Indoor Air BULLETIN™ Hal Levin, Editor

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Fiberglass Insulation and IAQ

Fiberglass and other porous materials are used extensively to line air handlers for acoustic control and in ductwork for thermal or acoustic insulation. Compressed fiberglass bonded with urea formaldehyde resin is used to form ductwork. A hotly debated question is whether the use of porous insulation inside air handling units and in ductwork means likely microbial contamination. This is a critical question for IAQ consultants, designers, engineers, and facility managers. It is also a critical question for the manufacturers of these building products.

Health Concerns

The Thermal Insulation Manufacturers Association (TIMA), representing the major manufacturers of man-made mineral fiber (MMMF) products (including fibrous glass insulations and ductboard materials), is currently concerned with two major health issues related to their products. One is whether fibers released from their insulation products cause cancer. The other is whether the use of their products in HVAC systems causes indoor air contamination by facilitating microbial growth on moist, dirty insulation.

Michael J. Hodgson, MD, MPH, immediate past chairman of ASHRAE's Environmental Health Committee, told the ***BULLETIN***: "The evidence is still inconclusive but does not appear to indicate a significant cancer threat for the types of fibers used in most building thermal and acoustic insulation products." Hodgson is Associate Professor of Medicine in the Occupational Medicine Program at the University of Connecticut, Farmington. He said: "Only ceramic glass fibers appear to be potentially carcinogenic like similarly shaped asbestos fibers."

Hodgson thinks there are really three health issues related to MMMF. "First," he said, "The majority of MMMF as used in air-conditioning systems are not carcinogenic because they are too big to get into the lungs and because their mechanism of degradation in the lungs is different from that of asbestos. They break cross-sectionally into shorter and shorter pieces whereas asbestos breaks longitudinally into finer and finer fibers."

"Second," he went on to say, "there are some MMMF that are carcinogenic including ultra-fine fiberglass, rockwool, mineral wool, and high-fired refractory fibers. The relevant question is whether they are present in indoor air long enough and at high enough concentrations to pose a hazard to human health. Certainly maintenance workers who may be exposed to insulation in the course of their job duties even in modern buildings may have similar risks from MMMF as do asbestos-exposed workers in the same trade. That is an issue of occupational exposure rather than ambient environmental exposure. It is unclear whether current building-related applications of ultra-fine fiberglass and rockwool and mineral wool result in indoor concentrations of fibers that may pose risks to human health."

"The third issue," according to Hodgson, "is the question of MMMF's role in microbial contamination of buildings. There is substantial and convincing evidence that dirty, moist fibrous glass insulation will increase the likelihood of microbial growth and air contamination." This is discussed at length below.

The Evidence: A Problem Exists

According to Philip R. Morey of Clayton Environmental Consultants in Norristown, Pennsylvania, "The

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continued use of porous insulation in HVAC systems appears to be incompatible, from a microbiological point of view, with the concept of a healthy building."

Morey, one of the most experienced IAQ investigators we know, says that "[d]iscouraging the use of porous insulation inside HVAC system components will have a profound effect on the manner in [which] the HVAC systems are designed and constructed in the future." In a paper he presented at IAQ '91 - Healthy Buildings, Morey said that "...insulation should [only] be applied outside main air supply ducts and outside other HVAC system components that periodically become moist. This will help in preventing growth of microorganisms and their release into the ventilation air stream."

Morey began his focus on indoor air in 1981 when he worked for the National Institute of Occupational Safety and Health (NIOSH) while on assignment from Texas Tech University. His many slides of microbial contamination in buildings and his explanations of some of the foolish and easily avoidable causes are testimony to the importance of good building design, construction, and operation/maintenance practices to avoid significant IAQ problems. Morey says that microbial contamination in buildings is common when inefficient or poorly maintained filter banks allow particulate matter to enter the air distribution system and contaminate the porous insulation. Dirty insulation becomes a secondary source of fungi commonly in the outside air (where the source is vegetation).

As insulation becomes dirty, it takes up water from humid air. Morey says that air downstream from cooling coils or humidifiers "...often contains relative humidities approaching 100%." If that's the case, then a key issue is the ability of porous insulation to take up water. Two papers presented by Mike West at ASHRAE's IAQ '91 showed that *clean* materials do not take on much moisture even when exposed to moisture-laden air. However, as materials become dirty their moisture uptake increases substantially.

Once it is wet, Morey says, soiled insulation becomes an amplification (growth) site or a primary emission source for fungi and bacteria not found in outdoor air. The availability of both water and nutrients controls microorganism growth in porous insulation, Morey explains. He has reported several problem building studies where dirty insulation inside the HVAC system functions either as a primary or secondary emission source of various microorganisms.

Testing Insulation for Microbial Growth Potential

Thermal insulation manufacturers test their products according to ASTM Standard C1071 to determine the products' ability to support microbial growth. But Morey says that test standards that verify the low susceptibility of new insulation to microbial contamination are "inappropriate" for assessing dirty, aged insulation commonly present in HVAC systems.

Morey warns that dirt- and debris-encrusted insulation almost always can be a microbial amplification site if adequate moisture is available. We asked Morey to define "adequate moisture" in terms of his warning. He said: "Adequate moisture ranges from a condition where insulation is physically wet (for example, in contact with water in a drain pan) to conditions where the equilibrium moisture content of the insulation is 10% or greater."

He says there is a need for a test method that can evaluate aged or dirty insulation in HVAC systems with respect to microbiological growth. According to Morey, a useful test for dirty, aged insulation could:

1. "Determine the maximum hygroscopic moisture content of the insulation sample at 99% relative humidity." The sample is "probably inadequate to support fungal growth...if the moisture content is in the 5 to 10% range." When the moisture content exceeds 10%, the likelihood that it will support microbial growth increases. The moisture-holding potential increases with the deposition of dirt and debris on or in an insulation sample.

2. "Determine the concentration and taxa of fungi present in dirty insulation that is periodically wetted or in insulation that is visually contaminated..." with a layer of fungi on the insulation surface. If toxigenic species such as *Stachybotrys atra, Penicillium viridicatum, Aspergillus flavus,* or *A. versicolor* are present, the insulation must be removed (using proper respiratory protection as required by Public Law 91-596, Section 5). A useful control is the determination of fungi taxa and concentration "...for dirty insulation that is unlikely to have been wetted."

Morey's Experience May Be Biased

Dr. Morey acknowledges that a disproportionate number of the (problem) buildings he sees have microbial contamination. This is largely due to his reputation as a highly qualified and extremely knowledgeable professional with respect to microbial problems in buildings. Therefore, while it may be true that the vast majority of buildings he investigates have microbially contaminated fibrous glass insulations in the HVAC system, it does not necessarily follow that the majority of buildings with

MMMF HVAC insulations, sound adsorbers, and duct liners have microbial contamination.

We asked Morey whether he thought that the majority of buildings with MMMF materials in HVAC air distribution systems were contaminated. He answered: "Research is needed on a cross-sectional population of HVAC systems to answer the question. Important variables that must be quantified include the deposition of dirt in insulation porosities both as a function of filtration efficiency and building age, the equilibrium moisture content of dirty insulations, and the fungal and bacterial taxa that may be present in HVAC insulations."

Mitigation Techniques

To minimize the risk of microbial growth, Morey recommends upgrading filters, controlling humidity inside the air distribution system, and as a definitive preventive technique, discouraging the use of porous insulations. But there are practical limits to the extent to which these techniques can address the problem of microbial growth. In the end, Morey says, porous insulations are best avoided inside air handling units and ductwork.

Upgrading Filters

While more efficient filters can significantly reduce dirt on insulation, supply fan capacities limit the amount of additional filter capacity that can be installed. More efficient filters increase the pressure drop (resistance to airflow) across the filters.

Barney Burroughs, past president of ASHRAE, formerly in the filtration products industry, and now an indoor air consultant, sees it differently. Burroughs says: "With regard to filtration, I disagree that fan capacities limit the ability to do better filtration. The common 30% ASHRAE-rated pleated filter is a substantial upgrade over throw-away and other lint collectors and yet is extremely effective (in the 90% range) against 10-micron sized particles. This particular filter can fit in existing space and operate within the same static pressure ranges as throw-away filters. Further, it demonstrates negligible life cycle cost premium because of its longer life. Thus, there is no justification for not installing at least this level of filtration."

"I concede," Burroughs added, "that higher efficiency filters, in the 80/85% or 90/95% ASHRAE range, require more space, more fan capacity, and higher first cost. Thus owners resist going to this level of filtration for first cost reasons even though it will do an excellent job of protecting coils, systems, space,and people, as well as providing energy payback."

Vacuum Cleaning

Vacuuming airstream surfaces with a cleaner incorporating a HEPA filter can effectively remove visible microbial growth. However, merely cleaning the surfaces may not be enough. Morey reported such a case where previously entrained dirt and debris within the insulation apparently provided the nutrient for subsequent fungal proliferation.

Encapsulating Surfaces

A wide variety of sealants are available for encapsulating surfaces. In one case Morey described, a vinyl acetate material was applied, but microbiological growth subsequently appeared on its surface. Morey says that the encapsulants themselves may contain sufficient nutrients to support microbial growth. Additionally, dirt and debris within the insulation may support growth that penetrates the encapsulant layer.

Barney Burroughs Comments

Because Burroughs has been advising TIMA on IAQ issues, we asked him to comment on Morey's paper. Burroughs said: "Phil Morey's conclusion that porous insulation is 'incompatible with the concept of a healthy building' is not one shared by most in the industry - or demonstrated by the science. It is true that any dirty, wet surface can harbor contaminants - even bare sheet metal. But there are many cases of such growth occurring in indoor, conditioned spaces - like on rugs and inside unlined HVAC systems - without growth on the fiberglass in the same system. The lesson is that any dirty, wet surface can host such contamination - if it is not kept clean and dry."

Burroughs continued: "If water and dirt, both critical to microbial growth, are present in the fiberglass of an HVAC system, it can no more be considered the fault of the fiberglass than if the same were true in a sheet metal unit. There are few items in an indoor environment which are completely immune to this sort of contamination - if they are not kept clean and dry. I have seen growth on carpeting, furniture, drapes, wallpaper, as well as on other architectural components, the air handler itself and the HVAC distribution system. Pointing the finger at these would-be hosts misses the point."

Morey Responds

Morey commented that Burroughs assertion that "...our conclusion is not backed by 'the science' overlooks the technical data presented on pages 128-135 of *IAQ '91 - Healthy Buildings*. We stand behind the technical data presented and the conclusions that we made."

Morey continued: "It is true that fungi and bacteria can grow in many locations in a building providing that adequate moisture and nutrients are present. Items such as contaminated drapes and rugs can easily be removed from a building during remediation activities. Drain pans in air handling units should be subjected to a vigorous preventive maintenance program. Sheet-metal surfaces in HVAC systems can also be subjected to vigorous cleaning. However, porous insulation on the airstream surface of air handling units and supply ducts *can not* be effectively cleaned. This is a major problem with porous insulation in HVAC systems and this is a major reason why porous insulation may not be compatible with the concept of a healthy building."

Burroughs' Last Word

Burroughs says, "Water and dirt become present because of malfunctioning drains or plumbing, inappropriate condensation or basic leaks. If a rug were contaminated from dirt and water growing microbes on it, would you say that it didn't belong in the house or would you clean it properly and get to the source of the problem - the source of the dirt and water."

Tentative Conclusions

While Morey is an experienced and careful investigator, a field survey of randomly selected buildings with and without porous insulation and laboratory investigations are necessary to validate many of his findings. Until such tests are conducted, however, we find his conclusions the best available on the subject.

Burroughs disagrees. "It appears to me," Burroughs said, "that the resistance to really good filtration is economic from the first cost standpoint. If we are talking about eliminating both the insulation and the acoustic benefits provided by fiberglass, this too will carry a premium in cost and a premium in performance. Thus, I do not agree that the best available interim conclusion on the subject is to eliminate fiberglass from the HVAC system. However, including high efficiency filtration will pay for itself in energy efficiency, housekeeping, and healthy occupants."

Thermal insulation can be applied to the exterior of ductwork, thereby eliminating the difficult problem of creating clean joints which themselves may create turbulence, pressure drops, noise, and entry paths for dirt and moisture into the insulation. We think there is a need for new materials and designs to control noise in air handling systems. Materials are needed that can: absorb sound; not excessively increase airflow resistance (pressure drop) in the ducts; and, not present an increased likelihood of microbial contamination when all other factors are equal.

References:

P. R. Morey and C. M. Williams, 1991, "Is Porous Insulation Inside an HVAC System Compatible with a Healthy Building?" In *IAQ 91 - Healthy Buildings.* Atlanta: American Society of Heating, Refrigerating, and Air-conditioning Engineers, Inc. Available from ASHRAE, 1791 Tullie Circle NE, Atlanta, GA 30329, (404) 636-8400.

M.K. West and E.C. Hansen, 1989, "Determination of material hygroscopic properties that affect indoor air quality." In *The Human Equation: Health and Comfort.* Atlanta: American Society of Heating, Refrigerating, and Air-conditioning Engineers, Inc. pp. 60 - 63.

TIMA, "Health Aspects of Fiber Glass in Air-Transmission Systems for Building Construction." Pamphlet available from TIMA at address below.

"Man-Made Mineral Fibers," 1988, Environmental Health Criteria No. 77, World Health Organization, Geneva. Available from WHO Publications Centre USA, 49 Sheridan Avenue, Albany, NY 12210, (518) 436-9686.

"Man-Made Mineral Fibres and Radon", 1988. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Volume 43. Lyon, France: International Agency for Research on Cancer, World Health Organization. (Also available from the WHO Publications Centre USA, address above.)

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Comment

Building Ecology: Towards Healthy Buildings

Many building designers, operators, and investigators treat buildings as though they were static and unchanging. They see buildings as constants: rigid, predictable edifices that define their internal and external environments. Many studies, investigations, and design analyses are implicitly based on this static view and, as a result, fail to determine or mitigate the true causal factors of indoor environmental problems.

In fact, study after study has shown that buildings are complex, dynamic entities. They constantly respond to their occupants and occupant activities: changing thermostat settings can change ventilation air supply and distribution patterns. They react, sometimes unpredictably, to substances brought into the buildings: moisture in the ventilation distribution system can promote microbial growth resulting in the circulation of irritants, allergens, and toxins from bioaerosols. Buildings also continuously interact with their surroundings — the natural or built environment: wind patterns, traffic characteristics, or soil composition can each have a profound effect on a building's internal climate. The buildings in turn create exhaust and entrainment patterns that affect other, neighboring structures.

We coined the term "Building Ecology" to describe a comprehensive systems approach to understanding building-environment-occupant interactions. In the science of biology, ecological studies investigate living organisms in relationship to each other and to their environments. From the standpoint of building ecology, we view the building as part of a larger system of interdependent elements and relationships: with building occupants, activities, and contents as well as the surrounding environment.

Others, internationally, are using the building ecology term in a variety of contexts. A continued, open discussion of the concept will improve the dialogue about what goes on in buildings and will stimulate more effective research designs and investigation protocols. We believe that many existing research and investigation methods are inadequate precisely because they lack this comprehensive, ecological view of buildings. Most studies and analyses could be more effective if they reflected the principles we have set forth here. These views are in a preliminary and raw form; we hope that readers will consider them and share their reactions with us.

Four Principles of Building Ecology

Building ecology is a conceptual approach to understanding how buildings work. However, understanding it results in very practical applications. It can be applied to design, construction, operation, cleaning, maintenance, and analysis procedures. The architecture and maintenance of healthy buildings requires the application of four principles:

1. Buildings are dynamic.
2. Buildings are complex.
3. Buildings affect and are affected by their occupants and contents.
4. Buildings affect and are affected by the built and natural environments where they are situated.

Building Dynamics

Even buildings without HVAC systems or other mechanical equipment react to thermal, moisture, solar, wind and other features of their site. All buildings respond to their occupants' metabolic products, activities, and direct interactions with the structure. These are obvious and simple notions: they mean that buildings are constantly changing in response to the forces exerted on them, and that these forces may be intermittent and not entirely controllable or predictable.

That buildings are dynamic also means that tests taken at any point in time or across any time span can only suggest what might occur during other time periods. Many studies in the literature support this view. Among them are studies of variations in formaldehyde or radon concentrations over time. The supporting data on variability exist for these two contaminants because these contaminants have been widely studied. Does this mean we can assume the same variations exist for other contaminants? We believe that what data do exist support the notion that most indoor air contaminant concentrations are generally not constant in time.

Further, we see abundant data suggesting that contaminant concentrations vary significantly in space. Even where indoor air is relatively well-mixed from an air supply distribution or air exchange perspective, unless sources are uniformly distributed, concentration gradients will exist within and among spaces inside buildings.

Building Complexity

That buildings are complex is indicated by the large number of diverse professionals, technicians, mechanics, and laborers required to construct, operate or maintain one properly. Design teams for large buildings we have participated in have included upwards of twenty specialized consultants in addition to the usual assembly of architects, mechanical, electrical and structural engineers, space planners, interior designers, specifications writers, cost estimators, and others. Competently investigating problem buildings may require the skills of engineers, industrial hygienists, chemists, geologists, medical doctors, epidemiologists, and even psychologists and statisticians.

As an example of the complex interactions between building parts, material used to control acoustic problems (such as duct liners, carpets, ceiling tiles, or fabric wall covering) can become a sink and re-emission source for VOC released from some of these same products when they were new. Many of these same materials and others may be substrates that support microbial growth. Even particle filters in the ventilation system may become sources of chemical, fiber, or microbial emissions into the air.

Air movement between spaces through concealed penetrations or obvious openings may carry contaminants to locations distant from their origin or source, thus misleading investigators. A chemical used to control microbial growth in cooling tower or humidifier water can itself inadvertently reach occupied spaces and cause adverse occupant responses.

Internal Interactions

A building doesn't just stand alone: it is built to house activities. And like children pounding on a playroom wall with sticks, those activities may have a profound effect on the structure itself. When activities are not foreseen, the building may not be able to respond properly to the imposed loads. Unanticipated activities such as photo processing or food preparation can generate contaminants that the building is not able to control or adequately dilute. Changes in occupant density impose greater thermal loads that may result in less outside air being supplied to the interior.

Material surfaces may not be designed to withstand spilled food, chemical exposures, or heavy foot traffic. Cleaning-up after unexpected activities may require using chemicals that contribute contaminants to the indoor air.

External Interactions

Siting obviously affects buildings: sun exposures, wind patterns, precipitation or soil moisture, acid deposition, and ambient air contaminants can significantly impact the building shell and interior.

Building processes may release into ambient air contaminants such as *Legionella pneumophila* bacteria or cooking odors that create problems for people outdoors or in adjacent buildings. Entrainment in the building air supply of various building exhausts from toilet stacks, kitchens, boiler flues, chimneys, and others can result in indoor air contamination. Motor vehicle exhausts entrained in building supply air can cause significant pollution concentrations. Soil contents of radon, methane,

1. **Identify contaminant sources to be certain they are appropriately controlled. This must be done during design and construction and periodically throughout the life of the building. Contaminant sources may include the following:**
   a. Building site: air, soil, and water supply.
   b. Building materials and equipment: emissions, adsorption, maintenance, life cycle.
   c. Occupants and their activities: schedules, timing of routines, peak loads.
2. **Provide the necessary ventilation air, thermal control, and illumination when and where they are needed:**
   a. Outside air supply quality must be controlled.
   b. Outside air supply quantities must respond to the nature, timing, and location of contaminant loads.
   c. Occupant- or activity-related air supply and illumination can be most responsive and energy efficient when controlled by users or by sensors with user override.
   d. Air quality must not be compromised to achieve thermal control.
3. **Operate and maintain buildings according to the changing activities and needs of the building occupants:**
   a. Schedule HVAC system operation to provide IAQ and climate control at all times buildings are occupied.
   b. Inspect and maintain building equipment periodically as required by equipment design, condition, and usage patterns.
   c. Conduct required professional cleaning to keep exposed surfaces free of excess chemicals, dust, moisture, and microorganisms.
   d. Evaluate all changes in occupancy patterns (timing, activities, occupant locations and densities) to determine necessary modifications to building operation, maintenance, and housekeeping services.

Table 1 - Guidelines for Healthy Buildings

or VOCs can be entrained in supply air or penetrate the building shell and reach significant levels indoors.

Indoor air usually contains more contaminants, at higher concentrations, than outdoor air. While increased outside air supply is often seen as the remedy to indoor air quality problems, there are many urban areas where outdoor air is so contaminated that increasing ventilation only results in changing the type of contaminants in the indoor air. Urbanized southern California has high ozone levels outdoors during much of the year. This precludes high ventilation rates as an acceptable remedy to indoor air pollution unless ozone removal is provided for in the air-cleaning process. In many other U.S. urban areas, combustion byproducts from power plants and motor vehicles are present at unacceptable concentrations in outdoor air and must be controlled.

Guidelines for Healthy Buildings

The guidelines for healthy buildings in Table 1 were developed on the basis of the principles of building ecology and our experience in the field. These guidelines are intended to maximize indoor environmental quality without compromising energy efficiency and economy of building operation.

Conclusions

When the principles of building ecology are applied to the practical design, construction, operation, and use of buildings, the indoor environment will be healthier and the building will be more efficient and economical over its entire life cycle. Architects and builders benefit because the building is safer and less of a liability. Owners and operators benefit because the building is likely to be more cost-effective and easy to maintain. And, most importantly, occupants benefit because the building is a healthier, more productive environment in which to work and live.

Carpet

EPA Carpet Dialogue Concludes

On September 27, representatives from EPA, other government agencies, carpet industry, public interest, and scientific groups approved the final report of the Carpet Policy Dialogue. The agreement was reached after several compromises between industry and public-interest group representatives. At the conclusion of the dialogue, EPA officials said they were pleased by the outcome and amazed at the amount of progress that had been made.

The report is a 525-page compendium of the information developed during the dialogue. Among the useful contents are detailed descriptions of the carpet industry, carpet manufacturing processes, studies of carpet emissions, the dialogue's standard test methods, carpet installation guidelines, carpet industry associations, and others.

The results of the dialogue assure, in part, that VOC emissions testing of many types of building materials and furnishings will be more common. Industry representatives have voluntarily agreed to test their products and periodically report the results. Associations representing manufacturers of carpet, carpet cushions (pads), and carpet adhesives have each signed agreements with EPA that will govern testing of their products in the coming months and years.

The Carpet and Rug Institute (CRI) has also agreed to institute industry-wide internal quality-control programs to reduce the likelihood that changes in manufacturing processes or component materials will result in significant changes in emissions profiles. CRI represents nearly all of the more than 160 U.S. carpet manufacturers.

Dialogue Discussions and Issues

Several issues dominated the discussions during the 13-month-long dialogue. Some dialogue participants believed that testing only for total VOCs without identifying emissions of individual compounds would diminish the usefulness of the results. Another issue concerned the need for product-by-product, company-by-company testing versus testing of representative samples of products and companies. In the design of the testing method itself, there was considerable attention to the development of a more economical method using a single sample collected at a standard point in time to characterize a product's emissions rather than a series of samples over an entire one- or two-week test period. The need for standardized testing protocols was also discussed.

TVOC Versus Individual Compounds

Dialogue discussions were limited to TVOC. When EPA published the Federal Register Notice announcing its response to the NFFE petition, it determined that the dialogue would only address total VOC and not individual compounds. This decision limits emissions testing costs and the uses that can be made of the results. As long as individual compounds are not identified, health effects analysis of emissions will be reasonably limited.

The majority of available relevant data were from the testing program conducted by Air Quality Sciences Inc. (AQS) of Atlanta, Georgia, under contract to the Carpet and Rug Institute. There were no comparable test data available from other laboratories with the exception of a small amount of testing conducted by EPA's own lab at Research Triangle Park, North Carolina, under the direction of Bruce Tichenor. However, Tichenor's results appeared reasonably similar to those from AQS.

Product-by-Product Testing

For the first half of the dialogue year, much of the discussion was focused on whether testing needed to be on a product-by-product, company-by-company basis. The Federal Register Notice called for product-by-product, company-by-company testing. CRI and its consultants (AQS) asserted that the SBR-latex carpets were reasonably homogeneous as a whole, and that product-by-product, company-by-company testing was not necessary.

The discussion revolved around test results presented at a September meeting but not distributed until January. The results indicated that the 19 SBR-latex backed carpet products tested had reasonably similar emission characteristics. Questions were raised regarding the representativeness of the tested samples and the soundness of the conclusion that emissions of VOCs from SBR-latex backed products were as homogeneous as claimed by the industry. Another issue was whether non-SBR-latex-backed carpets were homogenous within and among product types. Research was agreed to but not reported to the dialogue.

Single Time Point Testing

An important technical issue was whether carpet emission profiles could be reasonably characterized by a sample collected at a single point in time. AQS proposed that a 24-hour test point was adequate to define emission characteristics for TVOC.

It was determined that once the characteristic decay curve for a product or class of carpet products is known, a single time point can adequately represent the emission rate and decay rate of the emissions curve. Developing the characteristic curve is a matter of testing a sufficient number of products and determining the mathematical expression that will describe all products in that class. Similar decay curve studies are underway for carpet adhesives.

Test Standards Are Needed

Testing is only meaningful when results can be compared and test methods are standardized. Currently, there is only a limited basis for evaluating and comparing test results. Standardization of materials testing is not widespread, and there is a need for methods specific for testing various types of products. Tests used for carpet are for newly manufactured products. There is a need to understand emissions from products as they are delivered to a building. There is also a need for standardized tests of carpet installations including carpet, pad, adhesive, and substrates where they are used.

Adhesives Manufacturers Clean Up Their Act

It became clear early in the dialogue that the carpet industry intended to claim that their products were not among the stronger sources of VOCs in indoor air. The representatives frequently asserted that carpets were low emitters compared to other products and repeatedly insisted that carpet emissions data be put in context with other sources. Compared with emissions from adhesives, carpet emissions are relatively insignificant. Figure 1 compares carpet, carpet pad, carpet adhesive, and carpet system emissions as measured by AQS.

As a result, adhesive manufacturers organized a committee under the Adhesive Manufacturers' Council to develop its own testing program. Meanwhile, virtually every U.S. manufacturer of floor-covering adhesive developed a new formula for their product that did not use a solvent to "carry" the adhesive.

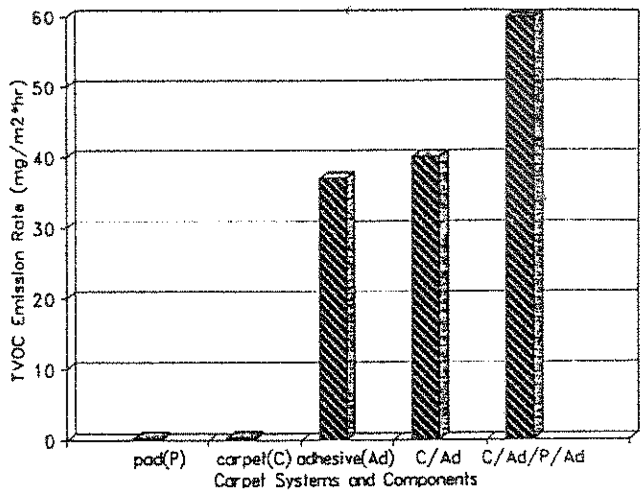

Figure 1 - TVOC Emission Factor Comparison of "Carpet System" and Individual Contributors.
(Source: AQS)

Although these products are not yet in general use, representatives of some of the major adhesives manufacturers indicated their desire to convert their customers to the new products as rapidly as possible.

Non-solvent-based adhesive products emit extremely low quantities of VOC compared to very large emissions from the solvent-based products. Given the very large difference in emissions, it appears to be in everyone's interest for the switch from solvent- to non-solvent-based carpet adhesives to take place. What is missing is a mechanism to bring about a rapid change.

GSA To Require Emissions Testing

Partly as a result of the dialogue, the U.S. General Services Administration (GSA) — the organization responsible for building or leasing and operating buildings for federal government agencies — is developing requirements that emissions testing be done for products used in their projects. Once such a requirement is in place, any manufacturer wishing to sell its products to the government will have to test emissions and make the results available. At that point, state and local governments as well as private developers will be more able to require that such testing be done for products considered for use in their construction and renovation projects.

Future "Dialogues"

Since it is likely that EPA will initiate somewhat similar processes with other building product manufacturers, the testing agreements are important precedents. However, we think it is likely that EPA will obtain more data on emissions from products before inviting participants to join a dialogue. In the carpet dialogue, the carpet manufacturers had initiated their own testing program before the dialogue began. Few independent studies were available, so the industry data drove the process.

Hopefully, future dialogues will consider health effects. This issue was excluded by EPA from this dialogue. However, the ultimate purpose of testing is to reduce the likelihood of adverse reactions from exposure to the emitted VOCs.

While low VOC emissions is generally a wise approach, it is not a substitute for health-based standards. It is quite conceivable that a lower total VOC emission could contain more toxic or irritating components than a higher total VOC emission from another formulation of a similar product. Therefore, while total VOC concentrations should generally be maintained as low as possible, attention must be paid to the composition of the emissions and the toxicity of each major component.

For more information:

To receive a copy of the "Final Report, Carpet Policy Dialogue," contact: Carpet Policy Dialogue, EPA/OTS, TS-778, 401 M Street SW, Washington, DC 20460. or phone: TSCA Assistance (202) 554-1404, fax (202) 554-5603. Copies are free while the supply lasts. Then report copies will be available from the National Technical Information Service, NTIS, 5285 Port Royal Road, Springfield, VA, 22161, (703) 487-4650.

Write to Richard Leukroth, Carpet Dialogue Project Coordinator, EPA/OTS, TS-778, U.S. EPA, 401 M Street SW, Washington, DC 20460, (202) 260-1832, fax (202) 260-8168.

Materials Emissions

Swedish Researchers Report on Survey

The Swedish National Testing and Research Institute in Boras, Sweden, has done a critical review of the international literature on chemical emissions from building materials. The final report includes 24 case studies in which building materials were identified as major emission sources. The principal investigator, Hans Gustafsson, reported on the work at "IAQ '91 - Healthy Buildings."

The report's authors found that it is difficult to estimate relative volatile organic compound (VOC) concentrations due to the building materials alone because so few studies have been done in unfurnished, unoccupied buildings. Variations over time are large due, for example, to temperature changes and their effects on emissions.

Paints and Floor Coverings

Gustafsson reports that "[c]ertain building materials have been identified as major emissions sources in buildings. Especially solvent- or monomer-containing surface materials such as paint and [floor coverings] are reported as emission sources."

Linoleum (containing cured linseed oil) "...can sometimes give rise to an unpleasant smell due to oxidation of fatty acids. Linoleic acid and other unsaturated fatty acids in [the linoleum] are split to aldehydes with lower molecular weight."

Alkyd paint (based on linseed oil) "...may emit aldehydes to the indoor air and even [emit] carboxylic acids at increased temperatures on radiators." Acrylic paint intended for outdoor use releases butylmethacrylate which is dangerous indoors.

The most common control measure to reduce emissions is source removal. In the case of floor coverings, removal of the adhesive may also be necessary. In some cases where contaminant compounds remain in the concrete, a covering layer of polyurethane or epoxy lacquer has successfully controlled emissions.

Semi-volatile Compounds

One of the report's interesting findings is that compounds adsorbed on dust can be released when the dust is heated by electric light bulbs, radiators, and cooling panels on refrigerators. When dust and other airborne particles settle on these devices, semi-volatile compounds such as phthalates, TXIB, and PCBs can be released.

We would add electronic and other office equipment to the list of potential heat sources. Therefore, the notion that concentrations and exposure to such compounds should typically be low due to their low volatility requires re-evaluation.

Recommendations

Gustafsson made five recommendations based on his research:

- When buying building materials, require information about the manufacturer's quality assurance system, "...especially for products based on solvents and monomers." Without this information, single emission test data are less valuable.
- Protect building materials from moisture during construction and afterwards. Materials particularly susceptible to moisture-induced problems include carpet, mineral wool, casein-based floor topping compounds [a problem documented in Sweden for several years], and vinyl flooring with high plasticizer content. Be sure concrete is dry before applying floor covering.
- Do not apply building materials for unspecified uses. In particular, do not apply outdoor sealants and paints inside a building. Use moisture repellents for exterior walls with caution.
- Reformulate building materials during product development to improve their overall performance including emissions characteristics. For example, substituting constituents in water-borne paints can minimize long-term emissions.
- Learn more about the chemical mechanisms influencing VOC emissions. Producers should also incorporate emerging emissions test methods in product development activities.

Final Report Will Be Published in Late 1991

Dr. Gustafsson told the ***BULLETIN*** the final report would be available in October. We have not yet received definitive information on ordering a copy, but as soon as it is available, we will pass it along to readers.

Reference:

Hans Gustafsson, 1991, "Building Materials Identified as Major Emission Sources," in *Proceedings of IAQ '91 - Healthy Buildings.* Atlanta: American Society of Heating, Refrigerating, and Air-conditioning Engineers, Inc. pp. 259-261.

Materials Emissions

Chemical Analysis Versus Mouse Bioassay

Testing materials emissions for chemical content is widely considered useful and is becoming far more common. But, until more is known about the health effects of exposure to the chemicals, these tests will be of only limited help in developing and selecting healthier building materials. Tests that indicate the potential effect of material emissions on people are needed to help building design professionals and facility managers select better products.

Danish and U.S. scientists are developing various tests, and several useful tests already exist. We described a number of these tests in recent issues of the ***BULLETIN.*** For example, Danish researchers are establishing a research center to study building materials and health. Their announced plans include the following activities:

- Development and design of a multi-purpose exposure chamber for chemical, biological, and sensory tests.

- Methods development for sampling, chemical analysis, identification, and characterization of irritants and odors based upon sensory experience.
- Further development and documentation of mouse bioassay for test of irritants.
- Methods development to quantify eye irritation from building materials.
- Methods development for combined characterization of chemical analysis and sensory evaluation of the emission.
- Investigation of the sink effect in materials.
- Pilot study for the development of healthy carpets, paints, and sealants together with manufacturers. Identification of potential VOC substitution.

Mouse Bioassay for Respiratory Irritation

One North American private laboratory, Andersen Labs in Boston, Massachusetts, tests emissions from building materials, furnishings, and consumer products using the mouse bioassay — ASTM Standard E-981, Standard Test Method for Estimating Sensory Irritancy of Airborne Chemicals. (See "Yale Conference: Assessing the Sources That Cause SBS," *Indoor Air BULLETIN*, May 1991, for more details.)

This test provides information on the sensory irritation potential of chemical vapors and gases by examining the decrease in respiratory rate of a group of four mice exposed to controlled concentrations of the chemicals. The system assesses the potential of a material or product to cause sensory irritation in laboratory mice.

Human Sensations
Eye, airway irritation.
Burn, cough, gag, and headache.
Human Systemic Effects
Heart rate and kidney function down.
Blood pressure up.
Fatigue.
Mouse Response
Resperatory rate down.
Change in respiratory pattern.

Table 2 - Activation of 5th Cranial Nerve by Irritant Chemicals.

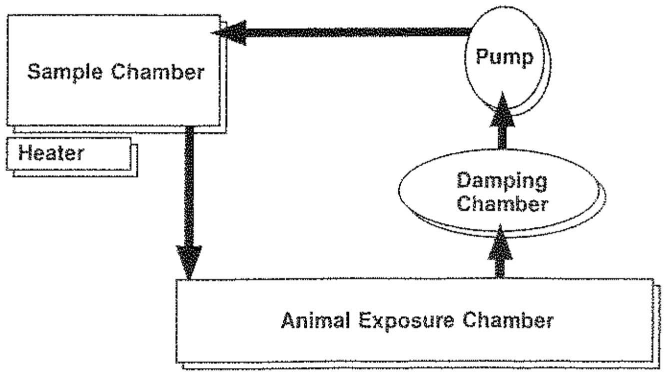

Figure 2 - Test System for ASTM E-981.

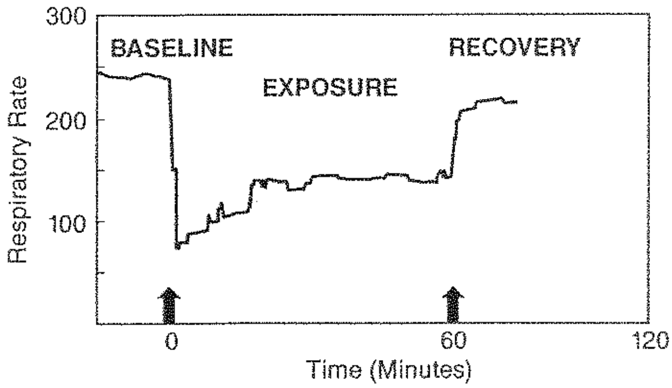

Figure 3 - Typical Respiratory Response Pattern to Irritant* in the ASTM E-981 Bioassay.
* Mean of four mice.

Examples Of Mouse Bioassay Results

Table 2 shows how irritant chemicals activate 5th cranial nerve responses in humans and also how they affect mice. Figure 2 shows a schematic of the ASTM E-981 test system. Figures 3 through 5 show a typical response pattern and two examples of the type of results obtained using the mouse bioassay. All figures were kindly provided by Andersen Labs.

Promising New Developments

Now Rosalind Andersen, president of Andersen Labs, has found that she can use a test atmosphere of grab samples of indoor air collected in Tedlar bags and get reproducible results. She has also found a correlation between the air in "sick buildings" and the mouse response. There have been numerous complaints of headaches, fatigue, dry eyes, nose, mouth, and difficulty breathing that have been going on for years in a building she recently tested. This, she says, is an extremely promising development because it links the reported human symptoms of irritation and the ability of that atmosphere

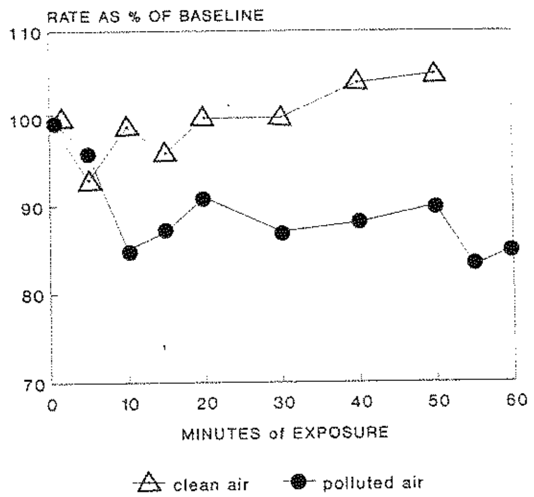

Figure 4 - Sensory Irritation Test of Room Air.
80L recirculating system. Samples obtained from clean or spiked room.

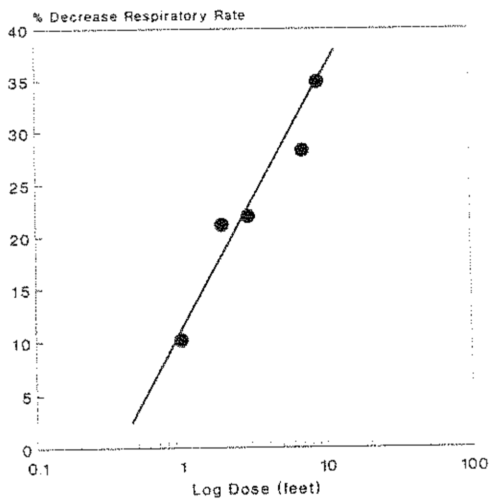

Figure 5 - Sensory Irritation from Commercial Carpet.
80L recirculating system. 39C, carpet remnant.

to cause such symptoms. This is what has been missing in the straight chemistry approach, she says.

While this work is only preliminary and requires more detailed follow-up, the results are extremely clear and strongly suggest that the technique will be a useful one.

Criticism of the Mouse Bioassay

One criticism of the method is that the concentrations are not controlled or, usually, even measured. Instead, the researchers vary the amount of material exposed to the air stream and contributing to the test air. For example, a certain area of flooring or wall covering or painted gypsum board might be used to generate the test atmosphere. The tests rely on standardizing the generation of the test atmosphere rather than standardizing concentrations to which the mice are exposed.

Bruce Tichenor of EPA asks: "How do you correlate the exposure of the animals in the test chamber to what people are exposed to in indoor air?" The time-varying nature of concentrations that occur due to most sources is not accounted for in the mouse bioassay. Would you get the same response for an exposure to one concentration at ten hours as you would for ten times that concentration for one hour? The total exposure would be the same, but the timing and peak concentrations would be different.

Another fundamental question is the correlation between the response of the mouse and the human health effects from exposure to emissions from the same or similar products. Andersen says that since most SBS symptoms are associated with sensory irritation, the test is extremely useful in gaining insight into IAQ problem sources.

Contaminant concentrations causing respiratory rate changes measured by the ASTM test appear to correlate well with ACGIH TLVs that are based on irritation. And the dose-response curves for most substances when plotted on a graph are parallel. This indicates that the tests do provide comparable dose-response information.

The Indoor Air Branch at EPA's Office of Research and Development (ORD) in Research Triangle Park, North Carolina, has done a lot of emissions test method development during the past five years. Drs. Gene Tucker and Bruce Tichenor have been the scientists leading the program. Now other EPA scientists have also begun to use mouse bioassays as well as other biological exposure systems.

Criticism of Chemical Emissions Tests

Dr. Andersen says that you have to know what is important to investigate first, and then get into the details of the chemical components. She argues that getting all the details of the chemical composition of emissions first before you know whether there is a health effect from exposure is starting at the wrong end of the problem. She seems to think that the abundant chemical testing is the result of the existence of all the expensive equipment and expertise without an adequately defined purpose for the testing.

Dr. Tichenor says that in the absence of any other information, chemical emissions data is useful. It allows predictions of how a product will impact the indoor environment and allows comparison of products. It appears to be at least one useful tool in attempting to improve the quality of indoor air. Furthermore, he says, health scientists do want the detailed chemical information and request it from his laboratory.

IAB Comments

We believe that EPA's history of regulating individual chemical substances rather than products or indoor air is largely responsible for their approach. We also believe that there is real value in doing the chemical tests, but that total volatile compound concentrations by themselves do not adequately indicate the potential for adverse reactions. Individual chemical compounds (species) must be identified, and, where information is available, assessed.

In the future, mouse (or other) bioassays will help us evaluate air quality for sensory irritation potential more quickly, economically, and reliably than the more prevalent elaborate chemical analyses that dominate today. But the chemical analyses are essential for determining other potential health effects including carcinogenicity, immuno-toxicity, teratogenicity, and neuro-toxicity. Furthermore, odor perception and acceptability will be an important evaluation for chemicals and chemical mixtures in indoor air.

For more information:

Contact Rosalind Andersen, Ph.D., Andersen Laboratories Inc., 30 River Street, Dedham, MA 02026, (617) 364-7367, fax (617) 364-6709.

Conference

Call for Papers: ASHRAE IAQ '92

ASHRAE's IAQ '92, co-sponsored with The American Conference of Governmental Industrial Hygienists (ACGIH) and The American Industrial Hygiene Association (AIHA), will be called "Environments for People." ASHRAE started sponsoring the annual IAQ 'XX conferences in 1986 and has organized them each year except 1990 (to avoid drawing participants away from Indoor Air '90 in Toronto which ASHRAE also co-sponsored). The symposium will take place in San Francisco from October 18-21, 1992.

The symposium is designed to let practitioners and scientists exchange their experience and knowledge of indoor climate issues: particularly IAQ. Participants will discuss technical requirements and solutions contributing to environments for people to live and work in. Panel discussions, directed by symposium organizers, will encourage participation by others with practical experience.

The symposium will also encourage recommendations on materials selection, systems, methods of operation and maintenance procedures. ASHRAE will publish selected papers and session summaries including those that concern enhancing the productivity and economic benefits of providing suitable environments for people.

The program will include technical sessions, panel discussions, and poster sessions on the following topics:

- Environmental criteria.
- Policy issues: certification and standards development.
- Measurement issues: microbial agents.
- Measurement issues: volatile organic compounds.
- Ventilation: local exhaust and ventilation efficiency.
- Building operations and maintenance.

Conference Chairman Michael Hodgson said: "This joint meeting of industrial hygienists and engineers allows us to address appropriate measurement and control techniques for indoor environmental pollutants. We hope that by bringing together the interests, concerns, and expertise of various professional disciplines concerned with IAQ investigations and solutions, a new understanding will be developed that moves the disciplines closer together as they work to improve the quality of indoor environments."

Abstracts Invited

Abstracts of no more than 300 words are due by January 10, 1992. Notification of acceptance will be by February 7. Manuscripts will be due April 10. Following the conference, ASHRAE will publish a Conference Proceedings containing the accepted papers.

For more information:

For more information on submitting an abstract or conference registration, contact Jim Norman, Manager of Technical Services, ASHRAE, 1791 Tullie Circle NE, Atlanta, GA 30329, (404) 636-8400, fax (404) 321-5478.

On Miller, Morey, Burge — Bioaerosols

Dear Mr. Levin:

Congratulations to you for providing a forum for some very exciting debates and comments on the roll which fungi play in indoor air quality. Until now, this type of scientific and philosophical interaction had been lacking, although important to the advancement of the indoor air quality field. Airborne microorganisms as a factor in indoor air quality have been, in general, overlooked. Most people forget that, besides physical and chemical parameters, there are microbiological factors. However, I would differ with the statement that ACGIH'S Guideline is "accepted guidance." The U.S. Public Health Service, Division of Federal Employee Occupational Health (USPHS-FEOH) Region III in Philadelphia, PA for one, does not endorse these guidelines. I, as a contract consultant, assisted in setting up an environmental microbiology laboratory that is dedicated to perform analytical services as well as research and development in the field of aeromycology and other indoor biological pollutants. The laboratory is staffed with two trained mycologists/microbiologists with doctorate degrees, including myself.

From all the discussions and comments, one thing is clear. There is tremendous need for more research in this important field. Chemical and physical parameters in buildings can be easily felt, observed, tested, changed, or corrected. Very few people realize that microorganisms can *grow and multiply exponentially* if conditions are suitable. They grow and are always a part of our buildings (whether residential, office, or industrial). That "fungi should not be permitted to grow in or on building materials, surfaces and systems" is a noble statement. While we should not permit fungi to grow to such a degree that obvious mildew is visible to the naked eye, fungi will always be with us. Vegetables and fruits will rot (caused by fungi and bacteria) even if they are refrigerated. Wood will eventually decay after many years of service. Microscopically speaking, many fungi and bacteria are growing both slowly and furiously in their small niches found in our moisture rich, nutrient rich, and temperature comfortable building environments. We can limit their growth but we can not eradicate them. *Remember — we do not live in a sterile world.*

As a trained mycologist with a background in microbiology, I had the opportunity to talk to Dr. [David] Miller at the Indoor Air '90 conference, on the issues of indoor aeromycology. I also have had opportunities to meet, hear the presentations by, and read articles published by both Drs. Burge and Morey. Their contributions to the field of bioaerosols (as defined by them, from viruses, bacteria, fungi, protozoa, algae, arthropods, other allergens, to VOCs and toxins) are valuable and important contributions to the field of Indoor Air Quality in the USA. As you know, both of them played major roles in the drafting and publication of ACGIH's *Guidelines for the Assessment of Bioaerosols in the Indoor Environment* and ASTM's *Biological Contaminants in Indoor Environments.*

The arguments over the sampling of airborne fungi are not new. The uses of sampling techniques and devices, sampling time, sampling media, and incubation conditions (particularly temperatures) have been discussed and reviewed on numerous occasions. The golden era of aeromycology was in the 50's and 60's when many important works were performed in this country and in Europe. While most of these studies were conducted outdoors, however, much of this valuable information is useful and can be selectively applied to today's interest in indoor aeromycology. However, I found that very little of these works were cited in many of Dr. Burge's and Dr. Morey's publications, including those in the ACGIH and ASTM books. As in many fields of science, a careful and exhaustive review of the literature is the important first step for any scientific work. Many important article were not cited, including a series of articles entitled "Kansas Aeromycology" published in *Transactions of the Kansas Academy of Science and in Mycologia* (official journal of American Mycology Society - MSA), a monograph entitled "Sampling Microbiological Aerosols" (Public Health Monograph No. 60, 1964), and many original articles published by such well known aeromycologists as Gregory and Hirst.

The report by Dr. R. M. Rylander, cited by Dr. Miller, may be high quality research. However, the use of β 1,3 glucan analysis for airborne biomass does not distinguish spores from hyphae, does not discriminate spore sizes and numbers, nor does it provide identities of the fungi. Fungal spores are considered the major source of allergens. Hyphae may or may not carry fungal allergens. Without these identities, the information of fungal biomass in the "Sick Building Syndrome" is of limited use.

The reasons given by Dr. Burge for not taking air samples for fungi are misguided. False negatives are always a part of any sampling or any experiment. However, the proper scientific solution to the problem is to increase sample size, conduct strategic sampling, and finally to perform a critical analysis of the results. Microorganisms are, by definition, microscopic. Without air sampling, there is no way anyone can detect airborne microbes. If a fungus grows to such a degree that a fungal colony can be visually detected, the problem may have been there for a long period of time. Visual observations of fungal growth also may not translate into airborne species, as cited by Dr. Morey.

Another reason cited by Dr. Burge is her concern regarding "inexperienced hands." Mycologists and microbiologists should play an important role in working with indoor air quality professionals. (If industrial hygienists do not conduct air sampling, then there is no demand for a mycologist. We'll never have any experienced mycologists involved in indoor air quality if there is no need for such professionals.) There are several highly qualified mycologists and microbiologists working directly or indirectly in aeromycology.

[At this point the letter identifies several individuals as follows: James Kimbrough, U. of Florida, Gainesville (indoor aeromycology); Brian Shelton, PathCon Laboratory, Norcross, GA (consultants); George Barron, Canada (mycology); Mark Buttner and Linda Stetzenbach, U. of Nevada, Las Vegas (evaluating sampling techniques for airborne microorganisms); Ling-Ling Hung and William Denison, Oregon State U. (consulting mycologist/microbiologist); Fred Terracina, formerly State U. of New York, Syracuse, (consultant in aeromycology); and, Dr. Yang himself.]

In addition, there are many mycologists and plant pathologists with training in mycology who can provide high quality consultation to interested IAQ professionals. Mycologists may be a "silent bunch," but never say there are *no* mycologists.

There are many sampling techniques for airborne fungi and bacteria. In addition, there are many nutrient media that are used for sampling. As aforementioned, many publications exist which compare and discuss the pros and cons of the techniques and nutrient media used. However, a simple fact is that there is no perfect technique or universal medium for this type of sampling. The β1,3 glucan analysis may be a noble technique, but there are limitations as discussed above. Other techniques include but are not limited to the Andersen sampler, SAS (Spiral Air System) sampler, the filtration technique, and the settling/gravity plate technique. A recent article (published by Mark Buttner and Linda Stetzenbach of the University of Nevada in the April 1991 issue of the *Applied and Environmental Microbiology)* describes some very useful results using a controlled bacterial model, which were critically analyzed and discussed. There are uses for each of the four techniques (Andersen, SAS, impinger, and settling/gravity plate technique), provided sampling or experimental conditions are carefully defined. Because no perfect technique is available, at this time or in the foreseeable future, the prudent approach is to select a feasible technique and nutrient medium, perform sampling strategically, and analyze the results critically and in accordance with the sampling procedure.

The approach offered by Dr. Morey provides a useful protocol to IAQ investigations. However, there are some obvious problems with the approach. How can you use winter outdoor fungal concentrations? In temperate climates, there are practically no airborne microbial populations detectable in freezing conditions. The approach emphasizes inspection of the HVAC (heating, ventilating, and air-conditioning) systems. Carpets, woods floors, drywall sheet rock, fiberglass insulation, papers (which are abundant in offices), and many materials common to offices or houses can be a source of microorganisms. A comprehensive approach to all building systems is much more important. We have seen *Penicillium* growing in trash cans, on wet sheet rock, in the soil of potted plants, for example. We have also seen that fiberglass insulation from a HVAC system which appeared to be coated with a "fungal growth," but, in fact, turned out to be chemical crystals when examined under a microscope. Additionally, visible fungal growth may not actively release spores. The fungi have to grow (accumulate resources and energy), produce spores, and then discharge spores. Visual inspection is important and critical in any IAQ investigation. Laboratory testing and air sampling can greatly improve the quality of any investigation. Dr. Morey's approach is obviously workable and working well for him. However, there are many other approaches which may work even better.

I realize the precious space that you have. Please feel free to edit this long letter. Again, thank you for providing a forum for these exciting and useful interactions.

Sincerely,
Chin S, Yang, Ph.D.
Ling-Ling Hung, Ph.D.
Cherry Hill, New Jersey.

[Editor's note: we have not edited the letter other than the italicized portion. Also, we have invited the ACGIH Bioaerosols Committee to respond.]

Calendar

November 4-7, 1991. **ASTM Subcommittee D22.05 on Indoor Air.** San Diego, California. Contact: George Luciw, ASTM, 1916 Race Street, Philadelphia, PA 19103.

November 10-13, 1991. **IFMA '91**, San Diego: "Improving the Environment," sponsored by the International Facilities Management Association (IFMA), San Diego, California. Contact: Christine Katnich, IFMA, 1 East Greenway Plaza, 11th Floor, Houston, TX 77046-0194. Fax (713)623-6124. There are three sessions on IAQ at this year's IFMA meeting including two on Tuesday, the 12th and one on Wednesday, Nov. 13. Exhibition also: 200 exhibitors.

November 14-16, 1991. **"Blueprint for a Healthy House Conference."** The Urban Center, Cleveland State University. Sheraton City Centre, Cleveland, Ohio. Contact: Barbara Benevento, The Urban Center, Cleveland State University, Cleveland, OH 44115. (216) 687-6947.

November 18-19, 1991. **"How to Meet New Ventilation Standards: Indoor Air Quality and Energy Efficiency."** Sponsored by the Association of Energy Engineers. Atlantic City, New Jersey. Contact: AEE Energy Seminars, P. O. Box 1026, Lilburn, GA 30326 (404) 925-9633, fax (404) 381-9865. *Instructors are Francis J. "Bud" Offermann, and Thomas Gilbertson. Registration fee $750; $650 for AEE Members.*

November 18-21, 1991. **"Measuring, Understanding, and Predicting Exposures in the 21st Century."** Sponsored by the International Society of Exposure Analysis and seven other national and international organizations. Westin Peachtree Plaza, Atlanta, Georgia. Contact: Julia King, Atlanta Conference, ASci Corporation, 1365 Beverly Road, McLean, VA, 22101. *Topics include Issues Related to Industrial Hygiene, Measurement of Exposures, Activity Patterns and Databases, Environmental Epidemiology, Methods Development, Modeling Exposures, Risk Assessment, Dose, Multimedia Issues, Status and Trends, and Latin American Issues. Registration is $150 for the three full days of the conference, Tuesday through Thursday. Separate fee for one of the full-day workshops on Monday include sampling, survey design, and risk assessment.*

December 10-12, 1991. **Indoor Air Quality Course**, Harvard School of Public Health, Boston, Massachusetts. Contact: Mary F. McPeak, Office of Continuing Education, Harvard School of Public Health, 677 Huntington Avenue, Boston, MA 02115. (617) 432-3515, (617) 432-1969. *This course focuses on the health hazards of various indoor air pollutants, their physiological, toxicological, and perceptional aspects, and in-field monitoring strategies and instrumentation. Enrollment is limited to 50. Fee is $750.*

January 26-29, 1992. **ASHRAE Winter Meeting and Exhibition**, Anaheim, California. Contact: ASHRAE Meetings Department, 1791 Tullie Circle N.E., Atlanta, GA 30329 (404) 636-8400.

April 30 - May 2, 1992. **The First Annual IAQ Conference and Exposition**, "Indoor Air Quality: Service & Technology," Tampa Convention Center, Tampa, Florida. Sponsored by the National Coalition on Indoor Air Quality. Contact: National Coalition on Indoor Air Quality, 1518 K Street, NW, Washington, DC 20005

July 12-17, 1992. **"Asbestos Measurement, Risk Assessment, Laboratory Accreditation."** Johnson State College, Johnson, Vermont. Sponsored by ASTM Committee D-22 on Sampling and Analysis of Atmospheres. Contact: George Luciw, ASTM, 1916 Race Street, Philadelphia, PA 19103, (215) 299-5471.

International

November 5-8, 1991. **1991 Far East Conference.** 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. Tel. +81-3-441-711 Ext 240, (after Jan. 1, 1991, +81-3-3441-7111 Ext 240); Fax +81-3-446-4635.

April 28-30, 1992. **"Quality of the Indoor Environment,"** Sponsored by The International Association for Indoor Air Quality, Athens, Greece. Contact: Conference Secretariat, Quality of the Indooir Environment, Unit 6, 2 Old Brompton Road, London SW7 3DQ, UK.

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).

September 2-4, 1992. **Roomvent '92, The Third Internation Conference on Air Distribution in Rooms.** Aalborg, Denmark. sponsored by Danish Association of HVAC Engineers. Contact: Danish Association of HVAC Engineers, Ørholmvej 40B, DK-2800 Lyngby, Denmark.

October 12-16, 1992. **Second International Course on Sick Building Syndrome**, sponsored by the Nordic Institute of Occupational Health (NIVA). Hotel Oranje Boulevard, Noordwijk aan Zee, The Netherlands. Contact: Gunilla Ahlberg, NIVA, Topeliuksenkatu 41 a A, SF-00250 Helsinki, Finland. Tel +358 0 474 498. Telefax +358 0 414 634. *A five day course intended for occupational safety and health experts and industrial hygienists working in the field of indoor air quality. Enrollment limited to 50.*

Indoor Air BULLETIN

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