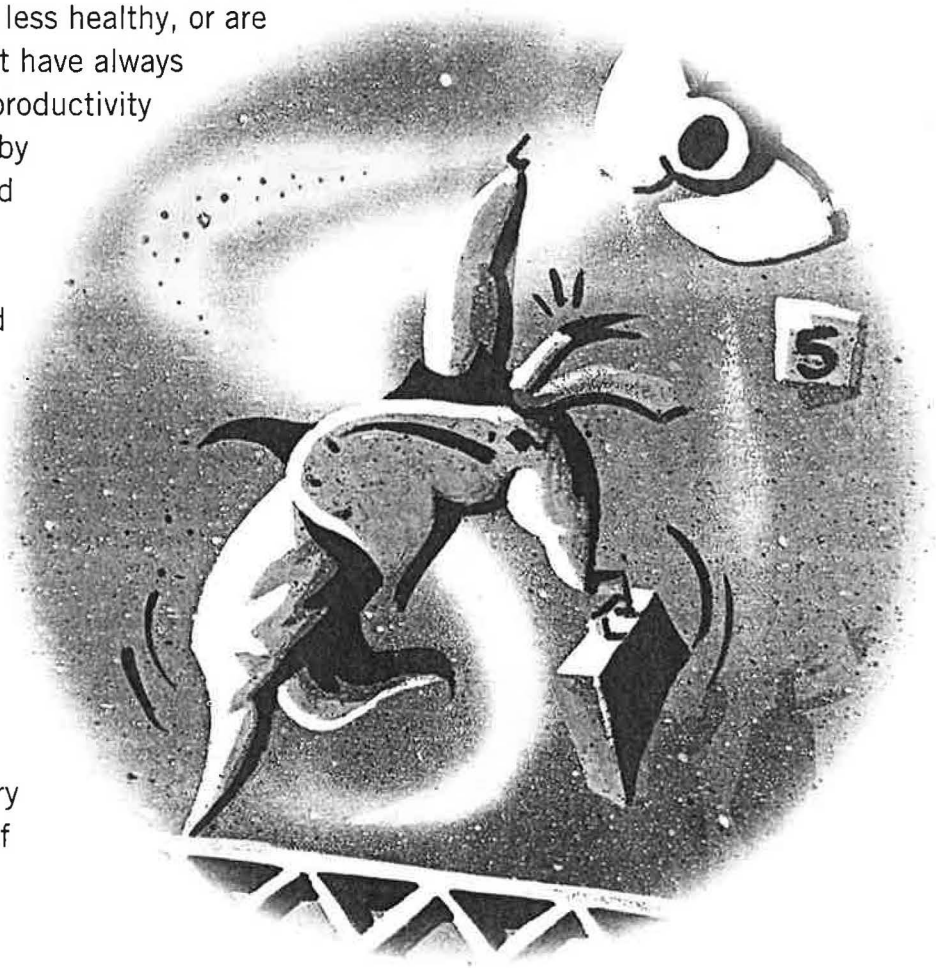
INDOOR AIR QUALITY

Why are we getting more concerned over indoor air quality? Are modern buildings becoming less healthy, or are we just identifying problems that have always existed? If human comfort and productivity is being seriously compromised by chemicals from photocopiers and fungi from furnishings, are our ventilation rates and cleaning regimes really sufficient? Should we ventilate our way out of the problem, or simply engineer out the pollutant source?

benchmarks for better buildings

The second part of our campaign Benchmarks for Better Buildings looks at the health and comfort needs of building occupants.

In this introductory feature on indoor air quality, the BRE's Gary Raw identifies the key sources of pollution within buildings.



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We know that poor indoor air quality is a growing problem – the difficulty lies in defining it. Although illnesses such as Legionnaires' Disease and asbestosis are primarily airborne diseases, in general non-industrial work places have to deal with very low levels of pollutants. Loss of life or serious disease is not normally an issue.

The nature of indoor pollution is very difficult to assess because of the many different chemicals involved and the fact that some of them are not perceptible, for example radon. Furthermore, the relationship between low-level exposure and the occurrence of sick building-type symptoms such as irritation of the eyes, nose, throat and skin, headaches, lethargy and lack of concentration is not very well defined.

Even for those pollutants which can be detected because of their odour or irritation effects there is the issue of who should be the judge of what is acceptable. One option is to use all of the occupants or a random selection of them to assess a building, or a panel of the most sensitive occupants could be used.

Although any standard method of assessment should be predictable from building to building, occupants will vary and the individual occupants may vary from day to day in their responsiveness.

Productivity or staff efficiency could be used to determine standards for indoor air quality, but it is proving difficult to assess whether performance has been improved or reduced by a certain level of indoor pollution. Whatever criteria are chosen they must somehow be converted into pollutant limits. This still requires very extensive research because of the vast number of pollutants and the difficulty in establishing their effects.

In the meantime there is still an imperative to minimise all pollutants now, and not wait for the research to be completed. For example, if material A produces less pollution than material B then, all other things being equal, we should use material A.

Probably the greatest technical challenge in setting standards for indoor air quality is the fact that it interacts with other factors to cause complaints. The same human responses can result from failings that are quite distinct from indoor air quality. Therefore, it is risky to assume that a specific complaint is due to indoor air quality problems.

Sources of indoor pollution

Pollution can come from chemicals and equipment used in the majority of today's offices, such as correction fluid or photocopiers, but also the building and furnishing materials themselves. Indoor surface pollution is not widely appreciated as a cause of building-related sickness, but the evidence for this potential cause is at least as good as the evidence for any other cause.

Indoor surface pollution refers to the particulates and adsorbed vapours on or within surface materials, such as desktops, chair covers and flooring materials. The level of particulates to which office workers are exposed can be four to five times higher than ambient airborne levels, as people create their own dust cloud in the course of their work by stirring up settled dust.

Particulates should not be regarded as simply air pollutants, effective only when inhaled, as they can be transferred direct to the skin or ingested with food or drink – aspects which have yet to be properly explored.

Attention is often focused on new buildings and new furnishings, but this is an inadequate view of the problem. Although new buildings

give rise to certain pollutants, the emission of these chemicals normally decreases with time while the emission of other pollutants increases over time.

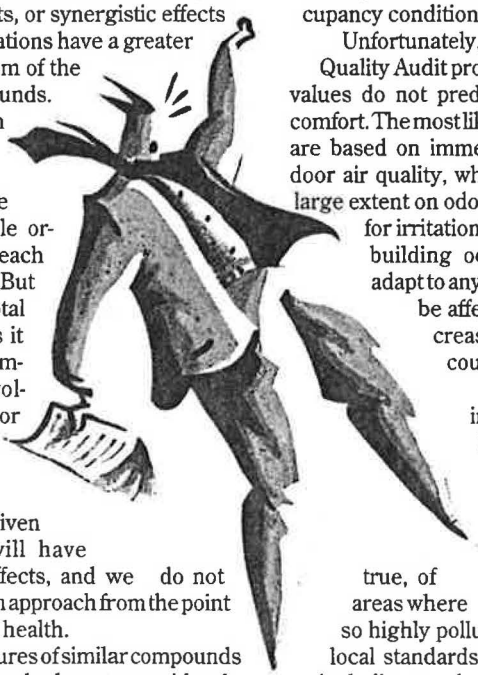
As a building ages the furnishings become contaminated with the debris of everyday life, for example food residue, skin scales and paper dust. All these accumulate, particularly in soft furnishings and in paper stores which are rarely used or cleaned. This provides a habitat for fungi, bacteria and dust mites which can then release effective allergenic and irritant material into the air.

Building services can also be a source of emissions, both from new materials and the collection of dust and dirt in older materials. Almost any part of an air conditioning system can harbour dust and dirt, from the filters through to the ductwork. Indeed it has been shown that filters can become a source of fungal growth, the hyphae growing through the filter and releasing spores onto the building side. More research is needed to investigate the ways in which this kind of development can be controlled.

Volatile organic compounds

Of all these pollutants probably those most in need of further investigation are volatile organic compounds (voc). Many hundreds have been identified in indoor air, and they are relatively expensive to identify and measure in low concentrations.

In general, concentrations have been found to be several orders of magnitude lower than occupational standards for industrial work places. However, the health effects of long-term exposure to low concentrations have not been established and neither have the possible additive effects, or synergistic effects whereby combinations have a greater effect than the sum of the individual compounds.



Indoor air in most non-industrial buildings will contain a large number of volatile organic chemicals, each at a very low level. But how should the total be defined? Does it depend, for example, on mass, volume, molecules or carbon content? Depending on the constituents of the mixture a given concentration will have quite different effects, and we do not know the optimum approach from the point of view of human health.

Assessing mixtures of similar compounds is one issue, but we also have to consider, for example, mixtures of organic compounds, particulates and allergens. There is a need to develop methods of measuring these mixtures in order to determine their effects.

However, the sheer complexity of measuring indoor pollution raises the question of using people themselves as the test instruments. If a problem is defined in terms of human reaction (symptoms, complaints and diseases, etc), why not use people to measure the problems? The use of questionnaires given to building occupants is a well established procedure for assessing problems of the indoor environment. An alternative to using occupant questionnaires is to use panels of assessors who visit buildings to judge the air quality. This approach, championed by Professor Ole Fanger, has given rise to the development of the olf and decipol units of assessment, and forms the basis of the proposed European standard *prENV 1752*[1].

The olf is a unit of the source strength of pollution. The starting point of the derivation of this unit is that odour is an important measure of indoor pollution levels, and can only truly be measured by people.

One olf is the amount of air pollution produced by one standard person (a standard person is defined as an average adult working in an office or a similar non-industrial workplace, sedentary and in thermal comfort with a hygiene standard equivalent to 0·7 baths per day), whereas one decipol is the perceived air pollution level in a space in which there is a source strength of one olf, and which is ventilated at 10 litres/s with unpolluted air.

Panels of people have been trained to give decipol ratings, and are then taken to different buildings under different ventilation and occupancy conditions.

Unfortunately, the European Indoor Air Quality Audit project[2] showed that decipol values do not predict occupant health and comfort. The most likely reason is that decipols are based on immediate impressions of indoor air quality, which would be based to a large extent on odour, with little opportunity for irritation to begin. In contrast, the building occupants would quickly adapt to any steady odours, but would be affected by irritants to an increasing degree during the course of a working day.

All the concern surrounding indoor sources of pollution should not cloud the fact that the outdoor environment is also a source of pollution. This is particularly true, of course, in central city areas where the outdoor air may be so highly polluted that it does not meet local standards. In almost any location, including rural areas, the outdoor air, soil and water can be sources of pollution.

Source control

Setting aside considerations of running costs and capital costs for the moment, the normal first choice for control of pollution should be to deal with the source before trying to remove pollutants that might be produced. There are essentially three ways of controlling a pollution source: substitute one material, process or piece of equipment for another, modify the pollutant source to reduce the rate of emission or isolate the source from the air in the building.

There is a great deal of activity worldwide to identify and promote substitute materials with lower emission rates. For example, the BRE is involved in measuring voc emissions from building materials.

Many private companies and some governments are now making requirements for emissions testing of materials for building fabric and furnishings. This is all to the good, but it may be some time before sufficient alternative materials are available which also meet all the functional requirements of the materials currently in use.

Other methods must therefore be considered, such as "building bake-outs" – currently favoured in the US – where internal temperatures are raised in new buildings to drive off pollutants from the building materials. This is combined with ventilation of the building to remove the pollutants.

While results have been encouraging, energy costs must be minimised and the cracking of plaster or lifting of floors must also be avoided.

Current knowledge

There are many gaps in current knowledge about indoor air pollution. However, there is also a great deal of knowledge which exists mainly in the research community – the problem is that it only trickles through very slowly to the people who actually design, build and manage office buildings.

An additional problem is that those who have a sound knowledge of the issues do not always apply it. While we seek to plug gaps in our existing knowledge, we should also implement the good practice which we can already define.

This means creating a construction practice which allows an integrated approach to building at all levels, from the whole building through to the environment and organisation in the building and down to the individual (and at all stages in the life of the building, from the design brief right through to maintenance and operation).

Without this, plugging the gaps in our knowledge will be of limited value since we will continue to fail to apply existing knowledge in the right way.

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References

[1]Sims B, "Fanger's standard faces further delay", *Building Services Journal*, 11/96.
[2]Aizlewood C E, Oseland N A and Raw G J, "Testing times for indoor air quality", *Building Services Journal*, 7/95.