

accessible, and might fall prey to microbial infestation.

• Intake vents should be located where they will receive the largest supply of fresh air. That means away from cars or factories, as close as possible to any natural flora.

Dr. Morey has pointed out that of the 100 or so buildings sampled each year by NIOSH, only a small percentage are determined to have serious health problems. What is of more concern, however, are privately owned buildings whose owners have had unreported outbreaks of "humidifier fever" and even Legionnaire's Disease.

The severity of the problem depends upon the age, location, HVAC system, and maintenance program of the building. Government and industry professionals alike have pushed for elimination of inadequate systems that breed and then cannot recapture airborne microorganisms, as well as programs to check filters, drainage trays, and condenser coils on

a regular basis.

As one safety engineer, who wished to remain anonymous, put it, "When it comes to the possibility of population wide health problems that you as an operator could be held responsible for, an ounce of prevention is worth more than your weight in gold." Ω



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tems, Inc. (EMS), Washington, DC, an industrial hygiene consulting firm that specializes in identifying and solving problems associated with indoor air contamination. During the last three years EMS has conducted investigations of building contamination in 150 facilities along the central east coast.



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Sick Building Syndrome Sources of Building Contamination



here are many sources and causes of indoor air pollution.

Improperly designed and maintained HVAC systems have been found to be a major cause of indoor air contamination.

Inhalation of microbial contaminants that have been able to enter and breed within a heating, ventilation, and air conditioning system (HVAC) can cause allergic reactions that result in inflammation of the nose (allergic rhinitis), the airways and alveolar spaces (allergic asthma), or alveoli and bronchioles (hypersensitive pneu-

monitis). The aerodynamic diameter of particles determines where they will be deposited within the human respiratory tract. Particles whose aerodynamic diameter is 20 microns or more, and half the particles down to five microns are deposited in the nose and upper respiratory tract. The respirable fraction involves particles such as bacteria, mold, and fungi that are four microns or less and deposited in the bronchi and alveoli.

Filters Fresh air intakes for HVAC systems filter incoming air to reduce levels of air-borne par-

By David E₁ Custer

ticulates entering the building. Many buildings use low efficiency filters that allow many particulates to enter the system. These particles themselves can cause respiratory irritation, and when deposited in ductwork can themselves multiply as well as serve as a breeding ground for other microbial growth and contamination.

Location of air intakes Many air intakes are located in or near underground garages, in alleys, or near loading docks, where high concentrations of carbon monoxide can be drawn into the ventila-

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tion system. A condominium dweller in Chicago is suing his building's owners for building code violations that allowed so much carbon monoxide from a basement garage to enter his condo that the inhabitant developed high blood pressure and severe chest pains.

HVAC system shutdowns In order to reduce operating costs, HVAC systems are often shut down in the early afternoon and not reactivated until mid-morning the next day. These same systems are usually shut down through the weekend as well. This inactivity allows humidity and condensation to build up, promoting the growth of bacteria, mold, and fungi.

Reduced fresh air intake Costconscious building operators may also reduce or eliminate the introduction of fresh air for periods of time. Air within buildings where this is done is continually recirculated without being mixed, or "diluted" with clean outside air. Because fresh air also helps to maintain a comfortable temperature range in buildings, the absence of this element keeps ductwork warmer — levels of contaminants rapidly increase.

HVAC systems inadequacies As one professional commentator put it, "It may be that we have overestimated our technological skill at reconstituting the complexity of the natural environment.' HVAC systems components often lack the flexibility to react to changing air pressure conditions within a building. Fans may create an exhaust system that sucks "used" air out without allowing equal volumes of fresh air in. HVAC components, buried within a building's infrastructure, may operate at reduced capacity or not at all, and are not discovered or repaired due to the difficulty of getting to them.

Condensation from cooling coils, if not properly drained, provides an ideal medium for the proliferation of bacteria, mold, and fungi. Common Indoor Pollutants

Asbestos—a known carcinogen (acoustical tiles, 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, and other substances all emit air contaminants either through evaporation or "out gassing."
- Formaldehyde—used as a sealant in furniture, fire-retardants, foam insulation, coatings on paper, and numerous other building materials.
- Methanol-from duplicating machines.
- Nitropyrenes—found in one type of photocopier toner (in March 1980, the formula was changed to reduce the nitropyrene content significantly). Ozone—emitted from photocopy machines.
- Polychlorinated biphenyls (PCBs)—from water-proof adhesives, carbonless paper, and various plastics.
- Radon—found in building materials derived from soil and rock (a particular problem in the Denver area).
- Trichloroethylene (TCE)—found in correction fluids and attributed to at least four deaths.
- Trinitrofluorenone (TNF)-found in copy machines.

Vinyl chloride—a known carcinogen and found in most plastics; it is also known to cause ulcers and chronic bronchitis.

If condensate trays are not properly sloped to allow gravity drainage, or if the drains become clogged — both conditions that are quite common in dead buildings, water stagnates and becomes highly contaminated. As air is drawn over the contaminated water at high velocity, organisms are aerosolized and distributed throughout the ductwork into occupied areas. This is, by far, the most common source of microbial contamination in buildings.

Humidifiers If not properly maintained, humidifiers can become an ideal breeding ground for microbial flora. Water in most humidifiers is continually recirculated. Anything growing in it has ample opportunity to spread throughout occupied areas.

Variations in humidity High humidity within a building can affect building materials, vapor concentrations, and bacterial growth. Low humidity can cause air-borne particles and vapor to irritate the eyes, nose, and upper respiratory tract. In buildings with high moisture, bacteria, mold, and fungi can grow on virtually any surface.

NIOSH Division of Respiratory Disease Studies has conduced environmental studies of "dead" office buildings. They concluded that as relative humidity rises above 70 per cent, fungal spore germination and proliferation are greatly accelerated by the increase moisture content of organic substances.

High moisture in the indoor environment promotes a greater release of formaldehyde from the formaldehyde-based resins used in many wood products and fabrics. Formaldehyde-based materials in- co clude carpets, office furniture, draperies, and laminated wood products. In small concentrations formaldehyde can irritate the eyes, nose, and upper respiratory Ce tract. Formaldehyde is currently being investigated as a potential carcinogen. 02

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Cigaret smoke is a major source of contaminants in buildings. There are two types of exposure to cigaret smoke — smokers who inhale mainstream smoke, and non- (or passive) smokers, who inhale sidestream smoke. Cigaret smoke contains more than 2,000 compounds — many of which are carcinogenic.

While the health hazards cigarette smoke poses to smokers has been well documented, only recently has research been focused on passive smokers. The National Cancer Center Research Institute, at Tokyo, found that incidents of lung cancer were three time greater among wives of smokers than among wives of non-smokers. The EPA has concluded that sidestream cigaret smoke results in 500 to 5,000 deaths per year in the non-smoking population.

Asbestos This naturally occuring fibrous mineral is fire-resistant, durable, and has excellent insulating properties. Because of these characteristics, asbestos was used in construction materials such as thermal and acoustical insulation, cement products, plaster, ceiling tiles, and vinyl floor tiles, as well as in spray applications for fireproofing.

A fairly common, but potentially hazardous, use of asbestos was in preformed asbestos ductwork. The material is tan-colored, similar to cardboard in structure, and can contain about 75 per cent asbestos. As the ductwork ages, it deteriorates, causing delamination of the interior surface. As air passes through the ductwork, fibers are released and carried by the supplied air to occupied spaces.

Since installation of asbestos for all these applications, it has been found to be highly carcinogenic. Inhalation of asbestos has been found to cause the lung disease, asbestosis, lung cancer, cancer of the chest and abdominal lining (mesothelioma), and cancer of the esophagus, stomach, and colon.

Who is to blame for allowing this fiber to become so intrinsic a building material?

Who will be responsible for its removal from buildings?

Who will be accountable for the buildings and interior spaces that must be torn apart or abandoned due to its presence? Who has the responsibility for tracking down all asbestos-laden building materials around the country?

Who must ultimately pay for the physical damage to humans caused by asbestos?

All these questions are hotly debated today.

Actinomyces thermophilia	Diseases of unknown etiology	Meningococcal meningitis
Air-borne lead poisoning	Histoplasmosis	Micropolyspora faen
Air-borne phenol poisoning	Hypersensitivity pneumonia	Pseudomonas aeruginosa
Aspergillosis fungus	Influenza	Psittacosis
Bizarre case of air- borne rabies	Inhalation anthrax	Pulmonary tuberculosis
Brucellosis	Klebsiella	Smailpox
Coccidioidomycosis	Legionella pheumophila	Staphylococcal and
Coxsackie	Lymphocytic choriomeningitis	streptococcal pneumonia

Ozone Photocopiers used in almost all offices produce ozone. Ozone is a sweet-smelling gas formed by the reaction of atmospheric oxygen with high electrical voltage. The oxygen becomes electrically charged, and it can be highly irritating to eyes, skin, and the upper respiratory tract. Electric air cleaners are another source of ozone.

When exposed to concentrations of ozone of 0.5 ppm or more, individuals become more susceptible to respiratory infections. At one or two parts per million, ozone causes headaches, chest pains, and dryness in the upper respiratory tract.

Polychlorinated Biphenyles

PCBs have been found to be indoor as well as outdoor contiminants. They are used in closed systems, such as transformers, capacitators, and other electrical/ cooling applications. They are also found in nominally closed systems that use hydraulic fluids and lubricants, and for open applications in plastics, water-proof adhesives, paints, inks, dyes, pesticide extenders, and carbonless copy paper.

There have been several wellknown incidents in recent years where PCBs were introduced into a building's HVAC system after and electrical transformer containing PCBs exploded or burned. These buildings had to be completely isolated and abandoned due to the destructive nature of

this substance.

PCBs are virtually non-degradable and can enter the body through the skin, by inhalation, and through ingestion. PCBs are toxic and can irritate the eyes, skin, nose, and throat. In sufficient quantities they can cause liver damange and are known carcinogens.

Electro-magnetic radiation Television sets, microwave ovens, video display terminals, satellite telecommunications, and certain types of electrical equipment all emit electro-magnetic radiation. In sufficient intensities, electromagnetic radiation can cause cataracts, genetic mutations, and other adverse health effects. The exact cause and effect relationship between this radiation and the harm done is currently being researched and debated.

Radon This radio-active gas is produced by the decay of radium. Radium occurs naturally in rocks and soil that is commonly used in building materials. Radon gas is emitted from these materials and the ground beneath and surrounding buildings. Upon entering the indoor environment, its inhalation can cause cancer. A recent survey showed that a significant number of homes have radon levels that expose their inhabitants to the same risks as smoking 40 to 60 cigarettes per day. One EPA official estimates 10 per cent of all lung cancer deaths can be attributed to radon. Resourch