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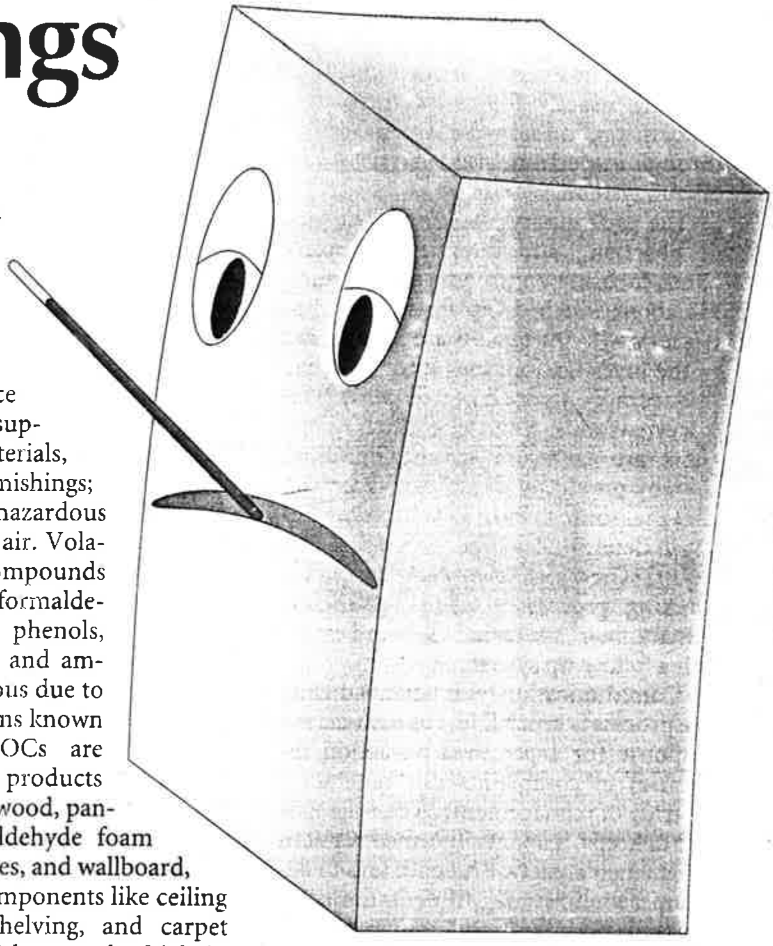
Strategies for Sick Buildings



By Ronald V. Gobbell and Nicholas R. Ganick

"SICK" buildings are becoming a major concern for designers and owners; a growing number of workers and residents have made it so. When 20 percent of a building's occupants display symptoms of illness that are clearly linked to the time spent in the building, but no specific illness or cause is known, that building is said to have sick building syndrome (SBS).

Buildings with SBS cause illnesses, typically: eye irritation, including scratchiness or watering; nasal irritation or stuffiness; throat dryness or lower respiratory tract difficulties; headaches, fatigue, dizziness, drowsiness; and skin dryness or rashes. These symptoms are often vague and generally worsen as the day progresses and ease or disappear when occupants leave the building.

Causes of SBS

Buildings that are sick have one or more condition. "Bad" air—caused by vehicle exhaust, industrial pollution, pollen, soil gas, or microbial growth from standing water—is brought inside by the HVAC system. It can affect air quality three ways: by creating the contamination source through wet conditions that may exist in cooling towers or in duct work adjacent to humidifiers; by transporting airborne contaminants through the system; and by not being able to handle sufficient outside air and diluting its contaminants.

Bad air is also created by office equipment and supplies, cleaning materials, pesticides, and furnishings; all can send hazardous fumes into inside air. Volatile organic compounds (VOCs) such as formaldehyde, benzene, phenols, alcohols, acetone, and ammonia are hazardous due to their toxic emissions known as offgassing. VOCs are found in building products such as paints, plywood, paneling, urea-formaldehyde foam insulation, adhesives, and wallboard, and in building components like ceiling tiles, draperies, shelving, and carpet backing. Even finishes can be high in VOCs.

In 1989, the Building Owners and Managers Association estimated that productivity would increase up to 21 percent with improved indoor air quality (IAQ). The Environmental Protection Agency (EPA) estimates that decreased productivity equates to some $60 billion annually. (Compare this to the national cost of lost productivity from major illnesses: estimated $4.7 to $5.4 billion yearly.) This decreased productivity may be a conservative estimate because some workers do not connect their non-specific symptoms with poor air quality, and many workers continue to work even when ill.

Lost productivity is only part of the bleak economics of sick buildings. Buildings vacated because of SBS, and those that are occupied and sick, create significant health, economic, and legal implications for owners and managers; many become primary defendants in the rising number of lawsuits related to poor IAQ. According to EPA and World Health Organization statistics, 20 percent of U.S. buildings have serious IAQ problems and 40 percent have somewhat serious problems.

Investigations of 529 buildings by the National Institute of Occupational

Safety and Health in 1987 showed that the causes of poor indoor air in these facilities were due to inadequate ventilation (52 percent), inside contamination (17 percent), outside contamination (11 percent), microbiological contamination (5 percent), and building fabric contamination (3 percent).

Investigating the Sickness

The diagnosis and treatment of a sick building usually follows a three-step process: preliminary assessment, walk-through inspection, and analysis of the HVAC system.

The preliminary assessment consists of observing and interviewing occupants, focusing on the area of the building about which complaints occur. Interviews with the tenants are at the heart of the investigation; they must feel that their complaints are taken seriously. The interviews must determine which symptoms are common in the building, thereby providing a track for discovering the source and, most important, must determine when the complaints occur. Create a complaint response tracking procedure using a standard questionnaire for consistency and establish a follow-up system.

Communication with tenants during the process is crucial. Just as a no-action response (or a *perceived* no-action response) to complaints can generate a distrust of management, so can the failure to keep occupants informed result in heightened anxiety. Prudence says to develop a sound strategy for communicating with occupants and anticipate having to deal with the media.

Once data have been collected, conduct a walk-through inspection. Look (and smell) for visible fungal growth, odors, signs of moisture damage, stains, smoke damage, storage of hazardous substances, soil gas (wet earth smells), unusual noises from light fixtures and mechanical equipment, and general unsanitary conditions (especially in mechanical rooms). Also look closely at and around HVAC equipment for signs of inadequate maintenance: oil leaks or water stains, dirty drain pans, and dry drain traps that allow sewer gas to enter an occupied space.

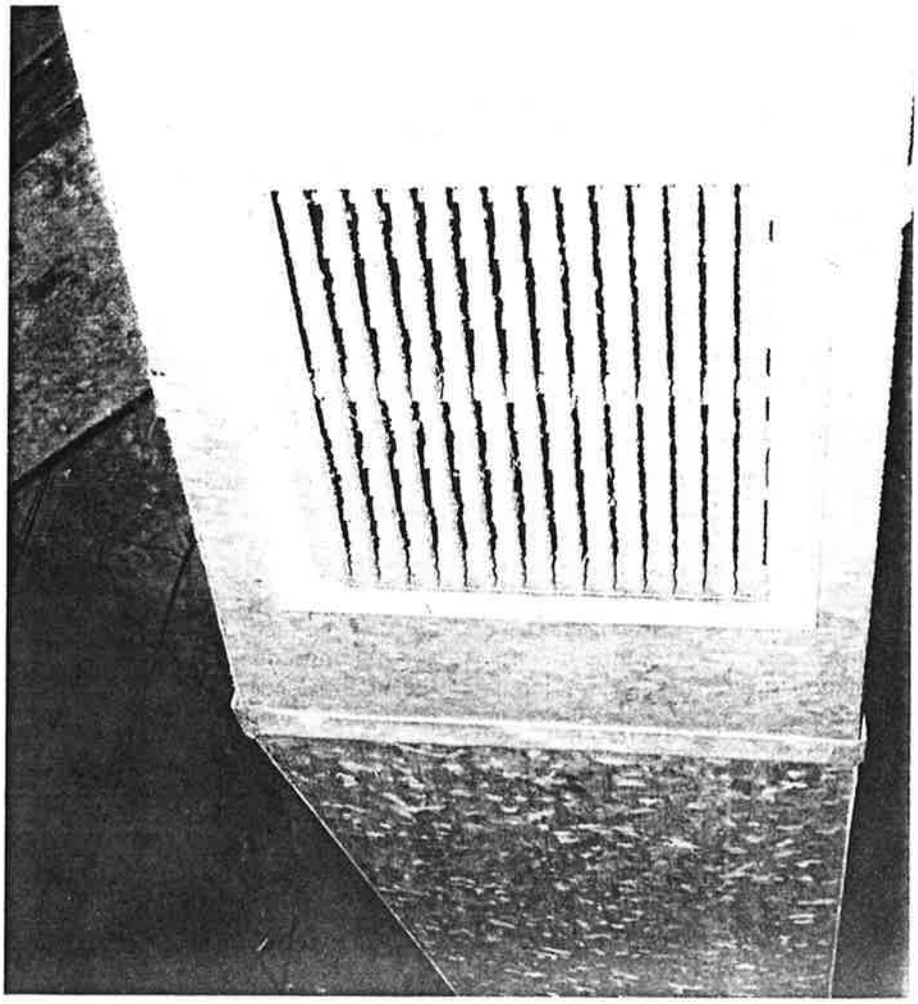
Check, too, for obstructed vents and faulty dampers that may block airflow; walls which obstruct or divert the movement of air in ceiling plenums; improperly located vents, exhaust and air intake grilles; high concentrations of electrical fixtures and equipment; humidifiers, dehumidifiers, and duct linings that may be the source of biological contaminants which are spread by the ventilation system. Note conditions such as uneven temperatures, drafts, stuffiness, propped-open corridor doors, blocked diffusers, and overcrowding of spaces originally designed for general or minimal occupancy.

Special use areas—elevator shafts, stairwells from garages, loading docks, print shops, janitorial closets, storage areas, kitchens, and smoking lounges—often allow fumes to funnel into places where many people live or work. And, although certain spaces may be visually identified as smoking areas, they may not be in a HVAC zone that provides exhaust capabilities. Finally, look for changes in the function of spaces and in thermal and contaminant loads which depart from the original design due to new furnishings, equipment, or increased occupancy.

Note: Carbon dioxide (CO^2) is not considered a contaminant unless levels are exceptionally high; generally, high CO^2 levels will indicate inadequate fresh air ventilation. Samples are taken at problem areas and where there are no problems (to serve as a baseline). CO^2 readings provide valuable patterns to the investigative process.

The next step in the investigation requires considerable understanding of the design and operation of the HVAC system. A thorough inspection of the system should be made to determine if it functions properly. The examination should verify the design intent, capacity, and all system modifications. Injecting a tracer gas into the HVAC system can verify its functioning. The gas, injected at the inlet to the supply fan, travels

When return grilles are allowed to gather clumps of dust, heating and air conditioning equipment can negatively influence air quality.



through the supply air distribution system, the supply diffusers into the space and return grilles, through the return air distribution system, and finally into the mixing/outside plenum. Measuring the gas at the return air fan often verifies proper operation of the ventilation and/or exhaust systems.

Air tests, made under the supervision of a Certified Industrial Hygienist who uses ASHRAE guidelines, may be advisable as well. ASHRAE Standard 55-1981 is intended to achieve "comfortable" conditions for eight out of ten persons. A "comfort zone" is considered to be one between 20 to 60 percent RH with temperatures between 73 and 77 degrees Fahrenheit (23 to 25 degrees Celsius). ASHRAE Standard 62-1989 further recommends a minimum standard ventilation rate of 15 cfm per person in office areas (this represents an increase from ASHRAE's previous minimum ventilation rate of 5 cfm per person).

Correcting the Sickness

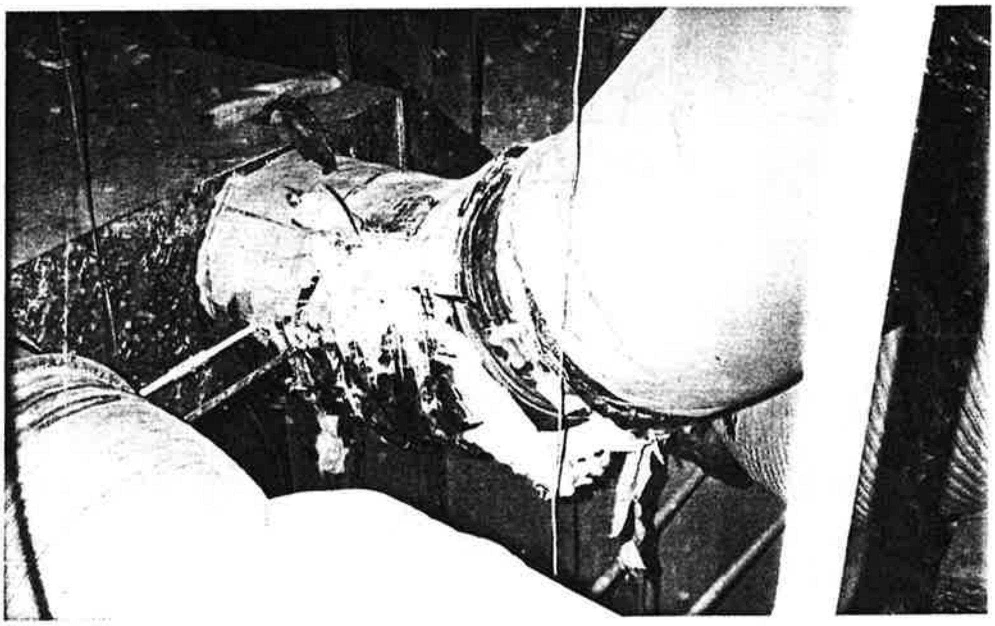
It is clear that SBS is due to the interaction of many factors: the source and nature of the contaminant, the building's structure and site, the activities and equipment in the building, as well as its climate and occupants. Overcoming SBS problems requires changing the relationship among these factors.

Source control is considered the most effective way to correct SBS. The source could be eliminated: prohibit smoking or remove equipment that produces the contaminant. Or, it could be isolated: seal or cover contaminant-producing materials or improve the storage of these materials. Or, modify the environment. For example, prevent the regrowth of microbiological organisms after the contaminated area has been cleaned and disinfected by improving humidity control or adding insulation to prevent surface condensation. However, source control may not always be feasible. For example, if an investigation identifies formaldehyde (under a 25,000-square-foot area of carpet) as the culprit, removing the carpet to gain access to the source may be less than prudent.

Inadequate ventilation—insufficient quantities of outside air or an inadequate distribution of ventilated air—accounts for a large percentage of indoor air problems. Modifying the ventilation may involve diluting a contaminant with outside air by increasing the amount of supply air, by increasing the proportion of outside air to total air, or by improving air distribution. Controlling air pressure relationships can also remove or isolate contaminants. The physical layout of grilles and diffusers relative to the occupants and pollutant sources is a factor in controlling air pressure relationships. Properly designed local exhausts can also remove or confine the spread of contaminants.

Ventilation modification is an effective corrective strategy; it may be as simple as adding 10 percent more fresh air to the system. But other factors must be equally considered before taking this step. For example: Does the system have the heating and cooling capacity to handle the added fresh air? Is the outside air so polluted that its value for ventilation is limited? Will more ventilation raise the energy consumed by the heating and cooling system?

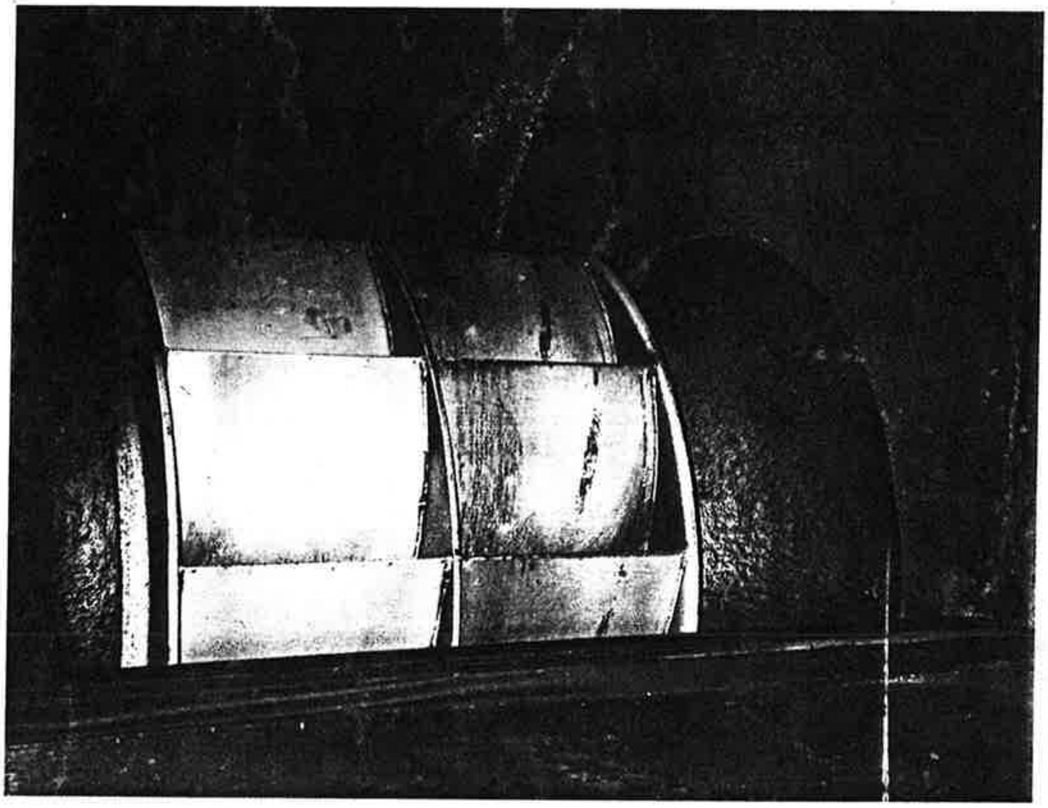
Air cleaning—the use of an effective and efficient air cleaner—is an attractive solution because contaminants are always being generated. Air cleaning is recommended in conjunction with source control or ventilation modification. While this is a broad and changing field, cleaning the air by removing particulates or gases is usually effective. Respirable particulates, 10 microns or less in size, are the easiest to remove by using high-efficiency particulate air filters or electrostatic precipitation. These filters are more expensive to install and operate, but are considered effective in particulate filtration.



Through a well co-ordinated Operations and Management Program, conditions such as damaged ductwork can be properly managed.

Gases such as carbon dioxide, radon, formaldehyde and other VOCs, and nitrogen oxide can be removed with activated carbon filters that bind gas molecules to carbon molecules. The filters are expensive in initial and maintenance costs, and their effectiveness may be impaired if there is a strong source nearby.

Finally, contaminants can be subjected to exposure control. Although this is a least desirable option if used alone, when combined with other strategies or when other strategies are ineffective, it can work. Exposure control is an administrative approach that involves scheduling shifts to work around contaminant-producing activities, providing relief breaks, or relocating those individuals who experience adverse symptoms in certain areas. A combination of controls is often recommended. Many VOCs, for example, defy individual treatment.



Unclean ventilation equipment, such as this dirty fan motor, can contribute to sick building syndrome.

Preventing SBS

Building owners and managers who wait for a problem to occur before taking action will pay a price in time, emotions, health, and dollars. Compared to prevention, reaction is a poor strategy. At the heart of prevention is a sound operation and maintenance (O&M) program. Scheduled inspections of the HVAC system must be made regularly and should include cleaning and changing the filters, coil and drain pans, air duct liners, and ensuring that controls operate properly. All leaks should be regularly inspected and promptly repaired. Also, good management of cleaning procedures and schedules is necessary to achieve an effective O&M program.

Indoor Air Quality

An IAQ management plan, which includes an IAQ manager and a trained staff with specific responsibilities, can help avoid SBS and its costs. Such a plan includes an IAQ profile which describes the building's structure, function, and occupancy features that affect indoor air quality: How was the building originally intended to function? Is it functioning as designed? What changes in layout and use have occurred since the original design and construction? What changes may be needed to prevent IAQ problems from developing?

New Control Technology

Owners and managers should also pay attention to the ongoing development of controls, equipment, and software that can affect IAQ. Direct digital control technology can be used to effectively monitor IAQ and initiate control strategies when used with equipment that is designed for them. Air quality sensors detect offgassing and, after detection, increase ventilation. They are more accurate and less expensive than carbon dioxide monitors.

Good Building Design

Use building commissioning to identify and solve problems prior to occupancy. Commissioning an HVAC system will include air testing, balancing, and flushing with 100 percent outside air to dilute compounds that may contribute to indoor pollution.

Healthy buildings require co-ordination among A/E disciplines and address many elements: site planning and building design; selection of materials, systems, and finishes; lighting; ventilation; and maintenance requirements. When all disciplines and the methods suggested here are put into play, SBS can be eradicated.

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