Indoor Air Quality

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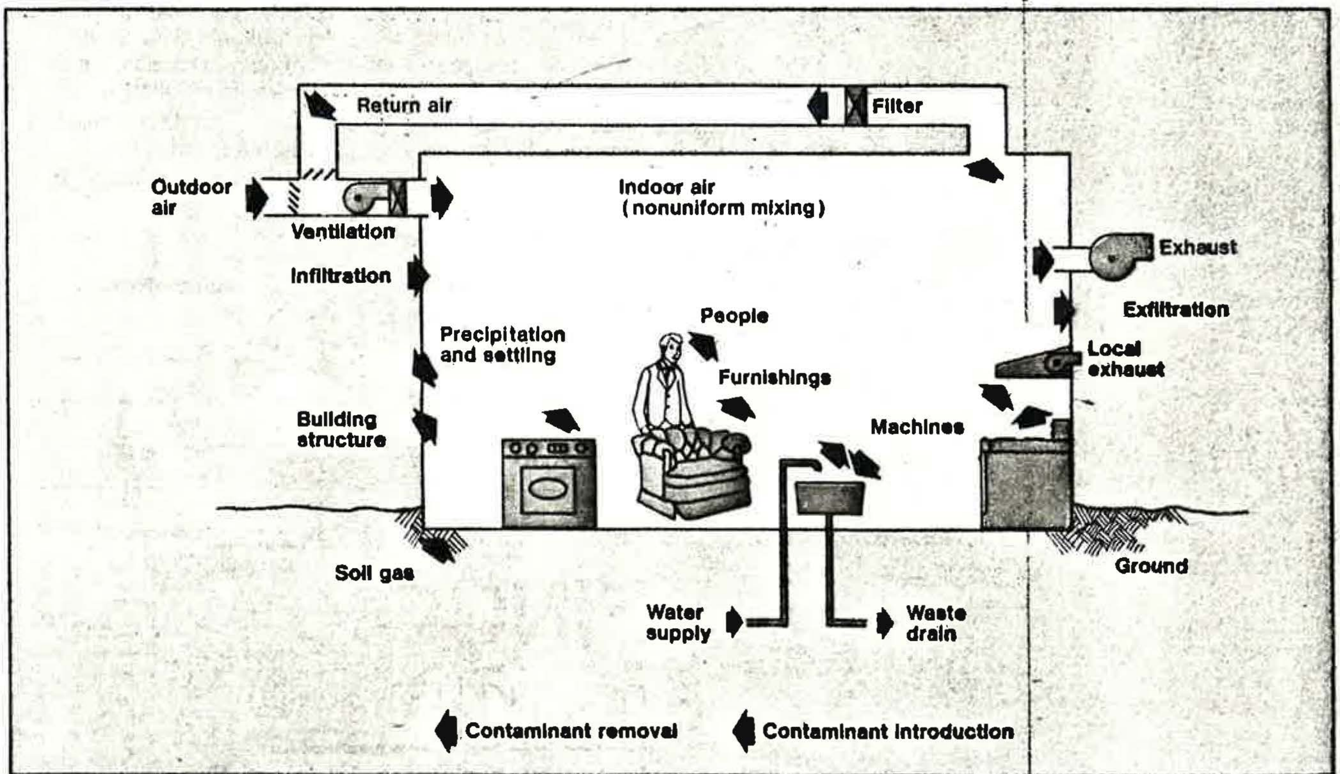
Pollutants enter the indoor environment through a variety of avenues, including furnishings, equipment, construction materials, people, and the surroundings. An effective contaminant removal system must be designed and installed to ensure the health and maximize the performance of occupants.

Terms such as indoor air pollution, tight or sick building syndrome, and acceptable indoor air quality standards are prominently featured in many trade publications. The effects of indoor air quality on the health and performance of the building's occupants are certainly important, but just how serious is the problem?

The 1985–86 president of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), Donald R. Bahnfleth, PE, probably summarized the significance of the situation best when he spoke at "IAQ 86, Managing Indoor Air Quality for Health and Energy Conservation," a conference sponsored by the association, the Department of Energy, and the Environmental Protection Agency. He said, "Indoor air quality is, and will remain, the single most important health issue facing us in the 1980s. Poor indoor air quality can impair our health, affect our sense of well-being, and reduce our productivity."

Causes of Contamination — A num-



ber of related factors adversely affect the ultimate quality of the indoor environment. Emphasis on energy conservation in recent years has led to lower ventilation rates and tighter building envelopes to prevent outside air infiltration. This sealing effect, in turn, has resulted in higher concentrations of pollutants trapped inside.

In addition to obvious problems such as tobacco smoke and dust, construction and maintenance materials, along with many other factors, are contributing to an increased level of contamination by giving off (outgassing) chemical compounds. Poor maintenance of HVAC systems, cooling coils, and humidifiers creates breeding grounds for biological contaminants. Some office machines generate or leak chemical pollutants. Radon gas and its radioactive progeny exist in many homes in concentrations that may be excessive. And the increased use of nonvented combustion appliances in residences has added to carbon monoxide and carbon dioxide levels.

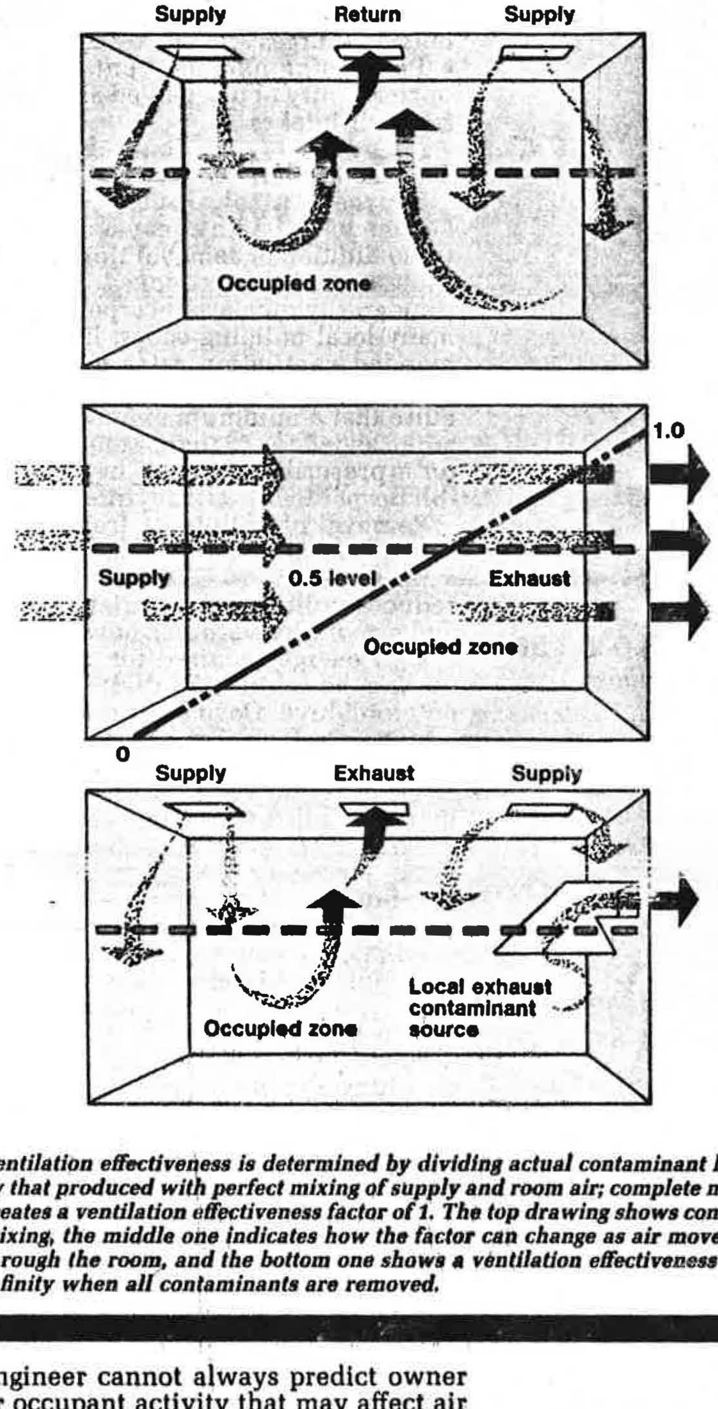
Merely tightening the envelope of a new or existing structure does not automatically degrade the air quality. On the contrary, limiting conduction and air losses with better insulation, vapor barriers, and seals around doors and windows not only prevents the entry of some pollutants but can permit an optimum airflow and distribution pattern to improve air quality within the building.

The operative word in the preceding sentence is can, not will. Indoor air quality can only be controlled through proper design, construction, operation, and maintenance of the structure and its systems.

Control Methods — There are three ways to combat indoor air pollution: source control, dilution, and removal. The design of HVAC systems is directly involved with dilution and removal, but the contractor and engineer must also be aware of the sources and types of indoor air pollution to eliminate or decrease the risk of problems where possible.

Source control encompasses isolation, material and product substitution, and local exhaust. Dilution involves infiltration, natural ventilation, and mechanical ventilation. And removal includes fan-filter modules, central forced-air systems with recirculated air, and electronic air cleaners.

It may be impossible, and certainly impractical, to eliminate all sources of indoor air pollution. Many plywoods, particle boards, and textiles give off formaldehyde from the resins used in their manufacture, as does the urea-formaldehyde foam insulation found in 500,000 U.S. homes. And the design engineer cannot always predict owner or occupant activity that may affect air quality. This statement is particularly true in office buildings, where the installation of modular work area partitions alter airflow patterns or where photocopying machines, which are notorious sources of pollutants, are scattered about work areas.



Ventilation effectiveness is determined by dividing actual contaminant levels by that produced with perfect mixing of supply and room air; complete mixing creates a ventilation effectiveness factor of 1. The top drawing shows complete mixing, the middle one indicates how the factor can change as air moves through the room, and the bottom one shows a ventilation effectiveness of infinity when all contaminants are removed.

It is possible, however, to eliminate many potential sources of pollution through careful planning. In addition to product substitution and local exhaust for polluting equipment, design considerations should include

- Placing air conditioning units to provide easy access for maintenance and cleaning
- Locating HVAC air intakes to mini-

mize entrainment of pollutants from outside sources

- Positioning exhaust vents to minimize re-entry of discharged air through fresh air intakes
- Incorporating a radon-impermeable design where indicated.

Source control alone may not be enough to maintain adequate air quality, so dilution or removal through ventilation must be employed. ASHRAE standards, which are incorporated into many local building codes, list recommended ventilation rates for various types of buildings. These standards require that a minimum amount of fresh air be added to the indoor environment on a prescribed basis. The fresh air dilutes pollutants already present.

Removal of pollutants from the indoor environment becomes a matter of simple economics. Dilution effectively reduces polluting particulates, gases, and vapors by volume; however, the cost of energy required for heating or cooling the continually diluted air may be prohibitive. Devices to remove pollutants are efficient in eliminating particulates, but most do not remove gases or vapors effectively. Thus, a combination of dilution and removal design is usually required for cost-effective control of air quality.

Ventilation Effectiveness — Another factor affecting indoor air quality is ventilation effectiveness, or the degree to which supply air mixes with that already in the space. Studies show that design and placement of supply and return air diffusers often result in short circuiting; in other words, some supply air is drawn directly into the return vents without ever mixing with room air.

Several factors must be considered to prevent short circuiting and other problems related to ineffective ventilation: location and type of supply, return, and exhaust air terminals; location of windows and doors; vented and unvented space heaters; window or room air conditioning units; and thermal barriers, such as insulation.

It is also important to consider the less than obvious solutions to ventilation problems. Canadian Public Works performed a study on an open-plan office building with supply and return air vents in the ceiling. Partitions about 5 ft high divided the open office into small work stations. The study showed little supply air actually reaching the workers at their desks. Experimentation discovered that raising the partitions 4 in. above the floor increased supply air mixing 50 percent.

Improving Air Quality — HVAC system design will undoubtedly contribute to a higher quality indoor environment as knowledge and perception of its importance increases and as codes and standards incorporate this information. As this evolutionary process occurs, existing systems can be equally effective in maintaining air quality if installed and maintained in accordance with accepted industry principles.

Architects and engineers, while continuing to refine building design, must be aware of the potential pollutants inherent in materials and products and must educate clients and owners about their responsibilities to indoor air quality.

Most important to air quality improvement is a continuing study of the problem. As Bahnfleth said at the air quality conference, "At this point our information is limited, and those associated with a building during its life cycle need more definitive information to guide their activity. We need more [information] so that design professionals, engineers, architects, and interior designers can make appropriate decisions. These professionals need information and guidance on materials, sources of possible contamination, system configurations that promote energy economy, and the use of available control systems.

"The construction profession needs standards and guidelines that will define methods, techniques, and practices that help avoid indoor air quality problems. The manufacturing community also needs standards and guidelines to ensure that the materials and equipment they supply are not, or do not become, sources of poor indoor air quality. Homeowners and building management professionals need guidance in operating and maintaining systems and equipment to ensure that well-conceived and well-constructed buildings do not become problems once they are put into service and are subjected to the pressures of the occupying population."

Asbestos — a known carcinogen found in acoustical tile and air duct or pipe insulation

Carbon dioxide — from people

Carbon monoxide — from parking garages, hot water heaters, boilers, etc.

Consumer products — plastics, paints, solvents, artificial fibers, cleaners, bleaches, disinfectants, deodorizers, etc., that emit air contaminants through evaporation or outgassing

Formaldehyde — used in furniture, fire retardants, foam insulation, coatings on paper, and numerous other building materials

Methanol — from duplicating machines

Ozone — from photocopy machines

Polychlorinated biphenyls (PCB) — from waterproof adhesives, carbonless paper, and various plastics

Radon — from building materials derived from soil and rock

Trichloroethylene (TCE) — found in correction fluids

Trinitrofluorenone (TNF) — found in copy machines

Vinyl chloride — a known carcinogen found in most plastics