Indoor Air Quality Update™

A Guide to the Practical Control of Indoor Air Problems, from Cutter Information Corp.

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EPA Report to Congress Released (At Last!)

Much has been made of the fact that EPA has finally released its *Report to Congress*. What could possibly be so important about EPA releasing a report on indoor air quality?

First of all, the just-released *Report to Congress* represents the most comprehensive effort to review indoor air quality problems and solutions in eight years. Not since the 1981 National Research Council's *Indoor Pollutants*, and the 1982 California Department of Consumer Affairs' *Clean Your Room! A Compendium on Indoor Pollution*, has there been such a comprehensive government report on indoor air quality technical, policy, and research issues.

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Second, the report represents an official administration position on indoor air pollution. The absence of such a position in the past resulted in a frustrating and unproductive face-off between Congress and two administrations; first Reagan's and then Bush's. The Senate Environment and Public Works Committee did approve Senator George Mitchell's (D., Maine) proposed comprehensive IAQ legislation last year, but the bill never made it to the Senate floor. Congress' failure to move on effective IAQ legislation in the past has been partly attributable to the lack of consensus and cooperation regarding a federal role in solving indoor air problems.

Bush Administration IAQ Policy?

The Office of Management and Budget approved EPA's *Report to Congress*, which means it is (at least for the time being) a working statement of Bush Administration policy on indoor air. Until now, there not only has been a lack of such a position, there appears to have been an intention not to formulate one. The release of the report puts the Federal government on record and offers a slim promise that EPA will support the comprehensive indoor air quality legislation moving through the hearing process in Congress.

What's In the Report?

The report consists of four parts:

- Executive Summary and Recommendations
- Volume I: Federal Programs Addressing Indoor Air Quality
- Volume II: Assessment and Control of Indoor Air Pollution
- Volume III: Indoor Air Pollution Research Needs Statement

We discussed the draft report's contents briefly in the May 1989 ***IAQU***. The major change from the draft to the approved report is the deletion of dollar figures in the research recommendations. The rationale for the deletion, provided by EPA Administrator William Reilly in his cover letter to Congress, is "...uncertainties concerning the accuracy of the estimates as well as the need to address resource issues in the budget process." Clearly, OMB does not support large (approximately $20 million per year) expenditures for IAQ research.

Another change is the deletion of training from the fifth recommendation (see recommendations below). The Reilly letter provided no mention of or rationale for that change.

A comparison of the draft report's recommendations to the provisions of Senate Majority Leader Mitchell's bill, S. 657, and its House clone, HR 1530, does not reveal very many significant differences. If compromises can be reached between congressional sponsors and administration officials in the next few weeks, com-

prehensive indoor air legislation might get on the books. We are not making optimistic predictions, only suggesting that the possibility exists where it did not exist previously.

Will It Make a Difference?

What will it take for the federal government to establish a well-funded, comprehensive program to address indoor air quality problems? As long ago as 1979, a General Accounting Office report decried the absence of a clear federal program to address IAQ problems. The GAO report characterized IAQ problems as a major public health issue. In its 1982 report, the California Department of Consumer Affairs found indoor pollution to pose a serious health threat potentially costing the nation between $15 and $100 billion annually in health care costs alone. The *Report to Congress* estimates the cost in the "tens of billions."

Now, finally, the administration has permitted the lead federal agency on indoor air pollution to address the issue directly. In its just (officially) released *Report to Congress*, the EPA writes: "Indoor air pollution represents a major portion of the public's exposure to air pollution and may pose serious acute and chronic health risks." While indoor air researchers and policy makers have known and have been saying this for years, the report is the first official administration policy document to even hint at it.

Everyone who follows indoor air quality issues knows that most people's exposures to air contaminants are indoors. The same folks know that most air contaminants are found at much higher levels indoors than outdoors. Furthermore, most know that illness, discomfort, and disease caused by indoor air pollution costs the U.S. billions of dollars in health care costs, lost work time, and productivity annually.

Last week, with the formal release of EPA's *Report to Congress*, the federal government went on record declaring what is obvious to those who deal with indoor air quality problems. Based on the evidence presented in the approximately 240-page Volume II, *Assessment and Control of Indoor Air Pollution*, EPA concludes: "This evidence warrants an expanded effort to characterize and mitigate this exposure."

The big question raised by the release of the report is what will happen next. Will Congress act on the report? We think this will depend in great measure on the administration position on the pending indoor air quality legislation.

If the administration fights or vetos the bill because it creates a "new program" or calls for new budget burdens, the bill may not make it through the process. It appears to us that some changes will have to be made in the twin versions of the "Mitchell bill" for the Bush administration to support it. If the administration supports it, there is a reasonable chance that meaningful, funded legislation will emerge.

"No New Taxes" for IAQ?

The major barrier is money. Clearly, OMB will resist efforts to establish any new programs as it strives for "no new taxes." In particular, grants to states and a significantly increased federal IAQ research program are likely areas of resistance.

Practical Problems Too

Another major barrier is the practical problem that the government would face were it to acknowledge the public health significance of IAQ. There are very significant health effects issues to be researched, and major changes in public policy to be made in relation to air quality legislation.

New programs and budget requirements would be implied. The dominant view is that occupational exposure limits based on industrial or agricultural workplace contaminants are inappropriate to protect people in nonindustrial indoor environments. Accepting this view would throw the whole occupational safety community into a tailspin. Who would set indoor air pollutant limits and on what basis? These are not trivial questions, and no practical and effective solutions have been suggested or even discussed to date.

Support for IAQ Legislation

On the other hand, the constituencies supporting indoor air legislation are growing. Many of the interested and affected parties are deciding that the lack of knowledge and the ambiguity surrounding questions of professional and corporate liability are creating unnecessary and substantial costs.

Building product manufacturers, building owners, and financial institutions want clarification of the responsibility and liability issues. House Natural Resources Subcommittee ranking minority member Claudine Schneider (R., Rhode Island) has been working on the indoor air quality issue for several years. Representative Schneider has been approached by these groups, who say they will support

reasonable regulation if it is fair and clear.

But enlightenment on the critical health effects questions that are the foundation of any IAQ regulation or professional response is far off. Among the few OMB deletions from the draft report were the dollar amounts attached to the research recommendations contained in Volume III and the recommended training as part of the national response program. The administration does not appear prepared to support a significant research effort for indoor air.

The Report's Recommendations

Specifically, the Executive Summary contains six recommendations to address indoor air pollution:

1. Significantly expand research to better characterize exposure and health effects of chemical indoor air contaminants.
2. Develop a program to characterize biological contaminants in indoor air.
3. Characterize significant indoor air pollutant sources and evaluate appropriate mitigation strategies.
4. Jointly develop with private sector organizations guidelines covering ventilation and building design, operation, and maintenance practices to maintain indoor air quality protective of public health.
5. Develop a technical assistance and information dissemination program at the federal level to help public and private organizations solve indoor air quality problems. The program would include an indoor air quality information clearinghouse.
6. Finally, determine the nature and extent of the health effects resulting from exposure to indoor air quality problems, and develop and promote guidelines for diagnosing and controlling such problems.

All of these recommendations are conceptually consistent with provisions in the IAQ bills pending in Congress. The bills, however, contain provisions likely to be opposed by OMB and, therefore, EPA. (For a detailed digest of the Mitchell bill, see *IAQU*, May 1989.) Specifically, the health advisories required by the bills would include "no effect levels" (NOELs) for each contaminant covered. That requirement may be opposed even by EPA, which has the responsibility to determine NOELs. EPA is more likely to support basing the national response plan on NOELs or some other health-based criteria.

The legislation calls for publishing a comprehensive list of all indoor contaminants. Some observers believe this serves no useful purpose since there would be no relationship between a listing and health effects. Why list literally thousands of chemicals unless there is a context of adverse health or welfare? The effort would mean considerable work at the agency which will then have difficulty addressing the more useful provisions of the bill.

Congressman Scheuer Pried It Loose

Representative James Scheuer (D., New York), chairman of the House Natural Resources Subcommittee, has been instrumental in getting the report out. At the July 20 subcommittee hearing on the Mitchell-Kennedy bill, Scheuer blasted the Bush administration for sitting on the draft *Report to Congress*. He threatened to use a parliamentary rule to pry it loose, a "rule of inquiry" which had not been used since Congress forced a reluctant Nixon administration to release a report on U.S.-Vietnam relations in 1971. It worked, and the report was approved and released.

Test Coming Soon

A good test of the possibilities for indoor air legislation is scheduled for September 27, when the House Natural Resources subcommittee will hold its second hearing on the bill. This committee appears serious about moving on the proposed legislation and on forcing the administration to take a stand. The *Report to Congress* might never have received a formal administration position without pressure from Congress.

The September 27 date was chosen to take advantage of the debate on many key indoor air policy issues that will occur September 25 and 26 in Washington at *IAQU*'s policy forum. At that meeting, "IAQ Update 89," leading indoor air authorities will discuss some of the critical technical and policy issues. Presumably, the forum will focus media, administration, and Congressional attention (at least a little) on indoor air that week, and Wednesday's hearing could be a productive one.

To Get a Copy of the Report:

A limited number of copies of the report are available at no charge from EPA's Public Information Center, EPA, Washington, D.C. 20460. Or call, (202)382-2080, and ask for it by name. When they are gone, the report can be

obtained from Cutter Information Corp. for a small shipping and handling charge; phone (617)648-8700, and the report will be sent right out to you.

Feature

ASTM Symposium on Bioaerosols

Over the past five or six years, we have observed a steady increase in the mention of bioaerosols as causing health and physiological effects attributed to indoor air pollution. Sick building syndrome (SBS) and building-related illness (BRI) are often attributed to microorganisms such as fungi, bacteria, and viruses. Some expertise has developed on the sampling, identification, and quantification of indoor bioaerosols, but very few published reports exist.

ASTM Subcommittee D22.05 on Indoor Air, with financial support from EPA's Office of Research and Development, organized a symposium titled "Biological Contaminants in Indoor Environments" in order to develop a comprehensive overview of the subject. About 90 people gathered July 16-19 at the Conference Center Inn, University of Colorado, Boulder, for the symposium. Some of the world's leading authorities presented papers on various significant microorganisms in an effort to understand their significance in indoor air.

The symposium was organized by two of the leading U.S. investigators of microorganisms in indoor air: Phil Morey of Clayton Environmental Consultants (Wayne, Pennsylvania) and Jim Feeley of Pathogen Control Associates (Atlanta, Georgia). They asked each speaker to address the occurrence, human health effects, sampling, analysis, and control of an organism or class of organism, including bacteria, viruses, and fungi.

While some of the speakers failed to discuss the indoor air implications of their topic, they left no doubt that the bioaerosols occur indoors and that they have significant health effects. Among the microbial agents discussed were *Legionella pneumophila* (Legionnaire's Disease), viruses, *Coxiella burnetii* (Q fever), *Chlamydia psittaci* (psittacosis), mycobacteria, endotoxins, and mycotoxins. Generally, the symptoms of nearly every disease attributed to indoor air microbial contaminants resemble some of the symptoms of sick building syndrome and building-related illness. It is difficult to say what constitutes the "mild symptoms" of exposure to some of the agents. However, most of the speakers opined that there are far more actual cases of disease resulting from microorganism contamination than are reported. There is a consensus that this is the case with the bacterial infection that culminates in Legionnaire's Disease.

Bacteria

Mark LaForce of the University of Rochester Medical School presented data on gram positive bacteria, especially *Bacillus* species. One species of *Bacillus* (*B. anthracis*) is a human pathogen that is transmitted by the airborne route. LaForce discussed historic epidemiologic data which show how this pathogen was recognized as the etiologic agent of anthrax. He pointed out that other *Bacillus* species are commonly found in the indoor and outdoor environments and these species do not normally present a hazard or disease risk.

Mary Hood of the University of West Florida described gram negative bacteria (named for the staining process used to identify them) as causal agents in an outbreak of hypersensitivity pneumonitis. The source of the organisms was a water spray in a ventilation system in an industrial facility manufacturing synthetic fibers. She cautioned that water must be kept clean and low in nutrient levels essential to microorganism survival. She recommended sodium or potassium hypochlorites (household bleach) or ammonium and metallic compounds for this purpose.

There was considerable discussion about acceptable concentration levels. Mary Hood said that many organisms can be present at levels of 10^4 to 10^5 colony-forming units (CFU) per milliliter (ml) of water without disease, except for *Legionella*, which can be problematic at levels of 10^3/ml. Jim Feeley suggested that a better approach than setting acceptable levels is to monitor organism concentrations frequently and watch for unusual increases.

Dr. Hood cautioned that, while adding chlorine or other antimicrobials to water changes the flora present, you can't remove slime from HVAC system components without mechanical scrubbing.

An important question frequently asked of various speakers was whether investigators should wear personal protection (respirators, independent breathing apparatus, etc.). The consensus was that it depends on the outbreak. Some believe that protection is warranted even for routine maintenance such as HVAC system filter changes. Many recommend

that investigators should generally wear protective clothing and breathing apparatus; this is especially true when poking around cooling towers. In addition, selecting the proper protection is a real problem without knowing the nature of the organisms that might be present.

Mycobacteria

Joseph Falkinham from Virginia Institute of Technology in Blacksburg discussed mycobacteria. He told the audience that the incidence of tuberculosis had steadily declined in the U.S. until three years ago. (Currently an estimated 30,000 new cases, resulting in 7,000 deaths, occur each year.) This reversal is attributed to changes in immigration patterns — the main source has shifted from Europe to Southeast Asia and Central America. AIDS patients are often infected, and that population is shifting from white homosexual males to inner-city ethnic groups and drug abusers.

A more important *Mycobacterium* species, according to Falkinham, is *M. avium*, which occurs in natural waters. Approximately 30% of AIDS patients are infected with *M. avium*, and it is common in geriatric patients and others in their 60s or 70s.

M. avium is hydrophobic (lacks affinity for water) although it comes from natural waters. Surfactants added to many biocides used to control microbes can actually elevate airborne levels of *M. avium*. The bacterium escapes from water by entering bubbles which jet out of the water. Scientists have actually measured the rate of entry into air from water by measuring the bubble jet escape rate and the concentrations of *M. avium* in bubbles. This, of course, is an issue for whirlpools, hot tubs, and shower water.

The organism is not considered hazardous for healthy people, and it is not particularly infectious. However, it should be controlled in hospitals, nursing homes, and elderly housing. Near-UV light radiation works well to control it, and heat treatment works also. However, chlorine, which is often used to disinfect water, does not work to control *M. avium*.

Rickettsia

Russell Regnery of the Centers for Disease Control (CDC) in Atlanta discussed *Coxiella burnetii*, a species of rickettsia, which causes Q fever (Q is for query: the name has stuck ever since its first discovery). Q fever occurs worldwide. *C. burnetii* are resistant to many antibiotics including tetracycline. The incubation period is from days to weeks, and airborne exposure is considered the most probable source of human infection. While many outbreaks have been documented among people who work with animals or in abattoirs, recent work has shown that others are infected as well.

C. burnetii also resists many common disinfection agents. Outbreaks have occurred in medical facilities where sheep were brought into the building for research. In Nova Scotia, domestic cats were implicated as the source of a Q fever outbreak. However, no reported investigation of Q fever has been attributed to catborne *Coxiella* in other countries. Between 32% and 73% of dairy cattle in Wisconsin and 82% of dairy cattle tested in California have been carriers, although infection is often not apparent in animals. Also, Q fever often resolves without medical intervention. So how many reported cases of SBS or BRI are caused by *Coxiella*? No one was willing to venture an estimate, but Regnery estimated conservatively that 5% of the population has antibody titers.

For environmental monitoring, Regnery suggested using dust samples as indicators of airborne levels. He also suggested that guinea pigs might be used as sentinel animals in the laboratory. Experiments are difficult due to the stringent safety standards established for handling the organisms. A new diagnostic technique, polymers chain reaction (PNR) analysis, shows promise for *Coxiella* as well as other organisms.

Chlamydia

According to Eugene Cole of the University of North Carolina in Chapel Hill, *Chlamydia* is an important indoor air organism. There are three species of interest, *C. trachomatis*, *C. psittaci*, and *C. pneumoniae*. The last, *C. pneumoniae*, is known as the TWAR (Taiwan acute respiratory) agent. Researchers first isolated it from the eye of a child in Taiwan, and identified it as the causal agent of an acute respiratory illness in a college student.

C. trachomatis spread mostly through nonairborne routes, although there is one known case of airborne transmission.

C. psittaci is an important indoor air contaminant. Reactions in infected individuals range from no symptoms to death. It comes from bird source aerosols (droppings, skin flakes, dander), is inhaled, and lodges in the lung. From there, the 1-1.5 μm (mean diameter) pathogen can be disseminated by the blood and cause systemic illness. Fatal outcomes are

restricted to elderly people in poor health.

Recovery can take up to a month or more. Antibodies are not protective against future infection. Man-to-man transmission amplifies the virulence. There are presently 50-100 cases per year reported to CDC, but Cole believes it is underreported due to asymptomatic or mild cases and misdiagnosis. In adults, its effects are most often seen in the upper respiratory tract. For teenagers, it manifests as prolonged bronchitis. Infected 5-12 year olds often display no symptoms.

There was a world-wide pandemic of *Chlamydia* infections in the 1920s when the importation of exotic birds became popular. At least 200-300 deaths were the direct result. In other reported case studies, 27 out of 80 employees in an Ohio turkey processing plant were infected, and two were hospitalized. Their symptoms included weakness, headache, fever, coughing, and pneumonia. In a veterinary school, another outbreak occurred with similar symptomology.

Conditions of overcrowding and dietary deficiencies in the bird population can mask overt clinical symptoms. Fifty percent of the cases are owners of pet birds. *C. psittacosis* is the fifth most commonly reported form of laboratory infection, and some of those cases have been fatal.

Investigators have not employed bioaerosol monitoring for *Chlamydia*. All glass impingers (AGI) have been employed successfully in the laboratory with significant recovery. Cole recommends collecting two samples at each sampling site with a 30-minute sampling duration using a buffered solution. If collection on filters is attempted, filters must be detergent free.

Infected rooms can be disinfected with phenolic compounds. Routine monitoring is not generally warranted, but where bird contamination exists, it may be. Where people are ill, serological testing might be more productive. Investigators should wear full-face respirators with HEPA filters during sampling.

Viruses

Viruses cause great concern as disease agents in indoor air. They spread from person to person in indoor environments by respiratory routes. Respiratory viruses affect everyone. In the United States, the average person suffers three respiratory infections per year. Viruses also cause discrete illnesses like diarrhea and mumps. When normal, healthy adults get virus infections, recovery occurs. If people have underlying diseases or compromised immune systems, viral infections can be extended or fatal.

There are a great variety of both RNA and DNA viruses. They can all be spread in the air, and they cause a wide range of illnesses. According to John Hierholzer, chief of the Respiratory Virus Laboratory at CDC in Atlanta, 200 or so viruses have been recognized.

Viruses can be sampled for in air, but such sampling is not practical for routine monitoring. It is expensive and not worthwhile unless disease is present, and is done mainly for research purposes. Direct antigen tests can be administered to ill or exposed people for some, but not all, of the viruses.

Two viral diseases receiving considerable public attention lately are the Epstein-Barr virus, which causes mononucleosis, and the Herpes Type 6 virus, which causes chronic fatigue syndrome.

Protozoa

Richard Tyndall from the University of Tennessee spoke on protozoa. Among the protozoa, amoebas are readily found in municipal water supplies. Tap water, then, can be a source. They are of great interest for indoor air quality because, among other reasons, they can encyst and incorporate *Legionella* within the cyst, thus making the *Legionella* resistant to chlorination. *Legionella* are usually found in association with amoebas.

Some protozoa are allergenic. Some are pathogenic in themselves. And others, like the amoebas, have a symbiotic relationship with other microorganisms (such as *Legionella*).

Protozoa are thermophilic — they can grow best at high temperatures. They can occur in hot tubs and spas, and are often found in cooling tower systems and thermal effluents from power plants. Protozoa are also found in sewage and solid waste processing effluents. Some proliferate in bird dung and have been found in abundance in both pets and poultry confinement facilities.

In a study in Tennessee, about 85% of home humidifiers tested had free-living amoebas in them. Dr. Tyndall said the amoebas themselves are generally too large (20-40 µm) to be aerosolized.

Indoor sources of protozoa include tapwater, or they can be dragged in on people's shoes with soil particles. They can be controlled in water with oxidizing biocides

(chlorine or hydrogen peroxide at 100 ppm).

Fungi

"We mycologists look at the world as moldy environments." So began the presentation on pathogenic fungi by Libero Ajello of the CDC in Atlanta. Ajello said that well over 100,000 fungi have been described already and every year another 1,000 to 2,000 are added. Generally, fungal spores are two to 40 microns in diameter and some reach the lower portion of the respiratory tract. Many can't live in the human body at 37°C or are removed or destroyed by the body.

Medical mycology is advancing. Many people with degenerating immunologic systems are living longer due to control of other problems with immuno-suppressant drugs. As we live in a sea of fungal propagants, it is no surprise that fungi seem to find immuno-compromised people.

Scientists are finding new species causing systemic, subcutaneous, and cutaneous infection. We don't know how widespread mycoses are because they are not reportable diseases. Medical mycology remains an iceberg — most of it is hidden from us at this time, due to inertia and a reluctance to explore this field.

An example of a pathogenic fungus is *Cryptococcus*, which may be present in bird feces. It infects animals as well as people. It can be isolated, but we lack rapid methods of isolating most pathogenic fungi. Serology helps with identification. Positive proof is obtained by directly observing the organism in the sputum.

Candida albicans is a very common pathogenic fungus. As the fad disease of the 80s, it is blamed for nearly every ailment known to man. However, it does have real pathogenic capability when proliferating unchecked. If sufficient numbers reach the lungs, infection occurs, and it can subsequently spread from the lung.

Saprophytic fungi

Harriet A. Burge is associate research scientist, Allergy Section, University of Michigan Medical Center, and she now chairs the Bioaerosols Committee of the American Conference of Governmental Industrial Hygienists (ACGIH). She is one of the leading authorities on indoor bioaerosols in the U.S. today. Dr. Burge spoke on saprophytic fungi and on bioaerosol sampling.

Saprophytic fungi live on nonliving organic material. There are about 300,000 species of these yeasts and molds, according to Dr. Burge.

Some fungi produce volatile organic compounds (VOC). Burge is currently measuring these VOC in order to characterize the types of compounds they form and the source strengths of some common organisms. It is quite possible that many adverse health reactions to indoor air result from VOC of biological origin.

Burge spoke of BRI, particularly the hypersensitivity diseases: humidifier fever, asthma, allergic rhinitis, and hypersensitivity pneumonitis. She said that any fungus can be an allergen for susceptible persons due to genetic make-up.

Mycotoxins

There are thousands of distinct chemicals called mycotoxins, which are metabolic products of fungi; each fungus has its own metabolites (mycotoxins). Some of them are very useful antibiotics, some are very potent poisons. South of the Mason-Dixon Line the major problem is from aflatoxins that are produced by *Aspergillus flavus*, according to Bruce Jarvis, professor of chemistry at the University of Maryland. Jarvis says the major problem north of the Mason Dixon Line is from trichothecene mycotoxins produced by *Stachybotrys atra.*

Nearly everyone has heard that aflatoxins are among the most toxic chemicals known. Most peanut butter has aflatoxins at parts per trillion concentrations. Under favorable conditions, the concentrations increase and become potent enough to cause serious illness (e.g., cancer).

Stachybotrys atra produces trichothecenes that are also very toxic. *S. atra* is particularly fond of paper (and other cellulose material) and thrives in the presence of moisture. *S. atra* is extremely potent; the amount grown on five grams of rice fed to a steer was lethal. The LD_{50} in mice is less than 1 mg/kg. Trichothecene mycotoxin is a heavy compound with a molecular weight over 600 and a melting point above 300°C. Stachybotryotoxicosis is rare, but it may occur in people who handle straw and hay.

The subtle effects of a low-level case are often difficult to properly diagnose because the symptoms are so similar to other illnesses and the disease is not well known. Thus, *S. atra* is another possible cause of low-level health effects similar to SBS. Among the effects on humans are adult respiratory distress syndrome, susceptibility to secondary infection, and inhibition of protein synthesis. *S. atra* can

get to an organ and create local tissue insults in such a way that the local surveying immune system cannot properly respond to other insults.

According to Jarvis, many agents cause the symptoms found in SBS and other "civilization diseases." It is not likely, Jarvis says, that a single agent causes all of these problems.

In a Chicago area suburban "estate house," occupants were experiencing all sorts of symptoms for five years. *S. atra* was found on a filter used for air sampling; it was the dominant species identified. The suspended ceiling was lay-in panels on a T-bar grid. There were roof leaks and subsequent water damage. The ceiling tiles were covered with *S. atra*. The house was so contaminated that the remedial contractor's workers got skin rashes. This is the only case that has been reported in the literature.

Mycotoxin IAQ implications

The role of mycotoxins has not been established in terms of IAQ. *S. atra* does not survive well in air, does not culture well on media, does not compete well with other organisms, and is difficult to collect. Therefore, its actual concentrations may be underestimated. We know that mycotoxins are always present as part of the general community of organisms.

Jarvis' advice:

Look at the organisms in a building. If you find an unusual fungus, look for mycotoxins. If the flora are normal or typical, don't spend too much (or any) time looking for mycotoxins.

Endotoxins

In *Lives of the Cell*, Lewis Thomas wrote: "Endotoxin ... The very worst of bad news." Endotoxins, found in the cell walls of gram negative bacteria, are everywhere, according to Stephen Olenchock, chief of the Immunology Section of NIOSH's Division of Respiratory Disease Studies in Morgantown, West Virginia. They're found in high concentrations in especially dusty agricultural situations. But they are also found in the air of offices, homes, and other buildings.

Endotoxins cause swelling, especially in the lungs. Symptoms include chest tightness, cough, shortness of breath, fever, and wheezing — all of the SBS and many of the BRI symptoms. In one published study, acute pulmonary dysfunction is correlated to endotoxin exposure but not with dust or other environmental agents.

There are no "magic numbers" for acceptable or threshold levels for endotoxins. Different endotoxins have different levels of toxicity.

Sampling Bioaerosols

Many speakers only briefly responded to the symposium organizers' request to discuss sampling and analysis. Dr. Burge, however, shared a brief overview of her widely touted expertise on the subject. In no uncertain terms, Burge joined the growing number of "settle-plate bashers." She said that settle-plate sampling does not tell you much at all — it picks up the "boulders" 10 to 15 microns in diameter. She described a number of useful instruments including the roto-rod, which is used mostly for outdoor air where there can be many thousands of spores per cubic meter. In passing, she said that mushroom spores are probably very important in asthma.

Burge said that the very popular Anderson sampler always underestimates the number of organisms present. If you use it, she suggests using only the fifth and sixth stages, sampling for one minute, and always collecting duplicate samples. She cautions that the Burkhard trap is less than 50% efficient for organisms at 5-μm diameters; the rotating plate slit sampler is best for viable sampling. The SAS (surface air sampler) is very useful, Burge said. Although it is heavy, it is still portable enough for indoor air work. It is battery operated, which gives it great portability.

Burge warned that "culture medium matters enormously." However, she complained of the lack of standardized culture media, so that results from different investigators could be compared. She warned that Rose-Bengal is dangerous to use because of the extreme care required to make it work right; it is the current NIOSH recommendation. She suggested that different media result in different morphology; therefore, the morphology should be characterized for each useful medium.

Filter cassettes can be used, according to Burge, but as little as 20% of the aerosol is collected (counted). Analysis is more complicated, but collection is far easier for the industrial hygienist who is accustomed to using the cassettes.

For antigen sampling, Burge recommended filters with analysis by immunological assay. This, she said, is not suitable for routine screening. She said that swab sampling is OK for identifying what species are present, but it will not indicate what is in the air.

Whenever indoor air sampling is done, Burge requires outdoor sampling every two hours. She has measured significant diurnal variations and geographical variations, so she urges investigators not to skip the outdoor sampling. The single largest outdoor source she has found is monoculture agriculture.

When planning indoor sampling, Burge advises starting with the air intake and following the entire path of the ventilation system. She recommends that particular attention be paid to the humidification equipment and any other water source or wet location in the ventilation system.

In order to establish a cause-and-effect relationship, Burge tries to match the suspect agent with the disease. She tries to determine if an adequate dose was present. Where many individuals are affected, she looks at the epidemiological pattern to see if it is appropriate for the agent.

Burge and her colleagues teach a course each year, "Assessing Bioaerosols in Indoor Environments," which usually fills up quite far in advance. The next course is October 25-27 at the University of Michigan. This is the premier opportunity to gain considerable knowledge of indoor environment biological aerosols. For information, contact: Kay Cullin, Conference Coordinator, University of Michigan, 1205 Beal Ave./IOE Bldg., Ann Arbor, MI 48109-2117; Phone: (313)936-0148.

What's New?

Joseph Plouffe is a physician and professor of medicine, microbiology, and immunology at Ohio State University. He specializes in respiratory diseases and his current focus is on detection and characterization of new agents that may cause pneumonias of unknown etiology. The symposium organizers asked him to address the topic "New Agents." His talk was as much a commentary on modern society as it was a description of organisms and the diseases they cause.

Describing what is common to new organisms found to have caused pneumonias, Dr. Plouffe listed the following characteristics:

- They do not grow on standard media in the laboratory.
- They do not stain well.
- They are known organisms.
- They were not considered pathogenic in the past.
- They were discovered through astute clinical observation or the occurrence of an epidemic.

Why are these organisms, previously thought to be innocuous, now found to be causing illness? Plouffe identified three changes as reasons:

1) changes in the organisms;

2) changes in the environment; and,

3) changes in the human population.

The organisms may be becoming resistant to control. Significant changes in the environment include energy conservation efforts, increased concentrations of susceptible populations in nursing homes, the widespread use of air conditioning in homes and cars, and general increases in pollution. The population is becoming older, and the immuno-compromised population has increased with the occurrence of the AIDS epidemic.

An important element of the newly discovered illnesses is the change in population, primarily the shift toward an older population as life expectancy increases. Thus, as people live longer, respiratory system function declines and people are more susceptible when exposed to pathogens. The result is more respiratory illness.

Plouffe pointed out that you have to look for the organisms or you won't find them. For example, *Legionella* cultures are not usually done. In a study of samples submitted for analysis in 1987, many turned out to be positive for *Legionella* even though there had not been a request for *Legionella* culture.

Microbials in Indoor Air: Overview

So how important are microbial contaminants in indoor air? This question was put to *IAQU* editor Hal Levin to answer in the final symposium presentation. At present, the indoor air community would probably rank microbials fifth in importance behind ETS, radon, asbestos, and VOC. However, as we learn more about them, they move up the ladder of dubious distinction.

The major control strategy seems to be controlling moisture and nutrients in buildings. Over time, as we learn more about specific organisms and the diseases they cause, we may target control measures as has occurred with *Legionella*. As we invest more in researching microbial contaminants in indoor air, our perception of the risks will increase. Such investments are already contemplated. But the current baseline of knowledge is so low that small investments will yield

significant initial gains in understanding.

It is our view that in the long run, microbial contamination in indoor air bears many similarities to VOC contamination. There are a multitude of sources and agents. They can be collected and characterized, but not cheaply, quickly, or easily. Control measures are available for many of them, mostly involving moisture control, housekeeping, maintenance, and adequate ventilation. Building designers and operators will do well to pay more attention to these considerations to avoid unnecessary microbial contamination of indoor air.

For More Information:

ASTM is now preparing proceedings from the symposium. When published, they will represent the most comprehensive and relevant collection of information on indoor bioaerosols. From there, the ASTM group plans to develop guides and practices to assist indoor air investigators deal with microbial contaminants in indoor air. *IAQU* will let you know when they become available.

If you are interested in participating in the ASTM indoor air subcommittee's section on bioaerosols, contact Phil Morey at Clayton Environmental Consultants, 151 S. Warner Road, Wayne, PA, 19087; (215)688-4080. Or contact Staff Manager George Luciw, ASTM, 1916 Race Street, Philadelphia, PA 19103; (215)299-5571.

Products and Services

High-efficiency Vacuum Cleaners and IAQ

Many indoor air investigators find that poor housekeeping practices contribute to particulate matter air pollution. Particulate matter can cause a wide range of health and comfort problems. The kind of problem depends on the size and type of the particles.

Particles fall into two categories: biological and nonbiological. Biological particles include microbial particles as well as plant and animal matter. Airborne microbial particles — biological aerosols (see related article in this issue) — can cause allergic reactions, irritation, illness, and can even lead to death. Microbes may also emit organic gases into the air as part of their metabolic process or at the end of their life cycle. These gases may be responsible for many occupant reactions.

Nonbiological particles include dust and dirt generated by occupant activities, brought in by ventilation systems or on occupants clothing, or generated from the deterioration of building materials and maintenance products. These materials can directly affect an occupant's eyes, skin, respiratory system, and digestive system.

Particles also act as adsorption surfaces for semivolatile chemicals (such as pesticides and PCBs). These gases can be adsorbed by particle surfaces and then interact with the human who inadvertently inhales or ingests the particle. This results in increased exposure to the chemical at body sites where the chemicals may directly act on organs. Radon daughters attached to airborne particles increase our exposure to biologically active radon decay products. Some of the semivolatile chemicals that indoor air particles adsorb are the most toxic organic chemicals known to health scientists, such as dioxins and pesticides.

We can lessen indoor air particulates by reducing the entry of particles from the outdoors, by removing particles from indoor air, and by removing particles from indoor sources. Various strategies are available for each of these particle control methods. We can select the appropriate strategy depending on the type of particles involved, the particle sources, and the uses of the space. In clean rooms, particle entry is very carefully controlled by using high-efficiency particle arrestance (HEPA) filters in the ventilation system. This is expensive due to the high cost of moving air through the HEPA filters; they offer considerable resistance to air movement. This requires larger fans, which use more energy.

Typical HVAC particulate filters effectively remove only larger particles (greater than 0.5 microns) and their efficiency is lower for particles smaller than about 1.0 micron (see Figure 1). Larger particles pose a threat to building equipment (e.g., fan motors, heat exchanger coils). Particles smaller than one micron penetrate most deeply into the human respiratory tract and potentially do the greatest long-term harm to health. These smaller particles also remain suspended in air longer than larger particles. Therefore, the possibility of inhalation is greater.

Normally, high air filter efficiency means using 85% or 95% efficient filters. These filters only remove about half the 0.5 micron particles and even less of the 0.3 micron particles. HEPA filters remove nearly all (99.97%) of the 0.3 micron (or larger) particles.

One alternative strategy is to use electrostatic precipitators. However, they have significant capital, maintenance, and energy costs.

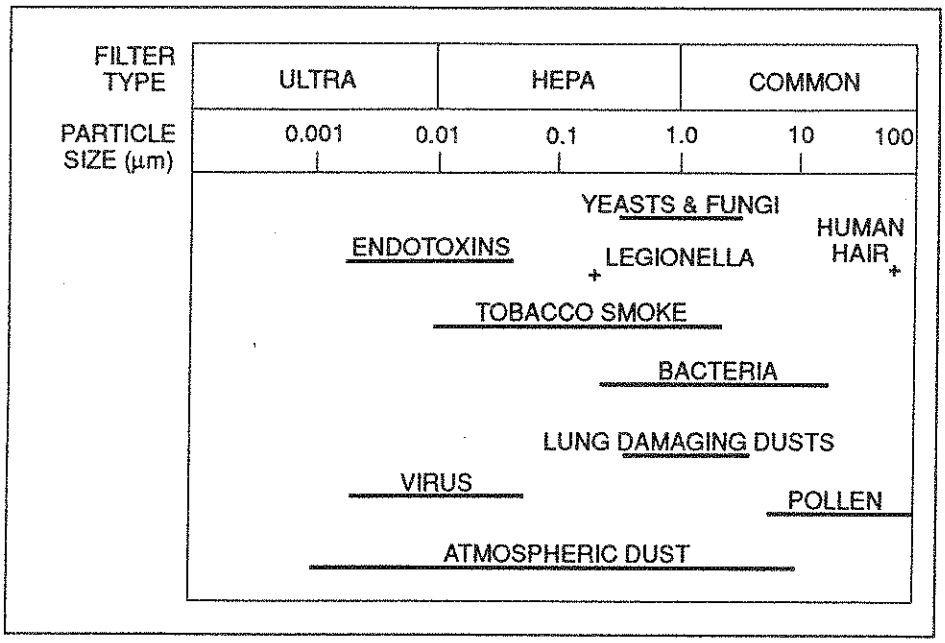


Figure 1 — Typical HVAC filters effectively remove only larger particles

Another approach involves compromising on particle filtration in the HVAC system and controlling particle sources more diligently. A final strategy is to control particulate matter by cleaning more efficiently.

Careful daily vacuuming of carpets can significantly reduce indoor air contaminants. Increasing the efficiency of vacuum cleaners by adding HEPA filtration increases the effectiveness of daily maintenance without significantly raising its cost. A commercial vacuum equipped with microfilters and HEPA filters can remove particles at the low end of the respirable range (0.1-2.0 microns) more efficiently than one without the special filters. Since the vacuum cleaning is taking place anyway, why not use more efficient equipment?

The Impact on Cost

According to an estimate we received from a major U.S. commercial building development and management company, a janitor services about 2,500 (rentable/billable) sq ft per hour or about 20,000 sq ft per shift. Assuming a total cost of about $1.00 per year per sq ft, the cost of the janitorial service is about $20,000 per janitor; about $1,500 per year of this is equipment and supply costs (including the vacuum cleaner). Enhanced air quality would require an extra $200 or $300 per year for HEPA filtration.

The impact of better filtration on an environment and its occupants depends on the types and concentrations of small particles present and on occupant density. Assuming an average occupant density of five people per 1,000 sq ft, approximately 100 people are affected by each additional expenditure of $200 to $300 per year, a cost of $2 to $3 per occupant.

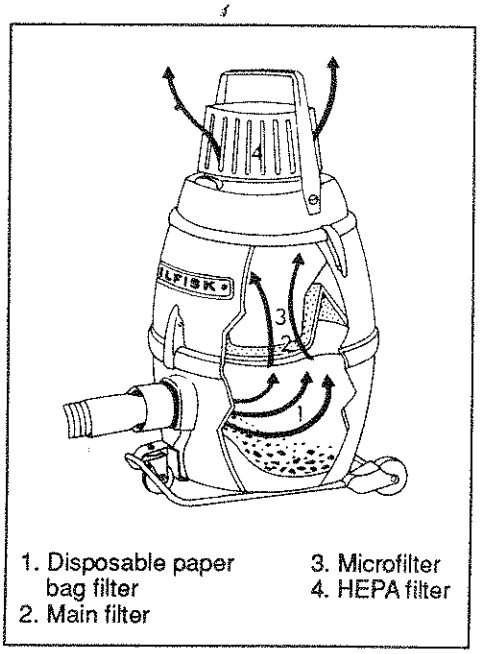
Available Products

One commercial and industrial vacuum cleaner manufacturer, Nilfisk of America, makes a range of products suitable for household, commercial, and hazardous materials applications. In this article we discuss the company's products, applications, and pricing.

Nilfisk of America distributes the Nilfisk equipment that is manufactured in Sweden. The devices have up to four stages of filtration including a HEPA filter on the motor exhaust port. Figure 2 shows a cutaway view of the low-end Nilfisk machines. Nilfisk machines are suitable for a wide range of applications.

IAQ Control Applications

Currently, Nilfisk sells primarily to the hazardous materials abatement and household markets. The hazardous materials market is largely asbestos and lead paint removal companies. The household market is mostly consumers concerned about allergens. Nilfisk estimates that there are over 35 million allergy sufferers in the United States. It has developed a machine and



1. Disposable paper bag filter
2. Main filter
3. Microfilter
4. HEPA filter

Figure 2 — Cutaway view of a low-end Nilfisk machine

Table 1 — Nilfisk Specifications and prices

	GS 90	GS80	GS81	GS82	GS83
Voltage	115	115/220	115/220	115/220	115/220
Amps	7.8	7.8/-3.9	7.8/3.9	12/12	14/12
Air flow (cubic ft/min)	87	87	75	75	59/75
Tank capacity (gallons dry bulk)	3.25	3.25	5.25	12	18
Paper bag capacity	2.25	2.25	4	12	18*
Filter area (square inches)	900	1,396	1,744	3,447	4,031
Base system	$455	$545	$695.	$1,575	$2,590
Typical system price	$576.50	$731.50	$1,118.88	$2,609.84	$3,856.99

* Polyliner, not paper bag

marketing program aimed at this large market.

The commercial and residential maintenance area should be ripe for high-efficiency vacuum cleaners, especially where concerns exist about IAQ. Indoor air hazards in office buildings, stores, hospitals, schools, and other nonindustrial environments can be significantly reduced at little cost by using far more efficient vacuum cleaning in routine janitorial services. Facilities managers, maintenance and janitorial supervisors, and contractors should consider the higher performance of HEPA vacuum cleaners.

The low-end Nilfisk models (see Table 1) are price-competitive with other high-quality residential and commercial machines. The difference is that Nilfisk offers the added power and performance of an industrial-strength motor and the HEPA filter. These features are not available on many of the more commonly used products. These models are small (see Figure 3) and light enough (13.5 pounds) for household or commercial applications. The GS 82 and GS 83 have two and three motors respectively, much larger tank capacity, and additional HEPA filters for each motor.

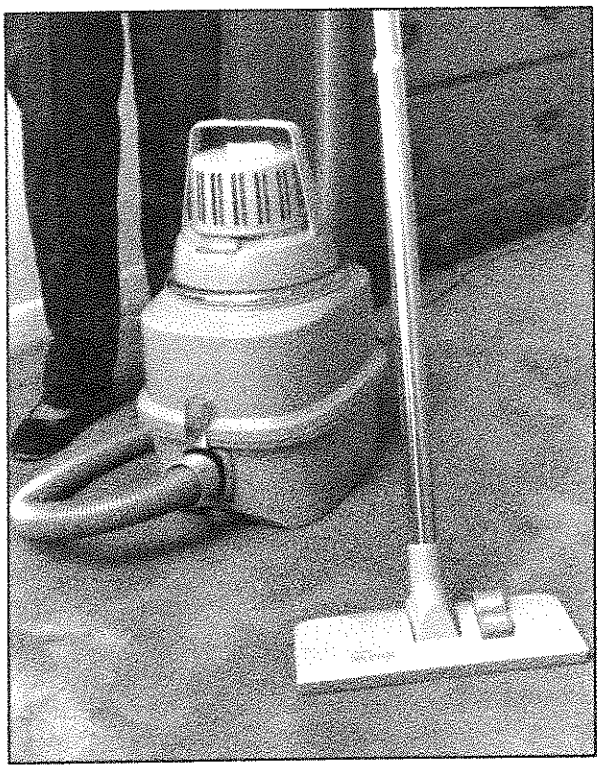


Figure 3 — Nilfisk's HEPA filtered GS 90 model

Nilfisk's Patty Dinelli told *IAQU* that their sales are increasing as the number of indoor air quality service companies increases. Dinelli noted that orders are coming particularly from new start-up companies in duct cleaning and home cleaning businesses. She also said that they are seeing more orders from companies that specialize in supplying products for allergy sufferers and cleaning services for allergic or chemically sensitive patients. Some parts of the country where she has seen orders growing are the northeastern region, California, Texas, and Georgia.

Systems and Prices

A typical Nilfisk system includes the vacuum cleaner, accessories, microfilter, HEPA filter, exhaust filter, and a package of disposal bags. The base price for the GS 80 vacuum cleaner without the microfilter or HEPA filter is $545. Fully equipped it costs $731.50. The GS 80 is for smaller offices and residential applications. The GS 80, GS 81, and GS 90 each have one 7.8 amp (115 volt) motor rated for an airflow of 87 cfm. The tank capacities are 3.25 and 5.25 gallons for the GS 80/90 and GS 81 respectively. The GS 90 sells for $576.50 equipped with

the HEPA filter and accessories for the home "allergy" market.

The recommended replacement frequency for the HEPA filter is once a year for home use. For commercial or larger applications, replacement frequency will vary depending on loading and extent or level of use. Nilfisk also manufactures a model GS 80I ("I" for industrial), which has a more durable neoprene rubber hose instead of the standard plastic one. It also has an optional 12-inch wheeled metal floor nozzle. It is the same cleaner as the GS 80, only the accessories differ. It has a heavier-duty trolley with larger wheels. Equipped with an eight-inch rubber crevice nozzle, three-inch adjustable dust brush, and 12-inch wheeled floor nozzle, it sells for $819.87.

The GS 82 and GS 83 are intended primarily for industrial and hazardous materials applications. The GS 82 has two motors and the GS 83 has three. The tanks are much larger and each motor has a HEPA filter. These machines are much larger and heavier than the others. They are considerably more expensive, costing $2,610 and $3,857 respectively.

When to Replace the Filter

Since the HEPA replacement filters are quite expensive ($166.55 each), it is important to know when to replace them to optimize performance without excessive cost. The guidelines given by Nilfisk are as follows:

- The main filter is clogged when it loses suction.
- Replace the microfilter ($10.95) when it is visibly dirty.
- Replace the HEPA filter ($166.55) when light does not pass through it. Under most applications, the HEPA filter should last for one year.

For More Information

Contact: Nilfisk of America, 300 Technology Drive, Malvern, PA 19355. Phone 1-800-NILFISK. They will take VISA and M/C for home vacuum orders. Readers can get more information and product literature by calling Customer Service at Nilfisk.

On the Horizon

IAQ and Productivity: Economic Reality?

The measurement of IAQ impacts on productivity is like the weather. Nearly everyone is talking about it but nobody knows how to do much about it.

The most common form of argument in favor of spending more money for buildings — either design/construction or operation/maintenance — is that a small increase in productivity would justify a large increase in building acquisition or operating costs. The numbers are fairly simple and fairly overwhelming. Let's look at the square foot costs in dollars for a typical U.S. office building, whether owner-occupied or rented (Table 2).

What fractions of these totals affect IAQ? Assuming an employee cost of $265/sq ft/yr, the total cost per square foot is $305.40, and nonemployee costs are 13.2% of the total. Of these, the ones which most directly impact IAQ are building, design, utilities and janitorial. They account for an annual cost of $13.77/sq ft/yr (acquisition), and $3.00/sq ft/yr operating expenses, or a total of $16.77/sq ft/yr. This is compared to the $240 to $290/sq ft/yr employee costs, and the contribution is only about 5.5% of the total cost of operating the building (Table 3).

Architects and engineers find this argument appealing as they try to convince clients to spend a little more on the building. Indoor air quality consultants find this argument seductive and they cannot understand why their clients would hesitate to spend a little bit more to make a building a lot better.

They argue that a one percent increase in employee productivity would be worth $2.65/sq ft/yr ($0.01/sq ft/work day) and that this would justify a 15.5% increase in IAQ-related building acquisition and operating expenses. Let us see how we might spend this money if we wanted to optimize IAQ.

If we invest $2.00/sq ft/yr in the construction of the HVAC system, we could double the cost of the system and still have enough left over to pay additional energy costs that might result from the use of high-efficiency filters and more outdoor ventilation air.

We could buy a separate VAV box and thermostat for every work station. We could install sensors to detect changes in relative humidity, carbon dioxide levels, and even some advanced sensors to detect particle concentrations or VOC concentrations in the air. The sensors could input to the building HVAC system computer.

In a building with raised floors, we could supply air from the floor space to an occupant-controlled, desk-top outlet. The occupant could control the flow rate and direction of the air inlet, getting air movement when too warm, directing it away when too cool.

Table 2 — Costs per square foot per year for an office building as a total operating entity*.

ITEM	$/sq ft	COSTS $/sq ft/yr
ACQUISITION:		
BUILDING:		
Land Costs	$20.00	
Design and Permits	$13.50	
Building Construction	$110.00	
TOTAL	$143.50	
Amortized at 9.0% for 30 years = $1.32/sq ft/month		$16.00
FURNISHINGS	$20.00	
Amortized at 10% for 10 yrs. = $.265/sq ft/month		$3.18
OFFICE EQUIPMENT	$50.00	
Amortized at 10% for 5 yrs. = $1.06/sq ft/month		$12.72
OPERATING EXPENSES:		
Utilities		$2.00
Janitorial		$1.00
Taxes and Insurance		$2.00
Management and Services, Vacancy Factor		$3.50
TOTAL $0.75/sq ft/mo.		$8.50
TOTAL NON-EMPLOYEE COSTS		$40.40
EMPLOYEE COSTS:		
Salaries ($15,000 to $85,000 per year)		
Benefits @ 20% ($3,000 to $17,000)		
Total = $18,000 to $102,000/p/yr		
Assuming densities from 75 sq ft/person to 350 sq ft/person $240 to $290 or =		$265.00
TOTAL COSTS FOR BUILDING, FURNISHINGS, EQUIPMENT AND EMPLOYEES		$305.40

* Many of the costs assumed for purposes of this analysis will vary considerably among geographic regions, building quality, organizations and other factors. The costs used here are illustrative only and not intended as guidelines nor as an authoritative representation of actual costs in any particular locale.

Table 3 — Facility and Employee Costs Related to Indoor Air Quality

ACQUISITION:	
Design	$13.50
Construction (amortized at 8.5% for 30 years)	111.10
TOTAL	$13.77
OPERATING EXPENSES:	
Utilities	$2.00
Janitorial	$1.00
TOTAL	$3.00
Non-employee IAQ-relatedTotal	$16.77

We might even have enough left over for higher-efficiency particulate filtration equipment or gas filtration.

All this might be convincingly argued if we could demonstrate that good air quality can produce just a one percent improvement in worker productivity.

Readers who have data on productivity and indoor air quality are invited to send it to *IAQU*. We would very much like to know what kind of information is available.

Information Exchange

Book Review: *The Healthy House*

Allergic, asthmatic, or chemically sensitive individuals seeking a healthy living environment now have yet another book to read. Lyle Stuart Inc. of Secaucus, New Jersey, has published a 392-page hardbound volume. It is a comprehensive description and analysis of the indoor residential environment from the specialized perspective of sensitive individuals. The author, John Bower of Bloomington, Indiana, is a "designer, builder, writer, and consultant specializing in non-toxic house construction," according to the book jacket.

The full title of the book is *The Healthy House: How to Buy One, How to Build One, How to Cure a Sick One*. Unfortunately, it promises more than it can deliver. It is rather encyclopedic about many of the problems but less concrete about the solutions than some of its more than a dozen predecessors. It often describes the prin-

ciples involved in the solutions, whether they are design details or the mechanics of air filter operation. And we think this kind of understanding is valuable. It is useful in laying a groundwork of understanding. But most readers are more likely to know of the problems than the solutions.

Bower avoids the pitfall of developing a catalog of "safe," "marginal," and "harmful" products. Instead, the book is sprinkled with an uneven scattering of specific product or material-oriented suggestions. Where available, he has provided names of products and suppliers which have been reported as safe. However, we hasten to point out that the book includes pervasive references to materials as toxic or nontoxic. This is in direct contradiction to the fundamental principle (set forth by Swiss physician Paracelsus in the 16th Century) that everything is toxic — it is simply a matter of dose.

Many people want to know "what is safe?" Consequently, a considerable amount of mythology is afoot responding to that desire. Among the myths are the notions that natural is good, synthetic is bad; and the notion that outdoor air is always better than indoor air.

In our experience, differences among chemically sensitive or allergic individuals are very large, and, therefore, generalizations about the safety of common building materials are risky. We always recommend that individuals test the candidate product directly through a "sniff test," and we caution against accepting other people's experience as reliable for yourself (see *IAQU*, October 1988). In this sense, Bower has not misled the readers by issuing decrees of safety or danger as much as he has tried to present concerns that have been identified. This is less immediately helpful, but it is far better in the long run.

Building a healthy house is a difficult task, and like all building design and construction problems, involves substantial compromises. Some of the difficulties and contradictions inherent in building a nontoxic house emerge in the chapter titled "Putting it all together," where Bower describes the house he and his wife built (she is chemically sensitive).

He chose metal studs to avoid offgassing from softwood framing lumber, but used fiberglass batt insulation and plastic-coated electrical wiring. Wiring in the interior walls was wrapped with aluminum foil. He acknowledges the chemical emissions problems with the insulation and wiring in the exterior walls, and he solved the problem with foil-backed drywall. This, he said, sealed the walls well and prevented any emissions. The expense of metal framing was unnecessary since the foil-backed drywall apparently successfully sealed the walls.

Recommendation: For architects, builders and dwellers looking for an overview of the issues involved in creating healthy houses (or other buildings as well), this is a useful, accessible introduction. It contains lots of good insight, but the difficult choices are still squarely in the lap of the reader.

Reference: John Bower, *The Healthy House: How to Buy One, How to Build One, How to Cure a Sick One*. Secaucus, New Jersey: Lyle Stuart Inc. 392 pp.. 1989. $17.95.

Clarification: Fungi Reference in June *IAQU*

In the June *IAQU* we referred to an article, "Significance of Fungi in Indoor Air: Report of a Working Group," without giving the year for the reference. A number of readers have called to try to locate the article. Our apologies to any readers we might have inconvenienced by the incomplete reference. Thanks to Laura Oatman, State of Minnesota Department of Health, for letting us know where she found the article. The reference should be *Canadian Journal of Public Health*, Volume 78, No. 2, March/April, 1987.

Calendar

NORTH AMERICA

September 19-21. Indoor Air Quality. Boston, Massachusetts. Sponsored by Harvard School of Public Health. Contact: Office of Continuing Education, 677 Huntington Avenue, L-23, Boston, MA 02115; (617)732-1171.

September 21-23. **HVAC Commissioning/ Facilities Management Seminar.** Atlanta, Georgia. Contact Ken Gill; (214)960-4092.

September 25-26. **IAQ Update; Forum on Current Issues in the Practical Control of Indoor Air Quality.** Washington, D.C. Sponsored by ***Indoor Air Quality Update*** Newsletter. Contact: Kim Gay or Ed Coburn, Cutter Information Corp., 1100 Massachusetts Avenue, Arlington, MA 02174; (617)648-8700; Fax: (617)648-8707.

October 8-13. **American Association for Aerosol Research, Eighth Annual Meeting.** Reno/Sparks, Nevada. Contact: Ms. Chloe Smith, American Association for Aerosol Research, Center for Aerosol Technology, Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709-2194; (919)541-6736. *The program includes plenary lectures, symposia, technical sessions, and tutorials as well as an exhibit. The symposium on Indoor Air Quality and Radon has 50 papers in the fields of measurement, control, sources, transport, and deposition*

of viable and nonviable particles in the indoor environment. 29 of the papers are on radon.

October 11-13. **Blueprint for a Healthy House Conference.** Cleveland, Ohio. Contact: Housing Resource Center, 1820 W. 49 St., Cleveland, OH 44102; (216)281-4663.

October 15-17. **Third Annual AARST Radon Conference: The Radon Industry, A New Beginning.** Ellicott City, Maryland (just outside Baltimore). Contact: AARST, Mid-Atlantic Chapter, 1916 Grayslake Drive, Silver Spring, MD 20906; (301)598-4008.

October 19-20. **Indoor Air Quality Conference.** Florida West Coast Chapter of ASHRAE. Contact: Carl Lawson, LRW Engineering, Inc., 1810 South MacDill Avenue, Tampa, FL 33629; (813)254-5588.

October 24-25. **Healthy Buildings '89.** New Haven, Connecticut. Sponsored by United Illuminating Company and Northeast Utilities. Contact: Frances Buglione Mayko, United Illuminating Company, P.O. Box 1564, New Haven, CT 06506, Phone (203)777-6162 *Some outstanding leaders in the indoor air field are scheduled to speak. They include James Woods, Brian Leaderer, Jan Stolwijk, Niren Nagda, John Spengler, Gene Tucker, William Turner, and Jonathan Samet.*

October 29-31. **Better Buildings Conference and Exposition — Energy Efficient Building Trends and Technologies.** Syracuse, New York. Sponsored by New York State Energy Office with the New York State Builders Association. Contact: Jim Lafferty, New York State Energy Office, 2 Rockefeller Plaza, Albany, NY 12223; (518)473-7243.

November 6-7. **Radon in Buildings: Sources, Biological Effects, Monitoring, & Control.** Harvard School of Public Health. Contact: Harvard School of Public Health, Office of Continuing Education, Dept. A, 577 Huntington Avenue, L-23, Boston, MA 02115; (617)732-1171.

November 13-17. **Indoor Air Quality Diagnostics Professional Training Course.** Golden Valley, Minnesota. Contact: Honeywell Indoor Air Quality Diagnostics, MN10-1451, 1985 Douglas Drive North, Golden Valley, MN 55422-3992; (612)542-6488; or (800)232-4637.

November 27-30. **Total Exposure Assessment Methodology: A New Horizon.** Las Vegas, Nevada. Sponsored by U.S. Environmental Protection Agency, Air and Waste Management Association. Contact: Dan Denne, Air and Waste Management Association, P.O. Box 2861, Pittsburgh, PA 15230. *There will be training courses on "Human sampling" and on "Personal exposure monitoring and quality assurance." Technical sessions will include multi-media/ multi-pollutant exposures, Implications of Exposure and Dose in Health Effects Studies, TEAM and microenvironmental field studies, and others. The conference is designed for scientists and regulatory managers.*

December 4-6. **ASTM Subcommittee D22.05 on Indoor Air.** Disneyworld, Orlando, Florida. Contact: George Luciw, ASTM, 1916 Race Street, Philadelphia, PA 19103; (215) 299-5571.

February 11-14, 1990. **ASHRAE Winter Meeting.** Atlanta, Georgia. Contact ASHRAE Meetings Dept., 1791 Tullie Circle N.E., Atlanta, GA 30324; (404)636-8400.

April 25-26, 1990. **ASTM Subcommittee D22.05 on Indoor Air.** San Francisco, California. Contact: George Luciw, ASTM, 1916 Race Street, Philadelphia, PA 19103.

April 26-27, 1990. **Blueprint for a Healthy House Conference.** Contact: Housing Resource Center, 1820 W. 48 St., Cleveland, OH 44102//216/281-4663.

October 16-19, 1990. **Indoor Radon and Lung Cancer: Reality or Myth? — 29th Hanford Symposium on Health and the Environment.** Richland, Washington. Sponsored by the U.S. Department of Energy and Battelle Pacific Northwest Laboratories. Contact: Fred T. Cross, Symposium Chairman, Battelle PNL, P.O. Box 999, Richland, WA 99352; (509)375-2976.

INTERNATIONAL

October 16-20. **The Sick Building Syndrome.** Nordic Institute of Advanced Occupational Environment Studies (NIVA), Copenhagen, Schafergarden, Denmark. Contact: NIVA, c/o Institute of Occupational Health, Topeliuksenkatu 41 a A SF-00250 Helsinki, Finland, tel 358-0-47471. *This course has very limited enrollment.*

June 13-15, 1990. **Roomvent '90**, Second International Conference on "Engineering Aero- and Thermodynamics of Ventilated Room," Oslo, Norway. Contact: Room Vent, c/o Norsk VVS Teknisk Forening, P.O. Box 5042, Maj N-0301 Oslo, Norway.

July 29-August 3, 1990. **5th International Conference on Indoor Air Quality and Climate.** Toronto, Canada. Contact: Dr. Douglas S. Walkinshaw, Centre for Indoor Air Quality Research, University of Toronto, 223 College Street, Toronto, Ontario, Canada M5T 1R4; 613-957-11502. *See announcement on page 15 of July IAQU.*

September 3-6, 1990. **Energy, Moisture, Climate in Buildings.** Rotterdam, The Netherlands. Sponsored by CIB International Council for Building Research Studies and Documentation. Contact: Mr. G. de Vries, Bouwcentrum, Weena 760, P.O. Box 299, 3000 AG Rotterdam, the Netherlands. *The conference will consider three major topics: Heating, cooling and ventilating efficiency; condensation and mould growth; and, indoor climate.*

Editor: Hal Levin

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Production Manager: Karen Kunkel Pasley

EDITORIAL OFFICE:
Indoor Air Quality Update,
2548 Empire Grade
Santa Cruz, CA 95060;
Phone: (408)425-3846
Fax: (408)426-6522

SUBSCRIPTION OFFICE:
Cutter Information Corp.,
1100 Massachusetts Avenue,
Arlington, MA 02174, U.S.A.;
Phone: (617)648-8700,
Fax: (617)648-8707
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