EPA Inside IAQ

EPA's Indoor Air Quality Research Update
Office of Research and Development

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This issue of *Inside IAQ* is the second in a series of reports on EPA's Office of Research and Development's (ORD's) indoor air research. *Inside IAQ* covers indoor air research conducted by EPA's four ORD components located in Research Triangle Park, NC: the Air and Energy Engineering Research Laboratory (AEERL), the Atmospheric Research and Exposure Assessment Laboratory (AREAL), the Environmental Criteria and Assessment Office (ECAO), and the Health Effects Research Laboratory (HERL). Indoor air research conducted by ORD's Environmental Monitoring Systems Laboratory (EMSL), located in Cincinnati, OH, is also included.

The primary goals of *Inside IAQ* are to communicate EPA's indoor air research results in a timely manner and to provide sources of more detailed technical information. *Inside IAQ* is distributed twice a year. If you would like to be added to the mailing list, please refer to the last page.

EPA's Indoor Air Research Program

The goals of EPA's Indoor Air Research Program are to: 1) improve the scientific understanding of indoor air pollution health risks and techniques to reduce these risks, 2) provide critical scientific information to EPA program offices and regions in support of developing, implementing, and evaluating risk management options, and 3) promote private sector involvement in identifying, understanding, and addressing important indoor air pollution problems.

The Program covers five multidisciplinary areas:

- Source Characterization
- Exposure Assessment
- Health Effects
- Risk Assessment
- Solutions

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Research Project Highlights

The following sections provide information on 11 ORD indoor air research projects. The research topics included in this issue are: International Comparison of Small Chambers ■ Methods for Characterization of Biocontaminant Sources ■ Development of Gene Probes for Identification of Fungi ■ Development of Methods for Recovery of Aerosolized Fungi ■ Development and Testing of a Personal Whole Air Sampler ■ Results of EPA Carpet Emissions Tests ■ Health Effects Research on Exposure to NO_2 ■ Use of a High-Volume Small Surface Sampler for the Microbiological Evaluation of Dust ■ Pollution Prevention Research ■ Evaluation of In-Duct Particulate Air Cleaners ■ Catalog of Materials as Potential Sources of Indoor Air Emissions

Source Characterization Research

International Comparison of Small Chambers

EPA recently participated in an international study that compared small chamber measurements of volatile organic compound (VOC) emissions. The purpose of the comparison was twofold: 1) to obtain experimental validation of the various small chamber measurement guidelines used internationally, and 2) to assess the comparability of the results obtained by 20 different laboratories.

The experiment was conducted using three materials. The first material tested was a source that emitted n-dodecane at a known rate. The objectives of this test were to check for sinks and possible problems with the chambers and to determine the accuracy of the analytical procedure.

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The second material tested was polyvinyl chloride flooring material. The laboratories were asked to determine the emission rate for four compounds (phenol, 1,2,4-trimethylbenzene, n-decane, and n-undecane) and for total volatile organic compounds (TVOCs) at 48 and 72 hours.

Water-based floor wax was the third material tested. The participants were requested to use an average wax layer thickness of 0.05 mm. Sampling was carried out at 10 different times in order to determine the concentration/time curve for four compounds (α-pinene, linalool, geraniol, and α-cedrene) and for TVOCs.

No method was prescribed for VOC sampling and analysis, and each investigator was free to use his/her usual procedure. However, it was requested that TVOC concentrations be reported as toluene equivalents.

Results from the 20 participating laboratories showed that chambers of different materials (5 glass and 18 stainless steel) and of widely different capacities (0.035 to 1475L) appeared equally suitable. The repeatability of duplicate measurements (including sampling) within each laboratory was good.

The analysis for n-dodecane showed, for most laboratories, an unexpected and yet unexplained discrepancies. Hypotheses which might explain these discrepancies include irreversible or very slowly reversible sinks in the chambers, error in the flowrate determination, error in the analytical system, error in weight loss measurement, and inadequate chamber mixing.

The interlaboratory agreement appeared reasonable (coefficient of variation 26 - 42%) with the tile, but the scatter was very high for the wax. At least three kinds of difficulties seem to have occurred with the wax test: 1) chamber difficulties such as chamber sink effects or highly scattered data; 2) analytical difficulties; and 3) curve fitting difficulties. (EPA Contact: Bruce A. Tichenor, AEERL, 919-541-2991)

Source Characterization Research

Methods for Characterization of Biocontaminant Sources

AEERL and Research Triangle Institute are developing two methods for evaluating indoor biocontaminant sources. The first method uses static chambers (32 x 39 x 51 cm) and saturated salt solutions. This method can be used to assess the ability of indoor materials to support the growth of microbials such as fungi, bacteria, and dust mites. Both qualitative and quantitative analyses are used to characterize the microbial growth. Four types of ceiling tiles and two duct lining materials have been tested in these static chambers to validate the methodology. A standard guide for the static chamber test method is currently under review by the American Society of Testing and Materials (ASTM) Subcommittee D22.05.06.

The second method for evaluating biocontaminant sources uses a dynamic chamber (2.44 x 2.44 x 2.44 m). Continuous air flow through the chamber is provided to simulate a typical room, and the air mixing pattern in the chamber is controlled by a ceiling fan. Aerolized spores can be injected into the chamber, and the growth of biocontaminants on various sources can be monitored through observation windows. The chamber can also be used to evaluate in-room air cleaners (EPA Contact: John C.S. Chang, AEERL, 919-541-3747)

Exposure Assessment Research

Development of Gene Probes for Identification of Fungi

Current methods for identifying fungi in air samples are dependent on culturing the organisms, followed by detailed morphological examinations, both of which are time consuming and difficult methods. As a result, EMSL is researching the feasibility of developing molecular-based detection methods using polymerase chain reaction (PCR) amplification of small subunit ribosomal RNA genes. These genes were chosen because: they are present in all organisms; they contain highly conserved sequence regions which can serve as priming sites for PCR amplification; and they contain variable sequence regions which can serve as target sites for genus or species specific DNA probes.

The first phase of this project is to establish a data base of small subunit ribosomal RNA gene sequences from fungal species identified as being common to indoor environments and/or having potential adverse health effects. Data, thus far, indicate sufficient sequence diversity to allow the construction of species-specific probes. (EPA Contact: Gerard N. Stelma, Jr., EMSL, 513-569-7384)

Exposure Assessment Research

Development of Methods for Recovery of Aerosolized Fungi

EMSL and researchers at Georgia State University have been evaluating a variety of commercial and experimental growth media. The goal is to develop a standardized method for collecting the broadest possible spectrum of indoor fungi.

The media were first tested for their ability to quantitatively recover aerosolized fungi commonly found in indoor air. The best media are now being evaluated in the field to determine which recover the broadest spectrum of fungi.

Field tests conducted in a number of buildings in the Southeast U.S. are nearly complete. The results indicate that a set of three media used concurrently allows the best recovery of the widest variety of fungal species. This set of media will be evaluated in a second independent laboratory in 1994. (EPA Contact: Gerard N. Stelma, Jr., EMSL, 513-569-7384)

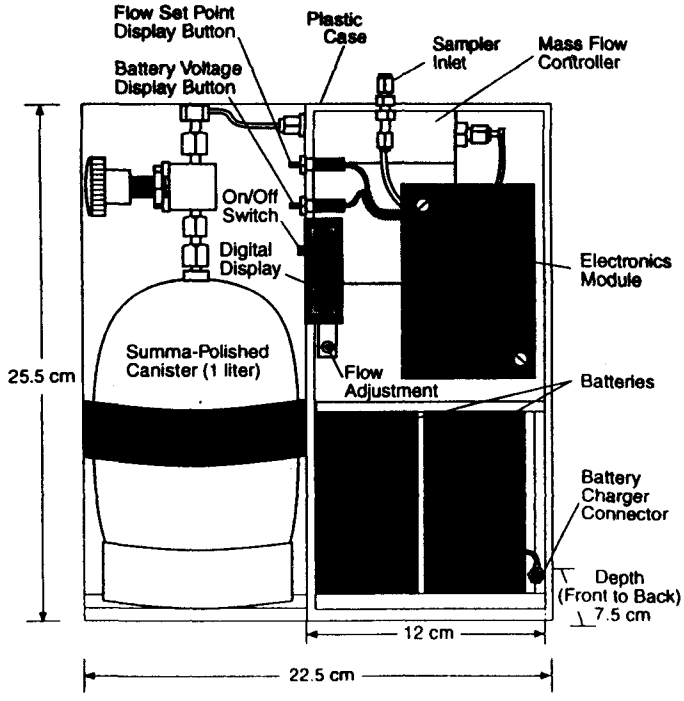
Exposure Assessment Research

Development and Testing of a Personal Whole Air Sampler

Research Triangle Institute and AREAL have developed and evaluated a small, lightweight personal whole air sampler. The sampler can be worn to monitor personal exposures to VOCs and is suitable for large-scale population-based exposure studies.

The prototype sampler is 25.5 cm high, 22.5 cm wide, and 7.5 cm deep. With a 1-L SUMMA sample canister in place, the unit weighs 3.35 kg. The unit uses rechargeable batteries that operate for approximately 16 hours. The batteries, electronics module, and flow controller are enclosed in a plastic case. The sampler can be placed in a laptop computer carrying case or carried over the shoulder. The unit could also be used as a compact microenvironmental sampler.

Laboratory testing of the unit demonstrated that the sample flow rate was not affected by temperature or the activity of the person wearing the sampler. Recoveries of methylene chloride, chloroform, 1,1,1-trichloroethane, benzene, n-octane, o-xylene, n-decane, and p-dichlorobenzene averaged 89% or higher for three final prototype samplers. Recoveries were slightly lower for vinyl chloride (74%) and n-dodecane (82%). The precision for the three prototype samplers was excellent during laboratory tests. Further evaluation of the sampler is required to fully validate its performance under field conditions. (EPA Contact: Andy Lindstrom, AREAL, 919-541-4866)



Personal Whole Air Sampler.

Health Effects Research

Results of EPA Carpet Emissions Tests

In 1992 Anderson Laboratories, a private testing company, reported that the off-gassing of certain "complaint" carpets caused sensory and pulmonary irritation, neurobehavioral effects and, in the most extreme cases, death, in exposed mice. Based on these test results, HERL and AEERL initiated a study to replicate the Anderson results.

Results from the EPA tests showed that, based on the assessment of respiratory irritation, neurobehavioral effects, measures from a general toxicity screen, and evaluation of carpet contaminants and emissions, there was no indication that exposure to emissions from the two carpets tested posed a serious health risk.

In the HERL and AEERL study, two standard test methods using laboratory mice, one for estimating sensory irritancy and the other for evaluating the neurotoxic potential of chemicals, were coupled with a postmortem assessment. The postmortem evaluation included measurements of hemoglobin, serum clinical chemistries, blood and lung lavage white cell counts, organ weights, and a gross necropsy with a microscopic evaluation of all major organs.

Three tests were run: two with preheated carpet emission exposures and one with a preheated control exposure. No toxic effects were observed from exposure to the two tested carpets. However, clinical chemistry and histopathological alterations were observed with exposure to both the control air and the carpet emissions when compared to the non-exposed, unrestrained control mice. These results indicate that the alterations were caused by the exposure procedure rather than the carpet emissions.

A detailed chemical and microbial evaluation of the carpets and their emissions was also performed. Pesticide residues, microbiological flora, and over 200 VOCs were present, but at insufficient quantities to result in acute toxicity.

A technical paper, detailing the EPA study, has been submitted to the Journal of the American Industrial Hygiene Association and should be published in 1994. To assist in better understanding the varying results between the EPA and the Anderson tests, the next step for EPA researchers will include discussions with physicians with experience in treating patients that associate health problems with carpet exposure. (EPA Contact: Robert Dyer, HERL, 919-541-2760)

Health Effects Research

Health Effects Research on Exposure to NO_2

Nitrogen dioxide (NO_2) is a common indoor air pollutant, especially in homes with unvented combustion appliances. Epidemiological studies suggest that children living in homes with elevated levels of NO_2 are more prone to respiratory infections than children living in homes with lower levels of NO_2.

The objective of this study by HERL was to investigate whether inflammation is induced by exposure to 2.0 ppm of NO_2 and whether alveolar macrophage host defense functions are altered.

In this study, 10 healthy adults (males and females, 22-35 years old) were exposed to either 2.0 ppm of NO_2 or filtered air for 4 hours while undergoing intermittent moderate exercise. Changes in a number of cellular and biochemical parameters, in both the airways and alveolar region of the lung, were measured.

Cells and fluid lining the lung passages of the volunteers were removed by bronchoalveolar lavage 16 hours after the exposure to NO_2. The lavage was divided into two parts: one which samples primarily the large airways of the lung (bronchial fraction) and one which samples the gas exchange region (alveolar fraction). Subjects exposed to NO_2 had a 3-fold increase in inflammatory cells (neutrophils), and a 1.5-fold increase in α-1 antitrypsin, an anti-inflammatory protein, in the lungs. There were no other changes in cells or biochemical mediators found in the bronchial fraction, and no significant changes found in neutrophils or biochemical mediators in the alveolar fraction. However, alveolar macrophages, the body's first line of defense against inhaled microorganisms, showed a decrease in ability to engulf yeast particles as well as a decrease in production of superoxide anion, a compound involved in killing microorganisms.

The results of this study showed evidence of mild inflammation in the large airways but not the alveoli of humans exposed to NO_2. In addition, NO_2 exposure resulted in a decrease in ability of alveolar macrophages to engulf and kill microorganisms.

A complete copy of this paper is available in the Indoor Air '93 Proceedings. (EPA Contact: Robert Devlin, HERL, 919-966-6255)

Risk Assessment Research

Use of a High-Volume Small Surface Sampler for the Microbiological Evaluation of Dust

Research Triangle Institute and ECAO have adapted a high volume small surface sampler for collection of microbials in surface dust. The sampler was previously developed by AREAL for the collection of residential carpeted and non-carpeted surface dust for pesticide and lead analysis. The major adaptations involve disinfecting the unit, using sterile polypropylene bottles to collect samples, and special bags on the exhaust of the unit.

Results show that the sampler can be used to collect surface dusts for the analysis of viable molds, yeasts, bacteria, endotoxins, and dust mite guanine on both carpeted and non-carpeted surfaces. Protocols for using the sampler are being developed. In addition, bioaerosol monitoring will allow the relationship between surface and airborne microbial concentrations to be evaluated.

The sampler has been tested on surfaces in two buildings (designated as A and B). Building A has routinely maintained carpeted and tiled floors. The carpeted floor surface of Building B did not appear to be routinely maintained and was noticeably soiled. Results from the sampling are shown in Figures 1, 2, and 3 for surface dust loading, fungi, and endotoxins, respectively. The microbiological composition of the surface dusts from the buildings was found to be similar to that of ordinary outdoor dirt. Microbial concentrations were higher in the carpet floor dust than in tile dust in both buildings. Dusts in building A had insignificant levels of endotoxin; however, Building B levels are elevated. Dust mite guanine was not detected in any of the dust samples. (EPA Contact: Mike A. Berry, ECAO, 919-541-4172)

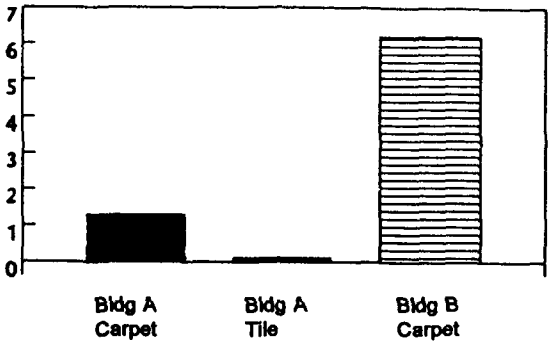


Figure 1. Surface Dust Loading (g/m^2)

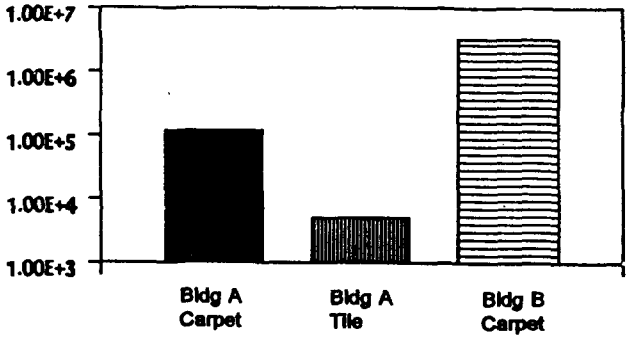


Figure 2. Fungi Concentrations (CFU/g of dust)

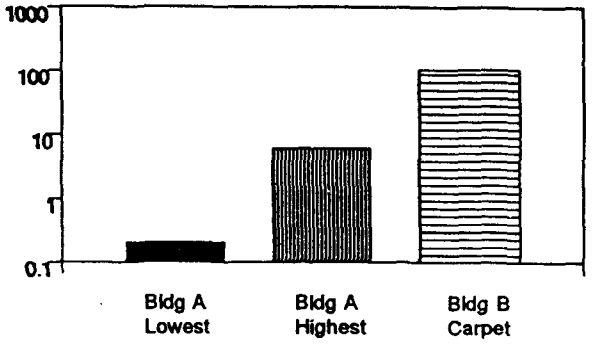


Figure 3. Endotoxin in Surface Dust (µg/g of dust)

Pollution Prevention Research

AEERL is researching various pollution prevention techniques (i.e., equipment or technology changes, process or procedure modification, reformulation or redesign of products) in order to reduce indoor air pollution through the development of low-emitting or low-impact materials. AEERL has initiated cooperative agreements in four different project areas for this research: aerosol consumer products, composite wood products, office equipment and products, and textiles.

Aerosol Consumer Products - The three objectives of this research project are to: 1) characterize emissions from aerosol consumer products as a function of time; 2) develop methods and models to measure and predict emissions and personal exposures; and 3) develop pollution prevention techniques and guidelines for the manufacture and use of these products. The research is being performed by Georgia Tech Research Institute, the University of Illinois, and Purdue University. (EPA Contact: Kelly Leovic, AEERL, 919-541-7717)

Composite Wood Products - This project focuses on the development of low emitting/low impact composite wood products. A product list will be developed and screened to determine emission characteristics and pollution prevention opportunities. Products offering opportunities for pollution prevention will then be selected for further research. Studies of manufacturing processes then will be implemented, and recommendations for lower emitting products will be made. The research will be conducted by Research Triangle Institute. (EPA Contact: Betsy Shaver, AEERL, 919-541-7915)

Office Equipment and Products - The objectives of this research project are to collect emissions data from office equipment and products, to identify the sources of these emissions, and to develop pollution prevention approaches to reduce or eliminate emissions from selected equipment/products. The research will be conducted by Research Triangle Institute and Underwriters Laboratories. (EPA Contact: Kelly Leovic, AEERL, 919-541-7717)

Textile Products - Five research projects are underway at the College of Textiles at North Carolina State University: 1) VOC emissions (e.g., formaldehyde) from finishes used on fabrics - A number of fabric and finish combinations have been surveyed and five have been selected for further study; 2) Fiber-based alternatives for plywood and particleboard - Initial research has resulted in several potential products, and these products will be tested for structural characteristics and VOC emissions; 3) Fusion bonding equipment - Emissions will be characterized for the most common fusion bonding materials, and research will determine process changes to reduce emissions; 4) and 5) Effects of physical and chemical structure on adsorption and emissioncharacteristics of textiles - Selected materials will be tested and a model will be developed. (EPA Contact: James White, AEERL, 919-541-1189)

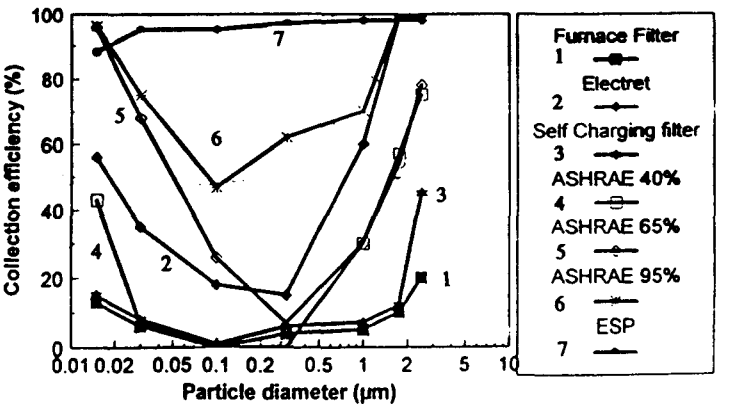
Evaluation of In-Duct Particulate Air Cleaners

AEERL has conducted an extensive evaluation of in-duct air cleaners. The evaluation included determining efficiency as a function of particle diameter for both clean and dirty air cleaners. The differential pressure across the filters was also evaluated because of its effect on energy consumption and the quantity of air moved through the filter. Commonly used air cleaners were included in the study: electrostatic precipitators (ESPs), high efficiency filters, common furnace filters, industrial American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) rated filters, and electrostatically augmented filters.

The ESP air cleaners offered the highest particle collection efficiency for all particle diameters and the lowest pressure drop. The performance of the ESPs was not affected by dust loading. The ESPs did, however, generate a few parts per billion of ozone. The ozone can be controlled by carbon filters located after the air cleaner. The filters would require occasional (i.e., annual) changing.

The high efficiency filters provided high particle collection efficiency but had much higher pressure drops than the ESPs. Commonly used furnace filters and the industrial ASHRAE rated filters had low particle collection efficiency, especially in the 0.2 to 2 μm diameter range.

The electrostatically augmented air cleaner based on electret technology provided improved performance compared to a furnace filter when clean. However, the performance of the filter was significantly reduced when the filter was dirty. The other type of electrostatically augmented filters tested did not show any significant improvement compared to a furnace filter. In addition, the pressure drops across the filter increased as the filter became dirty.



Performance of Various In-Duct Particulate Air Cleaners.

The major conclusions from the evaluation are:

- ESPs and high efficiency filters are the only air cleaners that provide high (>90%) collection efficiency for particles in the 0.2 to 2 μm diameter range.
- High efficiency filters significantly increase the pressure drop in the heating, ventilating, and air-conditioning (HVAC) system which increases fan motor amperage draw and reduces total air flow. The ESPs do not.
- Electrostatically augmented air cleaners do not appear to provide significant performance benefits compared to common filters, especially when they become dirty.
- Particle collection efficiency of all filters, except the electret filter and ESP, increased as the filters became dirty.

The test methods developed during this study will form the basis for an air cleaner evaluation test method recommended to the private sector. (EPA Contact: Leslie Sparks, AEERL, 919-541-2458)

Solutions

Catalog of Materials as Potential Sources of Indoor Air Emissions

A variety of research efforts, both in the U.S. and internationally, have focused on materials as potential sources of indoor air emissions. These research efforts typically do not concentrate on any one group of products or standard sampling and analytical methods. In addition, there is little consistency in the terminology used to describe the products tested. This lack of consistency in test methods and terminology makes the data difficult to compare.

As a result, AEERL published the Classification of Materials as Potential Sources of Indoor Air Pollution (EPA-600/8-90-074; NTIS PB91-125708) in 1990. This report presented a classification of building materials, fixtures and furnishings, and consumer products used or found in homes or offices, regardless of their potential to emit.

Materials and products considered to be potential sources of indoor air emissions were then selected for further study. The objective then was to: 1) generate a useful scheme for presenting the variety of material sources in homes and offices; and 2) present available usage, constituent, and emissions data for these material sources. The results of this second study are to be presented in Volumes I and II of the Catalog of Materials as Sources of Indoor Air Emissions. Volume I of the catalog (EPA-600/R-93-108a; NTIS PB93-212041) was published in June 1993, and contains sections on: insulation products, wall coverings, resilient floor covering, carpet, adhesives, caulks and sealants, and pesticide products. Volume II of the Catalog, to be published early in 1994, will contain sections on: wood products, paints and coatings, foam products, fabricated rubber products, and mineral products.

Each section presents a classification scheme for the product category, sales and usage volume data, qualitative data on product composition, and quantitative and qualitative data on emission rates. Emissions information is presented only for VOCs as these are the compounds most likely to be emitted from materials found in homes and office buildings. Data tables summarizing available emissions and constituent data are provided and are organized according to a product classification scheme. (EPA Contact: James White, AEERL, 919-541-1189)

Summaries of ORD Papers in Indoor Air '93 Proceedings

ORD scientists and engineers co-authored 24 papers at Indoor Air '93 in Helsinki, Finland. Below are summaries of those papers, which should be available individually from National Technical Information Service (see address on page11). To purchase the proceedings from the organizers of Indoor Air '93, write or fax your request to: Indoor Air '93, P.O. Box 87, SF-02151 Espoo, Finland (Fax: +358-0-451 3611).

The summaries are organized into the following five sections: Science /Policy, Source Characterization, Exposure Assessment, Health Effects, and Solutions.

Science/Policy

Establishing Priorities in the U.S. EPA's Indoor Air Engineering Research Program (NTIS PB93-221984) - AEERL consulted researchers within government, industry, and academia to help identify and rank priority program areas for IAQ engineering research. Specific program elements include chemical source characterization, bioresponse testing, air cleaning, ventilation, biocontamination, cost/IAQ modeling, and pollution prevention. Recommendations included expansion of AEERL biocontaminant prevention/ control research. Lead Author & EPA Contact: Michael C. Osborne (919-541-4113).

Indoor Air Quality: Exploring Policy Options to Reduce Human Exposures - This plenary paper presents factors policymakers must consider in establishing IAQ policies and the role researchers can play in ensuring policies are based on the best available science. Examples cited are environmental tobacco smoke, radon, problem buildings, and ventilation standards. Lead Author & EPA Contact: Kevin Teichman (202-260-7669).

Indoor Air Quality: The U.S. Environmental Protection Agency's Research Strategy - EPA's IAQ research strategy is to identify, characterize, and compare the health risks associated with exposures to indoor air pollutants so that risk assessors and risk managers can

make informed decisions to protect public health. This strategy emphasizes the quantitative evaluation of indoor exposures and associated health effects as the basis for relative risk assessment of both pollutants and pollutant mixtures. For pollutants for which the potential risks are relatively well characterized (e.g., asbestos, radon, environmental tobacco smoke, and formaldehyde), research efforts focus on developing approaches to prevent or reduce indoor exposures. Lead Author, Ken Sexton. EPA Contact: Kevin Teichman (202-260-5900).

Source Characterization

Assessment of Fungal Growth on Ceiling Tiles Under Environmentally Characterized Conditions (NTIS PB93-222024) - Static chambers with defined relative humidity, temperature, and light conditions are being used to study the effect of building environment on microbial growth. Four types of ceiling tile (one aged, two mineral fiber/crystalline silica, and one fire resistant) were placed in the chambers, allowed to equilibrate, and inoculated with either *Penicillium glabrum* or *Aspergillus versicolor*. The critical bulk moisture content for organism growth varied depending upon tile type and test mold. Lead Author, K. Foade. EPA Contact: John C.S. Chang (919-541-3747).

Bioresponse Testing of Sources of Indoor Air Contaminants (NTIS PB93-222032) - This paper reviews the concept of "bioresponse" testing of emissions from sources of indoor air contaminants. Examples of bioresponse methods that measure human, animal, or *in vitro* biological responses to emissions are briefly described. The potential value of bioresponse methods for evaluating health and sensory comfort in relation to indoor sources is discussed and related to product testing. Lead Author & EPA Contact: W. Gene Tucker (919-541 - 2746).

Fundamental Mass Transfer Models for Indoor Air Pollution Sources (NTIS PB93-221992) - A simple model based on Fick's Law of Diffusion has been developed for wet solvent-based sources. In this model, the mass transfer rate is assumed to be gas-phase limited and controlled by the boundary layer mass transfer coefficient, the saturation vapor pressure of the material emitted, and the mass of volatile material remaining. Results of static and dynamic chamber tests, as well as test house studies, are presented. Lead Author & EPA Contact: Bruce A. Tichenor (919-541-2991).

International Comparison Experiment on the Determination of VOCs Emitted From Indoor Materials Using Small Test Chambers (NTIS PB93-222073) - An interlaboratory comparison used small test chambers to assess the agreement among laboratories for characterizing VOCs emitted from indoor materials and products. Results from this paper are highlighted under Research Project Highlights on pages 1 and 2 (International Comparison of Small Chambers). Lead Author, Angelo Colombo. EPA Contact: Bruce A. Tichenor (919-541 -2991).

Modeling of Alkane Emissions from a Wood Stain - The effects of organic emissions from wood stain were evaluated in a test house. Concentrations of three alkane species - nonane, decane, and undecane - were measured as a function of time. Results showed that the test house concentrations can be simulated by an integrated IAQ model taking into consideration source, sink, and ventilation effects. Sink effects in the test house were significant, and an inverse relationship between the test house sink strength and the volatility of the three alkane species was found. Lead Author & EPA Contact: John C.S. Chang (919-541-3747).

Exposure Assessment

A New House Dust Collection System and its Use in a Study of Asthma in Dust Mite Sensitive Children in Raleigh, North Carolina - A prototype dust collection system, the House Dust Vacuum One, was designed for use in a study to investigate the relationship between house dust mite antigen levels and the presence of wheeze in dust mite sensitive children. No significant differences in mean micro-environmental dust mite antigen levels were observed between samples from the homes of wheezers and nonwheezers. The new unit was determined to be well suited for surface dust and dust mite antigen collection studies. Lead Author, Frederick W. Henderson. EPA Contact: Andrew B. Lindstrom (919 541-4866).

Assessing Potential Exposures from Routine Use of VOC-Contaminated Groundwater - Residential measurements were made to assess potential exposures from the routine household use of VOC-contaminated groundwater. Measurements were based on a single 20-minute shower using groundwater containing 185-367 μg/L benzene. Personal doses estimated over the 6-hour experiment for occupants of the bathroom and living room were <135 μg and <80 μg benzene, respectively. The 20-minute shower resulted in an estimated total dose of 281 μg benzene (113 μg for inhalation and 168 μg for dermal). Lead Author and EPA Contact: V. Ross Highsmith (919-541-7828).

Association of Personal and Workplace Characteristics with Reported Health Symptoms of 6771 Government Employees in Washington, DC - An IAQ questionnaire was completed by 6771 government employees. Regression analyses on 12 clusters of health symptoms indicated that both personal and workplace characteristics were associated with symptoms. The variables associated with the largest number of symptoms at the two agencies studied were dry air/dusty office, chemical/paint odors, hot stuffy air, and sensitivity to chemicals. Other variables that were often significantly associated with symptoms were glare, carpet/drape odor, dust/mold allergy, career frustration, and job pressure/conflict. Lead Author & Contact: Lance Wallace (703-341-7509).

EPA Base Program--Collecting Baseline Information on Indoor Air Quality - EPA's Office of Radiation and Indoor Air and AREAL have begun a major study of

IAQ and occupant perceptions in public and commercial office buildings. A set of core measurements will be made for this Building Assessment Survey and Evaluation (BASE). The cross-sectional study will include approximately 200 buildings over the next three to five years. Measurements include environmental conditions in a representative sampling space in each building, an occupant questionnaire, and characterization of the building and the HVAC system. The information collected will be coded for confidentiality and included in a publicly accessible database. Lead Author, Susan E. Wonble. EPA Contact: Ross Highsmith (919-541-7828).

Evaluation of "Before" and "After," Occupant, IAQ, and HVAC Parameters in a Building Remediated Because of Unacceptable IAQ - An Augusta, Maine, office building with 810 occupants has undergone many IAQ/HVAC diagnostic evaluations during the past ten years. In 1992, the owner upgraded the building's HVAC system. To assess conditions in the building before remediation, an HVAC evaluation, an occupant questionnaire, and measurement of VOCs, microbial levels, inhalable particles, and work station thermal comfort were conducted. After remediation in 1993, the evaluations will be repeated and results compared. Lead Author, Frederick T. McKnight. EPA Contact: Ross Highsmith (919-541-7828).

Indoor Concentration Modeling of Aerosol Strong Acidity - A model, developed for estimating indoor concentrations of acid aerosol in a semi-rural community in PA, was applied to estimate indoor concentrations of aerosol strong acidity (H^+) in suburban NJ. The purpose was to assess the applicability of the model for predicting H^+ exposures in a suburban environment and to evaluate the model's performance for daytime and nighttime periods. The model applied to the site in NJ did not predict the indoor H^+ concentrations as well as it did for the experiment for which it was developed. Lead Author & EPA Contact: Michael Zelenka (919-541-1326).

Indoor, Outdoor, and Personal Air Exposures to Particles, Elements, and Nicotine for 178 Southern California Residents - Personal, indoor, and outdoor concentrations of inhalable particles, associated elements, and nicotine were measured for a sample of 178 persons representing nonsmoking residents of Riverside, CA. Newly designed personal monitors were employed. Personal exposures often exceeded concurrent indoor and outdoor concentrations, both for particles and for 14 elements. The increase is due in part to personal activities such as cooking and sharing a home with a smoker. Personal and indoor nicotine levels were elevated for persons reporting exposure to environmental tobacco smoke (ETS) and living in homes with smokers. EPA Contact: Lance Wallace (703-341-7509).

Sources and Factors Influencing Personal and Indoor Exposures to Particles, Elements and Nicotine: Findings from the Particle Team Pilot Study - During the fall of 1990, a large-scale field monitoring program to characterize personal exposures to inhalable particles with aerodynamic diameter less than 10 μm was conducted in Riverside, CA. Results show that personal exposures to nicotine are strongly related to percent time spent indoors in the presence of a smoker. Modeling results also indicated that air exchange rate, amount of dusting, vacuuming and cooking affect indoor particle concentrations. Lead Author, Halûk Özkaynak. EPA Contact: Lance Wallace (703-341-7509).

Health Effects

Cotinine Elimination Following ETS Exposure in Young Children as a Function of Age, Sex, and Race - The determination of the elimination half-life ($t_{1/2}$) of cotinine from urinary excretion data is useful in correlating urinary cotinine concentrations to estimate ETS exposure. Currently, quantitative relationships between urinary cotinine excretion and ETS exposure in children have not been determined. This research determined the cotinine $t_{1/2}$ in children up to three years of age using urinary cotinine excretion data. Lead Author, Albert M. Collier. EPA Contact: George M. Goldstein (919-541-6204).

Electronically Enhanced Measures of Eye Irritation for Use in Studying Subjects Exposed to VOCs - Simple, rapid, and objective methods of measuring tear-film break-up time and quantitating eye irritation are needed in order to study the health effects in individuals that complain of ocular irritation following exposure to VOCs. The described method uses miniaturized, closed circuit television to non-invasively measure tear film break-up time. A procedure that uses computer enhancement of eye photographs to objectively score changes in eye redness is also described. Lead Author & EPA Contact: George M. Goldstein (919-541-6204).

Evidence for Mild Inflammation and Change in Alveolar Macrophage Function in Humans Exposed to 2 PPM NO_2 - In this study, 10 healthy volunteers were exposed to either 2.0 ppm NO_2 or filtered air for 4 hours while undergoing intermittent moderate exercise. This project is highlighted under Research Project Highlights beginning on page 3 (Health Effects Research on Exposure to NO_2). Lead Author, Susanne Becker. EPA Contact: Robert Devlin (919-541-6255).

Mite Antigen Concentrations in House Dust and the Occurrence of Wheezing in Children with Dust Mite Allergy - This study examined the relationship between dust mite antigen concentrations in house dust samples and the occurrence and frequency of wheezing in 58 children with dust mite allergy. Dust samples were obtained from six sites in each home: the child's mattress, blanket, pillow, bedroom floor, and the recreation room couch and floor. Differences in the degree of home environmental contamination with mite antigen did not account for differences in the occurrence or frequency of wheezing, bronchial hyperactivity, or lung function among children with dust mite allergy. Lead Author, Frederick W. Henderson. EPA Contact: Andrew B. Lindstrom (919-541-4866).

Neurobehavioral and Subjective Reactions of Young Men and Women to a Complex Mixture of Volatile Organic Compounds - The neurobehavioral and subjective reactions of 26 male and 15 female subjects to 4-hour controlled exposure to clean air and 25 mg/m^3 of VOCs were compared. Subjects reported greater odor intensity and unpleasantness; increased eye, nose and throat irritation; and reduced IAQ during VOC exposure. Neurobehavioral performance was not affected by VOCs. Contrary to previous reports, women did not express more sick building syndrome type complaints than men during VOC exposure. Lead Author & EPA Contact: D. Otto (919-541-6226).

Pulmonary, Respiratory, and Irritant Effects of Exposure to a Mixture of VOCs at Three Concentrations in Young Men - The objective of this study was to determine if the frequency of human respiration is affected by exposure to a mixture of VOCs (0, 12, 24 ppm). Twenty subjects were exposed to the mix for 4 hours during which respiration rate was collected continuously and questionnaire data were obtained hourly. Results indicate no effect on respiratory frequency. However, there was a linear increase in respiratory eyeblink frequency with time in the chamber. Eyeblink frequency was elevated by exposure. Increased eye irritation, odor strength, and degradation of IAQ were reported in comparison to control exposures. Lead Author & EPA Contact: J.D. Prah (919-541-6244).

Time Course of Odor and Irritation Effects in Humans Exposed to a Mixture of 22 Volatile Organic Compounds - Ratings of IAQ, odor and irritation intensity, and other variables were obtained before and during 4 hour exposures to clean air and three concentrations of a mixture of VOCs. Perceived odor intensity decreased, and irritation intensity increased gradually during VOC exposure in a dose-related fashion. Odor and irritation appear to be primary determinants of perceived IAQ. Lead Author & EPA Contact: H. Ken Hudnell (919-541-7866).

Solutions

Evaluation of Ventilation Performance for Indoor Space (NTIS PB93-212751) - Ventilation performance depends on room geometry, ventilation method, and operating conditions, as well as location, source strength, and types of contaminants. A menu-driven ventilation model was developed that is capable of determining the turbulent flow field and time-dependent/steady-state contaminant concentration distributions within isothermal indoor space. Lead Author, Toshiaki Yamamoto EPA Contact: Leslie E. Sparks (919-541-2458).

Status of ASHRAE Standard 62 - Ventilation for Acceptable Indoor Air Quality (NTIS PB93-222040) - This paper describes the purpose, history, and major features of ASHRAE Standard 62. The status of the review and revision process as of January 1993 and the current working outline of the revised standard are discussed. The complementary roles of ventilation, source management, and air cleaning are emphasized. Extending the standard beyond ventilation system design to include operation and maintenance of buildings and ventilation systems is also projected. EPA Contact: W. Gene Tucker (919-541-2746).

Summaries of Recent EPA Indoor Air Workshops

Indoor Air Quality/Pollution Prevention Workshop

To assist AEERL in identifying potential areas of research for applying pollution prevention to IAQ, a 2-day workshop was held March 9-10, 1993. The 64 Workshop attendees included scientists and engineers with experience in IAQ, pollution prevention, and/or industrial processes.

The Workshop covered background information on IAQ, pollution prevention, and AEERL's strategy to combine the two. Participants were then placed into one of six workgroups to focus on pollution prevention research in the following topic areas: adhesives and sealants, building materials, consumer products, furniture, office equipment, and textiles. On the second day, an ad hoc workgroup on biocontaminants was added because of participants' interest.

At the Workshop, a number of materials/products were identified as potential research options for applying pollution prevention techniques to improve IAQ. A ranking or prioritization of the materials/products suggested was not included as part of the Workshop.

AEERL will use the suggestions from the Workshop as input for both IAQ/pollution prevention strategic planning and for determining specific program direction and prioritization of future research projects.

In summary, the major themes from the Workshop were:

- There is a desire for EPA *to identify the major IAQ problems*. Many discussions focussed on the relative importance of different IAQ sources.
- Making the link between IAQ and pollution prevention was difficult. More specific examples or case studies would be helpful.
- The workgroups consistently identified a need for more emissions testing, methods development, modelling, consumer education, and source ranking.
- The issue of proprietary information must be considered in developing a pollution prevention research strategy for indoor materials and products.
- Participants felt that research on preventing biocontaminant growth is important.
- The Workshop served to initiate interaction between IAQ, pollution prevention, and industry researchers.

Detailed suggestions from each of the seven workgroups are summarized below. The suggestions are not meant as a comprehensive listing or ranking of AEERL research priorities, but only as summaries of the topics discussed by Workshop participants.

The following pollution prevention options were suggested for adhesives and caulks/sealants: material substitution; material elimination (e.g., eliminating unnecessary chemicals); innovative technologies (e.g., producing a carpet with an attached stick-on pad, producing adhesives without solvents); process substitution; and packaging reduction.

The biocontaminants workgroup concluded that research should concentrate on: improvement of biocontaminant measurement techniques; development of building codes to prevent places in buildings that encourage biocontaminant growth; development of effective building cleaning schedules; and public education.

The building materials workgroup discussed vinyl and fabric wall coverings; HVAC systems; interior panels; ceiling tiles; and electrical wire jacketing. General suggestions included research on the source characteristics of a material and the potential sink characteristics; coating or sealing exposed surfaces to prevent VOC release; easy-to-clean designs; and consideration of total surface area of material used, the toxicity of emitted compounds, and the emission mechanisms (e.g., physical, chemical).

Pollution prevention suggestions for consumer products included: packaging, delivery, storage, and disposal issues; consumer-based performance standards development; total cost benefit assessment; labeling; consumer education on proper product use; source characterization; and test method development.

The following products were suggested for potential research by the furniture workgroup: finish coatings, upholstery, institutional and residential furniture, and cushioning. Research should identify all emitters and emission rates, then the critical emissions and products. The next step is to identify manufacturing changes that will reduce emissions.

The office equipment workgroup suggested researching: blueprint machines; dry printers and copiers; toner emissions, increasing toner transfer efficiencies, and the secondary toner market; equipment bakeouts; propellants and other dispensing agents; and paper proliferation in the office. Emissions research should include: emission characterization, chemical transformations and interactions with emissions from other sources, and product aging. The workgroup also recommended designing products so that they are easily remanufactured; studying the relationship between equipment miniaturization and emissions; and understanding cross media and energy impacts, toxicity, and flammability issues.

The textiles workgroup suggested the following research: measure primary emissions from textiles and create a database; investigate source/sink behavior; understand exposures and health effects; conduct life-cycle analyses considering use patterns and exposures, consumer and end-use issues, aging, maintenance, and raw materials; finishes (e.g., formaldehyde, fire retardants), and the use of mechanical rather than chemical finishes; process changes (e.g., pressure drying rather than atmospheric drying); and process design changes (e.g., use optimally designed machines so that fabric does not need to be sized for different uses).

Proceedings from the Workshop (EPA-600/R-93/198; NTIS PB94-114782) are available from the National Technical Information Service (NTIS). (See address on page 11.)

Ventilation and IAQ Workshop

AEERL co-sponsored a Workshop on Ventilation and IAQ with the University of Illinois Bioenvironmental Engineering Research Laboratory (BERL). The Workshop was held September 14-16, 1993, in Raleigh, NC.

Over 80 IAQ researchers, HVAC industry representatives, engineers and architects, and buildings science and environmental professionals attended. The objective was to review an analysis of ventilation technology systems prepared for AEERL by BERL.

The analysis summarized emerging trends and technologies and identified research and development activities in these HVAC areas: system selection and application; design; construction and installation; commissioning and testing, adjusting, and balancing; and operations and maintenance. Non-industrial ventilation systems were the primary target of the document.

Workgroups focused on the impact of ventilation systems on IAQ related to buildings and ventilation. The Workshop identified several areas of needed research:

- Development of an acceptable definition of IAQ for industry use. It is important to define IAQ in terms of health risk, lost productivity, and associated costs.

- Design of more flexible HVAC systems to accommodate building use changes and renovations. For example, designs to allow supply and return air to be properly installed and balanced to match space alterations and expanded system capacity needs.

- Emphasis on life cycle costing to discourage least cost engineering. Installing the least expensive system can often lead to IAQ problems. In addition, these systems are typically harder to commission because of the lack of proper balancing and distribution components, and they are often more difficult and costlier to maintain.

- Development of improved field measurement techniques, instrumentation, and IAQ sensors. The industry needs tools and diagnostic procedures that are less costly, more reliable, and have greater accuracy than current techniques.

- Encouragement of building owners and operators to provide continuous building commissioning and preventive maintenance. Building owners and operators need to understand that commissioning of a facility does not end when occupancy begins. Many studies prove that continued good IAQ is dependent on continued preventive maintenance.

- Increased technology transfer and communications among researchers and industry professionals. Researchers need to realize that the ultimate end user of IAQ research is an engineer, architect, or building owner and that economics, profit margin, and practicality are driving forces.

Areas of emerging trends and technological advances discussed at the workshop included development of:

- Computer-based automated control and analysis system for continuous monitoring and evaluation of IAQ.

- Alternative ventilation strategies include displacement ventilation, under-floor supply distribution, and dedicated occupant environmental control systems for improved ventilation.

- Advanced/enhanced filtration (particle, gas, and microbial) technology to reduce outdoor air and energy requirements.

- Continued use of experimental computational fluid dynamics models to assist ventilation effectiveness research.

For additional information on the Workshop, contact Russell N. Kulp at (919) 541-7980.

Upcoming ORD Meetings

Symposium on Measurement of Toxic and Related Air Pollutants

This international symposium will be held May 2-6, 1994, at the Omni Hotel and Convention Center in Durham, North Carolina. The symposium is sponsored by AREAL and the Air & Waste Management Association (AWMA) and will include oral presentations and exhibits. Indoor air pollutant measurements are included in the program. For information, contact Bruce W. Gay, Jr., U.S. EPA, MD-80, Research Triangle Park, NC 27711 (919-541-2830).

Symposium on Characterizing Indoor Sources and Sinks

ASTM Subcommittee D22.05 on Indoor Air will be holding a Symposium on Characterizing Indoor Sources and Sinks. The Symposium will be held September 25-28, 1994, in Washington, DC, and will be chaired by Bruce Tichenor of AEERL. Topics will include: chamber design, characterization, and performance; operation; data interpretation and application; and other topics related to emissions testing. For information, contact ASTM (215-299 5413) or Bruce Tichenor (919-541-2991).

Biocontaminant Workshop

AEERL, EMSL, and AREAL are sponsoring a Biocontaminant Workshop in March 1994. The objectives of the Workshop are to assist EPA in planning both short-term and long-term (beyond 3 years) research in the areas of biocontaminant measurement and control. Attendance at the workshop will be limited. For information, contact John Chang (919-541-3747).

Summaries of Recent Publications

This section provides summaries of recent publications by EPA's Indoor Air Research Program. Papers presented at Indoor Air '93 begin on page 6.

The source of the publication is listed with each summary. Publications with NTIS numbers are also available (prepaid) from the National Technical Information Service at: 5285 Port Royal Road, Springfield, VA 22161, 703-487-4650 or 800-553-6847.

(*) Summaries listing "1992 Toxics Measurement Symposium" as a source abbreviates "Proceedings of the AWMA/EPA International Symposium on Measurement of Toxic and Related Air Pollutants, Durham, N.C., May 3-8, 1992. EPA-600/R-92-131."

Source Characterization

Fundamental Mass Transfer Model for Indoor Air Emissions from Surface Coatings - A simple model based on the boundary layer theory was developed to determine emissions from freshly applied paints and coatings. The model provides a better fit to chamber-derived emissions data than an empirical first-order decay model, especially over the decaying portion of the concentration versus time curve. In this model, the mass transfer rate is assumed to be controlled by the boundary layer mass transfer coefficient, the saturation vapor pressure of the material being emitted, and the mass of volatile material remaining in the source. Static and dynamic chamber tests and test house data indicate that the model can be applied to different products with similar solvents. Source: *Indoor Air* (accepted for publication). EPA contact: Bruce Tichenor, AEERL (919-541-2991).

Exposure Assessment

Comparison of Transfer of Surface Chlorpyrifos Residues From Carpet by Three Dislodgeable Residue Methods - The Dow drag sled, the California cloth roller, and the Southwest Research Institute polyurethane foam roller, three sampling methods developed to estimate the transfer of a chemical from a contaminated surface to the skin, were evaluated. The cloth roller was found to be less suitable than the other methods because its transfers exhibited greater variability and were altered by orientation of the roll relative to the lay of the carpet fibers. The effect of moistening the sampling media on transfer by the drag sled and the polyurethane foam roller are discussed. Source: 1992 Toxics Measurement Symposium.* Lead Author, D. E. Camann. EPA Contact: Robert G. Lewis (919-541-3065).

Methodology for Determination of Polycyclic Aromatic Hydrocarbons and Other Semi-Volatile Organic Compounds in House Dust - Analytical methods were validated to determine polycyclic aromatic hydrocarbons (PAH) and other semi-volatile organic compounds (SVOC) in house dust. The storage stability of three potential markers (solanesol, nicotine, and cotinine) for particulate-phase ETS in house dust was also examined. Results suggest that cotinine is a better marker for ETS particles in house dust than nicotine and solanesol is not a suitable marker. Results from a small field study that evaluated the effect of smokers in the house on PAH, cotinine, and nicotine concentrations in house dust are included. Source: 1992 Toxics Measurement Symposium.* Lead Author, Jane C. Chuang. EPA Contact: Nancy K. Wilson (919-541-4723).

Sampling, Supercritical Fluid Extraction and GC/MS Analyses of Indoor Air Semi-Volatile Toxic Organics - A method has been developed to sample indoor airborne semi-volatile toxic organics followed by supercritical fluid extraction and GC/MS analyses. The sampling module, parameters used in the wet chemistry preparation, typical quality assurance/quality control data, and preliminary results from several categories of homes (e.g., electric and gas heating/cooking systems, smoking/non-smoking) are discussed. Source: 1992 Toxics Measurement Symposium.* Lead Author, V. M. Kanagasabapathy. EPA Contact: Robert Chapman (919-541-6219).

The Mutagenicity of Outdoor and Indoor Air Samples Taken in Roanoke During Wintertime - The mutagenicity of wintertime ambient air samples in Boise, ID, and Roanoke, VA, was examined using the Salmonella mutagenicity assay. Twenty homes were sampled in 10 matched pairs. Each pair included one home with a combustion heat source (an oil heater, a woodstove, or a fireplace), and the other home without. Both the extractable organic matter and SVOC samples were mutagenic, and the level of mutagenicity could be associated with the known sources. Source: 1992 Toxics Measurement Symposium.* Lead Author & EPA Contact: Larry D. Claxton (919-541-2329).

Risk Assessment

Use of a High-Volume Small Surface Sampler for the Microbiological Evaluation of Dust From Carpeted and Non-Carpeted Surfaces - This paper discusses a building cleaning effectiveness study being conducted by ECAO. This study is discussed under Research Project Highlights on page 4 (Use of a High-Volume Small Surface Sampler for the Microbial Evaluation of Dust). Source: 1992 Toxics Measurement Symposium.* Lead Author, K. E. Leese. EPA Contact: M. A. Berry (919- 541-4172).

Solutions

An Analytical Solution to Describe the Pressure/ Flow Relationship in EPA's Soil-Gas Chamber - An analytical model has been developed to describe the relationship between pressure differential and flow rate in AEERL's soil gas chamber. The classic *method of images* is applied to simulate the boundary conditions imposed by the finite dimensions of the chamber. The resulting influence on constant pressure contours and the streamlines is shown. Source: 1992 Toxics Measurement Symposium.* Author & EPA Contact: Ronald B. Mosley (919-541-7865).

Case Studies of Radon Reduction Research in 13 School Buildings -This report details AEERL radon mitigation research in 13 school buildings located in Colorado, Maine, Minnesota, Ohio, South Dakota, Tennessee, and Washington state. The objectives of the research were to better understand the conditions under which HVAC systems can be used for effective radon reduction and to compare the performance of HVAC system control of radon with active subslab depressurization control in the same building. Source: EPA Report (EPA-600/R-93-225). Lead Author, Bobby E. Pyle. EPA Contact: Kelly Leovic (919-541-7717).

Case Studies of Radon Reduction Research in Maryland, New Jersey, and Virginia Schools - One school in each of these states was selected for this radon research project. In two of the schools the objective was to evaluate the potential for modification of the school HVAC system to control radon concentrations. The third school was recently constructed with radon resistant features, and the objective was to evaluate the effectiveness of those features. Source: EPA Report (EPA-600/ R-93-211; NTIS PB94-117363). Lead Author, David W. Saum. EPA Contact: Kelly Leovic (919- 541-7717).

Characteristics of School Buildings in the U.S. - To guide AEERL's radon mitigation research in schools, information on the physical characteristics of 100 randomly selected schools was collected. The results show: most school structures are of slab-on-grade construction; gravel was used as subslab fill material in approximately half of the structures; approximately 80% of the schools have either central HVAC or unit ventilators capable of delivering

conditioned outdoor air; and about 25% of the schools have subslab footings extending both beneath the classroom walls and along the corridors, thus complicating the installation of a subslab depressurization system. Source: EPA Report (EPA-600/R-93-218) Lead Author, Harry Chmelynski. EPA Contact: Kelly Leovic (919-541-7717).

Comparison of Measurement Techniques for Soil Permeability in EPA's Soil-Gas Chamber - Initial soil permeability measurements in AEERL's soil chamber yield relatively good agreement between two methods. One method uses a set of 23 point probes located in a vertical plane and is similar to the standard practice of measuring in situ soil permeabilities. The other method uses an arrangement designed to ensure ideal geometric flow patterns and yields a better approximation of the effective bulk permeability. The permeability measurements are then compared to the predictions of a widely used empirical model. Source: 1992 Toxics Measurement Symposium.* Author & EPA Contact: Ronald B. Mosley (919-541-7865).

Designs for New Residential HAC Systems to Achieve Radon and Other Soil Gas Reduction - Residential heating and cooling (HAC) systems can significantly impact the pressure-driven entry of soil gas into houses. Entry of soil gas is of concern because it can contain contaminants such as radon, VOCs, pesticides, and biocontaminants. HAC configurations that have lowered radon entry rate in new construction, and which could be applied to reduce the entry of other soil gas contaminants, are presented. Source: Proceedings of the 1993 International Radon Conference, Denver, CO., September 20-23, 1993. Lead Author & EPA Contact: Timothy M. Dyess (919-541-2802).

EPA's Indoor Air Quality/Pollution Prevention Workshop - To assist AEERL in prioritizing areas of AQ/pollution prevention research, a workshop was held March 9-10, 1993. The workshop is discussed on page 9. Source: EPA Report (EPA-600/R-93/198; NTIS PB94-114782) and the Proceedings of the Annual AWMA Meeting, June 13-18, 1993. EPA Contact: Kelly Leovic (919-541-7717).

Evaluation of Radon Movement Through Soil and Foundation Substructures - A 2x2x4m chamber filled with radium containing soil is being used to study convective and diffusive soil gas movement through soil and foundation substructures. A perforated pipe vacuum line draws air (or tracer gas) through the soil under varying moisture conditions to simulate convective flow conditions. Data from the chamber will be used to model soil permeability properties and radon entry conditions imperative to site characterization for soil gas source potential. Source: 1992 Toxics Measurement Symposium.* Lead Author, Marc Y. Memetrez. EPA Contact: Ron Mosley (919-541-7865).

Follow-up Radon Measurements in 14 Mitigated Schools - To determine the long-term performance of radon mitigation systems, radon measurements were made between February and April 1992 in 14 schools that had been mitigated between 1988 and 1991. Results show that active soil depressurization systems have been very effective in maintaining low long-term radon levels in these 14 schools. Source: EPA Report (EPA-600/R-93/197). Lead Author, Jean-Claude Dehmel. EPA Contact: Kelly Leovic (919-541-7717).

Measurements of Soil Permeability and Pressure Fields in EPA's Soil-Gas Chamber - An analytic solution for advective flow in AEERL's soil-gas chamber is presented. The solution includes the effects of moisture dependent variations of permeability with position. Relatively good agreement between the measurements and model is obtained except in the region near the water level where the boundary conditions are not rigorously satisfied. Source: Proceedings of the 1993 International Radon Conference, Denver, CO, September 20-23, 1993 EPA Contact: Ron B. Mosley (919-541-7865).

Measurement of the Surface Permeability of Basement Concretes - This report details the development and test results of a portable permeameter used for surface permeability measurements of concrete. Surface permeability of concrete determines the performance of seals between concrete sections, an important passive technique for preventing radon entry into new buildings. EPA Report (EPA-600/R-93-169; NTIS PB93-232114). Lead Author, Arthur Scott. EPA Contact: Timothy M. Dyess (919-541-2802).

Radon in Florida Large Building Study - This project is examining how IAQ is affected by ventilation, mixing, and leakage rates in two research buildings. Measurements include: radon, carbon dioxide, temperature, humidity, differential pressures, outdoor air intake flow rates, and tracer gas methods. The outdoor air intake is adjusted from no outdoor air to recommended ASHRAE ventilation standards. Source: 1992 Toxics Measurement Symposium.* Author & EPA Contact: Marc Y. Menetrez (919-541-7981).

Removal Efficiencies in Terms of Particle Size and Concentration of Console Air Cleaners in a Suburban Home - Removal efficiency data and cost/benefits for two commercial console air cleaners are presented. One is equipped with a high efficiency filter and the other with an ESP. Data show that both units are highly efficient at removing particles 1.0 μm and greater, the size range of spores and pollens, but less efficient at removing submicron particles. Source: Proceedings of the Annual AWMA meeting, June 13-18, 1993 (EPA-600/A-93-183, NTIS PB93-222016). Lead Author & EPA Contact: Raymond S. Steiber (919-541- 2288).

The Environmental Resource Guide (ERG) - The ERG is a comprehensive reference resource being developed cooperatively between AEERL and the American Institute of Architects (AIA). The ERG aids architects and other design professionals in evaluating environmental impacts of design decisions. The ERG's

six sections include case studies, professional advisories, and technical analyses of the life cycle of building materials. AEERL is involved with: 1) development of the materials analysis section; 2) development of a data gathering/data analysis methodology (i.e., modified Life Cycle Assessment); and 3) establishment of acceptable quality assurance and peer review procedures.

The ERG's goal is to meet the public's need for informed decision making in support of sustainable environments. It also provides public outreach for two of EPA's highest priorities: IAQ and pollution prevention. The ERG subscription service currently reaches more than 2000. For subscription information, contact Nancy Solomon at AIA (202-626-7463). EPA Contact: James B. White (919-541-1189).

The Indoor Air Quality Data Station: An Integrated Sensing and Logging Platform - This portable IAQ data logging system monitors HVAC influences on IAQ in schools and other large buildings. Temperature, relative humidity, carbon dioxide, radon, and differential pressure data can be retrieved via modem. Source: 1992 Toxics Measurement Symposium.* Author & EPA Contact: Bruce Harris (919-541-7807).

Glossary of Acronyms

AEERL - Air and Energy Engineering Research Laboratory
AIA - American Institute of Architects
AREAL - Atmospheric Research and Exposure Assessment Laboratory
ASHRAE - American Society of Heating, Refrigerating & Air-Conditioning Engineers
ASTM - American Society of Testing and Materials
AWMA - Air and Waste Management Association
BASE - Building Assessment and Survey Evaluation
BERL - Bioenvironmental Engineering Research Laboratory
ECAO - Environmental Criteria and Assessment Office
EMSL - Environmental Monitoring Systems Laboratory
EPA - U.S. Environmental Protection Agency
ERG - Environmental Resource Guide
ESP - Electrostatic Precipitator
ETS - Environmental Tobacco Smoke
GC/MS - Gas Chromatograph/Mass Spectrometer
HAC - Heating and/or Cooling
HERL - Health Effects Research Laboratory
HVAC - Heating, Ventilating and Air-Conditioning
IAQ - Indoor Air Quality
NTIS - National Technical Information Service
ORD - Office of Research and Development
PAH - Polycyclic Aromatic Hydrocarbon
PCR - Polymerase Chain Reaction
PMN - Polymorphonuclear Neutrophils
SVOC - Semivolatile Organic Compound
TVOC - Total Volatile Organic Compound
VOC - Volatile Organic Compound

Mailing List for *Inside IAQ*

If you would like to be added to or deleted from the *Inside IAQ* mailing list, please mail or fax (919-541-2157) your name and address to:

Inside IAQ, Attn: Kelly Leovic
U.S. EPA/AEERL MD-54
Research Triangle Park, NC 27711

IAQ Information Clearinghouse

Additional information on indoor air is available through the Indoor Air Quality Information Clearinghouse maintained by EPA's Indoor Air Division. The Clearinghouse can be contacted by phone at 1-800-438-4318 or 301-585-9020, or by fx at 301-588-3408.

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