Indoor Air Quality Update™

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

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Evaluating Building Materials Tests

Building products, materials, and furnishings are documented sources of indoor air contaminants. Architects, engineers, interior designers, and building owners are beginning to look more carefully at these products before specifying and installing them. Pressures from these professionals as well as from regulatory agencies are rapidly changing the building products industry.

In This Issue

Building Design Requirements

Several large building projects now in design or in the bid process require the manufacturers and suppliers of products and materials to submit information related to indoor air quality. Following the approach described in the April 1989 *IAQU*, architects are using the data to evaluate the chemical content and emissions of products. Designers, owners, and consultants evaluate the submittals to determine whether certain products contain hazardous ingredients that will be emitted into building air and pose a threat to the health or comfort of building occupants.

The products covered are not limited to interior furnishings, floor coverings, paints, adhesives, and other obvious sources of indoor air contaminants. They also include materials used in mechanical ventilation systems as well as in spray-on fireproofing. In one project, the submittal requirement is written into Division 1, General Conditions of the specifications; it is applicable to all products supplied or installed by the general contractor or any of the subcontractors. It is just as important to evaluate products like acoustic and thermal insulations that may be in a duct or concealed space as it is to evaluate carpeting, furnishings, or paint.

Regulatory Pressure

Air quality control agencies are beginning to impose strict limitations on the volatile organic chemical (VOC) content of paints and other "architectural coatings." By limiting the VOC emissions from these products, the agencies hope to reduce ozone, which is formed when hydrocarbons and nitrogen dioxide react in the presence of sunlight. The problem is so severe in the Los Angeles air quality basin that ozone concentrations exceed the legal limits more than half the days of the year.

California's Proposition 65 requires more disclosure of product contents than in the past. California has a lengthy list of chemical substances "known to the State of California to cause cancer or birth defects." Products that might expose building occupants to dangerous chemicals must be so labeled when sold in California. Buildings in which the air contains any of these chemicals must be posted with appropriate warning signs. Bars, restaurants, service stations, auto parts stores, and many other businesses in California bear Prop. 65 warnings.

Manufacturers' Responses

Manufacturers are responding variously to these new requirements. Some are moving quickly to obtain laboratory test data conforming to the requirements of the specifications. Others are simply submitting their already prepared

Manufacturer's Safety Data Sheets (MSDS), although these do not meet the letter or the spirit of the recommended requirements. Others are revising their MSDS to include products not required under OSHA rules.

Many manufacturers have recognized their potential liability for lawsuits that allege indoor air contamination as a cause of illness or injury. Others have chosen to see indoor air quality problems as marketing opportunities. They are developing advertising and sales programs around products they claim have low emissions, do not contain formaldehyde or asbestos, or are free of other well-known environmental hazards.

Other manufacturers, motivated by the growing concern for indoor air quality, simply want to develop "cleaner" products. They have tested their products and found that they contained and emitted one or more chemical contaminants they had not known were present. This has led them to investigate the materials they purchase to manufacture the product or to evaluate their own manufacturing process for the source of the "bad actors." The result is that products are being cleaned up.

Table 1 — Procedure and Criteria for Reviewing Materials During Design

a. *Identify generic building materials, products, and furnishings.*

All textiles, wet products, pressed-wood products, and other products believed to emit chemicals into the air.

b. *Determine the quantity and type of use for each material.*

Exposed surface area as well as cross-sectional area and mass are important.

c. *Determine whether the material will be exposed to the indoor air or the ventilation air supply and return stream.*

Air movement at the surface will generally increase emission from the surface. Return air ducts and concealed spaces above ceilings serving as return air plenums are as important as supply air ductwork and air handlers since recirculated air will have passed through the return air system. Thus, the upper surfaces of ceiling tiles or lay-in panels and insulations on structural floors, beams, and columns will be exposed to the return air.

d. *Determine whether occupants are likely to come into direct or close contact with the material or product based on its contemplated use.*

The closer the occupant is to the product, the less dilution of the emissions can occur before exposure.

e. *Identify high surface area (fleecy) materials.*

Textiles and rough textured insulation materials present large surface areas, which can emit at higher rates than smooth surfaces. Rough surfaces also act as adsorption sites for chemicals already in the air, then re-emit them later.

f. *Identify materials that will require "wet" maintenance products.*

Maintenance products such as waxes, polishes, cleaners, and solvents can result in indoor air quality problems if not properly applied or ventilated. Drying time available between application and occupancy and ventilation during and after application are critical elements to reduce air contamination during occupancy.

The Evaluation Process

Soliciting product information during design and evaluating it for indoor air impacts is new for most people. When we first asked for such information in connection with a very large building design back in 1983, few manufacturers were prepared to respond. Today the situation is altogether different; many manufacturers have recognized the need to address indoor air and other environmental concerns.

We described the materials evaluation process in the April 1989 ***IAQU***. Last month we presented a one-page chart that could be used as an outline for evaluating manufacturers' submittals. During design development and the preparation of construction documents, the design team can identify the products or type of products that will be used in the building. Before the bid documents are issued or negotiated contracts are signed, a requirement for submittals should include a requirement for information as described in the April ***IAQU***.

Table 1 shows (in outline form) the procedure and criteria for determining which materials should be included in the solicitation for product information.

The most difficult and least-developed part of the process is evaluating the information that arrives in response to a solicitation or requirement for submittals. We discuss three aspects of the process below.

1. Standards or Guidelines for Testing Specific Products

When emissions test results are submitted, those who evaluate them are confronted with the problem of determining how to interpret them. The absence of standards for testing means test methods are likely to vary significantly among competing products. Therefore, test methods as well as test results must be evaluated.

Standardized testing does not now exist; however, it is developing as a result of the rapidly increasing demand for it. The guideline for small chamber testing of materials' emissions into indoor air developed by EPA's Bruce Tichenor is generic. It does not provide the required detailed protocols for specific product types. Test methods appropriate for different products such as carpets, adhesives, paints, pressed-wood products, textiles, and furnishings vary. Each type of material or product requires a separate test method or test practice.

ASTM Subcommittee D22.05 has begun developing test method outlines for carpeting, solid materials (such as pressed-wood products), and wet products (such as adhesives, sealants, caulks, or paints). The outlines will be discussed at the subcommittee meeting in San Francisco next month. (See the listing in the Calendar section for details and contact information.) The group plans to draft standard practices for testing each basic type of material.

Specific product test methods will have to completely determine and describe each of the following:

- Test specimen acquisition, conditioning, and preparation;
- Chamber temperature, humidity, air flow velocity, and air exchange rate;
- Sample collection timing and duration;
- Procedures for determining how many and which chemicals to identify and to quantify; and,
- Standard formats for reporting test methods, conditions, and results.

The emissions of greatest significance occur at three stages:

- Installation: the emission rate when the material is removed from the shipping container or packaging or is freshly applied. This will usually be the "worst case" situation.
- Initial building occupancy: what building occupants will be immediately exposed to from the product.
- Long term: exposures when emissions have stabilized to a long-term pattern approaching steady state. This will be either days, weeks, or months, depending on the emissions decay rate.

Some of the affected industry groups are likely to develop their own standard test methods through industry associations. It is in the interest of all parties concerned that there be a "level playing field" for evaluating product emissions. If such industry initiatives occur, they will accelerate the standards development process and the comparability of data from different tests or laboratories.

2. Standard Procedures for Evaluating Test Results and for Determining Acceptable Emission Rates

Dr. Gene Tucker of EPA has suggested that no product's emissions should increase airborne concentrations of total VOC by more than 0.5 mg/m^3. This may be useful for surface coverings such as floors, walls, ceilings, and free-standing partitions; however, should it also be applied to materials that are present in far smaller quantities? What about materials such as caulks, fillers, and glazing compounds that are applied in beads, lines, or strips?

Dr. Tucker's advice is about the best available, but it is still only a very rough guideline. There may be products causing far less than the 0.5 mg/m^3 increase but that are emitting some very toxic or irritating compound. There may also be larger emissions that contain relatively harmless compounds. We need to know more from testing the health and comfort effects of individual compounds and mixtures before we can confidently make informed decisions about emissions results. EPA has begun to do such testing under Tucker's guidance.

3. Standards for Evaluating the Tests Themselves

Since very few laboratories are performing tests currently, it is hard to assess the reliability of the laboratories doing the work. We anticipate that many more firms will offer emissions testing services within the next year. During that time, standards for laboratory performance and evaluation need to be developed. This is an appropriate area for government involvement, such as the laboratory certification or proficiency testing that exists for other air sampling and analytical work.

For More Information

See the March 1989, April 1989, and January 1990 issues of ***IAQU***. Back issues and reprints are available from Cutter Information Corp., 1100 Massachusetts Avenue, Arlington, MA 02174; (617)648-8700, Fax: (617)648-8707.

AEERL, U. S. EPA, Research Triangle Park, NC 27711. Bruce Tichenor: (919)541-2991. Gene Tucker: (919)541-2746.

ASTM Subcommittee D22.05: See Calendar listing in this issue of *IAQU*, April 24-26, 1990. ♦

Practical Research Briefs

Measuring Environment at Each Workstation

Michael Hodgson's pilot study for an SBS investigation is far more important for its methods and philosophy than for its results. Titled "Symptoms and the Micro-Environment in the Sick Building Syndrome: A Pilot Study," the paper (presented at IAQ '89) reports results of an investigation in a chronic complaint building at the University of Pittsburgh.

Hodgson told ***IAQU*** that these kinds of studies are done for two reasons: for science and for solving problems. When it comes to solving problems, he advocates a careful, thorough engineering analysis. He says he does not recommend data collection, whether it is environmental or epidemiological, in most problem buildings. The Pittsburgh paper, presented at IAQ '89, was from a pilot study for scientific purposes. The full study has been submitted for publication; we will report on it as soon as it has been accepted for publication.

The Pilot Study

The researchers designed the "cross-sectional study" to simultaneously measure environmental characteristics and the level of short-term complaints. In most SBS studies and problem building investigations, environmental measurements are made for areas or portions of a building. It is very rare that measurements are made near or at the workstation of individual office building occupants. This is so partly because it is extremely costly and time-consuming. Also, many investigators, like Hodgson, question its validity in applications other than scientific studies.

Background and the Building

The 40,000-sq-ft building was first occupied in 1984. It is a three-story faculty office building and conference center with a large computer terminal hall for students. A variable-air-volume system ventilates six zones plus a separate zone for a computer repair center in the basement.

Complaints began almost immediately after occupancy and had persisted for almost two years at the time the study was initiated. Several prior industrial hygiene surveys had failed to identify contaminant levels believed sufficient to cause the complaints.

Pilot Study Method

Researchers administered questionnaires and made all the environmental measurements at the subjects' workstations during the same four-hour period (1 to 5 PM) on weekdays. The measurements were begun when the questionnaire was handed to the subject. Typically the questionnaires were completed in about 10 minutes while the environmental measurements required about 45 minutes to complete.

Measurements included light intensity, temperature, relative humidity, respirable suspended particulates, air movement, volatile organic compounds, carbon dioxide, formaldehyde, noise, and vibration.

From engineering drawings, an engineer with no knowledge of the level of complaints calculated the length of ductwork leading to each office. He then entered an ordinal number from 1 to 3 referred to as "duct" to represent the length of ductwork.

The data were entered using the Statistical Package for the Social Sciences (SPSS/PC+) computer program. The data were plotted and extensive statistical analyses were conducted. Details of the analyses are contained in the paper.

Results

Measurements of VOC and formaldehyde were abandoned after only two weeks since the equipment was rented and the measured levels were considered low, 0.5 to 1.5 ppm for 30 VOC measurements and less than 0.04 ppm for 55 formaldehyde measurements. Table 2, Environmental Characterization, contains the results of the environmental monitoring.

Note that while the range of temperatures from 62.7 to 81.3 °F extends from below to above the comfort range described by authorities, the small difference between the mean and the median (0.2 °F) and the small standard

Table 2 — Environmental Characterization

		Mean	Median	Standard Deviation	Total # Available	Range
Relative humidity (%)		35.5	34.8	8.3	90	19.3-65.0
75th, 90th and 95th percentiles:	40.8, 45.3, 50.0					
% at or below the limit of detection:	0%					
Temperature (°F)		74.5	74.3	2.8	105	62.7-81.3
75th, 90th and 95th percentiles:	76.4, 77.0, 80.1					
% at or below the limit of detection:	0%					
Airflow velocity (ft/min)		25.0	24.0	5.5	84	nd-43.0
75th, 90th and 95th percentiles:	27.0, 34.0, 38.0					
% at or below the limit of detection:	20 (24%)					
Carbon dioxide (ppm)		820	800	201	102	300-1250
75th, 90th and 95th percentiles:	1000, 1070, 1100					
% at or below the limit of detection:	0 (0%)					
Respirable suspended particulates (mcg/m^3)		36	30	15	103	nd-90
75th, 90th and 95th percentiles:	40, 60, 68					
% at or below the limit of detection:	20 (21%)					
Light (foot-candles)		42.0	38.5	25.1	100	2.0-150
75th, 90th and 95th percentiles:	52.0, 69.5, 89.5					
% at or below the limit of detection:	0 (0%)					
Noise (decibels on the A-weighted scale)		58.3	55.0	8.9	79	50.0-85.0
75th, 90th and 95th percentiles:	60.0, 68.0, 85.0					
% at or below the limit of detection:	0 (0%)					
Vibration (Herz)		10.3	10.0	8.9	72	nd-19.9
75th, 90th and 95th percentiles:	10.0, 10.0, 12.0					
% at or below the limit of detection:	68 (94%)					
Formaldehyde (ppb)		64.4	40.0	131	55	nd-1000
75th, 90th and 95th percentiles:	40, 64, 152					
% at or below the limit of detection:	40 (73%)					
Volatile organic compounds (ppm)		0.63	0.600	0.30	30	nd-1.00
75th, 90th and 95th percentiles:	1.0, 1.0, 1.0					
% at or below the limit of detection:	3 (10%)					

deviation (2.8 °F) indicate that the majority of measurements were within the comfort range. This is confirmed by the 90th and 95th percentile maximum temperature values at 77.0 and 80.1 °F respectively. However, eight of the 105 measured temperatures exceeded 78 °F, the maximum value for comfort according to ASHRAE Standard 55-1981, "Thermal Environmental Conditions for Human Occupancy." [That value is proposed to be revised downward slightly in the current draft revision of the standard.]

Relative humidity ranged from 19.3 to 65%. Air flow ranged from below the limit of detection (20 fpm) to 43 fpm. Carbon dioxide levels ranged from 300 ppm (background) to 1,250 ppm, a level considered by most authorities to indicate insufficient outside air ventilation. The standard deviation for the formaldehyde measurements was more than three times the median and twice the mean values.

Significance of Hodgson's Findings

One of the most important things about the results is the variation in the environmental measurements at various locations.

Careful review of the data in Table 2 reveals that one or two environmental measurements for an area occupied by several employees would probably have failed to provide the detail and variety obtained by measuring at each study subject's workstation.

We believe that Hodgson has described some of the most important reasons why prior studies intended to identify the environmental causes of SBS have failed. In the report of the study, he wrote the following (which we quote at length because we believe it is so correct):

"Area samples in buildings may not be representative of the exposures in different points in a single room. Physical characteristics such as windows and partitions, computers, and shelving may influence air currents. Radiant heat may lead to uneven distribution of pollutants. Finally, most pollutants result from point sources, so they will be diluted as a subject is farther removed from the source. The micro-environment around desks and within cubicles may have very different exposure characteristics than the macro-environment of a building. In addition, all applied occupational and environmental health research that attempts to relate dose to health effects suffers from the problem that dose is generally measured at several points in time and then extrapolated to allow development of exposure classifications over decades while most health effects are measured as a single result of these chronic exposures. Where the variability of sampling results is greater than the difference in average samples, and where the level of symptoms may change not merely from day to day but from hour to hour, such a strategy must fail."

For More Information

M. J. Hodgson and P. Collopy, "Symptoms and the Micro-Environment in the Sick Building Syndrome: A Pilot Study," in *The Human Equation: Health and Comfort*, Proceedings of the ASHRAE SOEH Conference, IAQ '89, April 17-20, 1989, San Diego, California. Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. 1990, pp. 8-16. (See Information Exchange for how to obtain a copy.) ♦

Social and Organizational Factors of SBS

Dr. Dean Baker, an epidemiologist, presents a clear, complete description of the role of psychological stress in sick building syndrome and the role of sick building syndrome as a psychological stressor in his chapter of *Problem Buildings: Building Related Illness and the Sick Building* (reviewed in **Information Exchange** this issue). He draws upon a traditional occupational stress model. "The basic model of stress states that stress arises when there is a perceived imbalance between environmental demand and response capabilities under conditions where failure to meet demand has important consequences." He writes that stress is not limited to "high-pressure" executives. Stressors among clerical workers can include low pay or status, limited opportunities for advancement, repetitive work, or lack of involvement with organizational goals.

Baker describes "modifiers" in the stress model as intangible factors that increase or lessen stress. These factors alter individuals' perceptions of their environment. Social support can lessen stress. Clarity of communication within an organization is "informational support." Baker writes that stress-related health problems can be reduced by "development of supportive networks and effective communication patterns on the job." Baker has frequently found efforts to resolve indoor air quality problems and complaints hampered by poor communication between building management and occupants.

"Mass Psychogenic Illness"

Investigators have found an increase of nonspecific symptoms in the face of inconclusive environmental evaluations. Workers' worries about indoor air quality grow, leading to a crisis of concern among the employees about the safety of the building environment. Baker prefers to label buildings in these cases "crisis buildings" rather than "problem buildings." He says the social dynamics of the crisis become the predominant feature. "Both management and employees tend to be locked into a 'toxicologic-hysteria dichotomy,' that is, the problem is posed as being either that there is a toxic exposure ... or the employees are hysterical." In these cases it is not unusual to have several investigations held sequentially over time. The key to understanding in these situations is social dynamics.

"Underlying stressors" (biological, chemical, physical, and social factors) are present first. Then, a "triggering event" results in employee awareness that the office environment may be causing their health problems. It may be an episode like eye irritation from one-time use of a solvent, it may be an odor, or it may be the illness of an employee. Baker cites a case of an epileptic having a seizure in the office which resulted in others believing that their health problems were related to the office environment. After the triggering event, employees have a reference and explanation for symptoms that they previously experienced individually. The recognition of similar symptoms is called "convergence."

Table 3 — Comparison of Crisis Buildings and Mass Psychogenic Illness

Crisis Buildings	Mass Psychogenic Illness
Timing: Subacute to chronic	Timing: acute
Cognitive reaction	Affective reaction
Nonspecific symptoms	Anxiety reaction
Social effects	Psychological effects
Convergence	Convergence-contagion

Baker recommends that investigators pay close attention to the social dynamics of the problem. The process of investigation and intervention itself becomes part of the social dynamics.

Baker explores the question of whether crisis buildings are actually cases of mass psychogenic illness. The answer, he says, is not straightforward because each building has unique, dynamic relationships among "multiple social and toxicological factors." Mass psychogenic illness can certainly occur among office workers, but Baker believes it is a factor only in a tiny fraction of the buildings with reported environmental problems. To distinguish crisis buildings from cases of mass psychogenic illness, Baker provides the information in Table 3.

Baker's Recommendations

Baker includes many excellent recommendations regarding investigations and interventions at the end of his chapter. Some of them are synopsized below.

1. Investigations of office building health problems should be based on a "systems perspective." That is, investigators should regard the health status of occupants "as the net result of an interaction of multiple factors — biological, chemical, physical, social, and organizational." It is unlikely that any one agent causes all the complaints or symptoms in a building. The evaluation strategy should not attempt "to identify the one agent most responsible...."
2. Psychosocial factors should be identified with the same rigor as environmental factors. Better questionnaires are needed to assist in this effort.
3. Document symptoms and medical conditions. This documentation is, in itself, an intervention because it validates occupant experience and provides an incentive for the organization to respond.
4. "Redefine the nature of problem to reduce expectations that a single agent ... will be found for the health problems." Convey the sense that the problem is "multifactorial." Not all symptoms will disappear either, since some may have predated the onset of the problem.
5. "Increase effective communication among employees and between employees and building management." Use committees with broad representation from all interested parties. Include building engineers. The committee can be a "clearinghouse" for information and can respond to health concerns.
6. Building occupants can be partners in the process of resolving the problems by monitoring progress and health status changes. They can actually record environmental data such as temperature and humidity.
7. By the time most buildings become "problem buildings," many of the obvious sources of contamination have been identified and addressed. All relevant parties must participate in the process of identifying and addressing the multiple environmental, organizational, and social causes in order to bring about the necessary environmental and organizational changes to reduce symptoms.

(See Information Exchange for how to obtain a copy.) ♦

John Girman on VOC Concentrations

John Girman is deputy director of the California Department of Health Services' Indoor Air Quality Program. *IAQU* has described Girman's pioneering work on building bake-out procedures in previous issues (December 1988, July 1989). In his contribution to *Problem Buildings*, Girman provides some basic back-

Table 4 — Representative VOC Concentrations

Compound	Range of Reported Medians		Reported Maxima	
	μg/m^3	ppb	μg/m^3	ppb
Acetone	0.49 - 53	0.20 - 22	157	65.2
Benzene	7.0 - 35	2.2 - 11	204	63.2
Trichoroethylene	0.67 - 12.0	0.12 - 2.2	112	20.2
n-Undecane	4.4 - 91.0	0.62 - 12.8	950	134

ground information necessary to understand bake-outs and the process of VOC emissions from building materials.

He provides a fairly comprehensive overview of VOC in indoor air. He also discusses non-building-material sources of VOC such as consumer products and human metabolism. [These sources can be far more significant than building materials themselves as buildings age, so the attention paid them by Girman is warranted.]

According to a table in Girman's chapter, 12 measured bioeffluents (compounds emitted by the people themselves as metabolic products) had an average total concentration of about 157 ppb in a lecture hall of 389 people. The highest single concentration was methyl alcohol (methanol), comprising one-third of the total.

Girman provides data on the VOC concentrations found in several representative studies of IAQ. We have summarized those data (and added ppb conversions) in Table 4.

The values in Table 4 and other values he presents indicate that there is a very wide range of VOC concentrations in indoor air, although Girman says there is "crude agreement" among the median values. Girman cites the EPA public buildings study (see *IAQU*, December 1988) which, he says, indicates that VOC concentrations for individual compounds are generally less than one ppm while total VOC concentrations are usually in the low ppm range.

Building Factors and VOC Concentrations

Girman explains that VOC concentrations are often related to building type. For example, residences generally have higher formaldehyde concentrations due to the large surface-to-volume ratio of formaldehyde-emitting pressed-wood products. However, at this time, Girman says, data are not available to allow us to generalize beyond the formaldehyde case. In general, he says, similar quantities and types of VOC are found in both residential and nonresidential indoor air.

Ventilation clearly affects VOC concentration, although usually not in a linear fashion, according to Girman. The cause of the nonlinear response of VOC to ventilation rate changes is not yet understood adequately, but Girman suggests it is related to ventilation efficiency changes and changes in source characteristics. To that we would add the effects of sinks and the stripping of VOC from surfaces by rapidly moving air.

Building age is often considered a surrogate for material age. In two studies cited by Girman, investigators measured VOC when buildings were new and then after six months. According to calculations based on these measurements, a half-life for VOC emissions from building materials is estimated as being "on the order of months."

Health Effects

Girman briefly describes some of the health effects of VOC. (For a more complete discussion, see the World Health Organization publication reported in the January 1990 *IAQU*.) He then reviews some recent studies from Denmark's Lars Mølhave who exposed subjects to different concentrations of VOC to determine the effect on mental performance and subjective evaluation. Girman reports that these tests were largely inconclusive with the exception of the short-term memory tests. Significant decrease in short-term memory occurred during exposure to a mixture of 22 VOC.

The tests mentioned above used VOC concentrations far lower than traditional occupational limits, many of which are based on irritation effects. Girman provided a number of explanations why occupant complaints might occur in buildings where the measured VOC concentrations are so low. These reasons are worth noting when evaluating the results of building investigations or assessing the significance of emissions from building materials, furnishings, consumer products, or other sources of VOC.

1. Occupational health standards are set too high to adequately

protect all members of the population from central nervous system effects. Girman points out the well-known example of formaldehyde, where mobile home residents' health problems were evaluated in terms of the occupational limits and levels.

2. Additive effects may be more important in indoor air settings than in industrial environments. In industrial environments, simultaneous exposure is usually limited to a fairly limited number of chemicals. In indoor air, exposure is usually to a large number of VOC.
3. Most measurements made in conjunction with SBS incidents probably occur too late. Many strong sources decay rather rapidly; therefore, the measurements do not accurately characterize the environment when the symptoms began.
4. Reactive compounds present at trace concentrations in solvents are not typically measured. Yet reactive compounds may be strong irritants.
5. Synergistic effects may be important. The effects of individual as well as multiple VOC are not adequately understood.
6. Exposure to VOC may not be anticipated and workplace stress may lower individual tolerance or resistance to low-level irritation and odors.

Control of VOC

Girman's work on bake-outs constitutes an important control approach. He summarizes his work on bake-outs in the section on control. He also describes other approaches including ventilation, local ventilation, air cleaning, source removal, and source modification. Ventilation is the most frequently employed solution, Girman says, and it does work. However, it is expensive and its effectiveness is limited. He seems to favor local ventilation, especially for special sources such as food preparation, photographic processing, and printing where exhaust hoods can be effectively employed.

Sorbent-based air cleaning of VOC is not likely to be practical for large buildings due to its limited capacity and high costs. Source removal is attractive because the results are certain. But source removal may be followed by a lag time in decreasing concentrations if secondary sources (sinks) were created before the source removal. Also, source identification is not always easy, certain, or economical. Girman cites the case of a carpet adhesive that was an alleged source of formaldehyde. Much time and money were spent to confirm the source before it could be removed.

Ultimately, Girman says that selecting low-emitting materials in the first place is the most attractive option. The problem, he notes, is the paucity of data on the emissions from alternative products. Finally, source modification can be effective. This might involve sealing a building material with a low-emitting coating. Delaying occupancy of a newly-constructed building can also be effective. The bake-out is another way to modify sources.

For More Information

Cone and Hodgson (Eds.), *Problem Buildings: Building Associated Illness and the Sick Building Syndrome*. Philadelphia: Hanley & Belfus, Inc., 1989. pp. 695-712. (See Information Exchange for how to obtain a copy.) ♦

From the Field

Virginia Investigation Exemplifies Common Shortcomings

At the IAQ '89 conference held by ASHRAE last April, researchers from the Bureau of Toxic Substances in the Virginia Department of Health described a 1988 investigation in a high-rise public office building. A previous investigation of complaints on two floors in January 1984 resulted in the principal finding that relative humidity averaged 22%.

[The investigation report does not fully reflect the considerable progress indoor air researchers and investigators have made during the past two decades. A general understanding now exists within the indoor air community that extensive measurement is not as likely to lead to problem resolution as a thorough walkthrough inspection and an engineering analysis of the building. A comprehensive, valid measurement program is also far more expensive and time-consuming.]

The investigation reported here resembles many we have encountered over the past 12 years: measurement by inappropriate methods with detection limits derived from industrial hygiene, and a failure to assess adequately ventilation system design, operation, and performance.

IAQU reports the investigation as a basis for discussion. The report illustrates how ostensibly qualified individuals can perform an apparently rigorous study that lacks critical elements for understanding indoor air problems. We wish to raise questions for the indoor air community regarding improvement of such studies.

The Report

The building was constructed in 1980. It houses 1,200 employees. The HVAC is a multi-zone, variable-air-volume system. Air intakes are near ground level, approximately 50 horizontal feet from a major interstate highway, and also on the 13th floor. Filtration was by electrostatic filters with a tested efficiency of 10 to 20%.

Table 5 — Frequency of Selected Symptoms Reported by High-Rise Office Building Personnel

Symptom	Frequency
Headache	61%
Sinus congestion	59%
Nasal irritation	58%
Throat irritation	58%
Drowsiness	53%
Eye irritation	52%
Cough	37%
Difficulty concentrating	26%
Muscle aches	19%
Chills	16%
Dizziness	15%
Shortness of breath	13%
Weakness	9%
Stomach ache	8%
Diarrhea	8%
Fever	7%
Rash	5%
Faintness	4%

Questionnaire Results

Of the 233 employees on the eight study floors, 94% returned a questionnaire regarding symptoms. Of the respondents, 55% said their symptoms worsened at work and 47% said they had missed work due to their symptoms. The response rate was more than 50% for each of the following symptoms: eye irritation, drowsiness, throat irritation, nasal irritation, sinus congestion, and headache. Thirty-seven percent reported cough and 26% reported difficulty concentrating. The researchers commented that these symptoms were "...compatible with air contamination by TSP [Total Suspended Particulate] or other irritants." See Tables 5 and 6.

Table 6 — Prevalence of Complaints by Floor in a High-Rise Office Building

Floor	Too Hot/Cold	Too Humid/Dry	Odor	Symptoms
09	82%	79%	82%	76%
10	69%	69%	63%	31%
14	67%	48%	67%	38%
15	87%	50%	44%	38%
16	85%	60%	70%	60%
19	59%	43%	63%	50%
24	71%	74%	52%	55%
Service	71%	79%	71%	75%

Environmental Measurements

VOC, CO, N_2O [sic], NO [sic], and SO_2 were not detected, probably due to the relatively high detection limits related to the sampling method used. CO_2, relative humidity, and temperature levels were not remarkable. Fungal spore counts were less than 25% of those measured outdoors.

According to the researchers, the only noteworthy environmental measurements were the TSP. In 17 of the 29 areas sampled, TSP concentrations exceeded the Building Officials and Code Administrators (BOCA) standard of <0.06 mg/m^3 (annual average).

Findings and Conclusions

Statistical analysis revealed that illness was significantly associated with air TSP concentration ($p<0.002$), CO_2 concentration, average number of hours worked per week, gender, and smoking status.

A sizable fraction of the building occupants surveyed said they experienced symptoms consisting primarily of headache; eye, nose, and throat irritation; drowsiness; and difficulty concentrating. A large segment of the building population experienced these symptoms while at work, and the symptoms generally disappeared within hours after leaving the building. This indicated to the researchers that the problem was consistent with an irritative process, not an allergic or infectious process. They found the symptoms similar to reported cases of "tight building syndrome."

The researchers went on to discuss the consistency of the symptoms with elevated TSP concentrations, which they found were a "statistically significant predictor of illness." They said that "...soot from vehicular traffic on the adjacent interstate highway was being drawn into the ventilation system, escaped adequate filtration, and was dispersed indoors...."

IAQU Critique

The report (and, apparently, the investigation) had several shortcomings.

- It is unusual to measure TSP in indoor air without also measuring respirable suspended particulates (RSP). Knowing the particle size distribution alone would help determine whether the source was primarily indoors or outdoors. No evidence regarding the location and nature of the source was offered, although the investigators seem convinced that the source was vehicular traffic. The investigators sampled for TSP without any size fractionation or chemical analysis of the constituents of the collected material. Such additional analyses would have provided more conclusive evidence of the sources and the potential for causing the complaints. It would have improved the reliability of the selection of methods for control.
- The efficiency of the electrostatic precipitators (ESP) was an "estimated" 10 to 20%. This figure simply makes no sense as presented. Properly maintained and operated ESP are generally rated at efficiencies approaching 80 to 90% for small particles. The key is proper maintenance, meaning cleaning of the plates as required by the loading. ESP must be cleaned to operate properly, and they are very efficient for smaller diameter particles: those below one micrometer where conventional building filters are effective.
- Given the nature of the findings, it would have been useful to know the outside air exchange rate for the building. If the source was assumed to be particles generated outside, then variations in ventilation rates should be accompanied by varied TSP concentrations. No outdoor TSP concentrations were reported, either at the face of the air handlers or elsewhere; measurements capable of confirming the main hypothesis of the investigators are simply missing.
- The investigators did not check for indoor sources of TSP such as smoking or the use of ultrasonic humidifiers. They did not take any precautions to avoid re-entrainment of particles generated by high-volume sampler motors.
- The investigators sampled VOC by "...infrared wavelength scans in the range between 2.5 m and 14.5 µm ... using a portable, single beam, infrared spectrophotometer (limit of detection equal to 1% to 5% of PEL values.)" This, apparently, was a MIRAN gas analyzer [based on the response to a question posed during the discussion]. On the basis of the MIRAN measurements, they concluded that VOC "...were not detected on any of the study floors."
- It is unlikely that there were no VOC present; the detection limits of the sampling instruments were just too high. Though we do not suggest that VOC were necessarily associated with the elevated complaint levels, the investigation was clearly inadequate to determine the role of VOC. A similar statement can be made regarding formaldehyde, for which a detection limit of 0.1 ppm was stated. That concentration of formaldehyde is known to cause adverse reactions in sensitive individuals. A detection limit of 20 to 40 ppb is far more appropriate.
- The environmental measurements fell short of the general standards that have evolved in the indoor air field. Inappropriate industrial hygiene sampling devices and detection limits were applied to a nonindustrial environment, and the results, not surprisingly, are largely speculative and unconvincing. In the one area where the researchers felt there was a strong association (TSP and complaint prevalence), possible sample collection problems and lack of analysis of the collected dust samples indicate low professional standards of care.
- Detailed investigation and follow-up work were not done by the investigating team due to time constraints, according to the discussion in the conference transcript. When an investigation cannot be completed satisfactorily in the minds of the investigators, it should be presented and published with appropriate caveats. It is extremely difficult to perform high-quality investigations; there are always important constraints in field situations. It is essential that investigators identify and acknowledge those constraints in analyzing their data, recommending remedial measures, and reporting their results.

Telephone Interview with Authors

IAQU spoke with epidemiologist Carl Armstrong, the lead author on the paper. We explained some of our criticisms of the work and asked for comments. Dr. Armstrong said he thought we might be judging the work by a research standard.

"We are just a plain old health department trying to address real building complaints," Armstrong said. "We have no formal program on indoor air, no funding for indoor air, and no employees in a program dedicated to indoor air. We are sort of doing these investigations in our spare time, so to speak.

"The equipment we have at hand was purchased for other purposes. We do what we can.... The focus of the study was epidemiologic, not sampling. In general we would advocate more of an engineering approach than just a shotgun sampling approach. In this particular investigation we did more sampling than we usually do."

We asked Armstrong if there had been any remediation or follow-up work. He said, "There has been remediation in terms of correcting and improving the filtration system and the housekeeping. We have not heard of further complaints." He said the health department has not done a follow-up investigation to determine whether the prevalence of symptoms has diminished.

Armstrong said EPA needs to develop suggested guidelines on exactly these issues: what constitutes an appropriate building investigation and what are the instruments that are available, appropriate, and affordable to do this kind of investigation. [In fact, EPA currently has such a publication in progress through one of its contractors. The publication is expected to be available later this year.]

Armstrong referred us to one of his two co-authors, Peter Sherertz, who told *IAQU* that the health department was asked by the governor's office to conduct the study and write the report within a three-week period. The Virginia Health Department has no equipment or personnel for environmental monitoring, he said.

Sherertz told us that they acquired all the equipment from the Virginia OSHA and used industrial hygiene personnel from labor and industry from all over the state to do the work. They used what was available. They could not size-fraction the particle sample with the equipment that was available.

The study started as an epidemiologic study. Then it became clear that there was a need to do environmental sampling to satisfy the concerns of the occupants. At one point, Sherertz said, they inspected the air intakes on the ground floor and there were no filters in place at that time. The building mechanics were the source of the estimates of the efficiency of the ESP and the investigators observed that the outside air intake damper was in the 20% outdoor air position.

Sherertz said: "We have come a long way since that project in the way we conduct indoor air studies. Eighty to 90% of all indoor air quality problems relate to ventilation."

Implications

- In our opinion, the Virginia investigation illustrates some important indoor air issues. As building operators and occupants become more aware of IAQ problems, building owners and operators are pressed to find qualified, experienced IAQ investigators. Many industrial hygienists and public health professionals who lack IAQ experience approach problem building assessment with inappropriate methods. They also lack the experience to interpret their findings.

  Qualified health scientists and industrial hygiene professionals require additional experience and knowledge to conduct a valid, competent indoor air quality survey. In these days of rapid growth in the IAQ field, it is important that technical qualifications of investigators include prior experience in IAQ investigations. If lacking, they should receive substantial guidance from others who do have such experience.

- It is disappointing that the reviewers for ASHRAE, the preeminent private sector source of wisdom in the IAQ field, failed to recognize the study's obvious inadequacies. The publication of this investigation in the proceedings of IAQ '89 makes us question the judgment of those responsible for accepting the paper.

- We should take serious note of the problems associated with quality control. It is likely that there are countless numbers of well-intentioned, under-funded, inexperienced IAQ investigators in the "real world." Inappropriate and inadequate investigations can increase occupant frustration and hostility, and they can leave serious health threats unattended. They can also mistakenly identify problems leading to costly, unnecessary, or ineffective remedial efforts.

The IAQ community needs to find ways to improve the quality of work that is done and minimize inadequate and inappropriate investigations. A large injection of governmental funding and support will be required to accomplish those objectives. If it does not occur, large sums of money and other resources will be wasted or poorly invested in inadequate indoor air problem investigations and solutions.

For More Information

C. W. Armstrong, P. C. Sherertz, and G. Llewellyn, "Sick Building Syndrome Traced to Excessive Total Suspended Particulates (TSP)," in *The Human Equation: Health and Comfort*, Proceedings of the ASHRAE SOEH Conference, IAQ '89, April 17-20, 1989, San Diego, California. Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. 1990. pp. 3-7. (See Information Exchange for how to obtain a copy.)

Bureau of Toxic Substances, Division of Health Hazards Control, Virginia Department of Health, Richmond, VA. For epidemiology: Carl W. Armstrong, (804)786-6029. For environmental monitoring: Peter Sherertz, (804)786-1763. ♦

News and Analysis

ASHRAE Publishes Standard 90.1-1989 on Energy Conservation

ASHRAE has published the revised standard for energy conservation, Energy Efficient Design of New Buildings Except New Low-Rise Residential Buildings. Many times we have heard engineers use the requirements of Standard 90A-1980 (and the predecessor Standard 90-75), "Energy Conservation in New Buildings," as a rationale for not providing more outside ventilation air. The new standard addresses the ventilation requirements by referencing the old IAQ ventilation standard 62-1981.

Specifically, Section 9.4.7, "Ventilation," states: "Ventilation systems shall be designed to provide outdoor air ventilation rates in accordance with 6.1.3 through 6.1.5 of ASHRAE Standard 62-1981. Exception: Outdoor air quantities may be greater if required because of special occupancy or process requirements, source control of air contamination, or local codes."

We interpret the "Exception" statement to support using the outside air quantities required for good indoor air quality. Conservative interpretations will argue that where smoking is prohibited, five cfm per person is sufficient outside air ventilation. More explicit guidance is absent.

Referencing the 1981 version of Standard 62 leaves the energy conservation standard in conflict with the current version (1989) of the ventilation standard. This is a result of the adoption process. ASHRAE publishes draft standards for public comment, considers comments, and moves the standard through to adoption. This process can take one to two years. In that time, many referenced documents are updated. But the standard adoption process rules require that no substantive changes be made to the public review draft without additional public review.

... And ASHRAE Revises Standard 62-1989, Already!

ASHRAE Standards 62-1989 and 90.1-1989 have similar problems of references to outdated documents. In fact, some of the appeals at the time Standard 62 was adopted were protests of references which had not been part of the public review draft. The project committee that developed Standard 62-1989 has been amending it to incorporate the more recent versions of documents such as EPA's National Ambient Air Quality Standards (NAAQS) and ASHRAE's own handbook volumes.

We hope the Standard 90.1-1989 committee will amend that standard to update the ventilation requirement reference to reflect the values in Standard 62-1989.

Copies of Standard 90.1-1989 and Standard 62-1989 are both available from ASHRAE, 1791 Tullie Circle NE, Atlanta, GA 30329; (404)636-8400. ♦

Information Exchange

Problem Buildings from State of the Art Reviews

Drs. James Cone and Michael Hodgson are the editors of a new indoor air quality book that combines medical, engineering, and industrial hygiene perspectives of indoor air problems. The focus of the book — titled *Problem Buildings: Building Associated Illness and the Sick Building Syndrome* — is the causes, assessment, and solution of "problem buildings." It includes limited explicit information on prevention, but it clarifies causes and diagnosis; this can provide guidance for preventive actions.

Although the book was written (and published) for the occupational physician as part of a quarterly series entitled "State of the Art Reviews in Occupational Medicine," most engineers, architects, industrial hygienists, and others involved with indoor air quality investigation, control, and remediation will find it very useful. It also serves as an excellent introduction to the subject for facilities management personnel.

Cone and Hodgson work on indoor air quality and other occupational health problems at occupational health clinics at the University of California, San Francisco, and the University of Pittsburgh respectively. Hodgson currently serves as chairman of ASHRAE's Environmental Health Committee, the group within ASHRAE with explicit, ongoing responsibility for indoor air quality issues.

The contents indicated by the chapter titles range from epidemiology to building bake-outs, from ventilation system problems to a protocol for comprehensive evaluations of building-associated illness. Several chapters contain material not previously presented or covered (as far as we know). A listing of selected chapter titles and their authors appears in Table 7.

To obtain a copy, contact the publisher: Hanley & Belfus, Inc., 210 South 13th Street, Philadelphia, PA 19107, U.S.A.; (215)546-7293. The cost is $29 per copy. ♦

Table 7 — Selected Chapter Titles and Authors in *Problem Buildings*

"The Epidemiology of Building-Related Complaints and Illness." Kathleen Kreiss.

"Clinical Diagnosis and Management of Building-Associated Illness and Sick Building Syndrome." Michael Hodgson.

"Social and Organizational Factors in Office Building-Associated Illness." Dean Baker.

"Role of Ventilation in the Causation of Building Associated Illnesses." Phil Morey and Douglas Shattuck.

"Volatile Organic Compounds and the Bake-Out Protocol." John Girman.

"Indoor Air and Infectious Disease." Harriet Burge.

"Cost Avoidance and Productivity in Owning and Operating Buildings." James Woods.

"Protocol for the Comprehensive Evaluation of Building-Associated Illness." Patricia Quinlan, Janet M. Macher, Leon E. Alevantis, and James E. Cone.

The Human Equation: Health and Comfort

ASHRAE has finally published the proceedings from the IAQ '89 conference held last April, the latest in ASHRAE's annual series of IAQ meetings, which started in 1986. The title of the 280-page large-format publication is the same as the conference: *The Human Equation: Health and Comfort.*

Last year ASHRAE joined the Society for Occupational and Environmental Health in sponsoring the conference. The theme of the conference reflects the collaboration and scopes of the two organizations. However, we think the conference did not dramatically increase the health emphasis compared with earlier conferences.

A large number of outstanding papers were presented at the 1989 conference. We reported on some of them in the May issue of *IAQU*. Elsewhere in this issue we describe two papers we consider significant: a study by Virginia health department researchers on TSP and IAQ complaints, and a University of Pittsburgh study where contaminants were measured at each work station. In fact, there are many interesting and valuable papers in the proceedings, and we encourage our readers to obtain a copy.

Copies are available from ASHRAE, 1791 Tullie Circle NE, Atlanta, GA 30329; (404)636-8400. The cost is $65, $44 for ASHRAE members.

Indoor Air Pollution Control

Lewis Publishers has just released an excellent overview of indoor air pollution and its control. This book should be of special interest to *IAQU* readers because it emphasizes **indoor air quality control**. However, much of the book is implicitly or explicitly focused on residential rather than commercial IAQ problems.

Thad Godish has written the book based on his many years of experience as a researcher and consultant on IAQ problems. Unlike many other researchers in the field, his focus has always been more on control and solutions to IAQ problems. We are pleased to see that he has assembled his vast knowledge and experience into a readable text.

Indoor Air Pollution Control is a welcome addition to the literature in the field, and, for the time being, is probably the most useful single book for those interested in problem prevention and control, particularly in residential and small commercial building environments. The book also discusses the nature of indoor air quality problems as a background for the presentations of control strategies and techniques. Its 401 pages are well organized, clearly illustrated, and a valuable addition to the air quality investigator or specialist's library.

Available from Lewis Publishers, 121 South Main Street, Chelsea, MI 48118; (313)475-8619. Cost is $59.95 per copy. ♦

"Measuring Ventilation Using Tracer Gases"

A useful booklet on ventilation is now available free from Brüel and Kjær, the Danish instrument maker. The booklet answers some basic questions about measuring ventilation using tracer gas. It explains some of the techniques and terminology used and gives some application examples.

The booklet is fully illustrated in a clear, easy-going style. While it makes ventilation measurement understandable to the novice, it is adequately supported with calculation methods and equations to provide the technical individual with access to ventilation measurement technology.

Too often we see reports of indoor air quality measurements without corresponding reports of ventilation rates during the sample collection. Because ventilation rates significantly affect airborne concentrations of most contaminants, reports lacking rate data are difficult to interpret. Certainly remedial or regulatory actions should not be based on such reports unless the contaminant concentrations are considerably above the appropriate guideline or target value or an immediate threat to occupant health is suspected.

Measuring ventilation rates correctly is neither cheap nor easy in most buildings. However, as more measurements are made in more buildings, it is possible that algorithms can be developed to allow reasonably accurate estimates based on fewer, easier-to-measure parameters. In the meantime, when extensive environmental measurements are made to assess indoor air quality, ventilation rates must be characterized to enable responsible interpretation of the results.

Brüel & Kjær has long been a manufacturer of high-quality environmental monitoring instruments. Its close association with many professional and academic indoor air quality investigators over the years has allowed it to stay on the cutting edge of the field. This new booklet is a valuable contribution.

To obtain a free copy, write to Brüel & Kjær World Headquarters, DK-2850 Nærum, Denmark; Telephone +45 42 80 05 00. In the U.S., phone (508)481-7000.

From Our Readers

Correction on the Mitchell IAQ Bill

A careful anonymous reader at EPA has informed us that we erroneously reported a change in the Mitchell IAQ bill. The Senate amended version does not **transfer** "...responsibility from EPA to OSHA for the comprehensive assessment of exposure of workers in non-industrial settings...." It actually requires EPA to **share** that responsibility with OSHA and NIOSH for the assessment. Our thanks for the tip. ♦

Calendar

March 28-29. **ASHRAE Professional Development Seminar: Indoor Air Quality.** Dallas, Texas. Contact: Education Coordinator, ASHRAE, 1791 Tullie Circle N. E., Atlanta, GA, 30329; (404)636-8400, Fax: (404)321-5478.

April 4-6. **Excellence in Housing '90** — Eighth Annual International Energy Efficient Building Conference and Exposition. Denver, Colorado. Sponsored by Energy Efficient Building Association, University of Southern Maine, Technology Center, Gorham, ME 04038; (207)780-5143, Fax: (207)780-5129.

April 23-27. **Improving IAQ in Non-Industrial Buildings.** Piscataway, New Jersey. Contact: Doris Daneluk, Program Coordinator, Robert Wood Johnson Medical School, Brookwood Plaza II, 45 Knightsbridge Rd., Piscataway, NJ 08854; (201)463-5062, Fax: (201)463-5233. Fee is $700.

April 24-26. **ASTM Subcommittee D22.05 on Indoor Air.** San Francisco, California. Contact: George Luciw, ASTM Headquarters, 1916 Race Street, Philadelphia, PA 19103; (215)299-5571.

April 26-27. **Blueprint for A Healthy House Conference.** Cleveland, Ohio. Contact: Al Wasco, Housing Resource Center, 1820 W. 48 Street, Cleveland, OH 44102; (216)281-4663.

April 30-May 4, 1989. **Measurement of Toxic and Related Air Pollutants.** Raleigh, North Carolina. Contact: Sandy Riley, Meetings Department, Air & Waste Management Association, P.O. Box 2861, Pittsburgh, PA 15230; (412)232-3444. *A&WMA is a non-profit technical and educational organization with nearly 10,000 members in more than 50 countries. Founded in 1907, the association provides a neutral forum where all viewpoints of an environmental issue (technical, scientific, economic, social, political, and health-related) receive equal consideration.*

May 3-4. **Indoor Air Pollution: The Sources, Effects, Liabilities, Research & Control.** Tulsa, Oklahoma. Contact: Sherry Haskin, Division of Continuing Education, University of Tulsa, 600 South College Avenue, Tulsa, Oklahoma 74114; (918)631-2347.

May 17-18. **ASHRAE Professional Development Seminar: Indoor Air Quality.** Detroit, Michigan. Contact: Education Coordinator, ASHRAE, 1791 Tullie Circle N. E., Atlanta, GA, 30329; (404)636-8400, Fax: (404)321-5478.

June 9-13. **ASHRAE Annual Meeting and Technical Conference.** St. Louis, Missouri. Contact: ASHRAE Meeting Section, 1791 Tullie Circle N. E., Atlanta, GA, 30329; (404)636-8400, Fax: (404)321-5478.

June 24-29, 1990. **Air & Waste Management Association 83rd Annual Meeting.** Pittsburgh, Pennsylvania. Contact: A&WMA, P.O. Box 2861, Pittsburgh, PA 15230; (412)232-3444.

August 26-September 1, 1990. **ACEEE 1990 Summer Study on Energy Efficiency in Buildings.** Asilomar (Monterey), California. American Committee for an Energy-Efficient Economy. Contact: ACEEE Summer Study Office, c/o Ed Vine, Building 90H, Lawrence Berkeley Laboratory, Berkeley, CA 94720.

October 1-5. **International Conference on Environmental Ergonomics IV.** Austin, Texas. Contact: Dr. Eugene H. Wissler, Department of Chemical Engineering, The University of Texas at Austin, Austin, TX 78712-1062; (512)471-7213, Fax (512)471-7060; or, Dr. Sarah A. Nunneley, USAF School of Aerospace Medicine, USAFSAM/VNC Brooks Air Force Base, San Antonio, TX 78235; (512)536-3814.

October 16-19. **Indoor Radon and Lung Cancer: Reality or Myth?** 29th Hanford Symposium on Health and the Environment. Richland, Washington. Inquiries should be addressed to Fred T. Cross, Symposium Chairman, Battelle PNL, P.O. Box 999, Richland, WA 99352; (509)375-2976.

October 29-31, 1990. **ASTM Subcommittee D22.05 on Indoor Air.** San Antonio, Texas. Contact: George Luciw, ASTM Headquarters, 1916 Race Street, Philadelphia, PA 19103; (215)299-5571.

INTERNATIONAL

April 24-26. **Indoor Air Quality and Ventilation in Warm Climates.** Lisbon, Portugal. Conference registration: Secretariat International Indoor Air Quality & Ventilation Conference, British Occupational Hygiene Society, 1 St. Andrew's Place, London NW1 4LB, UK.

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

July 29-August 3. **5th International Conference on Indoor Air Quality and Climate.** Toronto, Ontario, Canada. Contact: Dr. Douglas S. Walkinshaw, Canada Mortgage & Housing Corp., 682 Montreal Road, Ottawa, ON K1A OP7, Canada; (613)748-2714.

September 3-6. **Energy, Moisture, Climate in Buildings.** Rotterdam, The Netherlands. Contact: Mr. G. de Vries, Bouwcentrum, Weena 760, P. O. Box 299, 3000 AG Rotterdam, the Netherlands.

A Word to the Wise...

"For every complicated problem there is an answer that is short, simple, and wrong." H. L. Mencken, as quoted by Hunter Lovins in *Greenpeace*, January/February 1990. We find this statement particularly appropriate for IAQ problems.

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