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BUILDING-SYSTEMS APPROACH TO INDOOR AIR QUALITY

Executive Summary

It is generally believed that the vast majority of cases of poor indoor air quality are the result of energy-saving practices implemented since the 1970s, coupled with the inadequate design, operation and maintenance of ventilation, filtration, and other building systems. In studies of hundreds of buildings, the most common factors affecting indoor air quality were found to be poor ventilation, poor air filtration, and poor operation of building ventilation systems.

The building-systems approach to indoor air quality is a comprehensive, continuing process that promises to improve air quality indoors with a minimum of expense and regulatory intrusion. In the case of new buildings, this approach commences at the building-design stage, continues through the construction and commissioning stages, and includes proper operator training and effective building operation and maintenance throughout the entire life of the building. For existing buildings, it includes testing, maintenance, and possible redesign of ventilation, filtration, heating, and air conditioning systems. In either case, the building-systems approach incorporates the principles of a number of American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) standards and guidelines, including ASHRAE Standard 62-1989 regarding ventilation rates for acceptable indoor air quality. It also requires the use of appropriate design criteria and construction documentation, and the provision and implementation of operation and maintenance procedures to ensure the health and comfort of building occupants.

The Business Council on Indoor Air (BCIA) considers the building-systems approach to be an important management tool that should be applied to both existing and planned buildings to provide good indoor air quality. BCIA recommends that future regulatory approaches to indoor air include provisions for optimal air exchange and filtration and proper management of building systems. Because of its potential to address the majority of potential indoor air quality problems in the most cost effective way, the building-systems approach should receive high priority in federal or state indoor air research programs.

The Business Council on Indoor Air (BCIA) was formed in 1988 to address growing mutual concern of a wide spectrum of industries about the national issue of indoor air quality. This paper represents a consensus among BCIA member firms with industrial hygiene, analytical chemistry, and engineering expertise regarding the most effective program for ensuring good indoor air quality.

Introduction

Indoor air quality concerns emerged as an issue in the 1980s primarily as a result of the energy conservation philosophy that evolved from the energy crisis of the 1970s. While reducing the amount of outdoor air used to ventilate buildings, many new and renovated buildings also were made more airtight to improve energy efficiency. Other exacerbating factors included the proliferation of poorly designed and operated building ventilation systems, overcrowding and alteration of office spaces, and changes in building use without appropriate ventilation modifications.

As a consequence of these trends, concerns have emerged about potential emissions from construction materials, office equipment, pesticide applications, and other sources. In fact, measurable concentrations of substances attributed to these sources have been observed in several studies. These trends also have been found to exacerbate the potential for the proliferation of biological contamination.

In its 1987 report entitled "Policies & Procedures for Control of Indoor Air Quality," the National Research Council (NRC) concluded:

> The levels of both chemical and biological contaminants are strongly associated with the cleanliness of the heating, ventilation and air conditioning system.

Moreover, the NRC report noted the complexities associated with identifying the source of indoor air quality problems:

> A number of factors are involved in the generation of building-related occupant complaints. Many of these can occur simultaneously. It is rare that a specific source for the complaints can be identified, and solutions can usually be implemented without such identifications.

The U.S. Environmental Protection Agency (EPA), in the Research Needs section (Volume III) of its recent Report to Congress, further noted that "more can be done to reduce overall exposures and risks by altering building designs and ventilation patterns than by approaching the problem source-by-source or pollutant-by-pollutant."

Adequate Ventilation and Filtration

Two of the most common denominators in buildings with reports of poor indoor air quality are inadequate ventilation and poor filtration. Ventilation problems, in turn, can result from insufficient outdoor air intake and/or poor distribution of that air. Inadequate filtration is frequently a major contributor to the third most common problem: the accumulation of dirt, dusts, and microbes inside the air handling units and their associated ductwork.

The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), a standards-setting group that develops voluntary consensus guidelines for building designers and contractors, has recognized the importance of higher ventilation rates in improving overall indoor air quality. ASHRAE's new ventilation standard (ASHRAE 62-1989, Ventilation for Acceptable Indoor Air Quality) increases the base minimum ventilation rate from 5 cubic feet of air per minute per person (cfm/person) to 15 cfm/person. In developing its new ventilation guideline, ASHRAE recognized that the previously recommended ventilation rate was insufficient to provide adequate indoor air quality in most modern buildings.

For general office space, ASHRAE 62-1989 recommends a minimum rate of 20 cfm/person, assuming a maximum occupancy of seven persons per 1000 square feet. The ASHRAE guideline also prescribes supply rates of outdoor air required for acceptable air quality. In addition, ASHRAE 62-1989 specifies a second method for achieving acceptable indoor air quality (the "Indoor Air Quality Procedure") which provides a contaminant-based approach considering the different kinds of ventilation systems and incorporates both quantitative and subjective evaluations.

There are relatively few sources of indoor air contamination that cannot be at least reduced, if not eliminated, through proper design and management of heating, ventilation, filtration, and air-conditioning systems. In fact, if the prime factor in the design and operation of a building's ventilation system were air quality, rather than the maintenance of a specific temperature, far more emphasis would be given to minimum outdoor air intake levels, filtration efficiency, and a greater awareness of the hygiene aspects of air handling systems. Such a building-systems approach, including design, operation, and maintenance, is the most important and cost-effective step toward reducing contaminants in indoor air.

Building-Systems Approach

The building-systems approach incorporates the principles of the recently adopted ASHRAE Standard 62-1989 and a number of other ASHRAE Standards and Guidelines as the basis for achieving acceptable indoor air quality. Among these other ASHRAE consensus documents are the following: ASHRAE Standard 55-1981 (for comfort); ASHRAE Standard 52-76 (for filtration); and ASHRAE Guideline 1-1989 (for commissioning).

BCIA believes the necessary technology is already available to achieve acceptable indoor air quality. Based on the collective experience of BCIA members and others, few indoor air quality concerns result when an adequate ventilation rate is maintained in conjunction with clean, well-maintained heating, ventilating and air conditioning (HVAC) systems with efficient filtration equipment.

It is, therefore, unnecessary and counterproductive to develop an entirely new approach or avenue of research. The building-systems approach is a comprehensive, on-going process that commences at the initial building design stage, continues through the construction and commissioning stages, and includes proper operator training and effective building operation and maintenance throughout the life of the building. It requires the use of appropriate design criteria, construction documentation, and the provision and implementation of building systems operation and maintenance procedures to ensure the health and comfort of building occupants.

Within the expected life of the building, reasonable changes in its use and occupancy should be anticipated in the design stage. Consequently, specification of the design intent and performance of all installed building systems in suitable commissioning guidelines should be a critical part of the building design. Development of such a comprehensive statement of the ultimate heating, ventilation, and air conditioning (HVAC) system performance criteria will provide individuals interested in building renovation or modification with the necessary information to provide adequate indoor air quality.

Application of the Building-Systems Approach

The key to addressing potential indoor air quality problems is prevention. With the comfort of employees at stake and the prospects of increased absenteeism and the potential loss of productivity, forward thinking employers are finding it cost effective to ensure that indoor air quality and employee welfare are maintained. The building-systems approach, as described here, is an important management tool that should be applied to both existing and planned buildings to prevent problems rather

than attempting to cure them once they happen. BCIA recommends that any regulatory approach to addressing indoor air quality include the following items:

I. Incorporation of the minimum ventilation rates defined in ASHRAE Standard 62-1989 ("Ventilation for Acceptable Indoor Air Quality") into applicable building codes. These rates will maintain the levels of most, if not all, indoor contaminants below acceptable levels.

These ventilation rates presuppose that the air provided from the outdoors contains acceptable levels of any of the contaminants in question. If the outdoor air exceeds any of these levels, air cleaning systems may be required. If such technology is not available, it may be necessary to reduce the amount of outdoor air during periods of high contaminant levels (e.g., afternoon ozone level peak and rush-hour periods).

II. Provisions for annual inspections of the air handling equipment of all commercial buildings to ensure cleanliness and proper operation. These inspections should include, at a minimum: (1) internal chambers of each air handling unit, (2) coils and drain pans, (3) internal insulation of the air handling chambers and the main air supply duct, and (4) humidifying equipment. Inspections also should include verification of compliance with proper schedules for filter changes and maintenance and calibration of HVAC controls.

It is critically important that building system performance and air quality be periodically reviewed as part of an ongoing building systems audit process, thereby assuring that the health and comfort of building occupants are both monitored and maintained throughout the life of the building.

III. Specifications that air handling systems in commercial buildings contain filters that meet the applicable ASHRAE guidelines. This will assure an efficiency of approximately 15 to 20 percent for the respirable sized particles (generally accepted as under 3.5 microns in size), while minimizing resistance to the airflow for energy conservation purposes.

These filters should be fitted to prevent air by-pass, periodically inspected for fit and condition, and replaced according to manufacturers specifications to provide continuous performance at rated efficiencies.

IV. Provisions that new building designs include a comprehensive statement of the ultimate HVAC system performance criteria to provide individuals interested in building renovation or modification with the necessary information to assure adequate indoor air quality.

This statement should include the following information: (1) suitable design criteria for all appropriate building systems and components, (2) a complete description of the HVAC system and its intended operation and performance, (3) a commissioning plan including a complete description of the work to be performed during construction, (4) verification procedures for any tests and demonstrations to be performed, and (5) a complete list of documentation submittals required at the completion of commissioning that can be used as educational tools for operator training of building personnel.

A large body of experience from public and private environmental organizations supports the building-systems approach. Extensive field experience in recent years has shown a very high level of success when applying these principles. Application of this approach has already proven itself to be the most economical and effective means of immediately making indoor environments more pleasant places to work. The use of this building-systems approach would eliminate complaints in most reported problem buildings.

Additional Research on the Building-Systems Approach

Indoor air research funds should be directed toward those strategies that are proven, or most likely, to provide practical, effective, and permanent solutions. It is clear that proper design, operation, and maintenance of building systems is the most effective strategy for addressing the widest variety of indoor air quality problems. As such, BCIA recommends that greater emphasis be placed on ventilation, filtration, and building-systems research, and that this research be conducted in cooperation with the private sector.

While much is known about the potential for the building-systems approach to eliminate or mitigate any potential indoor air quality problems, additional research is necessary to refine our understanding of the application of such an approach. Among those areas requiring additional research, BCIA includes the following:

1. Ventilation optimization - Ventilation for indoor air quality not only depends on the quantity and quality of the outside air that is brought into the building, but also on the movement of that air within the building. Research into the distribution of outdoor air through the building may provide insight into the maximum use of outdoor air in

maintaining the comfort of all building occupants. It is possible that we could place less reliance on the quantity of outside air necessary to achieve acceptable air quality if more was known about optimal placement of the outside air coming into a building.

Such research could include extensive measurement of the actual outdoor air volumes taken into buildings and investigation of indoor air distribution patterns, as well as the design and placement of supply and return points within individual rooms. The use of sampling systems built into the construction of buildings should also be included in this research area.

2. Filtration - At present, no standards exist for filter efficiency testing that uses particles of a size and type most representative of indoor air environments. Furthermore, continued research should be encouraged in the use of adsorbents and absorbents for removal of gaseous contaminants in both supply and return air.

3. Dry and liquid dessicants - These technologies are emerging as potentially useful tools in indoor air quality control. The potential for their widespread use should be studied.

4. Biological contamination - There is insufficient information about the extent, routes of exposure, and health consequences of microbiological contamination within buildings. Given that great variations occur with regard to the numbers of a particular species of microbes required to trigger infections or allergic reactions, compounded with the variability of individual susceptibility, research is needed to elucidate the role of microbes in the indoor air. It is essential that standard methods of sampling and culturing be established so that the results of independent researchers are comparable. Suggested areas of research include the health effects of bacterial endotoxins and fungal glucans, including evaluations of substances from commonly found species previously discounted as "harmless."

5. Productivity - Research on the effects of poor indoor air quality on productivity should be combined with building-systems research to provide additional incentives for the implementation of recommendations on building systems.

Summary

BCIA recognizes that not all indoor air quality problems can be avoided through improved design, operation, and maintenance of building systems. It is clear, however, that the building-systems approach is the most cost-effective way to address the majority of potential indoor air quality problems. Consequently, the highest priority should be placed on the promotion of responsible building systems design, maintenance, and operation. Steps to identify and control sources of individual pollutants should be undertaken only after it has been determined that the building-systems approach will not adequately address the problem.