Clean air: *the inside story*

POWER STATIONS, heavy industries and motor vehicles traditionally are the focus of research and regulations aimed at keeping air quality at acceptable levels. In future, however, a new breed of emission controls is likely. These will target air pollutants emitted from indoor materials which have until recently received less attention from Australian scientists and environmental authorities.

The new controls will challenge Australian makers of modern construction materials, furnishings and office machinery, according to Stephen Brown from CSIRO's Division of Building, Construction and Engineering. Brown says compliance with overseas emission standards will be vital to this industry, which exports goods worth about $1000 million a year.

When adopted in Australia, the controls will bring economic benefits through reducing ventilation costs, improving productivity and lessening illnesses such as 'sick building syndrome' and allergies. Brown says the annual value of worker productivity gains resulting from healthier indoor environments is estimated to be at least $72 million, with gains from other effects, though difficult to estimate, likely to be substantially more.

Brown is the leader of CSIRO's indoor air quality research team based at Highett in Victoria. His project is one of three at the division that are part of the organisation's new air-quality program. The other projects involve thermal technologies and computational fluid mechanics (see box story on page 25).

Indoor pollutants

Pollutants are common in indoor air and many occur at concentrations high enough to affect the health of building occupants, Brown says. Typical pollutants are radon (from soil beneath buildings and some building products), formaldehyde and volatile organic compounds (from most synthetic building materials and contents), nitrogen oxides (from fuel combustion for heating, cooking) and microbes (from moist surfaces).

Since most people spend 70-90% of their time indoors, this is the major source of exposure to environmental pollutants. Brown says studies overseas have shown that people are exposed to a greater numbers and concentrations of air pollutants in buildings than outside them.

'We know that there are many organic compounds present in reasonably high concentrations in established houses,' Brown says. 'In new houses the concentration is even higher and we are fairly confident that the source is new building materials such as paints, adhesives or formaldehyde in particle board.'

As a result, environmental and health authorities around the world – including Australia's National Health and Medical Research Council (NHMRC) – are assessing the significance of exposures to indoor pollutants and are developing air-quality goals and control strategies.

For some pollutants, these controls will be based on building regulations or voluntary industry standards that limit the level of pollutants emitted by materials used indoors. This approach is being considered in several countries with the likely outcome that building materials and contents that comply with specific emission characteristics will be favoured.

Source control

In response to these needs, Brown's team at Highett is studying the sources of indoor air pollutants and their emission characteristics. The information will be used with indoor-air-quality models to predict the impact of source emissions on pollutant levels in buildings, and to select sources that do not adversely affect indoor air quality.

'With a better understanding of the sources of indoor pollutants, it will be possible to modify sources to reduce emissions so that indoor air goals are not exceeded,' Brown says.

In practice, this means that builders and home and commercial building owners will be able to select materials with low pollutant emission. This will improve indoor environments and at the same time could cut ventilation costs by dealing with pollutant emissions at their source.

The process of source control is not new. Asthmatics have used it for some time by removing or forming barriers around materials in which house dust

Tracey Nichols

A room-sized (33 cubic metre) stainless steel dynamic environmental chamber will soon be operational at the Division of Building, Construction and Engineering. This will enable the testing of full-scale items such as a complete set of kitchen cupboards, or photocopiers and laser printers. Dynamic environmental chambers are supplied with purified air at controlled temperature, humidity and ventilation conditions similar to those found in buildings.

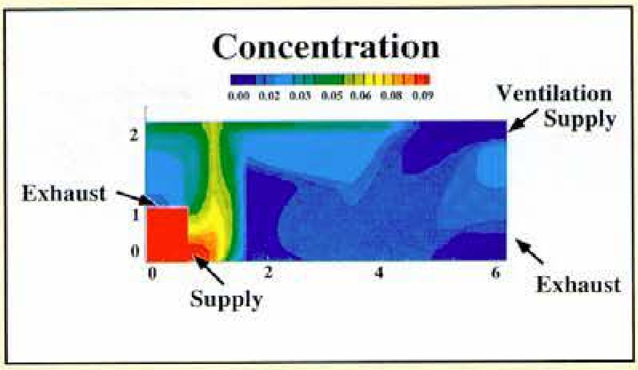
Modelling *air flows* and comfort

Pollutant dispersion and ventilation inside homes and commercial premises are the result of energy-use decisions made by building designers. Keeping pace with technological advances in this field, however, can be a difficult task, according to Dr Jeff Symons from CSIRO's Division of Building Contruction and Engineering.

Symons heads the division's Thermal Technologies Group which is based at Highett in Victoria. He says one of the group's aims is to help engineers, builders and architects design and construct buildings with reduced energy consumption and improved thermal comfort.

'We're interested in analysing air flows in buildings, such as commercial and industrial premises, hotels, supermarkets and airport terminals,' Symons says. 'We want to be able to predict air movement and both temperature and contaminant concentration fields that are affected by natural ventilation, forced ventilation from heating and cooling systems, and by other heat and contaminant sources.

'We will then use those predictions to calculate comfort conditions and air quality within the occupied zone of the building, which is normally around the lower levels of the space. In tall spaces, for instance, hot areas can occur near the ceiling and cool areas in the lower, occupied region where people are working.'



Computational fluid dynamics used to predict the pollutant concentration field from an unflued space heater in a room.

The Thermal Technologies Group uses computational fluid dynamics and experimental modelling to identify the air flows, temperatures and contaminants affecting comfort conditions in buildings. The dispersal and ventilation of indoor pollutants can be analysed in this way.

mite allergens can occur, and the prohibition of smoking in buildings is an approach that has completely removed environmental tobacco smoke. However source control is becoming more sophisticated, and by measuring source emission of pollutants, acceptable sources can be specified rather than prohibited from use in buildings.

Source emissions are characterised through the use of dynamic environmental chamber technology.

The dynamic chamber

Dynamic environmental chambers consist of non-emitting chambers (lined with materials such as stainless steel, glass, or teflon) which are supplied with purified air at controlled temperature, humidity and ventilation conditions similar to those found in buildings.

A pollutant source is placed in the chamber and the concentration of pollutants emitted over time (generally up to two weeks) is measured. Thus the 'emission dynamics' of each source can be mathematically described, usually by two parameters: the initial emission rate and the rate of emission decay. Examples of emission dynamics for particular materials are given in Table 1.

Floor wax for example, has a high initial emission, but a high decay constant. This emission decreased rapidly, with 90% of the emission occurring during the first 30 minutes. By comparison, polyurethane lacquer has a much lower emission, but decreases slowly and 90% of the emission occurred in 10 hours. Moth crystals, with a decay constant of zero, exhibited a constant rate of decay until fully consumed.

Indoor air models

With a characterisation of source emission behaviour, indoor air models may be used to predict indoor concentrations from such sources. Conversely, limits on source emission to achieve specific concentrations (such as NHMRC goals) can be estimated.

For example, the United States Environmental Protection Authority has developed a model that predicts the pollutant concentrations in a test house from simple sources when appropriate values are provided for source emission dynamics, outdoor air exchange, in-house air movement and deposition of pollutants on surfaces that adsorb or re-emit the pollutants. This last factor can be significant for some pollutants, so that short-term high release of pollutants is extended to several days by slow re-emission from surfaces. Brown's group will also investigate this 'sink' effect for common building materials such as gypsum board, carpet and furnishings using their chamber facility.

The dynamic chamber typically used at Highett has a 50-litre capacity, but a room-sized (33 cubic metre) stainless steel chamber will soon be completed. This will enable the testing of full-scale items such as a complete set of kitchen cupboards, or photocopiers and laser printers. Manufacturers of building materials and contents who wish to use this facility are welcome to contact the division.

Table 1 **Total volatile organic compound emission**

Source	initial emission rate mg/m²h	rate of emission decay (h⁻¹)
wood stain	17 000	0.40
polyurethane lacquer	6 000	0.25
floor wax	20 000	6.0
moth crystals	14 000	0
dry-cleaned clothing	27 000	0.43

More about indoor air

Brown SK (1993) Gaseous indoor air pollutants and their sources. *Building Science Forum – Indoor air quality and health. Is your building making you sick?* Melbourne. Nov. 4.

Brown SK Sim MR Abramson MJ and Gray CN (1994) Concentrations of volatile organic compounds in indoor air – a review. *Indoor Air* 4:123-134.