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Indoor Air Facts No. 3

Ventilation And Air Quality In Offices

Introduction

Millions of Americans work in buildings with mechanical heating, ventilation, and air-conditioning (HVAC) systems; these systems are designed to provide air at comfortable temperature and humidity levels, free of harmful concentrations of air pollutants. While heating and air-conditioning are relatively straightforward operations, the more complex processes involved in ventilation are the most important in determining the quality of our indoor air.

While many of us tend to think of ventilation as either air movement within a building or the introduction of outdoor air, ventilation is actually a combination of processes which results in the supply and removal of air from inside a building. These processes typically include bringing in outdoor air, conditioning and mixing the outdoor air with some portion of indoor air, distributing this mixed air throughout the building, and exhausting some portion of the indoor air outside. The quality of indoor air may deteriorate when one or more of these processes is inadequate. For example, carbon dioxide (a gas that is produced when people breathe), may accumulate in building spaces if sufficient amounts of outdoor air are not brought into and distributed throughout the building. Carbon dioxide is a surrogate for indoor pollutants that may cause occupants to grow drowsy, get headaches, or function at lower activity levels. There are many potential sources of indoor air pollution, which may singly, or in combination, produce other adverse health effects. However, the proper design, operation and maintenance of the ventilation system is essential in providing indoor air that is free of harmful concentrations of pollutants.

Sources of Indoor Air Pollution

Indoor air pollution is caused by an accumulation of contaminants that come primarily from inside the building, although some originate outdoors. These pollutants may be generated by a specific, limited source or several sources over a wide area, and may be generated periodically or continuously. Common sources of indoor air pollution include tobacco smoke, biological organisms, building materials and furnishings, cleaning agents, copy machines, and pesticides.

Health Problems and Ventilation

Harmful pollutants from a variety of sources can contribute to building-related illnesses, which have clearly identifiable causes, such as Legionnaire's disease. HVAC systems that are improperly operated or maintained can contribute to sick building syndrome (SBS); SBS has physical symptoms without clearly identifiable causes. Some of these symptoms include dry mucous membranes and eye, nose, and throat irritation. These disorders lead to increased employee sick days and reduced work efficiency.

A committee of the World Health Organization estimates that as many as 30 percent of new or remodelled buildings may have unusually high rates of sick building complaints. While this is often temporary, some buildings have long-term problems which linger, even after corrective action. The National Institute for Occupational Safety and Health reports that poor ventilation is an important contributing factor in many sick building cases.

Controlling Indoor Air Pollution

Control of pollutants at the source is the most effective strategy for maintaining clean indoor air. Control or mitigation of all sources, however, is not always possible or practical. Ventilation, either natural or mechanical, is the second most effecive approach to providing acceptable indoor air.

In the past, most buildings had windows that opened; airing out a stuffy room was common practice. In addition, indoor-outdoor air pressure differences provided ventilation by movement of air through leaks in the

building shell. Today however, most newer office buildings are constructed without operable windows, and mechanical ventilation systems are used to exchange indoor air with a supply of relatively cleaner outdoor air.

The rate at which outdoor air is supplied to a building is specified by the building code. Supply rates are based primarily on the need to control odors and carbon dioxide levels; carbon dioxide is a component of outdoor air, but its excessive accumulation indoors can indicate inadequate ventilation. Supply rates, hereafter referred to as ventilation rates, are commonly expressed in units of cubic feet per minute per person (cfm/person).

Ventilation Standards and Building Codes

After achieving industry consensus in 1989, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) published its "Standard 62-1989: Ventilation for Acceptable Indoor Air Quality." This is a voluntary standard for "minimum ventilation rates and indoor air quality that will be acceptable to human occupants and are intended to avoid adverse health effects." This standard applies to all types of facilities, including dry cleaners, laundries, hotels, dormitories, retail stores, sports and amusement facilities, and teaching, convalescent and correctional facilities. The specified rates at which outdoor air must be supplied to each room within the facility range from 15 to 60 cfm/person, depending on the activities that normally occur in that room.

Standard 62-1989 is a voluntary standard, which means that it becomes enforceable only after a state or locality adopts the standard in its building code. Furthermore, most current building codes pertaining to ventilation are standards only for the way buildings in a particular jurisdiction must be designed; they are not enforceable standards for the way the buildings are operated. A few states, through recently promulgated regulations, pending legislation, labor agreements and other mechanisms, are working to apply existing design codes and standards to building operations.

Ventilation System Problems and Solutions

The processes involved in ventilation provide for the dilution of pollutants. In general, increasing the rate at which outdoor air is supplied to the building decreases indoor air problems. The other processes involved in ventilation however, are equally important. Buildings with high ventilation rates may suffer indoor air problems due to an uneven distribution of air, or insufficient exhaust ventilation. Even in a well-ventilated building there may be strong pollutant sources which impair indoor air quality. The closer such a source is to an exhaust however, the more effective the ventilation; local exhaust ventilation, e.g., a chemical fume hood, is most effective. It is good practice to provide separate exhaust systems in areas where copy machines or solvents are used. Providing localized exhaust for these specific sources can result in a reduction of the amount of overall building exhaust ventilation necessary.

As was mentioned earlier, an HVAC system that is properly designed, installed, operated, and maintained can promote indoor air quality. When proper procedures are not followed, indoor air problems may result. Some common problems, and their solutions, are discussed below.

- ***System Design***

Intermittent air flow: Designs that specify HVAC system operation at reduced or interrupted flow during certain portions of the day in response to thermal conditioning needs (as in many variable air volume installations) may cause elevated indoor contaminant levels and impair contaminant removal. Minimum ventilation rates should be defined by air cleanliness and distribution, as well as temperature and humidity.

Distribution of air: Failure to maintain proper temperature, humidity, and air movement in a building can lead occupants to block supply registers if they emit air that is uncomfortably hot or cold; this disrupts air flow patterns. Placement of partitions or other barriers within a space can also impair air movement. In addition, locating air supply and return registers too close together can result in an uneven distribution of fresh air and insufficient removal of airborne contaminants. Precautions must be taken to maintain comfortable thermal conditions, and proper placement of supply and return registers, and furnishings.

Building supply and exhaust locations: Air supply vents that are installed too close to building exhaust vents re-entrain contaminated exhaust air into the building, increasing indoor pollution. Placement of supply vents near outdoor sources of pollution, such as loading docks, parking and heavy traffic areas, chimneys, and trash depots, provides a pathway for contaminants into the building's ventilation system. The location of all air supply vents must be carefully considered.

- ***Proportion of Outdoor Air***

To dilute and eventually remove indoor contaminants, HVAC systems must bring in adequate amounts of outdoor air. However, because it is costly to heat cold winter air and to cool hot summer air, some building engineers reduce or eliminate the amount of outdoor air brought into the system during hot and cold spells; this allows contaminated air to accumulate inside, causing pollutant concentrations to increase. Therefore, a continuous supply of fresh air must be provided.

- ***Periods of Operation***

An HVAC system that begins to operate after building occupants have arrived, or shuts off before the end of the work day can cause an increase in building- and occupant-generated pollutant levels. Similarly, if the system is off during periods of non-occupancy (e.g., at night and on weekends) building-generated pollutants may accumulate. Therefore, the ventilation system should be turned on several hours prior to occupancy, and shut down only after occupants have left.

- ***Maintenance***

HVAC systems must be properly maintained to promote indoor air quality. If this is not done, ventilation systems can become a source of contamination or become clogged and reduce or eliminate air flow. Humidification and dehumidification systems must be kept clean to prevent the growth of harmful bacteria and fungi. Failure to properly treat the water in cooling towers to prevent growth of organisms, such as Legionnella, may introduce such organisms into the HVAC supply ducts and cause serious health problems. Accumulations of water anywhere in the system may foster harmful biological growth that can be distributed throughout the building.

Air Cleaners

Air cleaners may be an important part of an HVAC system, but cannot adequately remove all of the pollutants typically found in indoor air. Air cleaners should only be considered as an adjunct to source control and ventilation. Air cleaners that have a high filter efficiency and are designed to handle large amounts of air are the best choice for use in office buildings.

Air cleaners include the simple furnace filter, the electronic air cleaner, and the ion generator. Mechanical filters, either flat or pleated, are generally effective at removing particles; flat filters collect large particles and pleated filters such as the high-efficiency particulate air (HEPA) filters collect the smaller, respirable particles. Electronic air cleaners and ion generators use an electronic charge to remove airborne particles; these devices may also produce ozone, a lung irritant. All air cleaners require periodic cleaning and filter replacement to function properly.

In addition to removing particles, some air cleaners may remove gaseous pollutants; this is possible only if the air cleaner contains special material, such as activated charcoal, to facilitate removal of harmful gases. Although some of the devices which are designed to remove gaseous pollutants may be effective in removing specific pollutants from indoor air, none are expected to adequately remove all of the gaseous pollutants typically present in indoor air. Information is limited on the useful lifetime of these systems; they can be expensive and require frequent replacement of the filter media. (For a more detailed discussion of air cleaners, read *Indoor Air Facts No. 7, Residential Air Cleaners.*)

Economic Considerations of Air Quality

It is generally agreed that poor indoor air can adversely affect employee health and productivity. These costs to industry have been estimated to be in the "tens of billions of dollars per year" (*Report to Congress on Indoor Air Quality*, 1989). Improvements in the indoor air environment may substantially increase employee moral and productivity. Therefore, it is important to include indoor air quality controls in operation, maintenance, and energy conservation strategies.

Resolving Air Quality Problems

Building managers and tenants must work together to improve indoor air quality; areas to address include:

HVAC system operation and maintenance: Operate the ventilation system in a manner consistent with its design. Perform maintenance and inspections on a regular basis, as prescribed by the manufacturer.

Record keeping: Maintain records of all HVAC system problems, as well as routine maintenance and inspection activities. Document the nature of complaints concerning the indoor air environment, as well as steps taken to remedy each complaint. These records may be useful in solving future problems.

Pollution control: Identify pollution sources. Implement source removal or special ventilation techniques (including restrictions on smoking).

Occupant activities: Eliminate practices which may restrict air movement (e.g., furniture placement relative to air vents).

Building maintenance activities: Increase ventilation rates during periods of increased pollution, e.g., during painting, renovation, and pesticides use; schedule use of pollutant sources to minimize the impact on indoor air quality.

Ventilation standards and codes: Keep abreast of revisions to ventilation standards and building codes affected by those standards.

Energy conservation: Reexamine energy conservation practices with regard to indoor air quality considerations, employee health, and productivity costs.

Identify areas for follow-up.

Summary

- An HVAC system that is properly designed, installed, maintained, and operated is essential to providing healthful indoor air; a poorly maintained system can generate and disperse air pollutants.
- Control of pollutants at the source is the most effective means of promoting indoor air quality.
- An adequate supply of outdoor air is essential to diluting indoor pollutants.
- In the absence of adequate ventilation, irritating or harmful contaminants can build up, causing worker discomfort, health problems and reduced performance levels.
- Ventilation rates specified in most local building codes are design standards only, and therefore are not enforceable for insuring healthful indoor air quality after the system begins to operate.
- Air cleaning is an important part of an HVAC system, but is not a substitute for source control or ventilation. All air cleaners must be properly sized and maintained to be effective.
- An objective evaluation of indoor air quality, employee health, and productivity costs should be included when considering energy costs and energy-saving strategies.

Additional Information

For more information on topics discussed in this Fact Sheet, contact your state or local health department, non-profit agency such as your local American Lung Association, or the following:

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US Environmental Protection Agency
Mail Code ANR-445
401 M Street, SW
Washington, DC 20460

National Institute for Occupational Safety and Health
US Department of Health and Human Services
4676 Columbia Parkway (Mail Drop R2)
Cincinnati, Ohio 45226

Office of Building and Community Systems
US Department of Energy
CE-13, MS GH-068
1000 Independence Avenue, SW
Washington, DC 20585

Public Relations Office
American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
1791 Tullie Circle, NE
Atlanta, GA 30329

Building Owners and Managers Association International
1250 Eye Street, NW
Washington, DC 20005

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