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Ventilation and Problem Buildings: A Self-Serving Approach?

Many manufacturers of products that are considered sources of indoor pollutants are pointing the finger at poor ventilation as the major cause of IAQ problems. It serves their interest to identify IAQ problems as ventilation problems. These manufacturers include major chemical, tobacco, insulation, and building products companies. Some argue that solving IAQ problems requires a "building systems approach."

Clearly, proper ventilation system design, operation, and maintenance is critical to maintaining good IAQ. Phil Morey and Doug Shattuck of Clayton Environmental Consultants (Wayne, Pennsylvania) have written: "Deficiencies in the design, operation, and maintenance of heating, ventilation, and air-conditioning (HVAC) systems are usually involved in building-associated illness in large commercial office buildings." (Morey and Shattuck, 1988)

But arguing that inadequate ventilation causes indoor air problems without addressing pollutant sources implies that the sources are not a problem. This is a self-serving argument for makers of many assumed sources of indoor pollution: building materials, furnishings, office equipment, and consumer products. It is also misleading.

BCIA and the "Building Systems Approach"

Promoting a "building systems approach" is the approach of the Business Council on Indoor Air (BCIA). This council includes producers of many known and even notorious indoor pollution sources as well as companies involved with ventilation systems. What BCIA seems to mean by "building systems approach" is focusing on the HVAC system — on its design, maintenance, and operation.

Why BCIA Advocates It

Why, we were recently asked by a leading IAQ expert, would BCIA and other industrial interests want to focus our attention on ventilation instead of sources? And, after all, what's wrong with that? We weren't sure at first whether our friend was serious or just playing devil's advocate. Actually, he was doing both. IAQ experts agree that source control is the most effective way to improve IAQ. Good ventilation is essential, but it is only necessary to the extent that source emissions cannot be or are not adequately controlled. Of course, there are sources such as occupants and their activities that can only be controlled to a limited extent. And, every building consists of materials that will contribute some level of contamination over the building's life.

BCIA offers a seat on their board of directors for a $15,000 contribution. Regular memberships cost $750 per year. Present directors represent several of the nation's largest manufacturers of building materials and products — for example, Owens-Corning Fiberglas, Dow Chemical USA, and Union Carbide Corporation. These and other companies' products often receive the blame for IAQ problems. In the next few years, many of these products will face regulation and substantial damage liabilities. Some manufacturers have already paid out millions of dollars in claims.

Inside This Issue:

How BCIA's Approach Helps its Members

BCIA serves its members well by advocating a "building systems approach" (meaning ventilation). An exclusive or dominant focus on ventilation issues distracts legislators, government officials, and IAQ professionals from focusing on pollutant sources. By obscuring their products' contributions to indoor air pollution, manufacturers can delay regulation and reduce the chances of successful legal action. Such delays mean that manufacturers can continue to manufacture and sell the products. Also, they can postpone any costs for required abatement actions or expenses for lawsuit judgments or claims settlements. It is economically advantageous to delay paying fines, legal costs, or settlements; the companies can use the money to make more money during the delay period.

Focusing on ventilation makes it less likely that Congress will authorize or fund EPA to regulate or investigate adequately indoor pollution sources. During the last three years, legislators in both chambers have introduced bills in Congress to provide EPA explicit indoor air regulatory authority and to increase funding for the IAQ research program. The current administration has fought off the increased authority by claiming it already has all the authority it needs. However, EPA's own research budgeting process has identified substantial unfunded indoor air research needs - including advancing our understanding of pollution sources.

Understanding Sources

Researchers have made important strides in identifying the role of sources and in characterizing their emissions. They have recently made progress in developing methods to assess how VOC emissions affect building occupants. Also, some building products manufacturers, and even whole industries, have begun aggressively to seek ways to clean up their products. They find it is in their best interest from both a marketing and a product liability perspective. Usually, industry-wide standards for testing and product emissions will best serve both the industries and their customers. But much is yet to be done.

We need government funding of basic research - to understand sink effects, emissions processes from various materials, the health effects of emissions, and more economical ways to test materials. Enhancing EPA's research budget could greatly accelerate our understanding of sources. And, spreading information is essential to promote the purchase and use of cleaner, safer building materials, furnishings, and consumer products.

Ventilation and Problem Buildings

The companies and consultants who want to narrow our attention to ventilation instead of pollutant source control options often cite data such as those from the National Institute of Occupational Safety and Health (NIOSH). The companies claim that most IAQ problems are caused by poor ventilation. NIOSH has spent more than a decade investigating IAQ problems. The NIOSH data are presented in a way that might lead to that conclusion; however, a careful examination of NIOSH's work suggests something else.

NIOSH Investigation Results

NIOSH investigators have presented the results from their investigations at conferences and in publications since 1984. The presentations are updated periodically to include more recent results. They usually include the numbers and types of buildings investigated by year and building type and the "problem type" by number and percent. Table 1 below is from the most recent published version of the data: a paper by Teresa Seitz of NIOSH's Cincinnati office. Seitz originally presented the paper at the Indoor Air Quality International Symposium at the American Industrial Hygiene Association's 50th Annual Meeting in St. Louis, May 23, 1989. It was published in the book *The Practitioner's Approach to Indoor Air Quality Investigations*. (Please see the reference at the end of this article). Nearly everyone who attends an indoor air seminar or conference has seen these data at least once.

Problem Type	Number Completed*	%
Contamination (inside)	80	15
Contamination (outside)	53	10
Contamination (bldg. fabric)	21	4
Contamination (microbial)	27	5
Inadequate ventilation	280	53
Unknown	68	13
TOTAL	529	100

* Investigations completed through 1988.

Table 1 - NIOSH Indoor Air Quality Investigations by Problem Type (Seitz, 1990)

What Do the NIOSH Numbers Mean?

When questioned about their data, several NIOSH officials acknowledged that the numbers in their table do not necessarily define the causes of the problems they investigate. Often, the NIOSH investigators (like many others) recommend improved ventilation when they are unable to define the etiology of the occupants' complaints. This, the investigators admit, does not necessarily mean that they have shown the presence of only a ventilation problem. Indeed, pollutant sources may have caused or contributed to the problem.

Although NIOSH reports imply that the cases they investigated are caused by ventilation problems, NIOSH investigators make no systematic effort to prove that poor ventilation caused the problems, and identifying the causes is not necessarily the focus of their efforts. Like most investigators of problem buildings, NIOSH teams attempt to alleviate complaints. The NIOSH teams do not follow a standardized protocol, nor do they conduct any routine follow-up to verify that their recommendations worked or were implemented.

NIOSH's data imply that ventilation problems caused 53% of the cases they investigated. Ken Wallingford of NIOSH prepared the original analysis of NIOSH's investigation reports and prepared the table that categorizes the problems by type. Wallingford told the ***BULLETIN*** that NIOSH investigators generally have used ASHRAE standards to base their comparisons. Of those cases attributed to "inadequate ventilation," roughly half did not meet ASHRAE Standard 62-1981 for outside-air supply rates; about one-quarter did not meet ASHRAE Standard 55-1981 criteria for thermal control and relative humdity; and, about a quarter involved other ventilation problems such as poor space air distribution and inadequate filtration.

Improving ventilation usually is less costly and more productive than demonstrating the causal relationships between contaminants and occupant responses.

Furthermore, in most problem buildings, both owners and occupants would rather reduce the effects than seek the causes. Since it is possible to improve ventilation in nearly every building, whether it has an air quality problem or not, it is almost *de rigueur* to recommend improved ventilation. And, for nearly every type of indoor air pollutant, increasing ventilation rates and improving ventilation system performance are likely to reduce indoor airborne concentrations. This, in turn, will mitigate the causes of many complaints.

What Really Causes IAQ Complaints?

Professor James Woods of Virginia Polytechnic Institute in Blacksburg, Virginia, conducted many investigations while he directed an interdisciplinary investigatory team at Honeywell's Indoor Air Diagnostic Program. Woods, a mechanical engineer and a physiologist, suggests that there are usually multiple problems that could be causing occupant symptoms. The results of his work are presented in Tables 2 and 3 below.

Woods says that of all the buildings he investigated, about two-thirds contained sick building syndrome (SBS), and one-third contained both SBS and building-related illness (BRI). Like many SBS authorities, Woods classifies SBS and BRI as distinct types of building problems. Woods adds that you can find SBS without BRI but that you are unlikely to find BRI without SBS. He has never seen BRI without SBS. "If BRI is found, you must identify the source and absolutely must mitigate it. A good example of that is Legionnaires' Disease."

His numbers in the tables (given in percents) add up to more than 100 because he includes each type of identified problem that his team defines as potentially contributing

Type of Environmental Stressor	Frequency (%)
Chemical and particulate contaminants	75
with odor discomfort	70
Thermal discomfort	55
Microbiological contaminants	45
Nonthermal humidity problems	30
(With eye irritation and mold growth from low- and high-relative humidities respectively)	

Table 2 - Types of Predominant Environmental Stressors (Woods, 1988)

Problem Category	Physical Cause	Frequency (%)
Design Systems	Inadequate outdoor air	75
	Inadequate air distribution to occupied spaces (supply, return devices)	75
Equipment	Inadequate filtration of supply air	65
	Inadequate drain lines, pans	60
	Contaminated ductwork or duct linings	45
	Malfunctioning humidifiers	20
Operations	Inappropriate control strategies	90
	Inadequate maintenance	75
	Thermal, contaminant load changes	60

Table 3 - Frequencies of Occurrence of Physical Causes of Problem Buildings (Woods, 1988)

to the complaints. As he says, there is usually more than one thing wrong with a problem building.

Woods' investigation method focuses on the ventilation system. He tends to exaggerate the contribution of ventilation by describing its many defects. His ventilation bias supports the notion expressed by Lars Mølhave of Denmark that the diagnosis of a problem building usually reflects the disciplinary bias of the lead investigator. Woods' data support the notion that ventilation problems often exist in problem buildings, but the data do not describe the nature of the contaminant sources.

The *BULLETIN* View

While poor ventilation alone does not cause IAQ problems, most problem buildings do have ventilation problems. Increasing outside air ventilation rates usually alleviates at least some of the problems that cause complaints. However, when complaint rates are unusually high, there is probably a pollution source — even if it's the occupants themselves.

An IAQ problem is usually the result of a constellation of factors. These factors are presumed to include some pollution source and often, but not always, ventilation system problems. We say "presumed" because few indoor air investigators definitively identify causes. They identify potential or likely causes and recommend remedial measures to address the complaints. In cases of building-related illness, for example, Legionnaires' Disease, Pontiac fever, humidifier fever, rhinitis, and a few others that can be medically confirmed, causes are more easily and definitively determined. These typically include biological contaminants, for example, bacteria or molds, particulate matter, or volatile organic chemicals.

Sick Building Syndrome

The specific etiology (causality) of symptoms and complaints is not identified in many problem-building cases. These cases, generally known as SBS, are usually defined, in part, by the fact that no cause is clearly identified. Many leading authorities consider the causes to be multifactorial. Another criterion for the SBS tag is that the symptoms often disappear when occupants are away from the suspect building.

SBS symptoms are sometimes classified in two major groups. The first involves sensory reactions such as irritation and itching of the eyes, nose, or throat. These symptoms are often accompanied by sensations of dryness of the mucous membrane and skin and sometimes by erythema (reddening) of the skin. The second set of symptoms are systemic effects such as headache, tiredness, dizziness, drowsiness, or digestive disorders. Studies that investigate the occurrence and correlates of the separate groups appear to be more productive than those that group all SBS symptoms together. We think it is important not only to distinguish SBS from building-related illness (BRI), but also to distinguish different forms of SBS.

The "Building Ecology" Approach

A building systems approach *is* necessary to solve SBS, but we mean something different from what BCIA and its allies mean. We use the term "building systems approach" to describe analyzing a building as a dynamic, complex system that is affected by and affects the environment in which it is located as well as the people and objects in the building. That analysis involves understanding building dynamics as responses to the external environment as well as to occupants, equipment, and processes within the building. It means understanding the behavior of pollutant sources, the environmental fate of pollutants, and the factors that affect them. It means understanding the effects of pollutants on the building, its contents, and its occupants. And, it means understanding the effects of occupants and building operators on the building systems and the building fabric.

We call the study of the interaction of these various factors "building ecology." This, we believe, is a more complete, valid, and therefore useful concept for dealing with indoor pollution problems. We coined the term "building ecology" in the late 1970s, introduced it in an April 1981 *Progressive Architecture* magazine article, and repeated it in the same journal in a March 1991 article. Ecology is the study of living organisms in relationship to each other and to their environment. Ecologists use energy flow analysis, population studies, material sampling, and other techniques for studying ecosystems. "Building ecology" expands the notion of ecology in biology to include humans and their edifices — it is the study of buildings as systems and therefore includes, but is not limited to, a building systems approach.

Conclusions

The causes of SBS symptoms remain elusive in most problem buildings. However, ventilation problems alone do not cause most building problems.

In the end, it is nearly always more economical to control sources than to try to dilute or filter their emissions from indoor air. A research, investigatory, or regulatory focus on ventilation alone without a parallel focus on pollutant sources is not in the best interests of building owners or occupants. And, it would ultimately have harmful economic consequences for everyone concerned.

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News and Research

Yale Conference: Assessing the Sources That Cause SBS

"If SBS were caused by frank irritants (such as acids), we would understand it by now. But, in fact, most authorities assume it is caused by lots of low-level irritants that reach some critical mass. Right now, researchers are looking for hypotheses: gathering data," said Yale's William S. Cain, a leading indoor environment expert who studies irritation and odor responses. Cain made the remarks at a landmark IAQ conference held last fall in New Haven.

The purpose of the conference was to begin a year-long process of exploring ways to evaluate indoor pollution sources. Conference speakers presented many promising evaluation methods ranging from chemical to laboratory-animal to human-subject experiments.

The Organizers

Four researchers organized the conference: Bill Cain and Brian Leaderer of the John B. Pierce Laboratory at Yale; Gene Tucker who is on a one-year leave from his job at EPA's laboratory in North Carolina to work at Yale; and Lars Mølhave from Denmark who has spent the past six months working with the group at Yale. Tucker pioneered much of the indoor pollution source-characterization work at EPA during the past six years. It was his initiative that created the conference and the year of seminars to follow and build on the conference momentum. He also sponsored the forerunner conference on indoor pollutant source characterization six years ago in Chapel Hill, North Carolina.

Industries from building products to personal hygiene items and cosmetics were represented. Conspicuous among them were several representatives of tobacco companies as well as IAQ consultants with tobacco interest funding. We learned from conference organizers that tobacco interests had wanted to send a much larger contingent to the conference. However, organizers had decided to keep the conference small.

The Topics

The conference had four topics, one for each of four half-day sessions of the conference:

- Lessons from field studies regarding sources, pollutants, and symptoms. The most important question was: "what is worth looking at/for?"
- Current approaches to source characterization and exposure modeling.
- Acute reactions of the airways and eyes to irritants.
- Acute neurological and other systemic effects of indoor pollutants.

Recently, some industrial interests have tried to focus efforts away from researching the control of indoor air contaminant sources. However, the Yale conference researchers are exploring an expanded range of methods for evaluating contaminant sources. The classic dichotomy of source control vs. dilution and removal by ventilation was not part of the Yale conference agenda.

Gene Tucker's Views

We spoke with Gene Tucker after the conference to get his assessment of the state of source characterization. He described the situation as follows:

1. Source control is generally the most effective strategy for IAQ control.
2. Emissions from indoor sources are almost always complex mixtures. They can be mixtures of chemicals or microbes.
3. These mixtures are not created toxicologically equal.
4. Low-emitting is not necessarily low-impact.

He said: "We brought a core of people together that can get us into the next phase of source characterization; then we can identify clean products and not just low emitting ones." Tucker thinks the following questions need to be answered:

- What are the health effects of concern?
- How well can we estimate those effects from existing toxicological knowledge of individual constituents?
- Does it make sense to develop source characterization methods that measure health and comfort effects more directly?
- What sorts of methods are currently available for physiological effects that might be used for indoor source characterization?
- What new methods need to be developed?

"Should we continue to look at composition, emission rates, sinks, exposure modeling and risk characterization?" he asked. "Or, should we look at other ways to characterize indoor air pollutants, such as by methods that measure biological responses directly?" He seems to have answered that question for himself, and his year at Yale is likely to help set the research agenda at EPA for the coming few years.

Tucker and his colleagues are now engaging in a yearlong process to try to answer these questions. They have invited leading investigators of immunological and neurological effects to participate in small, intense, exploratory workshops at Yale. In the summer, they will go to Denmark to conduct workshops on sensory irritation and protocols for using humans to evaluate source emissions. "I am even more optimistic than before the conference that either animal or human testing could be useful to us in characterizing indoor sources," Tucker said.

"In the longer term, *in vitro* approaches also might end up being useful for screening products and materials."

Brian Leaderer's Views

Brian Leaderer, Professor at Yale and long a leading figures in IAQ research, made the following comments:

"A major outcome of the conference was that scientists from different disciplines were talking to each other and exchanging ideas and information. As far as I know," Leaderer said, "this was the first time it has occurred on this scale: engineers, toxicologists, chemists, all talking to each other. It led to discussions about future collaboration for source-characterization work."

"It's also important that this is one of the few times that industry has participated in an active way. I see that as a major outcome of the conference. We made an effort and were successful in bringing industry into the discussions. They seem to be interested in learning what sort of research will be done that affects their products, and they are anxious to participate in the process. They should be commended for that."

"We went out to establish lines of communication and bring about collaborative work. Cross-fertilization: ideas of how these disciplines might come together. Now we are looking at the results and starting to get ideas of how these areas can come together and work. Now, at Yale, we are distilling what we learned from different disciplines. Looking at the range of effects that might be measured (in terms of humans) establishes a practical link between source characterization and health effects. It was successful."

Mølhave and Immune System Reactions and Neurotoxicity of VOC

Lars Mølhave told the ***BULLETIN*** that some important research provides evidence that immune system reactions are significant. Neurotoxic effects *seem* to be less important according to studies done at Mølhave's lab in Denmark and similar studies by EPA in North Carolina. However, he said, these studies are inconclusive due to inconsistencies in their designs and the use of traditional measurements of signs of neurotoxic effects.

Mølhave's and EPA's Studies

Mølhave's studies measured subjects' responses to a standardized mixture of 22 volatile organic compounds (VOC) at various concentrations from 0 to 25 mg/m^3. He studied sensory responses, physiology of the eyes, and performance on standardized mental tests. He said potential carryover (one test session impacting the results of a subsequent session) and using subjects more sensitive than the general population (although they were not medically hypersensitive) made interpreting the studies problematic. All subjects previously had SBS symptoms.

The EPA study was arranged to answer some of the problems in Mølhave's study. EPA selected subjects more randomly. Mølhave said the test battery may not have been the best one for the purpose - it was a standard test used for detecting severe damage. It was not adjusted for a population of students that had high mental performance levels.

The EPA study provided no evidence of neurotoxic effects, but Mølhave said it can't be ruled out — especially for sensitive individuals. Mølhave cautiously says that he is concerned with the possible significance of observed attention changes. This, he says, is a definitional problem - is attention change (distraction) a neurotoxic effect? Is it important?

The Causes of SBS

We asked Mølhave what it all meant. He said: "With regard to the various hypothesized causes of SBS, it is not sufficient to call them co-factors. Occupants of normal indoor environments are exposed to several factors and the relationships among these factors are complex and poorly understood.".

"Indoor air effects on people may have many different causes. Many biological mechanisms may be activated simultaneously. What we see are several unspecific effects which may result from different causes; they may be activated by various biological mechanisms."

"The problem we are facing today is that many investigators of SBS are looking for one specific cause. They expect that removing one cause or exposure type will reduce the frequency of effects or halt the occurrence of the effects. However, if we are facing a causal relationship based on different exposures causing the same unspecific effects in a non-additive way, we should not expect a simple dose-response relationship. We will have to consider all the possible exposures when dealing with indoor air complaints."

Studying Irritation Responses

While the Yale group considers what methods are most useful to study biological responses to emissions from building materials, an interdisciplinary group of Danish researchers has already conducted some studies. One researcher, Gunnar Nielsen of the Danish National Institute of Occupational Health, presented a summary of experimental work on sensory irritation of upper airways.

Nielsen reviewed a variety of animal assays for upper-airway irritation in order to screen materials and structure-activity relationships. Nielsen described three basic methods for investigating sensory irritation: psychophysical approaches to estimate the intensity of perceived sensations; measurement of neural activity of the trigeminal nerve; and, quantification of the intensity of reflex reactions initiated from stimulation of the trigeminal nerve. A fourth approach, structure-activity relationships, predicts the irritant potency of vapors from the physicochemical characteristics. Nielsen says that the fourth approach works well for non-reactive chemicals and to a limited degree for reactive chemicals.

Reflexively Induced Effects

Eye blinking, tear production, and involuntary disruption of breathing are all reflex reactions that correlate to human exposure to chemicals. Furthermore, reflexively induced involuntary disruption of breathing correlates to perceived irritation. Some scientists have suggested that the involuntary disruption of breathing could be used as an objective measure of sensory irritation.

The decrease in respiratory rate is the basis of a bioassay using mice in a controlled laboratory experiment. This bioassay is ASTM's "Standard Test Method for Estimating Sensory Irritancy of Airborne Chemicals" (E981-84). This method is used to evaluate consumer products and is now being considered as a method for testing sources of indoor air pollutants.

According to Nielsen, the ASTM method can be "calibrated" to predict the level of response in humans. By comparing the results obtained with the bioassay to Threshold Limit Values (TLVs) for chemicals that are known sensory irritants in humans, scientists have found that an excellent correlation exists between the two. For example, the concentration of ammonia needed to depress respiratory rate by 10% (RD_{10}) in mice is about 50 ppm; depressing the rate by 50% (RD_{50}) requires 303 ppm. A 390 ppm concentration of ammonia triggers the reflex in humans.

These relationships between concentrations and effects are close to those found in psychophysical studies in animals and close to the concentration at which disruption of human breathing occurs. "Thus," says Nielsen, "all the animal models used for investigation of sensory irritation have about the same sensitivity and close correspondence with human sensitivity."

Nielsen concluded that "highly different potencies of emitted substances [from building materials] can be revealed by the ASTM method. Furthermore, information about the duration of the emission can be obtained." By using the method several times over a period of hours, days, or weeks after preparing a sample, one can infer characteristics of the emissions process. By analyzing the time of response, one also might deduce or infer characteristics of the emitted chemicals themselves.

A disadvantage of the ASTM animal bioassay method, according to Nielsen, is that it has "a lower sensitivity than that of the human sensory irritation reaction." However, he suggests this problem can be overcome by using higher loading factors for the materials in the test chambers. Alternatively, a closed-loop exposure system to increase exposure concentrations or using a more sensitive strain of mice also can overcome the difference, Nielsen says.

Psychophysical Methods

Scientists use psychophysical methods to evaluate sensory irritation in humans. The results are in terms of the proportion of individuals responding (e.g., rating as acceptable or not) or the magnitude of the perceived intensity. Scientists have used these methods to evaluate single chemicals, two-component mixtures, and indoor air in buildings.

Scientists have developed an animal model using trained mice to study irritant effects at different concentrations. This method is about as sensitive as the ASTM mouse bioassays of the reflexively induced decrease in respiratory rate as an index of sensory irritation.

Electrophysiological Methods

Scientists using electrophysiological methods to study sensory irritation responses in humans found correlations with surface potential changes in the nasal mucosa. These responses appeared independent of odor, since odorous stimulants were not effective. The surface potential changes correlated to simultaneous pain sensations. Another method involves measuring evoked potentials in the human cerebral cortex to study effects of substances with simultaneous olfactory and trigeminal nerve stimulation. This bioassay, using measurement of the trigeminal nerve stimulation, is also about as sensitive as the ASTM method.

Structure-Activity Relationships

Scientists believe that sensory irritation can occur in one of two ways: either when substances react chemically with the receptor or when substances adsorb physically to the receptor. Most studies have used laboratory animals. Investigators have successfully determined the chemical activation mechanisms for several compounds including, among others, derivatives of styrene and aliphatic amines.

Scientists have determined various structure-activity relationships for non-reactive substances by using thermodynamic activity as the descriptor or by using boiling points. A recently proposed theory using modern solubility theory and linear solvation energy relationships not only provides a correlation between the potency of irritants in animals and humans; it also allows for deducing the types of adsorption mechanisms involved.

Understanding Irritancy

According to Bill Cain, threshold concentrations are pretty high for irritancy (compared with thresholds for odor detection, for example). Yet people complain of irritation effects in buildings. How does that happen? Cain says it happens either because of sensitization or exposure time.

For example, Cain showed data that illustrated the relationship between the intensity of odor and irritation responses to formaldehyde during a one-hour exposure to 1 ppm. During the first half of the time, the intensity of odor decreased while the intensity of the irritation increased. The intensity of the irritation was far lower than that of the odor at the beginning. They came closer together toward the middle and began to separate again toward the end. Both effects trailed off during the final portion of the test period.

Understanding irritation is probably a far easier task than trying to understand acute neurotoxicity. Nonetheless, Cain said, "As unappealing as it may seem, it may be necessary to do lots of tedious data gathering to develop an adequate data base so that promising hypotheses can be checked out. We have to check out many compounds, it will take many years. This is time consuming and often boring, but it must be done."

According to Cain, "We could understand irritation in about two decades with cooperation and the proper resources commitment." Cain's ideas about what should be done and how much it might cost seem practical and reasonable. However, given the current US budget crisis and similar constraints in some European countries with active IAQ researchers, we are not optimistic that the necessary resources will become available.

Cain told the Yale conference audience: "There is no way we can understand SBS just by doing buildings; we must go into the laboratory." Michael Hodgson of the University of Pittsburgh said he studies buildings in order to know what to look at in the lab.

Conclusions

Conference speakers presented many promising methods for evaluating emissions from sources of indoor air pollution. Many well-established research methods currently used in other fields, as well as some that already have been used for IAQ-related work, comprise a broad spectrum of tools for determining acute health and comfort effects of indoor air contaminants.

Existing emissions measurement methods coupled with developing technologies for identifying chemical compounds can readily advance our understanding of IAQ problem buildings. The results also can be applied to developing better building materials, furnishings, equipment, and consumer products.

Conference Proceedings:

The New York Academy of Sciences plans to publish the papers from the conference. ***BULLETIN*** readers should check these pages for notice of publication and information on availability of the proceedings.

Biological Contaminants in Indoor Environments from ASTM

Biological contaminants play an important role in many problem buildings — buildings identified with cases of sick building syndrome or building-related illness. Various authoritative estimates place the percentage of problem buildings with biological contamination between 20 and 35%.

Now, a comprehensive book describes the nature of the organisms; their origin, growth, and spread indoors; aerosolization and human exposure; means for controlling their presence and proliferation in buildings; and, the methods to sample them in air. Published by ASTM, the book is based on a July 1989 symposium sponsored by the ASTM Subcommittee D22.05 on Indoor Air. Edited by the symposium organizers — Phil Morey, Jim Otten, and the late Jim Feeley — the book is a definitive review of the essential information on most organisms of significance in indoor environments.

The book's "Overview" begins: "The purpose of this symposium on biological contaminants in indoor environments was to develop and explore sampling and analytical protocols for microbial agents that may be commonly or uncommonly found indoors." The classes of microbial agents covered in the book are

- Viruses
- Bacteria, including gram negative, gram positive, *Legionella*, and mycobacteria
- Specialized bacteria including *Chlamydia* and *Rickettsia*
- Protozoa
- New microorganisms
- Mycotoxins and endotoxins
- Fungi

Microbial Contaminants and SBS

While scientists still do not know how much these organisms contribute to building sickness, these organisms are responsible for a significant fraction of human illness including infectious diseases, allergies, and probably much irritation. Indoor air is often the medium through which they spread.

Building design, construction, maintenance, and operation problems often contribute to occupants' exposure to these organisms. These activities also contribute to the proliferation and dissemination of the organisms in the environment. The Overview says: "Sampling and analytical protocols for most types of microbial agents are poorly developed and in those few instances where protocols are available, interpretation of analytical results is inconsistent."

Superb Guidance for IAQ Professionals

Along with ACGIH's *Guide to Assessing Bioaerosols in the Indoor Environment,* the latest Special Technical Publication from ASTM Subcommittee D22.05 is one of the most important contributions to understanding and assessing bioaerosols in the indoor environment.

Each author was asked to address air sampling of the organism or class of organisms covered in their talk at the July symposium. While air sampling techniques do not exist for some organisms, each chapter discusses some method for assessing air contamination. Like the ACGIH guide, most of the book chapters' authors do not recommend air sampling for characterizing the occurrence of the organisms.

The authors are among the top authorities in the world on their particular subject, and many of them have pioneered the development of the scientific knowledge about the organism they addressed. There are various methods other than air sampling for assessing contamination and exposure, and the book discusses these individually for most of the organisms covered.

Legionnaires' Disease

Perhaps the most notorious of problem building incidents is the Legionnaires' Disease outbreak that occurred in 1976 after an American Legion convention at a Philadelphia hotel. Although Legionnaires' Disease affects only about 5% of those who are exposed, it is fatal in approximately 10-15%; it may be the most feared building-related illness. P. Julian Dennis, a British microbiologist and authority on Legionnaires' Disease, covered the topic at the symposium and in the book.

Dr. Dennis says the illness begins with "malaise, muscle ache, and a slight headache." It is quickly followed by "a rapid rise in fever associated with shaking chills. Chest pains often without a productive cough are common."

The bacterium responsible for causing Legionnaires' Disease was first isolated in 1947. The first well-documented outbreak of the disease occurred at a meat-packing plant in 1957. *L. pneumophila* also causes Pontiac fever, a "... self-limiting influenza-like non-pneumonia form of the disease which has been related to the inhalation of legionellas. The incubation period is short (usually 36 - 48 hours) and of those exposed to the aerosol, 95% will become ill. The illness resolves spontaneously in 2 - 5 days."

Legionnaires' Disease is linked to inhaling the bacteria, and in Philadelphia and elsewhere, cooling towers and water-distribution systems have been implicated as sources of airborne spread. This places a significant burden on building designers, engineers, and operators. Proper maintenance of the cooling towers and other hot water service systems is essential. Dennis discussed maintenance, monitoring, and sample collection. Dennis' chapter emphasizes preventive measures rather than investigations.

The Fungi

Harriet Burge (University of Michigan) prepared the chapter on fungi and one on future research needs. Her fungi chapter is a concise, well-referenced discussion of various types of fungi, human health effects, and environmental assessment.

The fungi include diverse organisms. Some are unicellular, but most are long chains of cells called hyphae. "A mass of hyphae is called a mycellium and constitutes the vegetative body of the fungus which carries on the activities that allow growth and reproduction."

Burge writes: "There are fungi that will utilize almost any non-living organic substrate, and a few that will invade plant and animal (including human) tissue.... All fungi spores found indoors are ultimately derived from outdoor sources. However, when a spore with broad nutrient requirements (able to use a wide variety of substrates) encounters damp organic material indoors, it is able to germinate and grow, producing metabolites, volatile compounds, and new spores, and resulting in indoor contamination. It is important to remember that any substrate, indoors or out, that contains reduced carbon compounds, and other nutrients and is damp will support the growth of fungus."

Burge warns against allowing humidity to rise indoors because fungi tend to grow on damp surfaces. Some will grow in standing water such as humidifier reservoirs or HVAC system drain pans.

Infectious Fungi

Some fungi cause infectious diseases, while others cause allergies or irritation. The infectious diseases include cutaneous infections (e.g., ringworm), subcutaneous mycoses, systemic mycoses, and opportunistic infections. The common airborne systemic mycoses include Histoplasmosis, Blastomycosis, Coccidioidomycosis, and Paracoccidioidomycosis. While none of these are caused by air contaminants routinely transmitted from indoor reservoirs, epidemics of the first two have occurred when reservoirs in occupied interiors were disturbed or when "...unusual interior situations allowed growth of the organisms indoors."

Allergens

Fungi produce antigens that cause allergic diseases including asthma, rhinitis, and hypersensitivity pneumonitis. Burge writes, "...some fungi can grow in the thick secretions that can build up in the lungs of some asthmatic patients. These fungi do not actually invade the human tissue but grow in the mucus and produce antigens (and possibly toxins) that cause disease. The most common fungus causing this disease is *Aspergillus fumigatus*, a ubiquitous environmental fungus that is also an opportunistic infectious agent."

Irritants

When they degrade substrates, fungi produce volatile organic compounds (VOC) "...that cause the typical 'moldy' odor associated with fungal growth, as well as a wide variety of other odors. These substances can be irritating to the mucous membranes, and some evidence is accumulating that they may cause headaches and possibly other kinds of acute toxic symptoms."

Environmental Assessment

Burge does not advocate air sampling for fungi unless documentation of airborne contamination is required. Otherwise, she suggests a visual investigation - looking for fungal growth in reservoirs such as "... dirty filters, damaged and wet sound lining in a ventilation system, standing water in drip pans or humidifiers, or condensation or intrusive water on surfaces." She says the presence of "...slime, obvious fungal growth or obvious moldy odors can be assumed to represent contamination." She also recommends looking for bird roosting sites or collections of bird droppings that can harbor fungal growth.

Source sampling is useful to confirm reservoir contamination and to identify specific fungi seen on surfaces. To do this, collect "bulk" samples from water sources, saturated materials, or organic material.

The best culture media for the samples depends on the specific fungi present. "No culture method is optimal for all fungi." The analytical process is tricky and requires experienced personnel to perform the preparation, culture, and identification/quantification. Burge herself teaches a course each fall that is one of the best ways to obtain skills in assessing biological contaminants in buildings.

Conclusion

As a non-microbiologist listening to the symposium presentations, I was repeatedly struck by the fact that so many of the speakers described sick building syndrome symptoms as low-level reactions to the organisms they were discussing. And, many authors said that a large fraction of the population has evidence of exposure (antibodies) to the organisms in their serum. I could not help but think that a significant fraction of IAQ-related complaints is caused by microbial contaminants.

There is a definite need for accelerating research on the occurrence, health effects, environmental assessment, and control of biological contaminants in indoor environments. The symposium and the published papers make a significant contribution to establishing an agenda for the necessary research programs. What is needed now are the funds and scientists to carry it out. Meanwhile, IAQ professionals should be aware of the potential contribution of microbial contamination to problem buildings and obtain competent, specialized assistance whenever it is suspected; this book can help them.

References:

Philip Morey, James Feeley, James Otten, (Eds.), 1990. *Biological Contaminants in Indoor Environments*, ASTM STP 1071. Philadelphia: American Society for Testing and Materials. 244 pages. Available from ASTM Publications, 1916 Race Street, Philadelphia, PA 19103. (215) 299-5400. Price is $49 per copy ($39.20 for members).

For further information:

* Dr. Philip R. Morey, Director, Indoor Air Quality Services, Clayton Environmental Consultants, Inc., 1729 Christopher Lane, Norristown, PA 19403. (215) 688-4080.

Reviews

Publications Received

We have received several interesting and valuable publications in recent weeks. Space limitations do not allow a full review of each, so this month we will list and very briefly describe each. In upcoming issues we will present them in greater detail.

- *Indoor Air Quality for People and Plants*. Edited by John C. Baird, Birgitta Berglund, and William T. Jackson. Published by the Swedish Council for Building Research, Stockholm, Sweden. 1991. (190 pages). Available from the Swedish Council for Building Research, S-171 88 Solna, Sweden. Approx. price: SEK 100.

This book contains papers presented at an interdisciplinary conference held at Dartmouth College, New Hampshire. The papers explore the possibility of using sensory reactions of people and biological reactions of plants and insects to detect and monitor indoor air contaminants. Many promising techniques are discussed, and the presentations are both interesting and technically detailed.

- *Environmental Exposures and Personal Factors Related to Sick Building Syndrome.* Dan Norback. Published by Uppsala University, Uppsala, Sweden. Available from Dan Norback, Department of Occupational Medicine, Uppsala University, S-751 85 Uppsala, Sweden. Price: US $25.

The thesis contains an excellent, comprehensive overview of indoor air quality research on sick building syndrome and published reports of five studies done by Norback. His studies are somewhat different from most others in terms of the populations studied and the techniques used. His findings are extremely interesting including evidence of several risk factors for SBS such as wall-to-wall carpets, childhood exposure to maternal smoking, childhood and current urban residency, electrostatic charge, exposure to VOCs and respirable dust indoors, and VDT work.

- *Current Federal Indoor Air Quality Activities.* Prepared by EPA in cooperation with the Interagency Committee on Indoor Air Quality. EPA 400/10-90/006. Available from the EPA Public Information Center, 401 M Street SW, Washington, DC 20460. No charge.

This booklet lists major activities, their purpose, status, lead agency or office, and contact individuals with phone numbers. This is the "Who's Who In the Federal Government Indoor Air Effort." A handy guide to accessing government programs and people. It also lists IAQ publications available from federal agencies.

• *Total Exposure Assessment Methodology: A New Horizon.* Proceedings of a conference held in November, 1989, at Las Vegas, Nevada. Published by Air & Waste Management Association. (675 pages). Available from A&WMA, P.O.Box 2861, Pittsburgh, PA 15230. (412) 232-3444. Price: $70 per copy, $45 for members.

Most of the papers address indoor air exposures, at least in part. Topics include field monitoring methods and results, modeling exposure, surveys of human activity patterns, implications of exposure and dose in health effects studies, micro-environmental field studies, and others. The papers are generally interesting and contain lots of good information on IAQ.

Managing Indoor Air Quality. Shirley J. Hansen. Published by Fairmont Press. (317 pages) Available from Fairmont Press, 700 Indian Trail, Lilburn, GA 30247. (404) 925-9388. Price: $62.00 per copy.

Dr. Hansen is a mechanical engineer. The book is fairly comprehensive but its emphasis does reflect Hansen's background and experience with HVAC systems. It will be useful to the mechanical engineer because of the common language and emphasis, and it will give the non-engineer some detail on HVAC systems and IAQ.

Techniques

Building "Detoxification"

Designers, builders, and building owners are under pressure to reduce residual VOC air concentrations when occupants move in to new buildings or back into renovated ones. Even if designers select "safe," low VOC-emitting building materials, there still are emissions - even from the safest of them.

The challenge for building owners and facilities managers is to protect occupants of partially completed buildings or buildings under renovation from air contaminants generated by construction activities. Health and safety staff, design professionals, contractors, and even product manufacturers have all been named in lawsuits resulting from problems during such activities. Construction activities such as extending ventilation ductwork, installing floor coverings, erecting demising walls, installing office work stations, and painting all generate air contaminants. Construction activities in partially occupied buildings expose occupants in adjacent and other areas to vapors and dust. The contaminants spread via the air-handling system, by airflow through corridors, or in concealed ceiling plenums.

These exposures can lead to occupant complaints, illness, and absenteeism. Some instances have resulted in legal action or worker compensation claims. Unless construction areas are isolated from occupied areas and separately ventilated, contaminants are likely to reach the occupants and result in complaints. Solvents, paints, adhesives, dust, and other normal parts of the construction process are simply not acceptable in occupied areas at air concentrations typically found in construction areas.

California Will Develop Guidelines

The California legislature passed a law in 1990 requiring the Indoor Air Quality Program (State Department of Health Services) to develop guidelines "for the reduction of exposure to volatile organic compounds from construction materials in newly constructed or remodeled office buildings." These guidelines will be submitted to the legislature by January 1, 1992 with recommendations regarding the "need for regulation regarding the occupancy of a newly constructed building or a building undergoing remodeling where VOC reduction is to be a consideration."

Specifically, the bill requires the state IAQ program to consider the following:

- The type of building for which the guidelines shall apply.
- The methodology for identifying indoor sources of VOC.
- Bake-out procedures prior to occupancy for newly constructed buildings.
- Procedures for VOC reduction during and after major remodeling of occupied buildings.

What to do?

The procedures for reducing VOC during and after construction would comprise a mini-primer of IAQ control. For our premier issue of ***Indoor Air BULLETIN***, we briefly mention various control options. Here are some ideas that can help you protect building occupants in your next project.

Isolate construction

Fully isolate construction zones in partially occupied buildings. Keep these areas under negative pressure relative to the adjacent spaces.

Do this with physical barriers such as polyethylene sheeting and with exhaust ventilation through building openings such as windows, doors, and smoke-relief fans in stairwells. In some cases, you may need to temporarily remove a few panes of glass to relieve adequately the pressure created by the supply-air fans.

Depending upon the climate and the stage of construction, you may need to protect completed interior construction from water intrusion or wind. Do this with louvers or fans installed in the temporary openings. A contractor or building owner might mount the fans or louvers on sheets of plywood; then, they can be easily fit into various-size openings.

This approach requires that supply-air fans operate when the building is closed up and construction occurs with partial occupancy. Not all project schedules provide for such early start-up of the fans. The general conditions of the construction contract will need provisions specifying when the fans must be installed and operational.

Fan operation prior to completing duct extensions requires attention to the control logic and various overrides and protections. Do this to prevent damage to the system while creating the desired operation.

Maintaining negative pressure in the space will protect return-air system components from unnecessary contamination. Return-air fans should not be operated. Supply-air ventilation should be 100% outside air with no recirculation.

Select the Right Building Materials

Carefully select building materials to avoid using unnecessarily strong emitters or those that contain known irritants and toxins. Require manufacturers to provide data on their products' contents and chemical emissions (if tested) and evidence that they have addressed IAQ concerns.

More and more manufacturers are willing to provide this information, but the majority of building product manufacturers still cannot or will not. All will provide copies of the Materials Safety Data Sheets (MSDSs) for their products as required by federal law. But MSDSs are often insufficiently specific about the substances in question or about their actual proportion in the product.

You can make additional inquiries, but the response will be variable until standard test procedures and industry-by-industry voluntary agreements are made. Competition, lawsuits, and regulations may accelerate this process in some industries. Designers and building owners can make clear their concerns about the IAQ impacts of products, thus at least shifting some responsibility onto the manufacturers. As the volume of such requests increase, manufacturers will generate the requested information.

Schedule Activities Appropriately

Schedule construction/installation to minimize the build-up of high levels of contaminants that can't be removed before occupants enter or return to the space.

In occupied buildings, this means scheduling painting or finishing work for Friday evening or Saturday morning, not weeknights or during occupied periods.

This off-hours construction can create significant additional costs particularly in unionized areas. Therefore, it is probably worth the additional costs to use the isolation and materials selection measures described above and avoid the high costs of overtime or weekend pay rates.

Plan Adequate Airing-out Periods

From the beginning, plan adequate time for the installation and move-in process. Airing out a construction area with 100% outside air and no recirculation before occupancy is essential. A sufficiently long airing-out period (weeks instead of days) can drastically reduce airborne concentrations of most contaminants.

When insufficient time is available for airing-out, complaints and health problems are far more likely. Therefore, it is essential to schedule an adequate airing-out period during project planning and scheduling.

Reductions of 90% or greater can be expected for emissions from many materials during the first few hours (for "wet" materials) and the first few days (for "dry" materials). However, many dry materials installed with wet adhesives take longer to cure; the dry material, such as a floor or wall covering, isolates adhesive from the air.

Maximize Ventilation

Maximize ventilation during installation. Seal return-air ducts and use direct exhaust to the outdoors either through openable windows or through temporary openings — possibly with fan-powered assistance.

Since such a large fraction of emissions occurs during the days or weeks after product installation, air concentrations of the emitted chemicals can be rather high. This increases the adsorption by sinks and slows the removal of the material from the building. By maximizing ventilation, air concentrations are minimized that, in turn, minimize the sink effect.

Sealing return-air inlets, plenums, and ducts protects the "fleecy" surfaces of insulations above suspended ceilings and in air-handling units from exposure to high contaminant concentrations.

Avoid Creating Sinks

Whenever possible, avoid installing adsorptive surfaces such as textiles, insulations, and carpets before applying "wet" products such as caulks, adhesives, paints, sealants, etc.

It may not always be possible to avoid completely exposing fleecy, adsorptive surfaces to the extremely high concentrations created when adhesives or paints are freshly applied. However, designers, constructors, and building managers can identify the major "wet" product installations and plan to do them prior to other procedures. It is remarkable how much adsorption takes place, and anything that can be done to reduce it will lower concentrations when occupants enter or re-enter the building.

Ventilate Wet Products

Never install any "wet" product without maximum outside air ventilation — preferably at least five air changes per hour.

This makes sense not only for the eventual occupants but also for the installers. Also, increased ventilation will likely reduce the drying time. You can't dry your clothes in a humid bathroom, and you can't cure the water or solvents from adhesives or paints very quickly in air that is becoming saturated with their vapors.

Commission the HVAC System

Commission the HVAC system thoroughly to avoid problems for occupants in buildings with newly constructed ventilation. This is much more than the routine "testing, adjusting, and balancing" that is normally required for new HVAC systems. It means defining the performance criteria for the system and measuring that performance to demonstrate system acceptability.

ASHRAE published Guideline 1-1989, Commissioning HVAC Systems, to help define the steps involved in the commissioning process. While the guideline itself is only an outline of the process, it does indicate the major steps and the parties that must be involved. Some engineers claim that following a rigorous commissioning process actually saves money, either in the long run or even, in some cases, in the short run. Copies of the Guideline are available from ASHRAE, 1791 Tullie Circle NE, Atlanta, GA 30329 (404) 636-8400.

More Research Needed on Bake-outs

Bake-outs (simultaneous heating and ventilation to accelerate outgassing of new or contaminated materials) have not been adequately studied to determine their efficacy or to guide their general use. More research is necessary to determine optimum bake-out conditions.

A balance between heating and ventilating is necessary; however, responsible, knowledgeable scientists disagree on what that balance should be. Until further research defines the optimum conditions for bake-outs, they should be employed with extreme caution. Our bias is toward maximizing ventilation even if the maximum achievable temperatures are significantly reduced by so doing.

Letters

Filtration and Ventilation System Contamination

[Editor's note: During ASHRAE's Winter Meeting in New York last January, we chaired a seminar at which Barney Burroughs (a former ASHRAE president) suggested that the use of filtration could eliminate many ventilation system contamination problems. Burroughs' letter below was in response to our request that he write down his thoughts and send them to us.]

Dear Hal,

This is to respond to your interest in a quick write-up of the case study in filtration. This represents a client so I cannot give owner specifics.

As you may or may not know, I have been in the high end of the filtration industry since the mid-60's until my retirement from Purafil, Inc. in 1988. Those early years were in the bloom of clean room construction and more recently my focus was upon gas-phase filtration. Over the years I have seen many buildings that could easily qualify as having Sick Building Syndrome except the word hadn't been invented. We did marvelous and magical things with filtration — we went to the moon, we sent divers to the sea bottom in deep saturation diving, we constructed disease-free chicken houses for commercial research egg breeding facilities, we protected the crown jewels of Scandinavia, England, and Russia. We used laminar flow and containment isolation laboratories to study the moon rocks. We protected books, and paintings, and computers, and laboratories, and processes...all with filtration.

Thus, it stuns me that folks are so resistent to using established, commercially available, and relatively simple technology to help solve the indoor air quality problem in commercial buildings. First, Hal, you must understand my perspective is from the South — where air conditioning and high humidity are the norm — and where high efficiency filters were never really accepted in commercial buildings as they have been on the west coast.

I performed a risk assessment walk-through on a pair of buildings which I believe demonstrates the value and role of filtration in air quality management. The two buildings are part of a higher learning institution located in a Southeastern coastal city. They are near each other in an urban setting relatively near high traffic areas. The prevailing temperatures are high much of the year and relative humidities are ofttimes at saturation. The buildings are functionally similar devoting generally the same space ratios to teaching, library research, and administration. One of the buildings is 14 years old and does not demonstrate SBS whereas the other building is 4 years old and has experienced serious and prolonged IAQ complaints. The interesting thing about the two buildings and their major difference is that the older building has 85% ASHRAE rated filters, prefiltered with pleated 30% efficiency media blankets. Close inspection of the air handlers indicated that the filtered unit had only the slightest perceptible build-up of particulate and no evidence of fungal growth on the downstream fiberglass air handler lining. The coil was quite dirty yet had been cleaned only a few months previously.

It has long been my contention that the best method for dealing with IAQ problems is prevention. I am not proposing that filtration is the "see-all/end-all" preventive measure. I am saying that filtration is the effective way to keep systems components clean whether air handlers, coils, drain pans, fiberglass ductwork or distribution components. Clean systems are a major deterrent to microbial growth. Admittedly, filters can't stop mold growth in the space when water invasion occurs, but it certainly will drop the airborne spore count which helps avoid propagation and lowers exposure levels. The side benefits of filtration are also numerous including energy efficiency of equipment, lowered maintenance costs, and lowered housekeeping costs.

Hal, filtration puts forward a pretty good case as a prevention measure for air quality management. I've seen it work and I hope my experience is helpful for others who still have doubts about the value of high efficiency filtration in commercial buildings.

Regards,
H. E. "Barney" Burroughs, Consultant
Alpharetta, Georgia

Editor's Response:

We think the published research supports Burroughs' assertions that filtration can be effective in protecting air quality. The benefits of removing particulate matter from supply air include the protection of mechanical equipment and surfaces within the air distribution system as well as the protection of occupants, building contents, and the building fabric itself. Clean fiberglass ductwork or duct liners do not wick moisture and, therefore, are not likely to support microbial contamination. Burroughs correctly points out that operational costs can be reduced when heat exchange coils and other components are kept clean.

The impediments to using more or better filtration are the installation and replacement costs, energy costs to operate fans with more efficient filters, and, for certain types of filtration, additional space requirements. Ultimately, we must know the costs of not doing it in terms of typical contamination levels and their effects on occupants, building fabric, and equipment. And, in the worst case scenarios, what are the human and economic costs of massive air quality problems resulting from badly contaminated HVAC system components.

Please Send Comments

We invite comments or suggestions based on your own situation or experience. Send them to the ***BULLETIN*** editorial office so we can share them with other readers.

Calendar

May 2-3, 1990. **Indoor Air Pollution Symposium**. University of Tulsa, Tulsa, Oklahoma. Contact: Center for Environmental Research and Technology, University of Tulsa 600 South College Avenue, Tulsa, OK 74104. (918) 749-4358.

May 7-10, 1991. **Measurement of Toxic and Related Air Pollutants.** Sponsored by Air & Waste Management Association and U. S. Environmental Protection Agency. Omni Hotel and Convention Center, Durham, North Carolina. Contact: Jon Fedorka, A&WMA, P.O. Box 2861, Pittsburgh, PA 15230 (412) 232-3444

May 18-23, 1991. **American Industrial Hygiene Conference**. Salt Palace Center, Salt Lake City, Utah. Contact: AIHA, P. O Box 8390, 345 White Pond Drive, Akron, OH 44320 (216) 873-2442 Fax (216) 873-1642

May 21-22, 1991. **Testing, Adjusting, and Balancing - Professional Development Seminar.** Cleveland, Ohio. Sponsored by ASHRAE. Contact: See information on registration and costs in the listing below.

May 23-24, 1991. **Indoor Air Quality - Professional Development Seminar.** Cleveland, Ohio. Sponsored by ASHRAE. Contact: ASHRAE Meetings Department, 1791 Tullie Circle N.E., Atlanta, GA 30329 (404) 636-8400. *Covers causes of poor IAQ and identifies strategies for alleviating difficulties. Includes discussion of implementation of Standard 62-1989. Registration is $415 ($340 for ASHRAE members), $40 less for advance registration until 3 weeks before the seminar.*

June 10-14, 1991. **Industrial Hygiene Laboratory: Air Quality and Ventilation.** Harvard School of Public Health, Boston, Massachusetts. Contact: Mary F. McPeak, Office of Continuing Education, 677 Huntington Ave., Boston, MA (617) 432-3515; Fax (617) 432-1969. *Topics covered include portable direct reading instruments for real-time monitoring, passive monitoring, techniques for measuring ventilation, and personal pumping systems. Fee is $1,300, enrollment is limited to 24.*

June 12-13, 1991. 1991 **HVAC & Controls Symposium.** Association of Energy Engineers. Boston, Massachusetts. Contact: AEE, P.O. Box 1026, Lilburn, GA 30246. (404) 925-9633. Fax (404) 381-9865.

June 16 - 21, 1991. **Air & Waste Management Association Annual Meeting.** Vancouver, British Columbia. Contact: Jon Fedorka, A&WMA, P.O. Box 2861, Pittsburgh, PA 15230 (412) 232- 3444

June 19-21, 1991. **Annual Symposium, Pan-American Aerobiology Association.** Sponsored by the Pan-American Aerobiology Association and the University of Michigan, University of Michigan, Ann Arbor. Contact: Michael Muilenberg or Harriet Burge at the Allergy Research Laboratory, 6621 Kresge I, University of Michigan, Ann Arbor, MI 48109-0529. Phone (313) 764-0227.

June 20-21, 1991. **Indoor Air Quality for Facilities Managers.** International Facilities Management Association (IFMA). San Francisco, California. Contact: Susan Biggs, IFMA, 1 Greenway Plaza, 11th Floor, Houston, TX 77048 (713) 623-4362, FAX (713) 623-6124.

1991 **ASHRAE Annual Meeting.** Hyatt Regency Indianapolis, Indianapolis, Indiana. Contact: ASHRAE, Meetings Department, 1791 Tullie Circle NE, Atlanta, GA 30329. 404-636-8400

September 4-8, 1991. **CIB - ASHRAE Healthy Buildings - IAQ '91.** CIB International Council for Building Research Studies and Documentation. Washington D.C. Contact ASHRAE Meetings Department, 1791 Tullie Circle N.E., Atlanta, GA 30329 (404) 636-8400.

September 16-20, 1991. **Ventilation '91.** Sponsored by the American Conference of Governmental Industrial Hygienists (ACGIH). Omni Netherland Plaza, Cincinnati, Ohio. Contact: William Kelley, Ventilation '91, ACGIH, 6500 Glenway Avenue, Bldg. D7, Cincinnati, OH 45211-4438. (513) 661-7881.

International

May 15-17, 1991. **First Ibero-American Congress on HVAC.** Cartegena Hilton, Cartegena, Colombia. Contact: Alvaro Tapias, Chair, Organizing Committee, c/o ACAIRE, Apartado Aereo 47418, Bogotà, Colombia. Telefax 571 210 0782. U.S. inquirers should contact Victor Goldschmidt, (317) 494-2130; Telefax (317) 494-0787.

May 29-31, 1991. **Priorities for Indoor Air Research and Action.** Hyatt Continental, Montreux, Switzerland. Indoor Air International. Contact: Indoor Air International, P. O. Box 460, Biggleswade, Bedfordshire SG18 0AW England.

September 9-13, 1991. **Clean Air At Work; New Trends in Assessment and Measurement.** Luxembourg. Sponsored by the Commission of the European Communities. Contact: Mr. D. Nicolay, Commission of the European Communities, DG XIII/C# JMO B4/087 L-2920, Luxembourg.

November 5-8, 1991. **1991 Far East Conference.** co-sponsored by ASHRAE. Hong Kong. Contact: ASHRAE, Meetings Department, 1791 Tullie Circle N.E., Atlanta, GA 30329 (404) 636-8400.

December 3-7, 1991. **International Conference on Human - Environment System, ICHES '91.** Nihon Daigaku Kaikan, Tokyo, Japan. Contact: Yutaka Tochihara, Secretary General, ICHES, c/o Department of Physiological Hygiene, The Institute of Public Health, 4-6-1 Shirokanedai, Minato-ku,m Tokyo, 108 Japan. +81-3-3441-7111 Ext 240; Fax +81-3-446-4635.

July 22-24, 1992. **1992 International Symposium on Ventilation Effectiveness.** Tokyo, Japan. Sponsored by the Institute of Industrial Science, The University of Tokyo (co-sponsored by ASHRAE). Contact ASHRAE.

August 30th - September 4. 1992. **9th World Clean Air Congress and Exhibition.** Montreal, Quebec, Canada. International Union of Air Pollution Prevention Associations. Contact (for the United States and Canada): IUAPPA 92, c/o Air & Waste Management Association, P. O. Box 2861, Pittsburgh, PA, 15230. For other countries, contact your national professional association. *Languages of the conference will be English and French.*

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Indoor Air BULLETIN sincerely invites letters or any comments you may have on either the topics presented within or on other indoor environmental issues of interest.