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Towards a clean bill of health

While we may not know all the answers yet, an understanding of the problems and causes of indoor air pollution is developing. Nancy Thomson reviews the current situation — and indicates standards for a healthy building.

Despite growing concern about outdoor air pollution, indoor air quality is more relevant to the health of most people. The average person spends 90% of his time indoors (1), and it is there that the highest levels of many pollutants and the longest exposure times are found.

The most important pollutants which might lead to ill health and discomfort in non-domestic buildings are:

- formaldehyde;
- organic gases and vapours;
- dust;
- airborne fibres;
- bacteria;
- fungi.

This article also discusses the measurement of carbon dioxide as an indicator of fresh-air ventilation and introduces the concept of a 'building health certificate' for non-domestic buildings.

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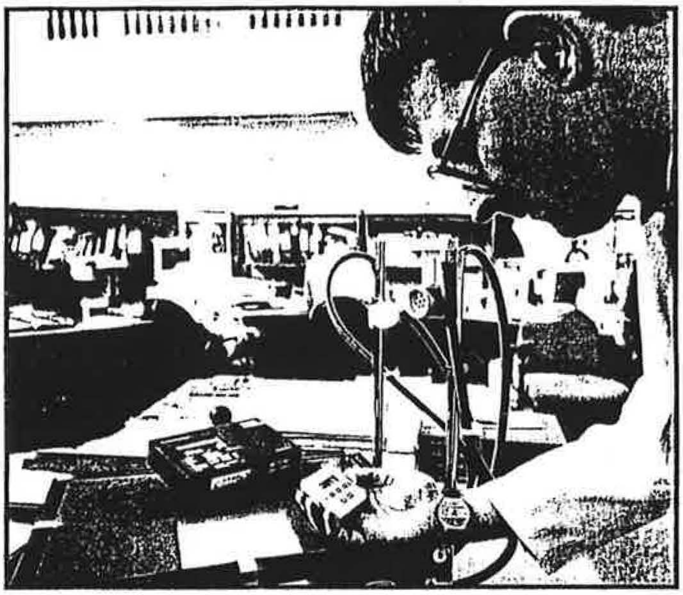
Formaldehyde is a colourless gas with many possible sources due to the widespread use of urea-formaldehyde as a bonding agent. Its major sources are particle board and urea-formaldehyde foamed insulation. Other sources are furnishings, floor coverings and carpet backing.

Toxicity

The recent substantial increase in information on the toxicity of formaldehyde (2) has led to many regulatory authorities reviewing their position on its carcinogenicity. The International Agency for Research on Cancer now says, 'The agent is probably carcinogenic to humans.' The EEC has placed formaldehyde in Category 3 — 'substances which cause concern to man owing to possible carcinogenic effects'. The United States Occupational Safety & Health Agency has reduced the occupational hygiene standards to 1 p.p.m. (8 h time-weighted average) and 2 p.p.m. (short term exposure limit, which is similar to the UK maximum exposure limit under the COSHH regulations).



Recording indoor carbon-dioxide concentration can make it possible to assess how fresh air can be used to dilute pollutants.

In buildings where formaldehyde is not used as a working substance, lower levels would be appropriate — based on its ability to irritate the mucous membrane. There is no agreement yet how far exposure levels accepted in the workplace should be reduced to apply to offices where the pollution has arisen from the building or its furnishings and fittings. The World Health Organisation has set an acceptable limit of 100 $\mu g/m^3$ (about 0.1 p.p.m.) as a 30 minute average based on its irritant effects (11).

One of the few published surveys of formaldehyde levels in UK buildings found that in those treated with urea formaldehyde foam, 70% had levels less than 120 $\mu g/m^3$, with some exceeding 1000 $\mu g/m^3$ (3).

While it may be possible to limit the use of formaldehyde-emitting materials in new building, this pollutant is of concern in the existing building stock.

One technique is for the ventilation system to introduce fresh air. According to one survey (3), urban air typically contains 7 $\mu g/m^3$ of formaldehyde. In some cases, it may also be possible to find the source of emission of formaldehyde and remove or seal it.

A recent review of building regulations and health (4) pointed out that little is known, in nearly all cases, of the effects of long-term exposure to low concentrations of the many organic gases and vapours inside buildings. Sources include the building fabric, furnishings, combustion, smoking and people.

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A large study of the exposure of individuals in California included personal air monitors (5). It showed that m,p-Xylene, 1,1,1-trichloroethane, benzene, o-xylene and ethylbenzene were ubiquitous. Often present were n-octane, m,p-dichlorobenzene, a-pinene, n-undecane, trichloroethylene and styrene. Many other compounds were occasionally found during the study.

Importance

Investigations by Thomson Laboratories in UK buildings found a similar range of substances. For most of these compounds, indoor levels exceed those outdoors — showing once again the importance of looking carefully at air pollution problems inside buildings.

The levels at which all of these compounds are found are lower by several orders of magnitude than those set for workers in industry. Some buildings have very much higher levels than others — particularly new ones.

This 'cocktail' of organic compounds has been suggested as one of the causes of 'sick building syndrome', (6,7). There are no generally accepted standards for these substances outside factories, so it only makes sense to take action when the levels are substantially above those in the ambient air and above those in most buildings.

Both indoor and outdoor air contain a wide range of particles of respirable size. Larger particles are intercepted in nose or oesophagus and intermediate particles deposited in the tracheo-bronchial region; these particles are not retained in the body and are likely to cause no more than coughs and sneezes. Very small particles less than 5 μm behave as a gas and are exhaled, even though they penetrate to the innermost part of the lung.

The most serious health risk is from asbestos. It has been widely used in the past for sprayed insulation, lagging pipes and boilers, insulation board and tiles. It can cause serious diseases, including asbestosis, lung cancer and mesothelioma. In existing buildings, asbestos is usually harmless unless disturbed.

Health effects of exposure to other fibres, such as man-made mineral fibres, have not been clearly established, although they are suspected of causing eye irritation.

Most airborne dust in offices is carpet and paper dust. A study of Danish town halls found mean levels of about 0.2mg/m^3. This dust has also been suggested as a cause of 'sick building syndrome', but no defintive studies have yet been made.

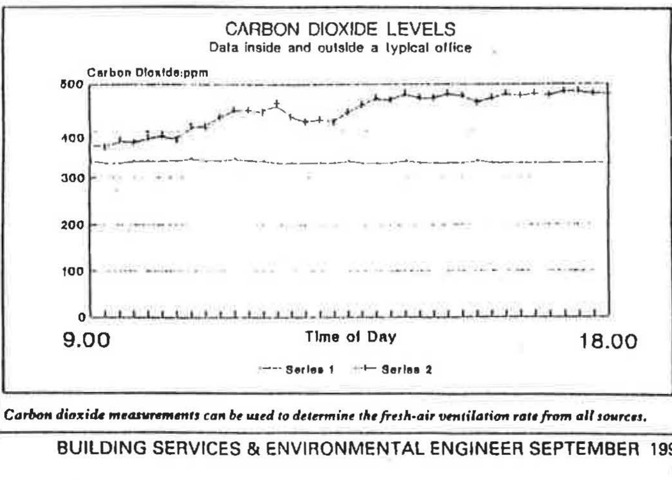
Due to the wide range of species and the limitations of measurement techniques, knowledge of the types and concentration of micro-organisms in indoor air is very limited compared with other pollutants (4). Concentrations depend on the ability to form colonies, which in turn depends on a suitable substrate, nutrient and environment — particularly humidity and temperature.

Ill-health effects are of two types.

— Allergies, ranging from allergic rhinitis to potentially serious conditions such as extrinsic allergenic alveolitis.

— Infection, ranging from

Thompson Laboratories uses this Quantitech Miran 1B2 gas analyser to measure levels of airborne containments.



Carbon dioxide measurements can be used to determine the fresh-air ventilation rate from all sources.

the common cold to Legionnaires' Disease.

Some sources have received particular attention, such as spray humidifiers in air conditioned buildings, where humidifier disease — sometimes known as 'Monday sickness' — can arise (10) when bacteria thrive in the drip tray. Air conditioning cooling coils can also act as a breeding site for organic growth.

Airborne levels of bacteria and fungi (moulds) will generally be higher inside buildings than outside. People release bacteria, and moulds are likely to form wherever the humidity exceeds 70% for long periods. Some investigators take swabs from surfaces in the occupied space and in the duct system. At Thomson Laboratories we believe this to be misleading as viable organisms are not necessarily a hazard, since bacteria and fungi are ubiquitous.

However, where the levels of viable organisms from an air conditioning or ventilation system significantly exceed those in the ambient air, it is likely that the organisms are growing within the building services, necessitating identification of the source followed by remedial treatment.

Where levels inside and outside the building are similar, it is likely that the building is free from serious internal sources of infection.

Carbon dioxide levels in occupied buildings are always greater than outside. Typical levels outside are about 330 p.p.m. and differ little between rural and industrial areas. Inside levels are usually 400 to 500 p.p.m. and sometimes as high as 800 p.p.m.

The level depends on the number of people using the space and the rate at which fresh air enters — not to be confused with the air flow into a room from the ventilation system. There are two sources of fresh air — make-up air from the ventilation system and natural ventilation. It is often possible to estimate the amount of fresh air available to dilute pollutants by counting the number of occupants and measuring the difference between indoor and outdoor carbon dioxide.

Measurements of carbon dioxide sometimes show the fresh air flow rate to be well below the design intention — either because the system has been poorly commissioned or, more often, has been modified, sometimes to reduce energy consumption. In such cases and where the measured level of pollutants is high, it is usually possible to increase the fresh air flow and improve the internal environment.

For the last two years, Thomson Laboratories has been developing and using in practice a building health certificate for existing office buildings. All the pollutants discussed above are measured in selected regions of a building at two seasons of the year. If levels are found to be within generally accepted criteria a 'Building health certificate' is awarded. □

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