SICK BUILDING SYNDROME AND THE MODERN OFFICE BUILDING

by James H. Boykin, CRE, and Ronald L. Sauer

People who work within an office environment make up an increasingly higher proportion of the work force. While these workers are entitled to a healthy workplace, this is not always the case. The consequences of an unhealthy work environment can be both physically harmful to employees and expensive for employers and office building owners to remedy. The purpose of this article is to identify the major causes of building-related health problems and to suggest strategies for dealing with them.

Growing Concern

Unquestionably there is growing public concern over indoor air quality. For example, a 1989 article noted that in a report by the Environmental Protection Agency (EPA), there were complaints of building-related illness in 20-30 percent of all existing buildings in the United States.[1] Later, in March 1992, the AFL-CIO petitioned the Occupational Safety and Health Administration (OSHA) to promulgate an overall standard for indoor air quality. Of the comments OSHA received on whether it should regulate indoor air quality, a majority (75%) supported regulation.[2] The concern increases as structures get older, more energy efficient buildings are built, capacities of building ventilation systems are reduced and rising[3] operating costs pressure building owners to reduce HVAC maintenance and operating expenses. In April 1994, OSHA proposed in the Federal Register to adopt standards which address air quality in indoor work environments. This notice states, "The basis for this proposed action is a preliminary determination that employees working in indoor work environments face a significant risk of material impairment to their health due to poor indoor air quality and that compliance with the provisions proposed in this notice will substantially reduce that risk."[4] The proposed standards would require affected employers to develop a written indoor air quality compliance plan. It would include details of each system that influence indoor air quality, how often and in what manner a system is maintained, what corrective changes are made, the number and type of complaints and

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what remedial actions are taken to resolve the complaints. The new standards could be quite costly to implement since many owners currently do not adhere fully to such requirements.[5]

There clearly is not universal support for new standards. In testimony given at a public hearing on proposed standards for indoor air quality before the United States Department of Labor Occupational Safety and Health Administration in Washington, D.C., on January 9, 1995, Edwin N. Sidman, of the National Realty Committee, expressed concern over three issues:

1. OSHA has not demonstrated that a uniform national rule applicable to all office buildings will produce benefits proportionate to its multi-billion dollar cost.
2. The proposed rule will not be effective in solving Inside Air Quality (IAQ) problems despite its disproportionately high costs.
3. Government can best protect workers currently exposed to IAQ problems by encouraging the development of science and technology that will lead to the identification and control of source contaminants.[6] The National Realty Committee goes on to state that: ". . .the costs of the proposed rules are not only very high in the aggregate, but they are totally unnecessary and arbitrary in many instances, because they will apply whether or not the building in question has had any indoor air quality problems. In our opinion, the costs do not change significantly if there are no IAQ complaints at the building, nor, for that matter, do they change because the building owner or occupants have chosen to ban smoking. The compliance costs are the same even if the building owner already has a sophisticated and progressive program aimed at separately ventilating all known contaminant sources or preventing them from being used in the workplace. In short, the rule is arbitrary and over broad in that it applies equally to buildings with excellent indoor air and those with large numbers of tenant complaints."[7]

Whatever the outcome of the proposed OSHA rules, property managers, building owners and employees must become more fully aware of indoor work environments and continually monitor their buildings for signs of deteriorating air quality. Building systems must be maintained in sound operating condition. Unfortunately, building contents are often installed by someone other than the current owner even though they may be the source of contamination. Many types of particles are released from modern office buildings and their expanding range of materials and furnishings. Most of these particles are too small to be seen with the naked eye while others are readily visible as gross dirt.

Most Common Building-Related Health Problems

Typically indoor air quality problems are placed into two categories: sick building syndrome (SBS) and building-related illness (BRI). While both cause significant health problems for building occupants, they differ in cause and severity. Sometimes the cause is obvious, and affected persons have symptoms that point to a specific problem. Other times it may elude even careful examination, and those affected will have symptoms which also could be attributed to such common afflictions as allergy or the common cold.

Sick building complaints commonly are attributed to very general and numerous (often unspecified) building design, operation and maintenance factors, but rarely is a specific source identified. Typical SBS complaints include lethargy (56%), headache (45%), stuffy nose (43%), dry throat (40%), dry eyes (30%), itchy/watery eyes (22%), runny nose (22%), flu-like symptoms (15%), breathing difficulties (8%) and chest tightness (8%).[8] Nausea and dizziness are common in this environment, but those affected usually recover completely after leaving the building. They are probably not diseased, but feel temporarily ill while inside the sick building.

Building-related illness is potentially very dangerous and is caused usually by an identifiable source which needs to be found and eliminated. Such buildings are commonly referred to as diseased buildings. Related illnesses may be an infection such as Legionnaire's Disease, a severe allergy or chemical poisoning due to something dangerous in the building. The signs and symptoms are not as vague as in SBS. The stricken people may become seriously ill and should not enter the building again until the source has been eliminated.[9]

Causes Of Harmful Building Environments

Office building discomfort from poor indoor air quality is traceable back to the Arab oil embargo in the mid-197Os, which resulted in skyrocketing energy costs. Two major by-products to conserve energy during this and subsequent periods were the "reduction in ventilation rates and the improving of the air tightness of buildings."[10] Modern office windows usually are rendered inoperable to ensure building tightness, and workers must rely on HVAC systems for comfort and recirculation of air. Thus the name tight building syndrome is used to describe the symptoms found in these buildings.[11]

Today's newly constructed office buildings become occupied almost immediately upon completion. The consequence of this tight sequence of events is that chemicals contained in the building furnishings, carpets, draperies, insulation and

many other building components are not given adequate time to fully cure prior to the building's occupancy. These products naturally offgas or cure throughout their lifetime, but when new furnishings are placed in a new tightly constructed building, higher levels of volatile chemicals accumulate. These chemicals can be diluted by increased quantities of fresh air or by providing for a longer time lapse between building completion and occupancy.

In a sick building, the balance has been altered between clean, safe air and the number of airborne particles.[12] The likelihood of building-related health problems increases as the interior air quality deteriorates. The National Institute for Occupational Safety and Health (NIOSH) conducted over 500 indoor air investigations throughout the late 1970s and 1980s and came up with the following finding: The most important problem with these ill buildings is inadequate ventilation which allows an increase of potentially harmful particles in the air.[13] These airborne particles are called aerosols. Some particles are gaseous and naturally airborne, others become airborne when disturbed and others exist in solid, liquid or gaseous phases. However, nearly all particles can be dispersed through a building by aerosolization. Three conditions can lead to a potentially harmful environment: 1. source or reservoir for the particles which later become airborne; 2. a way to increase or amplify the number of airborne particles; 3. a way for the particles to disseminate or spread throughout a building.[14]

Reservoir

A reservoir is where microbes, dust mites, chemicals and other potential hazards reside without significant danger of destruction. Such reservoirs can be animals, birds, insects, damp ventilation systems, stagnant water (in unlikely areas such as plant containers), leftover food, soil, storage tanks, new furniture, sanitary landfill, smokestack, poor hygiene by building inhabitants or any other breakdown in proper building management. Moisture accumulation in ducts or under refrigeration units, around walls, under floor tiles or carpets, poorly ventilated rooms and high humidity all provide reservoirs for microbes and other live pests to increase.

Amplification

Amplification is a process which increases the number of harmful substances in a reservoir. Moisture laden environments allow microbes to multiply and produce foul odors which may be aerosolized and spread throughout the building. Some of these microbes (such as common molds) are relatively harmless to a healthy person but can multiply on the surface of damp environments, such as contaminated air conditioning ducts, and produce offensive odors or cause infectious harm to extra sensitive people. Certain other microbes (Legionella) grow favorably in stagnant water found in cooling towers and drain pans. These organisms can be very dangerous to anyone who breathes the contaminated air. Thus, if a location stays moist, it will eventually become populated by some form of microbial life.

Toxic chemicals will amplify in a room if allowed to leak from a container. The number of chemical particles in the room is not increased by this leak, but they are redistributed disproportionately from their former state in the canister to the air as a gas. This causes the fresh air to quickly become contaminated with fumes. If the fumes are not too unpleasant, people may ignore them until serious and sometimes even fatal complications become evident. If new furnishings are placed in a poorly ventilated room, they also will release numerous gaseous products into the air, and if the air is not replaced or diluted with fresh air, the gaseous products will become the predominant airborne particles.[15]

Dissemination

Dissemination is the process of transmitting particles throughout the building or from person to person. Once they have multiplied, particles spread more easily by normal air flow or anything else that travels within a building. For example, volatilized substances can be carried long distances through the air, pests (such as insects or mice) can be carriers of whatever adheres to them and humans pass particles when sneezing, preparing foods or conveying papers and other materials to their coworkers.

Types Of Airborne Problems

Many substances that cause harm to humans are carried as particles in the air; these are known as aerosols. An aerosol can be any airborne substance, but some are more easily aerosolized than others. If an aerosol contains whole or partial living cells, such as bacteria, it is a **bioaerosol**. Yet, aerosols may consist of anything from water droplets to complex chemicals. There are numerous particles in every building, and while nothing can be done to completely eliminate them, steps can be taken not to increase (amplify) their number and to keep them from being dispersed.

An average building may contain hundreds of different volatile organic compounds (VOCs). These chemicals tend to volatilize or offgas away from their source and permeate the air as a gas. Some are more easily volatilized than others. These compounds are derived from a variety of household products and furnishings. They may be solids or liquids, but they tend to release gaseous products into the air. The primary sources of chemical aerosols are **consumer products**, such as deodorizers,

solvents and cleaning compounds; **building materials**, such as paints, glues, caulks, fabrics, furnishings, carpets, curtains, pest control chemicals and **personal activities** of building occupants, such as smoking, nail polish and remover, hair spray, dry cleaned clothes, perfumes and anything that evaporates.[16]

Tobacco smoke is known to contain many different volatile organic compounds.[17] Most VOCs are relatively safe but cause problems if the building gets an insufficient replacement of fresh air or if an office houses very sensitive individuals. Most people have a large tolerance to the VOCs found in common building furnishings, but prolonged exposure to low levels or any exposure by hypersensitive individuals can result in skin, respiratory or other symptoms/problems.

Formaldehyde is a chemical found in many building products. It can be a liquid or gas at room temperature, and it has a strong unique odor. A component of urea formaldehyde-based foam insulation, it is used to help bond plywood and particleboard and also as a treatment for facial tissues, toilet paper, paper towels and bags, water repellents, wrinkle resisters, stiffeners and many other consumer products. It may be emitted from permanent press clothing, carpet backings, adhesive binders, cosmetics and many other products used daily by nearly everyone. Formaldehyde can enter the body by inhalation, skin absorption and ingestion, but it has a high affinity for water, and thus attaches quickly to the moist mucus membranes of the upper respiratory tract.[18]

Pesticides are another potentially dangerous product. When properly used, most do not present a hazard unless in concentrated form[19] or in prolonged direct exposure. Nevertheless, human exposure should be minimized, especially during the initial pesticide treatment. Good ventilation should be ensured after pesticide treatment and during the ensuing routine human exposure.

The indoor environment may contain many potentially harmful gasses. **Nitrogen dioxide** and **nitric oxide** are produced from gas furnaces, stoves and tobacco smoke. **Carbon dioxide** is an odorless gas produced by the combustion of oil, gas, coal, wood, paper and other combustible organic products, and it is a natural byproduct of breathing. **Carbon monoxide** is an odorless gas produced by combustion. No significant quantities of carbon monoxide gas should be found indoors unless the building's fresh air intakes are located near a parking structure or loading dock where truck motors are left running while being unloaded or there are poorly vented fuel-burning motors or indoor combustion devices such as kerosene heaters. **Sulfur dioxide** is a colorless gas, produced by combustion, with a strong suffocating odor. It can irritate the skin, eyes and mucous membranes and cause restriction of the upper airways at higher concentrations. Sulfur dioxide does usually develop into an indoor problem unless there are science laboratories or unvented kerosene heaters present. Generally it is produced in the outside environment by power plants, oil refineries and other large industrial complexes. **Natural gas and propane gas** are commonly used for heating and may be detected if there is unburned gas escaping from leaky pipes or from improper combustion. **Methane gas** is a component of natural gas and may exist where there is a nearby swamp or rotting vegetation. Thus, if a building is constructed on or near swampy land, accommodations must be made for gas diffusion. The methane gas levels produced by swamps should not harm building occupants, but the gas odor easily could become offensive. Most of these gasses can be reduced significantly from the indoor air if all HVAC systems are properly vented to the outside and checked regularly.

Radon gas is released from rocks, soil and building materials and enters a building through the soil, groundfill materials or from well water.[20] In small buildings, the quantity of radon in the soil, rocks and backfill beneath and around the building is a far greater contributor to interior radon gas levels than poor ventilation. Radon gas also escapes from products inside a building because building materials (especially those built from earth or rock products), water and natural gas all release radon. Radon gas is found in most buildings, but the concentration is usually low. Few buildings have concentrations as high as those found in uranium and other underground mines. There probably is a greater chance that smokers would have increased risk in commercial buildings as well, but solid epidemiologic data are scant.

Building-related bioaerosol problems usually occur where there is excess moisture accumulation. To resolve the moisture problem, the source of the moisture must either be eliminated or accommodated by installing a permanent drain. Unseen moisture problems may result from a leaking roof, a blocked refrigeration unit drain, a leaky water line, excess condensation collecting on a water pipe or excess humidity caused by poor air exchange. Moisture and the resulting microbial growth will cause stagnant air or musty odors which are both unpleasant and harmful to building occupants.

Strategies For Dealing With Sick Or Diseased Buildings

In attempting to identify the source and eventually develop a plan to solve building complaints, there

may be: 1. infected people problems, 2. sick building problems or 3. building-related disease problems. The first problem generally ends when those infected go home. The sick building problem, while seldom fatal, nevertheless can cause worker loss of morale and productivity, absenteeism and even employee turnover. A diseased building, however, needs to be thoroughly examined and cured because it houses at least one potentially dangerous health problem. People with a building-related illness may not recover after leaving the building, and they may even be permanently damaged by a dangerous micro-organism, such as Legionella, or by highly toxic or allergenic substances.

Two well documented building-related diseases are Legionnaires disease and Pontiac fever. Both these diseases are caused by the same bacterium, Legionella pneumophila, which grows in untreated water of air conditioning cooling towers, whirlpool spas, industrial coolants, steam turbine condensers, evaporative condensers, shower heads and any other water source. It is a potentially dangerous bacteria that infects both healthy and medically compromised hosts. If these diseases are discovered in a person occupying a building, an examination and immediate cleaning and disinfecting of water and water handling equipment must be initiated.

Inadequate ventilation is a major problem associated with building-related complaints. When ventilation is reduced or the circulated air contaminated, indoor air accumulates numerous particles. Likewise, inadequate building maintenance can lead to health problems as the number of particles increase significantly and the probability grows that they will be disseminated throughout a building or will be acquired by humans through inhalation, trauma, skin contact or ingestion.

There is evidence that poor maintenance procedures contribute to indoor air problems in 75 percent of all buildings inspected. These maintenance deficiencies also drive up energy costs by reducing HVAC system efficiency. Some causes of impaired air quality are clogged air filters, untreated cooling water that has fouled surfaces with moss and fungi, moisture and dirt that combine in ductwork and promote growth of microorganisms, unrepaired damper linkages, causing too much or too little air to circulate and control settings that have been accidentally upset by marginally trained maintenance workers.[21]

Improved product labeling and usage, component substitutions and personal actions such as curtailing smoking; reducing use of perfumes, hair sprays, indoor application of fingernail polish and remover and the use of other volatile substances can enhance the quality of indoor air. If smoking is allowed within the building, designated areas should be incorporated and each smoking area should have its own independent ventilation which excludes any smoke from recirculating over the remainder of the building.

Some reservoirs are more difficult to eliminate than others. For example, new furnishings can be selected for minimal offgassing (release of volatile particles) properties and can be allowed to offgas in a properly ventilated area prior to human exposure. The danger of caustic chemicals can be reduced by using tight lids and properly storing chemicals. Routine cleaning and maintenance reduces the probability that dust, bird nests, dust mites and other similar nuisances will become a problem, but moisture can be very hard to control. If the building is kept too dry, there will be complaints of dry throats while excess humidity (greater than 60%) can cause serious moisture problems that encourage pests of all types and create both foul odors and a potentially large aerosolization hazard.

A small mouse or bird in a building is often overlooked, but it is an indication that there is an unwanted opening or that an environment exists which draws pests of all types. Moisture accumulation commonly goes unchallenged, but it will slowly damage a building and allow harmful creatures to reside and amplify. An open lid on a cleaning solution may appear harmless but, depending on the solution, may cause either immediate or long term damage. A room that smells stuffy may be avoided but nevertheless signals a lack of air circulation which can slowly lead to serious problems. Collectively these seemingly insignificant issues may present formidable air quality problems.

A well selected building site is the first step toward preventing building-related problems.[22] Careful site selection and a sound building design will help prevent both moisture accumulation and stuffy air. Proper building design will incorporate sufficient fresh air by using exterior air intakes that are located away from foul air sources, but these intakes still must be routinely maintained.

Basement construction must be tight and free of cracks and holes to reduce radon penetration from the soil outside the building. The most prevalent sources of entry are the crawl space, cracks in concrete slabs, sump holes and cracks in basement floors. Airborne radon gas levels are sharply increased when the interior air already contains particles such as tobacco smoke to which it can easily attach. Particulate bound radon can be removed by filtration while free radon gas levels are reduced by ventilation.

Thorough and regular cleaning practice should be used to remove contaminants. Merely disguising

the symptoms, so prevalent in hotel rooms previously occupied by smokers, by application of perfumed sprays and cleaning agents, can aggravate sick building problems. Chimneys and other exhaust systems should be kept free of leaks, bird nests and other blockages. Portable kerosene heaters and other internal combustion devices should be properly vented to the outside exhaust so gas buildup is avoided. The location of fresh air intakes should allow only fresh unpolluted air to be drawn into the building. These intakes should not be adjacent to loading docks and accompanying truck exhaust fumes, trash dumpsters and air exhaust outlets—especially those from rest rooms, kitchens and manufacturing processes.

Both corporate and building managers should give their highest priority to office workers' complaints regarding discomfort from a building's interior environment. Failing to do so may cause the workers to initiate legal proceedings. Several cases are noted by OSHA in the Federal Register regarding litigation involving many millions of dollars due to building-related health issues. Such issues are likely to become more prevalent as office buildings are constructed even more air-tight.[23] Lees-Haley suggests to first listen to the complaints. Next, the problem must be investigated and its source sought and eliminated if possible. Management must always demonstrate that the problem is being addressed in an open and timely manner. A common sense starting point is to inspect and search the interior and exterior of the building with the building engineer for air duct obstructions, ceiling stains and sources of foul odors. It is wise to provide employees with status reports on a building's environment through its environmental committee. In addition to building and environmental factors, personal mediating factors are associated with sick building syndrome. These include job duties, job dissatisfaction, job stress, physical and personal vulnerability and social support.[24]

According to two California-based attorneys, "most complaints about the indoor environment are the result of undesirable temperatures, humidity, air movement, odors and other sensory input such as lighting, noise and vibration. Many indoor air pollution problems can be solved by simply turning down the thermostat."[25] They also note that setting aside designated smoking areas may be of little help to reduce the level of pollutants in a building unless the area is separately ventilated.[26] A building owner may be liable for personal injury from indoor air pollution as the result of: 1. design and construction problems and 2. improper maintenance. The first source relates both to a building and its systems. Therefore, if a building is poorly designed, it may supply insufficient fresh clean air or, for example, if during installation of the HVAC a worker spills or leaves his/her lunch in the vents and encloses it, that material becomes a reservoir for microbes and odors. Two-thirds of all buildings are estimated to have some ventilation deficiency. Post-construction problems also may be a source of liability for property owners. This may result from improper servicing of HVAC systems. Even tenant-generated air quality problems may ultimately be a liability source for an owner who allows tenant improvements such as carpet installation and interior painting. The upshot is that financially weak tenants may avoid lease payments by claiming they have been deprived of their right to quiet enjoyment of the leased premises.[27]

As stated earlier, OSHA is currently considering a new set of standards for the essential steps building owners and managers can take to prevent indoor air problems.[28] These standards will require that all aspects of indoor air quality be monitored and documented. Someone must be designated, trained and given the task of ensuring that HVAC systems are maintained and verified to be operating properly. The standards, if adopted, definitely will increase the cost of constructing and operating a building. Since the health problems and legal costs associated with poor indoor air quality will likely worsen in the absence of legally binding standards, it is in a building owner's best interests to initiate a prevention program as soon as possible. The detailed OSHA standards may provide a useful way to maintain a healthy workplace environment and ward off tenant complaints and possible lawsuits. Moreover, the required documentation will protect the owners if an air quality problem occurs. These standards may not be adopted as currently written and should be modified to distinguish between buildings with and without indoor air quality problems.

NOTES

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