilled beam system. Other sound sources may be present, such as normal office activities, and fans on PCs and printers. These can provide some beneficial sound masking, but this is not consistent throughout the building or throughout the day. Additional measures were therefore necessary to achieve the required acoustic environment and levels of privacy.

Hoare Lee investigated two alternative approaches to improving the acoustic environment. First, the possibility of sound conditioning was assessed, and then its cost was compared with the likely cost of improved sound insulation.

The cost of sound conditioning was estimated at £4/m^2, or a total of £140 000 for the whole building. This choice would bring the additional benefit of doubling up as a building-wide public address system. The stand-alone figure of £140 000 appeared high until the cost savings associated with rerating the sound insulation performance of relocatable partitions was taken into account.

Partitions were needed to divide ~10% of the total floor area into cellular offices or meeting rooms (2775 m). To achieve the reasonable degree of speech privacy specified by the client, the requirement for office NR level plus partition sound insulation factor would equal 70 dB.

Considering the case without sound conditioning, with an office NR of 25, the rating for the partition sound insulation needed to be 45 dB. The cost of such a high degree of sound insulation boosted the cost of the partitioning system to around £275/m, resulting in a total cost for partitions of £625 000.

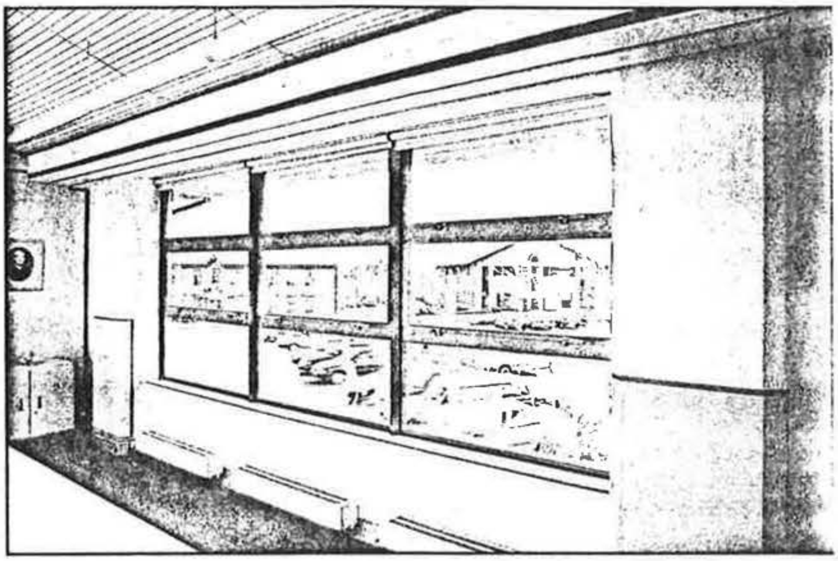


Figure 5: Displacement ventilation with static cooling creates a quieter office.

The difference made by using sound conditioning to guarantee a background noise rating of NR35 was to reduce the partition sound insulation requirement to 35 dB. The cost of the 35 dB version of the selected partitioning system was just £190/m, resulting in a total cost for partitions of £423 000.

The case in favour of sound conditioning looked persuasive. The saving in partitioning costs was £193 000, which more than compensated for the £140 000 cost of the sound-conditioning system in this case. In addition the partitioning system did not compensate for the lack of background noise in the open-plan parts of the office, which the sound-conditioning system did. Other factors may also be significant, such as the saving made by not needing to buy a separate public address system.

On the other hand, cheaper ranges of partitions could have been considered. One range, for instance, includes prices of around £70 for partitions with a sound insulation equivalent to 35 dB, and £85 for a 45 dB equivalent. In the same installation the choice between these two partitioning systems would be £42 000. The economics of this example may therefore appear to represent an extreme case, because they are based on an expensive partitioning system. It should be borne in mind, however, that 10% of floor space devoted to cellular offices or other rooms is a relatively low figure. The proportion is commonly 20–25%, which would again increase the cost of partitions.

The choice between the two solutions is often marginal in economic terms. Building services designers may therefore prefer the solution that offers the greatest control and flexibility in satisfying their particular needs, and this will most often be a sound-conditioning system.