

TECHNOLOGY REVIEW

Design and use causes indoor air pollution and related health problems.

By Hal Levin

The average American adult suffers two respiratory illnesses each year. There is convincing evidence that a significant portion of these illnesses are caused by exposure to indoor air pollutants. Much of this exposure occurs in offices and other work places, and could be avoided easily.

Building Sickness

Newly constructed and remodeled offices commonly are plagued by building sickness, a syndrome caused by exposure to chemicals emitted by many modern building materials, finishes and furnishings as well as by people, their office equipment and materials, and other contaminants brought in from outdoors. Examples of environmental factors that fall under the rubric of indoor pollution are noise and other forms of mechanical vibration such as those coming from heavy equipment or traffic that can cause physiological stress. Light and electromagnetic radiation such as microwaves from video display terminals (VDTs) or radiotransmitters might cause biological damage. Crowding, loss of privacy or security, and glare or insufficient lighting also are environmental sources of stress that can exacerbate problems related to air quality by reducing employees' capacity to cope.

The physiological effects of building sickness include breathing difficulties, dizziness, drowsiness and skin, eye and throat irritation, all of which resemble flu and allergy, two loosely used medical terms that describe symptoms, not diseases. Incidences of nausea, vomiting and fainting also have been reported. Chronic, low-level versions of these

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syndromes affect worker attitudes and job satisfaction, which can result in lower productivity, absenteeism and higher employee turnover. Studies on the factors affecting employee job satisfaction show that air quality, lighting and the thermal environment are almost always rated among the top five by workers surveyed.

Since the Arab oil embargo of 1973 brought about widespread awareness of the need for energy conservation, reduced ventilation rates in buildings have increased levels of many irritating and toxic substances in indoor air. The decline in the quality of indoor air along with other, economically motivated changes in modern buildings has resulted in increasing numbers of complaints filed with builders, employers and the courts about physiologic and health problems associated with indoor pollution.

have occurred. In more extreme cases, buildings are closed for months or even years. For example, when polychlorinated biphenyls (PCBs) were emitted after electrical transformers exploded, a state office building in Binghamton, N.Y., closed down and has remained shut for more than two years, and a private office building in San Francisco closed seven floors for 10 months while cleanup took place.

Impact of Ventilation, Humidity

To protect and promote the health and well-being of employees, it is necessary to address deteriorating indoor environmental quality not only during the building development stage, which includes planning, design and construction, but also the period of occupancy, in which building management, operation and maintenance are involved.

Prevalence of Symptoms by Type of Ventilation System (Percent)

Symptom	Natural Ventilation Only (3*/328**)	Mechanical Only, No Humidification Recirculation (1*/78**)	Mechanical Humidification with No Recirculation (2*/411**)	Mechanical Humidification with Recirculation (3*/561**)
Nasal	5.8	13.7	22.4	17.2
Eye	5.8	8.2	28.3	17.6
Mucous Membrane	8.1	17.8	37.9	32.6
Work Related Asthma	7.0	1.1	19.0	17.2
Humidified Fever	1.1	—	3.4	2.1

* Number of buildings

** Number of people interviewed

Source: Finnegan et al, "Prevalence Studies," *British Medical Journal* 289:1573-1575, 1984.

The National Broadcasting Company, Bank of America, American Telephone & Telegraph Co., and the federal government are among those who have had extensive and expensive indoor pollution problems resulting in closed buildings, downtime and lost productivity. In such cases, management typically sends employees home during investigations and attempts to remedy problems, for example, by completely ventilating the building. Closures lasting from hours to weeks

The *British Medical Journal* reported a study last year of two complaint buildings and seven control buildings to determine the effect of different types of ventilation on the incidence of health complaints. The study showed that the occurrence of symptoms is lowest in naturally ventilated buildings, higher in those with mechanical ventilation and no humidification, and highest in humidified buildings (see table). New office buildings in the U.S. are predomi-

nantly mechanically ventilated and humidified.

In more than 200 indoor air quality investigations conducted by the National Institute of Occupational Safety and Health (NIOSH) after complaints were filed, inadequate ventilation was found nearly half the time. Contamination inside and outside the building or of the building fabric itself was found in nearly one-third of the cases.

The specific indoor air pollutants that have been identified as most significant from a health perspective include tobacco smoke, formaldehyde, volatile organic compounds, carbon dioxide, asbestos and microorganisms.

More than 900 different volatile organic compounds, that is, substances that vaporize, have been identified by the U.S. Environmental Protection Agency, and 150 to 300 of them typically are found in the air of any building. The very large number of volatile organic chemical compounds found at low concentrations in building air also can explain building sickness. For example, Danish researcher Lars Molhave reported in 1982 that of the 62 chemicals most frequently found in modern Danish buildings, 36 percent are suspected and 48 percent are known mucous membrane or eye irritants.

Meanwhile, the discovery of the bacteria that caused Legionnaires' Disease in 1976 resulted in increased awareness of the importance of biological aerosols. The bacteria that caused the outbreak, which affected 182 individuals and caused 29 deaths, is found in soil, becomes airborne during windy periods or excavation, and is bred and spread by building air conditioning systems.

Factors critical to determining the significance of indoor pollutants are the extent of human exposure to them and their health effects. Exposure depends on pollution levels in various building environments and the amount of time people spend in those environments.

Aside from the obvious concern for employee well-being, there are economic reasons for employer concern about indoor pollution. According to the National Bureau of Standards, only about 3 percent to 5 percent of the cost of running a federal office building is for acquisition, and about 2 percent to 3 percent is for building operation and maintenance. The rest

is for equipment and worker salaries and benefits. It makes little sense to skimp on facility expenses when the results could be environmental problems that decrease employee attendance, productivity or tenure.

Corporate Checklist

One company that has addressed indoor pollution in the design and construction of a major facility is Pacific Bell. During design of its 1.75-million sq. ft. San Ramon Valley administrative facility, which will house 7,500 employees when completed later this year, Pacific Bell tested and evaluated many of the building materials and furnishings slated for use. Certain modifications were required of manufacturers and suppliers after tests were performed that indicated which materials might emit toxic gases. For example, formaldehyde emissions from particle board and work surfaces were reduced by fully enclosing them with plastic laminate. In addition, special consideration was given to ventilation during the installation of finishes and furnishings.

There are a number of things that companies can do to minimize indoor pollution problems, including the following:

- Proper consideration of environmental quality during site evaluation, selection, planning and design;
 - Adequate planning of building design and construction or remodeling to assure proper functioning of ventilation and other building equipment;
 - Evaluation of building materials and furnishings;
 - Adequate testing and control of air pollution levels prior to occupancy;
 - Complete checkout and shake-down of equipment in new buildings — especially mechanical ventilation, heating and cooling — prior to occupancy;
 - Utilization of employee feedback to develop a positive environmental monitoring program by acknowledging all complaints and following them up as quickly as possible.
- Many approaches to addressing the problems of indoor air pollution are available. As the challenges presented by the creation of healthy, productive office buildings are approached and mastered, an understanding of office environments as complex ecological systems will emerge. ■

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