Indoor Air BULLETIN™ Hal Levin, Editor

Technology, Research, and News for Indoor Environmental Quality

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The Experts Review Indoor Air '93 – Helsinki

The indoor air community recently gathered for its most important meeting, Indoor Air '93 in Helsinki, Finland. Many participants considered it an outstanding conference, and some said it showed how the IAQ field is maturing. The field, as defined by the conference series, is a teenager: the first conference of the triennial Indoor Air 'XX series was in 1978 — fifteen years ago. It has all the growing pains of teenagers; it is exploring its own identity learning its relationship to mature, "real world" fields, institutions, and values. As with a teenager, we can begin to see what it may be like as an adult.

The wide range of expertise held by conference participants showed that IAQ is clearly a multi-disciplinary and, at times, interdisciplinary field. But the lines of the field are not clearly drawn, nor are they free from conflict with other fields. For example, as pointed out by Professor Kimura later in this article, much of what we study in "indoor air quality" evolved from earlier studies of thermal comfort, heating, air conditioning, and mechanical ventilation. However, as new topics were added, understanding the relationships became more important and, perhaps, less likely. For example, a thermal comfort researcher expanding his or her work into subjects of air quality, lighting, noise, vibration, or even psychological factors is less likely to master the second and additional disciplines. Even when specialists from other fields are added to a research team, the investigation or study design tends to emphasize the subject matter of the lead investigator's specialty.

Ignoring the potential impact of all environmental variables is dangerous, yet integrating them is problematic as well. It's a challenge that the IAQ community, as evidenced at the conference, is earnestly trying to meet.

The *BULLETIN* Survey

We asked about 20 recognized international authorities in the indoor air field to identify the most important or valuable papers, trends, findings, and directions represented at the conference. Their answers included diverse viewpoints that usually reflected the focus of each expert's own work (as might be expected). Many responded that they had not been able to attend very many of the technical sessions due to conflicting conference and other duties. Others said that they simply had not yet digested the material in the six volumes of the *Proceedings*.

Our "collection" method of the sample of experts was neither systematic nor scientific. It was intended to reflect the vast variety of interests and disciplines as well as nationalities involved in the conference. Of course, we do not expect the comments that follow to represent any sort of scientific sample. Also, less than half the experts we asked were able to respond due to time limitations, vacations, and prior commitments.

Trends, Findings, and Directions

We asked the experts to identify the most important trends, findings, or directions for the indoor air field based on their experience of the conference.

Ken-ichi Kimura, Waseda University, Japan: "Indoor air research started from thermal comfort problems and studies on them have flourished so far as to find a lesser amount of new and interesting findings at this conference.

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Indoor air quality problems, on the other hand, arose later and a variety of interesting studies could be seen in this conference as well as in the past one in Toronto. New and difficult themes could be observed in the area of microbes especially made by building scientists in contrast to the past studies made by epidemiological scientists."

Jan Sundell, Karolinska Institute, Stockholm, Sweden: "IAQ research is emerging into an area of research on its own, instead of being an area where research methods, measurement techniques, etc. are taken from other environmental research areas as from research on industrial or ambient air. This is a maturing process going on within the entire field. Examples are research on indoor air chemistry (as opposed to conventional, unfruitful measurements of VOC), research on microbially produced toxins, VOCs etc. (instead of a simple counting of number of CFUs or spores), and research on objectively measurable health effects of low dose exposure."

Phil Morey, Clayton Environmental Consultants, Norristown, Pennsylvania, USA: "While no single sampling technique is going to elucidate or determine all the bioaerosols that are present and while causes and effect relationships between specific bioaerosols and disease remain difficult to study, the ecology of microorganisms in buildings and building systems can be directly studied. The availability of water determines what kind of microorganism grows. Control of microbial contamination (especially fungi) in buildings is rather straightforward once microbial ecology is worked out or understood."

John Girman, Environmental Protection Agency, USA: "In general, the technical papers were better than in past conferences, reflecting better study design and application of scientific principles. There seemed to be less pessimism about understanding causes and effects of poor indoor air quality and a stronger sense that indoor air quality, although complex, is a tractable problem which responds to pragmatic solutions currently being developed. This is not to say that indoor air quality is completely understood but rather that progress is being made."

Anne Hempel-Jorgensen, M.D., Institute for Worker Medicine, Århus University, Denmark: She saw that an important new trend was toward "objective biological response models in attempts to investigate health effects of indoor air pollutants."

Ole Fanger, Technical University of Denmark: "Overwhelming data from studies in thousands of buildings now available from five continents demonstrate a high degree of dissatisfaction among occupants in many buildings. The old thinking, that a fixed ventilation rate is sufficient to provide acceptable IAQ in all buildings, is outdated. Pollution from materials, furniture, carpets, and HVAC components are blamed for the poor air quality perceived in many buildings. [There are] strong trends to study and quantify pollution sources in practice. Such information is gathered in a new European Data Base for Indoor Air Pollution Sources planned to contain information in sensory and chemical terms on pollution sources from materials, HVAC components, and from entire buildings. In the US a source rating data base is being established. Methods are being more and more commonly used for screening of materials before they are applied in new buildings."

"In the thermal environment the trend is for widespread use of displacement ventilation and cooled ceilings to diminish the risk of draft, which is the most common reason for complaint on the thermal environment. The model of draft risk included in the new International Standard ISO 7730, in the new German standard DIN 1946 and in the ASHRAE 55 encourages the use of systems providing a low turbulence intensity in the occupied zone of spaces."

Helmut Knöppel, Commission of the European Communities Joint Research Centre, Ispra, Italy: "In this field there is a trend to focus on the validation of methods (which is badly needed). There appears to be an increasing interest in organics in house/surface dust. In this field, data and methods relating to measured concentrations in dust to exposures (via inhalation, skin absorption, and digestion) are required."

Richard Sextro, Lawrence Berkeley Laboratory, University of California, Berkeley, USA: "The apparent emergence of indoor air as an important issue in the Far East (China particularly) — judging by the growth in research." He also saw "better 'science' directed toward SBS [less anecdotal] — still a long way to go to sort it out and find proper solutions."

James E. Woods, Virginia Polytechnic Institute, Blacksburg, Virginia: There is apparently a "strong push for Commission of European Communities regulations [and] Eastern Europe [is] coming up to speed." Woods said he sees growing "recognition that technology alone is not sufficient." Finally, he noted the importance of the development of the International School of Indoor Air Sciences.

Important Unresolved IAQ Questions

We asked the experts to identify problems and questions that are important but not currently sufficiently understood.

Ole Fanger: "Develop and validate models predicting indoor air quality before the building is constructed. This could bring IAQ engineering up to the same level where acoustical, illumination, and thermal engineering have been for decades."

"Study what makes air fresh and pleasant rather than just acceptable."

"Study the relative and combined effects of IAQ, acoustics, and lighting."

Anne Hempel-Jorgensen, M.D.: "Does the hyper-susceptible individual exist as a somatic disease at all — or are these patients actually suffering from something different?"

Ken-ichi Kimura: "I personally foresee the greatest potentiality of the most important research in the area of microbes where interdisciplinary research among medical, physiological, and architectural scientists is needed." Professor Kimura says that public attention is being directed to every kind of comfort and to removing discomfort, and that mold and mildew problems urgently require attention.

Helmut Knöppel: "Is there a relation between organic and biological indoor pollution and an increased number of hypersensitive/susceptible individuals? Are there mechanisms other than allergy? What are these mechanisms? What are the critical pollutants/exposures?"

"How [do we] evaluate the health/comfort effects of emissions from indoor materials and products? A commonly agreed-upon approach is lacking."

Phil Morey: [What are the] "practical means to predict the availability of 'free' water (that can support microbial growth) in building systems and components? Our knowledge on biological mechanisms involved in SBS and most allergic (besides allergens) and hypersensitivity reactions and the causative agents involved (of chemical and microbiological nature) is still almost non-existent. There are a lot of hypotheses but no real knowledge."

Richard Sextro: "In the US — trying to keep funding for good quality science."

Shin-ichi Tanabe, Ph.D., Associate Professor, Ochanomizu University, Tokyo: "Allergy and hypersensitivity might be a big topic for future study. The thermal comfort field was the small part of the conference, but still included important aspects. The conflict between ventilation requirements and energy conservation should be discussed more. Productivity pointed out by Dr. Wyon might be an interesting aspect of indoor climate research."

James E. Woods, Jr.: "Are solutions [to indoor air quality problems] at the medical or engineering level? Integration of the two is needed."

"The economics of healthy buildings must be documented."

Anonymous US scientist: "The cause of Sick Building Syndrome."

"The role of dust in SBS and exposure to lead."

"How to make Europeans and Asians stop smoking now that the Americans seem to be waking up."

Anonymous US scientist (#2): "In the US, the indoor air community must try to keep the EPA from ignoring science and 'dealing' with other indoor air issues like they've done for radon and are doing for ETS."

Most Important or Valuable Papers

While at the conference, we could attend relatively few of the technical sessions due to our work editing the workshop chairpersons' summaries. So we asked the experts what they thought were the "...most important/valuable paper(s) presented at the conference? What were the key points of each?"

Many of the experts said that they too had only been able to attend a small number of technical sessions. I am sure they would agree that the papers they identified represent a selection from only a small fraction of all the papers presented. Nonetheless, we believe that they have selected papers that represent important findings, indicate important new research methods and topics, or suggest potentially valuable solutions to IAQ problems. As pointed out above, however, the papers they identified tend to represent work in their own specialty or area of research.

Below, we summarize each paper the respondents identified, and we provide some discussion including the experts' comments.

Sensory Evaluation of IAQ

Professor Ole Fanger identified three papers that related to his own pioneering work in developing a systematic way to quantify the subjective experience of a combination of odor and irritation, or, as he calls it, "perceived indoor air quality." There has been a rapid increase in its use since he introduced the concept at Indoor Air '87. Now many researchers are working to improve the method, and his own laboratory is seeking a more suitable chemical or mixture for calibrating odor panelists.

Sensors Better Than People at Estimating Perceived Air Quality

Fanger said there were "a couple of papers with promising data." One was by researchers at Johnson Controls in Milwaukee, Wisconsin. They are trying to develop a system using gas sensors that will duplicate human panels making perceived odor judgments in decipol units using the approach developed in Fanger's lab. They looked at every combination of 22 different sensors. The result of the work was that they found an optimum combination of sensors that could predict decipol values more reliably than a trained panel.

The paper by Jarrell Wenger and his co-workers was titled "A Gas Sensor Array for Measurement of Indoor Air Pollution - Preliminary Results" (*Proceedings*, Vol. 5, 27-32). Fanger described it as the "...[f]irst promising effort to measure perceived air quality by an instrument." He said, "The oral presentation gave further encouraging data."

We called Wenger to find out what the further data might be, and he sent us a copy of his presentation slides. Wenger told the ***BULLETIN***: "We assembled a set of sensors that was available and were sufficiently sensitive, and then tried optimizing that set. We did an optimization of the sensor array, and a lot of number crunching to get correlations for every combination of sensors possible.

"We have 21 different combinations of sensors that are the best in each category [each category is a separate total number of sensors]. The best combination of sensors for a 9-sensor array may not contain all the same sensors as the best 8-sensor array. We plotted the correlation coefficients between the best sensor array for each number of sensors. [See Figure 1.] We identified three ranges of the graph. With less than five sensors, the correlation increases as the number of sensors increases; additional sensors give additional information and improve the correlation. The middle part of the curve — from 5 to 13 sensors — is flat where essentially additional sensors

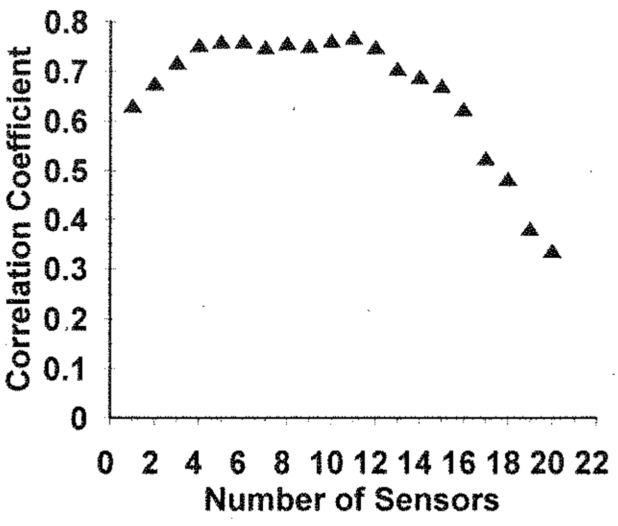

Figure 1 - Optimization of Sensor Array: Correlations for Best Cosine Sensor Sets.
Best cosine set: 12 sensors, r = 0.77

don't seem to give us additional useful information for the correlation."

The optimum combination of sensors was 12 with a correlation of 0.77, but all the optimum combinations from 5 to 13 gave correlations better than 0.70. As the number of sensors increases beyond 13, additional sensors actually decrease the correlation coefficient (up to 22 sensors). Apparently, additional information confounds the correlations.

Wenger says he is not attempting to validate or refine the "perceived air quality" system. "The approach we have taken here is something of a black box approach. We were forced to do that because of the lack of correlation between all of the published information." What they did do, he said, is show that they can identify an array, or even several different arrays of sensors that can predict decipol values in a reliable fashion.

Gaseous Air Cleaning

Fanger said a paper from The Netherlands described a "[n]ew, interesting technology for gaseous cleaning of air. Promising results." The paper, by Jan F. van der Wal *et al.* of TNO, is "Development of an Air Cleaner Based on Gas Absorption Membranes," (*Proceedings*, Vol. 5, 445-450). The technology is commercially available, hollow-fiber membrane absorbers using water as the absorbent. Gases cross the membrane from the air passing through the hollow fiber according to their solubility in the water — that is, the partition is determined by the absorbent. The use of the fiber membrane results in a very large specific surface area, on the order of 10,000 m^2/m^3, compared with 100 m^2/m^3 typical of conventional media absorbers, according to the authors. The contact surface is maintained regardless of the flow rate of the gas. The technology is relatively new, and is cited in the paper for its use in SO_2 removal from flue gas.

The researchers evaluated six different commercially available small-scale membrane modules. They first tested the modules with four selected chemicals at varied gas flow rates to determine pressure drop and found a linear relationship between gas flow rate and pressure drop. They then selected the filter with the lowest pressure drop and highest filter efficiency to evaluate the removal of environmental tobacco smoke (ETS) constituents. The research was supported by Philip Morris Europe Science and Technology.

The measured reductions for many water-soluble compounds such as aldehydes, ammonia, acetone, hexanal, nicotine, and NO_2 were >94% while removal efficiencies for many other common indoor air contaminants were from 6 to <42%. They determined the filter 65% efficient in lowering the odor threshold concentration judged by conventional threshold determination methods and 49%

efficient in improving "perceived air quality" based on the decipol method. They observed that "the sensory efficiency was lower than for the measured water soluble compounds of ETS, but higher than for benzene and other hydrocarbons." This, they conclude, indicates that the "sensorically perceived compounds are (mainly) caused by compounds that ... have low or no solubility in water." They did not identify the specific compounds responsible for the sensory response to ETS.

They conclude that an additional phase that includes an absorbent for non-water-soluble compounds is needed to achieve a "complete, high-efficiency cleaning system for all compounds." Future research needs include scale-up, demonstrating long-term efficiency, and developing a unit for non-water-soluble compounds. They believe that the life of the hollow-membrane filter is indefinite, at least in principle, when tap water is used as the absorbent. They expect that the cost of providing clean air using the filter to be less than that of supplying "fresh air" based on a reduced cost of heating and cooling; cheap tap water; an assumption that waste water disposal is not problematic due to contamination; the long expected filter life; and, eliminating the need for an alarm system to indicate residual filter life.

HVAC Filters As Contaminant Sources

Jussi Teijonsalo *et al.* from Finland evaluated the odor intensities and contamination of glass fiber and of synthetic (polyester) filters used in six central Helsinki office buildings. They studied the filters at regular intervals during the first six months in use by measuring pressure drop across the used filters; determining their odorous emissions using a trained panel (decipol method); and, visually evaluating filter "grayness."

In their paper, "Filters of Air Supply Units as Sources of Contaminants" (*Proceedings*, Vol. 6, 533-538), they concluded that odor intensities from the filters were "quite high...in some cases...after only 6 weeks of use...higher than 1.4 decipol which 20% of the population would consider dissatisfying in their working environment." After 19 weeks the filters had fairly constant odor intensities with half >2.5 decipol, an intensity 30% of the population would find unsatisfactory, according to the authors. Fanger said the paper provides "[f]urther evidence that the dust collected on particulate filters in HVAC systems is a serious source of gaseous pollution in many cases."

In two locations where pre-filters were used the researchers found the odor intensities "significantly lower than locations without pre-filters." Odor intensities of pre-filters and of combined filters (pre-filters and final filters together) were of equal magnitude though constantly lower than those of fine filters alone. This, we note, might suggest that the larger particles are the main source of the observed odors. The implication is that inexpensive pre-filters replaced frequently can economically reduce odor and, presumably, improve IAQ.

The decipol values rose sharply as a function of total air volume up to approximately 500,000 m^3 where they continued to rise but less sharply to 1,500,000 m^3 of air. The filters were 60 cm x 60 cm or 0.36 m^2 cross-sectional area. The mass of accumulated dust on the filters and the grayness of the filter material correlated well to the odor intensities, but the pressure drop correlated poorly. The two filter materials, glass fiber and polyester, resulted in almost equal odor intensities while "...the glass fiber filters collected significantly more dust." Table 1 shows the odor intensity and mass collected by filter media type.

Study Period (weeks)	Synthetic (polyester) Filters Odor (decipol)	Synthetic (polyester) Filters Mass (grams)	Glass Fiber Filters Odor (decipol)	Glass Fiber Filters Mass (grams)
6	0.53	2.9	1.29	7.8
13	2.60	5.5	2.43	13.3
19	2.93	4.7	3.43	17.0
26	1.76	11.2	1.65	31.6

Table 1 - Comparison of Filters According to Filter Material.

Note that the data show that the odor was actually less after 26 weeks than after 13 and 19 weeks, although the collected mass had almost doubled. The researchers suggest this decline occurred in the period "...from December to February, when snow frequently covers the ground and streets in Finland. Therefore, the composition of particulate matter might differ, and it might not be as odorous as in other seasons." Furthermore, they said the decreased odor intensity was within the measurement accuracy of the trained panel, "...so no definite conclusions can be drawn from the reduction in odor intensities." We suggest another explanation — that microbes might be responsible for some of the odor, and microbial growth would be slower during the colder weather.

The researchers found the contamination varied significantly among buildings, presumably due to the ambient air contaminant concentrations. At least for some locations, however, six months is clearly too long an interval between filter changes, they concluded.

Hypersusceptibility: Somatic or Psychological Disorder?

Anne Hempel-Jorgensen, M.D., identified the paper by Claudia S. Miller and Nicholas A. Ashford, "The Hypersusceptible Individual," (*Proceedings*, Vol. 1, 549-

554) as important. "The key point was the discussion whether this phenomenon exists — is it a somatic diagnosis or is it a psychological/psychiatric diagnosis?" While Dr. Hempel-Jorgensen did not tell us either the authors' or her own answer to this question, the published paper strongly suggests that the answer is not clear and that further research is "...essential for understanding the precise linkages between chemical substances and clinical illness."

The authors state that there may be a range in individual susceptibility to chemicals spanning several orders of magnitude. "MCS [multiple chemical sensitivity] patients...report disabling symptoms at levels of exposure apparently well tolerated by most people." More than two-thirds of college students reported that one or more common chemical exposures made them ill, according to a recent study by Bell *et al.* (1993) cited in the paper. "Cacosmia, feeling ill from odors, occurs in a sizable percentage of the population." Given the strong reactions of MCS patients, Miller tells us that it seems prudent to explore further the effects of low-level VOC exposure on humans by using "carefully designed provocative challenge testing in a controlled environment." Miller and Ashford have made a strong and persuasive argument — not just for the usual "more research." They have described exactly what sort of research they believe needs to be done to elucidate the important question they have discussed.

Modeling Heat and Moisture Movement Through Construction Assemblies

According to Ken-ichi Kimura, Harunori Yoshida of Japan presented "...a transient analysis of air conditioning load and room conditions considering simultaneous heat and moisture transport of multi-layered constructions, which had been regarded very difficult so far and certainly would ...[shed some light on]... the most important subject in close relation to mold growth in building materials."

The paper by Yoshida *et al.*, "Transient Analysis of Air-Conditioning Load and Room Conditions Considering Simultaneous Heat and Moisture Transport of Multi-Layered Constructions," (*Proceedings*, Vol. 6, 253-258) describes a computer model that predicts room air temperature and humidity and air conditioning loads considering both heat and moisture transport through the building materials. The paper describes the model and two case studies involving measurements and simulations using the model. The simulation results deviated only slightly from the measured data, thus indicating model validity. The authors recommend the model be used for building design analysis and decisions.

Extreme Post-Fire Microbial Amplification and Control

Professor Kimura also wrote: "Phil Morey introduced microbiological events after a fire in a high-rise building which gave a tremendous shock to the audience because of such a serious effect." We have often seen Morey shock audiences with his photographs of microbially contaminated buildings. According to Kimura's report, Morey has some new slides to add to his incomparable collection. His paper is "Microbiological Events After a Fire in a High-Rise Building" (*Proceedings*, Vol. 4, 323-328). Morey told the ***BULLETIN***: "The main message in the oral presentation – think of fungi after a fire in a high-rise building."

According to Morey's paper, the more than 10×10^6 liters of water used to fight a fire in a high-rise office building thoroughly wetted the building materials and furnishings on the lower floors of the building as well as those of a second building connected to the first by hallways. The post-fire investigation showed interior furnishings and building materials were still moist even three months after the fire.

Relative humidity and dry bulb temperatures were as high as 70% RH and 42 ºC respectively three months after the fire. There were fungi visible on surfaces of carpets, gypsum board, wood paneling, ceiling tiles, marble, plaster walls, and ceilings. Air sampling for microbial contamination showed indoor species and concentrations different from outdoors and extremely high for mesophilic and thermotolerant Aspergillus and Penicillium – as high as 10^4 cfu/m^3. Analytical results showed that fungi were being dispersed into the second building from the fire-damaged one, probably by foot traffic as well as air movement. Endotoxin levels were also higher than outdoors by about an order of magnitude.

The dissemination of fungi into non-fire areas was curtailed by negatively pressurizing water-damaged floors, erecting physical barriers to isolate water-damaged areas from occupied ones, discarding water-damaged finish and construction materials, and by using high-efficiency particulate air (HEPA) filter vacuums to remove settled dust and spores. Relative humidity decreased to less than 60%. Sampling at four months after the fire and after the implementation of the remedial measures showed significantly lower airborne concentrations of the organisms found previously even though strong reservoirs, especially of mesophilic Aspergillus, continued to be present in the fire-damaged building.

Six months after the fire, with relative humidity below 40%, airborne fungi concentrations were lower still in both the fire-damaged and adjacent building with concentrations in the adjacent building more than an order of magnitude lower than in the fire-damaged building. This, Morey said, indicates that the spread of spores into occupied areas of the adjacent building had been prevented. After seven months, sampling in the space above the plaster ceilings revealed up to 1.3 million spores per m^3. Concentrations of the same species in outdoor air and above never-contaminated plaster ceilings were two to three orders of magnitude lower. Contaminated ceiling and interior wall systems were subsequently demolished and removed.

One of Morey's conclusions is that personal protective equipment, including a respirator with HEPA filters (a powered air purifying device is best), is required for remediation workers removing furnishings and construction materials visually contaminated by fungi.

Organic Sampling and Analysis

Helmut Knöppel identified a paper on a new method for rapid, low-cost extraction and analysis of VOC analytes from gas samples. The method uses a fused silica fiber coated with a liquid polymeric phase and placed inside a microsyringe which protects the sorbent and facilitates handling. The paper, "Solvent Free Analysis of Gaseous Samples with Solid Phase Microextraction," (*Proceedings*, Vol. 2, 257-262) by C.L. Arthur and J. Pawliszyn, University of Waterloo, Ontario, Canada) describes the device and its use in detail. It also includes the results from using the method for 12 volatile chlorinated hydrocarbons that are common indoor air pollutants.

Analytical resolution by electron capture detection (ECD) was in the sub-ppbv range for ten of the twelve compounds, and near one ppbv for the other two. The method produces linear results over one to two orders of magnitude with relative standard deviations (RSD) $\leq 5\%$ at one standard deviation. The method appears extremely promising for use both indoors and outdoors for both gaseous and aqueous samples. It is portable, involves low capital costs, and provides much faster results than the currently dominant methods for VOC sampling and analysis. The rapidity of the process is an important factor not only in the time required to obtain analytical results but also in the personnel costs which are the main cost factor in indoor air VOC measurement.

IAQ and Public Health

Richard Sextro (Lawrence Berkeley Laboratory, US) suggested the plenary lecture by Jonathan Samet, "Indoor Air Pollution: A Public Health Perspective" (*Proceedings*, Vol. 1, 3-12). Sextro wrote: "Nothing earth-shaking, but good talk and put indoor air into a perspective." Others we spoke with agreed that the talk was not "earth-shaking" and even expressed disappointment that it did not go further. Nevertheless, it provided an overview of the topic that forms the basis for most concern about IAQ. Samet presented a useful "classification scheme for adverse health effects from indoor air pollution" as shown in Table 2.

Room Air Cleaners to Control ETS

Sextro said Johan Johansson's "...basic talk was about effectiveness of air cleaners (nothing new). But – they reported seeing particulate formation from re-emissions from the walls of the test room — this has important implications for ETS exposures." The paper, "Long Term Test of the Effect of Room Air Cleaners on Tobacco Smoke" (*Proceedings*, Vol. 6, 387-392), was authored by Johansson and his co-workers at the Swedish National Institute of Occupational Health. The researchers calculated the equivalent air flow rate causing the same decay in concentrations of particles and seven gases. The researchers found that the collection efficiency of the air cleaners was "good for particles and also approximately constant with the increasing smoke load." However, "...gases are much harder to collect" by use of air cleaners, and even the low collection of new devices decreases "considerably with increasing smoke load." They concluded that "...it is not possible to replace outside

Clinically evident diseases	Diseases for which the usual methods for clinical evaluation can establish a causal link to an indoor air pollutant.
Increased risk for disease	Diseases for which epidemiologic or other evidence establish increased risk in exposed individuals. However, usual clinical methods cannot typically establish the causal link in an individual patient.
Physiologic impairment	Transient or persistent effects on a measure of physiologic functioning which are of insufficient magnitude to cause clinical disease.
Symptom response	Subjectively reported responses which can be linked to indoor pollutants or are attributed to indoor pollutants.
Perception of unacceptable indoor air quality	Sensing of indoor air quality as uncomfortable to an unacceptable degree.
Perception of exposure to indoor air pollutants	Awareness of exposure to one or more pollutants with an unacceptable level of concern about exposure.

Table 2 - Samet's Classification Scheme for Adverse Health Effects from Indoor Air Pollution.

ventilation air flow with a room air cleaner." They also pointed out the importance of properly maintaining the air cleaner: "...without it the air cleaner becomes a pollution source." Finally, "...the surfaces of a room where cigarette smoking occurs become secondary pollution sources."

Mold Growth on Ceiling Tiles

Phil Morey identified Karen Foarde *et al.*, "Assessment of Fungal Growth on Ceiling Tiles Under Environmentally Characterized Conditions" (Vol. 4, 357-362). Morey wrote: "One kind of ceiling tile was more hydrophobic than others and more resistant to fungal colonization. This suggests that interior planners may one day be able to 'select' for bioresistant finishing and construction materials." An interesting finding was that mold could grow on both new and aged [read "dirty"] ceiling tiles.

The critical factors appear to be the composition and the bulk moisture content of the tiles. A new fire resistant tile did not support mold growth while an aged one did. The critical bulk moisture content to support microbial growth for the two new mineral fiber tiles and the one aged fire-resistant tile test was in the range from 5.4% to 6.9% in the various tests. Used or aged materials were capable of retaining more moisture than new materials under the same conditions. "Growth appears to be directly related to the moisture uptake of the tile." The authors believe that designers can reduce the potential for microbial contamination by considering moisture uptake properties when selecting building materials.

Dogs as Indoor Air Pollutant Source Detectors

Morey also noted the paper by Lena Lundin *et al.* (Sweden) titled "Mold/Bacteria Dogs: A New Tool for Tracing Microbiological Problems Hidden in Building Construction (*Proceedings*, Vol. 4, 305-310). Morey wrote: "Dogs are used for drug surveillance, so why not train them to sniff out MVOCs (microbiological VOCs) hidden in buildings? This concept needs to be tested rigorously." Trained dogs were instructed to "mark" portions of the building with recognizable odors. The materials removed from areas marked by the dog had tenfold higher bacteria concentrations and up to tenfold higher molds.

Allergy and Hypersensitivity

Shin-ichi Tanabe, Ph.D. (Associate Professor, Ochanomizu University, Tokyo) commented that Anthony Pickering's Plenary Lecture "Allergy and Environmental Hypersensitivity Related to the Indoor Environment" (*Proceedings*, Vol. 1, 13-19) "...was interesting. Report that one third of children are suffering by atopy in Japan. House dust mites and other origins may be related to the humidity in the room and housing characteristics." We found Pickering's plenary talk not only one of the most information-filled but also, clearly, the most entertaining of the invited presentations. The paper, unfortunately, lacks both the detail and the humor of the slide-assisted talk. Nevertheless, the studies Pickering discussed are all referenced, so the serious student can access the original studies. We hope Pickering will write a detailed review article containing the rich content of his presentation.

VOCs in Telephone Company Buildings

An anonymous US scientist noted "[Helen] Shields' work on VOCs in ~60 buildings will add major data to the existing data base." "VOC Survey: Sixty-Eight Telecommunications Facilities" (*Proceedings*, Vol. 2, 93-98) reports data from 9 data centers, 10 administrative offices, and 49 switching offices throughout the US. Using passive badges and samplers, Shields and co-author Daniel Fleischer report TVOC as the sum of the identified/quantified organic compounds using "standard gas chromatographic/mass spectrometric (GC/MS) procedures."

The authors found indoor TVOC values from 23 to 1288 $\mu g/m^3$ and outdoor values from 10 to 211 $\mu g/m^3$. Indoor/outdoor (I/O) TVOC ratios ranged from ~1 to ~22. The authors comment that the I/O values show that "...some buildings were not introducing sufficient outdoor air." The paper reports the most commonly found VOCs of indoor origin. Of particular interest was the universally high fraction of total VOC represented by Decamethylcyclopentasiloxane (D5) in the buildings with high occupant densities, data centers and administrative offices. In each region at least one site had a building in which D5 was at least 10% of TVOCs. Personal care products, especially underarm deodorants, contain D5. At one site with low occupancy and high D5 levels, there were painting and renovating activities occurring which the authors suggest may also be sources for high D5 levels.

[We immediately rushed to investigate the toxicity and irritation potential of D5 in numerous reference books, but found nothing more than a description of the chemical in the *Merck Index*. A trusted ***BULLETIN*** source told us that extensive tests over several years have suggested no deleterious health effects associated with D5.]

The authors conclude that there are large variations in building ventilation and maintenance practices that account for the large range of I/O VOC concentration ratios. They suggest that a lack of knowledge or attention to source control may explain the >20-to-1 I/O ratios in the administrative offices of two out of seven regions they studied.

VOCs in Canadian Residences

The same scientist said the work of Rein Otson on VOCs in Canadian homes provided valuable data. In three separate papers (*Proceedings*, Vol. 2, 117ff., 141ff., 281ff) Otson and co-workers discuss their survey of 750 randomly selected homes throughout Canada. They examined regional and seasonal variations of 53 target compounds. They found that mean indoor VOC concentrations decreased with temperature increases from 0ºC to ≥15ºC, presumably because people open windows more during milder weather periods. Mean concentrations of 26 target compounds were 10.3, 9.8, and 5.0 $\mu g/m^3$ respectively in periods of outdoor temperature ranges of ≤0ºC, 0ºC to 15ºC, and ≥15ºC. This presumably illustrates the importance of ventilation rates in determining airborne concentrations.

In a second paper, average concentrations of 53 target compounds in a composite sample intended to represent typical population exposure ranged from <1 to 104 $\mu g/m^3$. Analysis of the compounds and their patterns of occurrence allowed for tentatively identifying major sources including tobacco smoking, combustion of fuels, building materials and furnishings, and consumer and hobby products.

Finally, in a third paper, Otson discussed the limitations of TVOC measurements. There were correlations between TVOC values determined by GC-FID and values for 26 VOC determined by GC-MS ranging from <0.01 to 0.95 depending on data groupings. Otson concludes "...the results did not support the contention that TVOC values are reliable indicators of air quality or of potentially hazardous organics in air." There is a lack of a widely recognized standard procedure for measuring TVOC and of a consistent definition of TVOC or VOC, and "...little evidence of a relationship between FID-TVOC values and biological effects." TVOC may be used for determining the effectiveness of physical changes in a building only as long as source emission profiles remain constant. Other uses are not recommended until a standard method is developed.

"Personal Cloud" of Particle Exposure

According to our anonymous expert, results of the "Particle TEAM" pilot study (Özkaynak et al, *Proceedings*, Vol. 3, 445-450, 457-462), and also those of Sheldon *et al.* showed the "existence of a 'personal cloud' (composition unknown) surrounding people. It also provided the first elemental profile for cooking as an indoor source (high in calcium, copper, iron)."

"Health Effects Better Understood"

John Girman made the following comment on the papers: "I can't say that I found any one paper to be the most valuable presented at the Indoor Air '93 conference. Instead, I found most interesting the sessions on health effects of indoor air pollutants. I believe we are finally conducting studies (in many countries) which are leading to a better understanding of the health effects of pollutants at concentrations found in indoor environments."

Proceedings of Indoor Air '93 Available

Copies of the *Proceedings* are available from Indoor Air '93 for 900 Finnish marks per six-volume set plus 200 Finnish marks for postage and handling. That's $187.50 at the August 31 exchange rate of 5.8661 Finmarks per US dollar. A complete set includes copies of the edited workshop chairmen's summaries finalized after the conference by ***BULLETIN*** editor Hal Levin. Use the order form included with this issue of the ***BULLETIN***.

Letters

Menzies *et al.* Reply to *BULLETIN* Critique

One of the purposes of this newsletter is the free exchange of ideas and experience. Hopefully, this will contribute to a better understanding of the IAQ field and will help disseminate "real world" applications of the knowledge developed by scientists. We invite readers who disagree with the views expressed here to write; we'll publish such communication when possible. Of course, length limitations necessarily require discrimination on our part.

We published an article in Vol. 2, No. 10 that strongly criticized the work of Menzies *et al.* as published in the *New England Journal of Medicine*. Menzies' work was widely cited in the popular and technical press; it concluded that for the ventilation rates studied, increasing ventilation had no effect on SBS symptom prevalence. We criticized both the methods used and their interpretation. Dr. Menzies personally expressed his strong disagreement with our views during Indoor Air '93 in Helsinki. We invited his comments in letter form, and they follow complete and unedited.

Dear Mr. Levin,

Thank you for sending us your latest issue of *Indoor Air **BULLETIN*** (vol. 2, no. 10) in which you reviewed our publication which appeared in March in the *New England Journal of Medicine*. We regret that we find your analysis of the article inaccurate, and grossly misleading.

Regarding a number of specific points:

1) Contrary to what you have stated in your bulletin, our conclusions are very clearly limited to the ventilation levels that we achieved. The abstract is quite careful in specifying the ventilation levels achieved and that "these changes in the supply of outdoor air were not associated with changes in environmental ratings or in symptoms." This same statement is restated in the final concluding paragraph of the conclusions of the article. We do not agree with your many charges that we have overstated our conclusions or overgeneralized our results. We would agree that the findings of this study cannot be generalized to lower ventilation rates, although they probably can be generalized to 20 cfm per person given that these levels were achieved in four out of twelve trials, and no differences were seen. The fact that the generalizations were made in the popular press and media is unfortunate, but we do not believe that the kind of article that you have written will have sufficient credibility to counter this misinterpretation.

2) We do not agree that we "completely missed the mark" in the range of ventilation levels that we studied. Our objectives were to compare symptoms occurrence and environmental perception at 20 and 50 cfm per person. We chose these levels because 20 cfm per person was a standard that has already been established by ASHRAE, and was, at least in Canada, well accepted. We did not feel it was ethical to go below a currently accepted standard in an experimental study involving large numbers of human subjects.

On the other hand, we felt that 50 cfm per person was of interest because, at the time of the study, this was being proposed as a new standard by a number of diverse groups. The Ministry of Labour in Ontario had proposed this new standard, based on 2,500 investigations of indoor air quality problems by their personnel, from which they concluded that symptoms would only be relieved if CO_2 levels were maintained at less than 600 ppm. Here in Montreal, a group of consultants, health professionals, and union officials had formed an alliance to lobby the municipal and provincial governments to adopt 50 cfm per person as the local standard. In addition, on careful reading of the literature, it is clear that significant increases in ventilation rates were being suggested by a number of authors, including Ole Fanger. It is hard to come up with a single number from the new Nordic ventilation standards, but they certainly translate to higher ventilation levels and may be as much as 40 cfm per person (this was a number that Bill Turner suggested as his interpretation of their new standards). Most HVAC systems in office buildings in Canada can accommodate the current ASHRAE requirements of 20 cfm per person even if designed for 10 cfm per person. Raising the level to 50 cfm per person, however, might require an expenditure of up to \$100 m^2 [sic] to refit existing HVAC systems to be able to heat or cool the additional outdoor air in midwinter or midsummer. The proposed new standard would also substantially increase the operating costs of our 10,000,000 m^2 of commercial office space in Canada. We believed that the basis for setting ventilation standards for office buildings was anecdotal, and deserved more rigorous examination with a randomized doubleblind study.

3) The estimations of ventilation rates were based on cubic feet per minute per person as these are the units of the present ASHRAE standards, which were in turn, calculated from the formula stated in the paper. To repeat: the formula is $0.75/60 \times (1{,}000{,}000 \text{ indoor } CO_2)/(\text{indoor } CO_2 - \text{outdoor } CO_2)$ where 0.75/60 = cubic feet of pure CO_2 produced per minute by the average adult engaged in sedentary activities. The footnote to the formula in the *New England Journal* article was admittedly not that clear. However, this formula is correct as printed and is derived from ASHRAE Standard 62-1989 Appendix D. In this, we have assumed that the average office worker is somewhat active and is not purely sedentary, and therefore, we assumed an activity level of 1.4 METs.

It can be argued, as we discussed in our article, that estimation of outdoor air supply using CO_2 is less accurate than using tracer gas techniques. However, we felt that the choice of estimation based on CO_2 was preferable because:

i) we wanted to repeatedly measure the ventilation conditions at multiple worksites throughout the six weeks of the study. Over 3,000 separate measurements of CO_2 at worksites were made to enhance the accuracy of estimation of individuals "exposure" to outdoor air supply. This meant that worksite of every 5th or 6th participant was measured to provide a much more precise estimate of changes in outdoor air supply, which we considered crucial, and outweighed the technical limitations of CO_2 measurements.

ii) the estimation of effect in conditional logistic regression was based on the change of CO_2 at an individual's worksite. While the accuracy of estimation of outdoor air supply based on CO_2 may be affected by worksite or building characteristics. Such effects were minimized by the repeated measures design in which CO_2

was measured under varying HVAC conditions at the same worksites.

iii) we felt it important to use a measure that was in common use, so that the study results would be meaningful to workers and consultants in many other buildings. We felt that by using a commonly used measure, the generalizability and the relevance of the findings would be greater than by using measures of ventilation which could be done only by specialized research teams and cannot be translated into every day experience in other buildings.

4) Additional points:

i) The association of environmental dissatisfaction score and symptoms does not demonstrate the importance of ventilation as you believe. In fact, as clearly stated in our article, there was no association of environmental ratings, using this score or other more direct questions, and the ventilation conditions at the same time.

ii) You have stated that categorical reporting of symptoms is less sensitive than other measures. We measured symptom occurrence at the time of questionnaire completion. We are not sure what symptom measurement method would be more sensitive than such a direct and immediate measurement method. Perhaps you could provide references.

iii) Environmental measurements were made on the same day that questionnaires were completed at the worksite of every 5-6th participant. They were not made remotely in time nor space as you implied.

iv) We reported the association of temperature and air velocity which you have reproduced in your bulletin. We feel these findings were important to emphasize the between subject differences in worksite exposures related to differences in environmental conditions in their microenvironments. However, this was not the primary objective of this study and also was potentially biased by the between-subject nature of the comparisons. The relationship between symptoms and contaminants is of interest but again, was secondary analysis, in part, because the number of contaminant measures were far fewer being measured at only 1-3 sites per floor in each study week.

v) Preliminary results from this same study were presented at the ASHRAE IAQ '91 meeting in 1991 and published in their conference proceedings. The same methods of estimating ventilation on the basis of CO_2 levels were not criticized at that time, so it is somewhat surprising that two years later, you now judge the same methods to be invalid.

In conclusion, we believe that the study was strong, and that most of your comments and criticisms are inaccurate and misleading. Prior to publication in the *New England Journal of Medicine*, there was an extensive process of peer review in which the paper was reviewed by at least six external reviewers in addition to the author to the accompanying editorial. The identity of the reviewers is unknown, but that they presumably had considerable expertise in this area. The paper was revised in response to their suggestions and criticisms; other points, including the estimation of ventilation rate from CO_2 were raised by their reviewers, and were addressed by us to their satisfaction. The major conclusion, which was that at the ventilation rates achieved, there was no association between outdoor air supply and symptoms, was accepted by these reviewers. We are a research group that is seriously concerned about the problem of Sick Building Syndrome and we welcome constructive comments, criticisms, and suggestions that can lead to improved research in the future. Unfortunately, your review is filled with pejorative phrases and inaccurate comments that reflect either a pre-existing bias or a limited understanding of this paper. We do not feel that as such it represents a very positive contribution toward the resolution of the problem of Sick Building Syndrome.

Yours truly,

Robyn Tamblyn, Ph.D., Richard Menzies, M.D., M.Sc., Robert Tamblyn, P.Eng.

Editor's Reply

It is the responsibility of scientists to be sure that their work is reported accurately so that it will be used appropriately. The "Conclusions" section of the abstract preceding the article by Menzies *et al.* reads: "Increases in the supply of outdoor air did not appear to affect workers' perceptions of their office environment or their reporting of symptoms considered typical of the sick building syndrome." The authors failed to qualify sufficiently their conclusion such that the widespread popular media misinterpretation would not occur. Having discovered the misinterpretation, the burden is on them to take strong action to correct it. To date, no such action has been taken.

Many individuals have reported attempting to convey the nature of the flaws in the methodology and limitations of the research to one or more of the authors and particularly to Dr. Menzies. There is widespread agreement among authorities on ventilation that Menzies *et al.* misunderstood and misapplied their measurements and derived calculations of ventilation rates. The letter printed above indicates the authors still fail to understand the shortcomings of this essential aspect of their study. While we believe that very few similar studies have been conducted with high quality ventilation system characterization and estimation of ventilation rates, nonetheless, Menzies *et al.* cannot justify adopting a flawed method on the basis of its common use. Their letter's incorrect citation and interpretation of ASHRAE Standard 62-1989 does not improve their credibility.

A journal's publication of a submitted manuscript does not imply endorsement by all the reviewers. Ultimately, each of us must enter the scientific process including the dissemination of research results with our minds open and willing to acknowledge the shortcomings of our work and the incompleteness of our knowledge. Only in this manner can we, as Gregory Bateson said, "Ask a better question next time."

Letters

M. Hodgson Comments on Menzies *et al.*

Dear Hal:

This letter follows our recent discussion concerning the Menzies paper. You asked me to comment on two aspects: symptom characterization and statistical aspects.

Symptom quantification:

Dr. Menzies and co-authors classified symptoms as present or absent, i.e., categorically, on the day of study. An alternative approach is to quantify the symptoms by their intensity, i.e., using a continuous variable or a longer ordinal scale. It is almost universally recognized that analyses using continuous distributions are more powerful in documenting relationships when they are present. Such approaches are common in the examination of indoor environmental quality. Lars Mølhave uses a symptom intensity questionnaire in his chamber studies; all thermal comfort researchers use quantitative (ordinal) scales; my own work uses a linear analog symptom scale.

Dr. Menzies' group did obtain indirect measurements of "exposure" on the day of symptom measurement. This is the approach used by individuals who have documented dose-response relationship (Lance Wallace in the EPA study, and my group in a series of investigations in non-problem buildings). They also measured VOCs. The locations of sampling stations are not specified in relationship to persons responding to questionnaires. This has been the essential difference between studies by the EPA/Yale (Library of Congress) and my group, who detected relationships. Similarly, D. Wyon, in his elegant study in Malmø, attempted to link persons to specific exposures. Numerous studies that did not link environmental sampling in space to symptom reporting failed to detect relationships between questionnaire responses and exposures.

Potential explanations for this are that ventilation efficiency varies substantially within the same room and that pollution sources, such as laser printers, photo duplication machines, open typewriter correction fluid vials, and levels of perfume emissions vary certainly from day to day if not from hour to hour.

Statistical analysis:

Conditional logistic regression analyses are usually undertaken for matched case-control studies. They assume a categorical outcome, such as disease (or symptoms present and absent). Dr. Menzies assured me that his biostatistician assured him it was legitimate to perform the analyses in this fashion. A reference in BIOMETRIKA does indeed justify this approach.

No power analyses were presented, i.e., the chance of detecting a true difference if a difference was present at a certain expected difference. For example, if doubling of VOC levels were associated with a 25% increase in symptom intensity, as has been documented elsewhere, would this have been detected as statistically significant? "Power" calculations can be undertaken in several ways, including calculation of "adjusted" values and simulation through generation of random number sets.

Importantly there are "longitudinal" models to examine continuously distributed variables. In fact, those are much more frequently used by statisticians. These may be assumed to have more "power" to detect true differences, if differences are present, because they do not lose the information lost in symptom reduction. They could not be applied here because symptoms were defined categorically.

The authors describe symptom prevalence in office workers around the world as present independently of whether a building has been identified as having a "problem." Although that is true, symptoms occur in a frequency distribution within buildings. Work stress, and other aspects of social and organizational function and dysfunction, are important predictors of whether individuals voice complaints. This is independent of engineering solutions, which focus on materials development, operations, and maintenance procedures, and ventilation strategies, rather than on office functioning.

What is the right question?

There are many data to suggest that ventilation with less than 20 cfm outside air per occupant is inadequate.

This is the question the authors appeared to attempt to answer. The authors used four buildings. However, their data analyses used the unit of the individual work station, not of the building. What is the probability that one or more of those buildings belonged to the group of buildings requiring more? Inventories of source strengths might identify those. J. Woods has an algorithm by which he is reasonably sure he can identify such buildings. This study sheds no light on the topic.

The study does answer a question that many of us believe has been raised, and answered through experience. For most buildings, 20 cfm per person outside air are adequate. That is why the ASHRAE Standard 62 committee feels relatively comfortable with the ventilation rate procedure.

Does more outside air mean better air quality? That requires a study that has the power to detect improvement in symptoms.

There are "big complainers" in office buildings. They have varying levels of complaints over time in the same building. This study does not help them. Are concentrations of measured pollutants higher in their microenvironment than elsewhere?

There are buildings that have strong indoor sources, some of which occur independently of the HVAC system. These are likely to benefit from increased ventilation. In fact, the authors appeared to show that VOC levels went down. This study does not address the question whether symptom intensity improved.

Some buildings have strong indoor sources in HVAC systems. Ventilation increases will not likely reduce symptoms in those buildings. This study would support those conclusion but for the wrong reasons.

Michael Hodgson, M.D., MPH, Univ. of Connecticut Health Center

Letters

Hansen on Energy Conservation and IAQ

Shirley Hansen is a management consultant focusing on energy and IAQ issues for governments and school districts. She serves on ASHRAE's committee charged with revising Standard 62-1989, Ventilation for Acceptable Indoor Air Quality. She also chairs the board of directors of the Association of Energy Engineers.

Dear Hal,

My compliments on your excellent lead article, "The Myth of Energy Conservation and IAQ," in the ***Indoor Air BULLETIN***, Vol. 2, No. 8. As you probably recall, I got into the indoor air quality arena through the back door labeled "energy conservation," and your article is the most objective, balanced treatment of the issue I have seen.

At some point, a closer examination of ventilation rates in ASHRAE 62-1989 and energy costs might serve your readers well. An evaluation of the Eto and Meyer study, which has been relied on so heavily, is probably warranted. The work of Ventresca indicates increased energy costs to schools would average at least 20 percent, which would pull another $1.4 billion per year out of the schools' (and taxpayers') empty pockets — to many that's major. Barney Burroughs has estimated that compliance with ASHRAE 62-1989 could increase energy bills as much as 35 percent in hot and humid climates. It is very likely an area that needs further study and more attention.

Again, Hal, thanks for an excellent article and a solid publication.

Sincerely,

Shirley J. Hansen, Ph.D., President,
Hansen Associates, Annapolis, MD.

Editor's Reply

I agree that the Eto and Meyer (1988) data have been overworked; they should be evaluated more closely. It is also necessary to evaluate the changes brought about by Std. 62-1989 against other, non-energy criteria such as health, lost work or school time, and personal comfort.

Dr. Hansen is also right that schools are hit hard by the increased ventilation required in Std. 62-1989 compared with Std. 62-1981. Ventresca's extra school energy cost figure she cites is consistent with the 40 to 42% figures in the Bonneville Power Administration study by Steele and Brown (1990) presented in the ***BULLETIN*** article Dr. Hansen discussed. (See ***IAB*** Vol. 2, No. 8, Table 3.)

The increase reflects a couple of things. One is the assumption that smoking would have been prohibited in the school room designed under Std. 62-81. Therefore, the outdoor air requirement would be 5 cfm/p, not the 20 cfm/p required if smoking were permitted. Any building occupancy where smoking was permitted actually got a decreased outdoor air requirement or no change going from the 1981 to the 1989 version of Standard 62. Permitting smoking under Standard 62-1989 does not result in increased ventilation requirements; that's why anti-smoking advocates contested adopting the standard.

In fact, far fewer public and private buildings with public access now permit smoking than during the time period between the adoption of Std. 62-1981 and Std. 62-1989. Many buildings that previously permitted smoking would actually have experienced a reduction in outside air requirements (and associated energy costs) if the building operators prohibited smoking before designing under Std. 62-1989. Building owners still benefit from prohibiting smoking now by reducing maintenance and cleaning costs, filter replacement (and related energy costs), and liability exposure to lawsuits regarding involuntary exposure to environmental tobacco smoke (ETS).

The second reason schools are hit so hard is the typically high occupant density in school environments. At seven occupants per 1000 ft^2, an office environment is rather sparsely occupied. But schools where classroom design occupant density is estimated at 30 p/1000 ft^2 will need 4.3 times more outside air per ft^2 than offices, if the offices had previously banned smoking (assuming the schools had done so). The concerns about the economic impacts on schools are justified, but mainly because of the way schools are financed versus the private and societal costs of sick school children.

In 1988, Brundage reported a 50% higher incidence of febrile respiratory disease among army recruits in modern barracks than in older ones. The modern barracks were more densely populated and, presumably, less well ventilated. (Brundage *et al.*, 1988). If we assume some applicability here for Brundage's findings, then people in denser, less ventilated schools have considerably more febrile respiratory illnesses than their peers in more sparsely populated, better ventilated school spaces. There is further albeit indirect evidence to support this in the work of Nardel on protection against tuberculosis infection. (See ***IAB*** Vol. 2, No. 5.)

The Brundage study could not distinguish between the effects of ventilation versus the effects of occupant density. However, schools that are densely populated and poorly ventilated are obviously more likely to have higher infectious disease prevalence rates. If so, then the child pays for missed school time in lost learning and make-up homework and the parents pay for medical and personal care of sick children. The total, real costs are likely to be significantly more than the energy costs for increased ventilation, but it would be quite useful to have some solid data to support these arguments.

References:

Brundage, J.F., Scott, R.N., Lednar, W.M., Smith, D.W., and Miller, R.N., 1988, Building-associated risk of febrile acute respiratory diseases in army trainees. Journal of American Medical Association, Vol. 259, pp. 2108-2112.

Eto, J. and C. Meyer, 1988, "The HVAC Costs of Increased Fresh Air Ventilation Rates in Office Buildings." *Transactions*, Vol. 94, part 2, ASHRAE, Atlanta, Georgia.

Steele, Tim and Marilyn Brown, 1990, "ASHRAE Standard 62-1989: Energy, Cost, and Program Implications," Bonneville Power Administration, Portland, Oregon.

Conference Announcement and Call for Papers

Clean Air '94, Perth

Organizers have issued the Conference Announcement and Call for Papers for the 12th International Conference, Clean Air '94, in Perth, Western Australia. While the subjects to be covered include the entire range of air quality concerns, IAQ is among the eleven major topic areas. The conference is scheduled for October 23-28, 1994. Sponsored by The Clean Air Society of Australia and New Zealand, the conference is advertised as bringing international speakers supported by a range of expert speakers from Australia and New Zealand.

Potential presenters should submit a 300-word abstract that outlines the aim, content, and conclusions of the proposed paper. If the paper is selected, authors will be advised and asked to prepare a 4000-word written paper. The papers will be published in book form and made available to delegates at the conference. Abstracts should be submitted no later than August 31, 1993.

All abstracts and inquiries should be directed to The Conference Organisers, Promaco Conventions Pty Ltd., Unit 9A, Canning Bridge Commercial Centre, 890-892 Canning Highway, Applecross 6153, Western Australia, 09 364 8311, fax 09 316 1453.

Conference Announcement and Call for Papers

Healthy Buildings '94, Budapest

Conference organizers have issued The Second Announcement and Call For Papers for Healthy Buildings '94, to be held August 22-25, 1994, in Budapest, Hungary. The conference is sponsored by CIB, ISIAQ, and HAS, and is co-sponsored by the World Health Organization, ASHRAE, and other international organizations. Like the previous "Healthy Buildings" conferences, organizers intend that the 1994 meeting produce recommendations for professional, commercial and regulatory actions that will improve building environmental quality.

The initiators of the "Healthy Buildings" conference series intended for a meeting to occur each three years the year following the "Indoor Air xx" conference. While also based on scientific knowledge, the "Healthy Buildings" conferences are organized to produce recommendations for action as well as reports of scientific findings and accomplishments. This distinguishes them from the more traditional scientific format of the "Indoor Air xx" conferences.

The first conference was Healthy Buildings '88 in Stockholm, ably organized by Thomas Lindvall and Birgitta Berglund of Sweden. ASHRAE co-sponsored Healthy Buildings '91 in Washington, DC, as part of ASHRAE's on-going conference series "IAQ 'xx." CIB has co-sponsored each "Healthy Buildings" conference, and Thomas Lindvall has now announced that ISIAQ signed a memorandum of understanding with CIB to co-sponsor the series starting in 1994.

Potential authors may submit abstracts of not more than 300 words until October 15, 1993. Faxed abstracts are not acceptable. The official language will be English. Discounted advance registration fee is $450, $150 for students.

The conference president is Professor László Bánhidi of the University of Budapest. The Second Conference Announcements and Call for Papers is available by writing to Prof. Bánhidi at Healthy Buildings '94, Technical University of Budapest, H. 1521 Budapest, Pf. 91, Hungary, 361 1812 960, fax 361 1666 808.

Carpet Toxicity Research

Open Meeting Announced

Robert Dyer, Ph.D., of EPA's Office of Research and Development informed us that there will be an open meeting on recently conducted carpet toxicity tests. The meeting will take place September 15, 1993, at the Ritz Carlton Hotel, 1250 S. Hayes St., Arlington, Virginia, from 9am to 5pm. The purpose of the meeting is for industry researchers to provide an opportunity for the EPA's peer reviewers to look at the industry data.

The industry data represent efforts to test the same carpet samples tested by EPA and Anderson Labs (discussed last month in the ***BULLETIN***). Among the presenters will be researchers from DuPont and Monsanto laboratories, and, perhaps, Ives Alarie, the developer of the respiratory irritation test method adapted by Anderson for the conduct of their carpet tests.

The only discussion will occur among invited presenters and peer reviewers. Those who wish to attend may observe but not take part in the discussion. There is no fee to attend. Interested persons should contact Elaine Brenner, Eastern Research Group, 617 674-7334, fax 617 674-2906.

A second meeting is planned to identify future research needs to improve our understanding of the nature and causes of reported health complaints from carpet exposures. Readers interested in being informed of the second meeting should also contact Elaine Brenner at one of the above numbers.

Calendar

Domestic Events

September 20-23, 1993. **The 1993 International Radon Conference**, sponsored by the American Association of Radon Scientists and Technologists (AARST). Holiday Inn Denver Southeast, Denver, Colorado. Contact: 1993 AARST Radon Conference, c/o Michael Chase, 2450 Central Avenue, Suite A-1, Boulder, CO 80301. 303 444-5253. *Registration fee $275 after 8/21/93 (non-AARST members add $50).*

September 28-October 1, 1993. **Advanced Hands-on Indoor Air Quality/HVAC Diagnostics**, Harrison, Maine, The H.L. Turner Group Inc. Contact: H. L. Turner Group, Inc., RR#1, Box 535A, Harrison, Maine 04040, 603 228-1122. *An intensive course with a high-powered faculty.*

October 10-13, 1993. **Understanding the Workplace of Tomorrow**, 14th Annual Conference and Exposition on Facility Management, International Facility Managers Association (IFMA). Denver Convention Center, Denver, Colorado. Contact IFMA Headquarters, 1 East Greenway Plaza, 11th Floor, Houston, TX 77046-0194, 800-359-4362.

October 26-27, 1993. **ASTM Subcommittee D22.05 on Indoor Air**, Albuquerque, New Mexico. Contact George Luciw, Staff Manager, ASTM, 1916 Race Street, Philadelphia, PA, 19103, 215-299-5571.

October 28-29, 1993. **Diagnosing and Mitigating Indoor Air Quality Problems in Buildings**, sponsored by Indoor Environmental Engineering, San Francisco, California. Contact: IEE, 1448 Pine Street, Suite 103, San Francisco, CA 94109. 415 567-7700, fax 414 567-7763. *Bud Offermann is the instructor for this two day "practical, hands on workshop" on diagnostic procedures and mitigation strategies for solving IAQ problems. Participants will see and use state-of-the-art instruments, learn the basics and how to apply them. Fee is $785; BULLETIN readers get a $100 discount by mentioning the **BULLETIN** when registering in advance.*

November 1-3, 1993. **Improving Indoor Air Quality in Non-Industrial Buildings**, Environmental and Occupational Health Sciences Institute (EOHSI) - Centers for Education and Training. Contact: EOHSI, 45 Knightsbridge Road, Brookwood II, Piscataway, NJ 08854-3923, (908) 235 5062.

November 7-10, 1993. **IAQ '93: Operating and Maintaining Buildings for Health, Comfort and Productivity**, Philadelphia, Pennsylvania. Sponsored by ASHRAE. Contact ASHRAE Meetings Department, 1791 Tullie Circle NE, Atlanta, GA 30329, 404-636-8400.

January 22-26, 1994. **ASHRAE Winter Meeting and Exposition**, New Orleans, LA. See listing for November 7-10, 1993.

May 21-27, 1994. **American Industrial Hygiene Conference and Exposition**, Anaheim, California. Sponsored by American Industrial Hygiene Association and the American Conference of Governmental Industrial Hygienists. Contact: AIHCE, 2700 Prosperity Avenue, Suite 250, Fairfax, VA 22031. 703 849-8888, fax 703 207-3561.

September 25-28, 1994. **Symposium: Emissions from Indoor Sources**, Washington, DC. Sponsored by ASTM Subcommittee D22.05 on Indoor Air. Contact: Symposium Chairman Bruce Tichenor, EPA/AEERL, Research Triangle Park, NC 27711, 919-541-2991, fax 919-541-2157. *More details are available in Vol. 2, No. 11 of the **BULLETIN**.*

International Events

September 21-23, 1993. **Energy Impact of Ventilation and Air Infiltration**, 14th AIVC Conference, Copenhagen, Denmark. Contact AIVC, Univ. of Warwick Science Park, Sir Williams Lyons Road, Coventry, CV4 7EZ, UK, 44 203 692 050, fax 44 203 416 306.

October 27-28, 1993. **Volatile Organic Compounds**, Royal College of Physicians, London, England. Sponsored by Indoor Air International (IAI). Contact: Conference Secretariat, International VOC Conference, Unit 179, 2 Old Brompton Road, London SW7 3DQ, UK, +44 767 318 474, fax +44 767 313 929.

November 1-3, 1993. **Clima 2000**, Queen Elizabeth Conference Centre, London, England. Contact: Anne Gibbins, CIBSE Headquarters, 222 Balham High Road, London, SW 12 9BS, fax 44-1-6755449.

March 15 - 18, 1994. **Cold Climate HVAC '94 - International Conference on HVAC in Cold Climates**, City of Rovaniemi, Finland. Sponsored by FINVAC, Federation of Societies of Heating, Air Conditioning and Sanitary Engineers in Finland. Contact: FINVAC/Cold Climate HVAC '94, Mr. Ilpo Nousiainen, Sitratori 5, SF-00420 Helsinki, Finland, +358 0 563 3600, fax +358 0 566 5093. *The official conference language is English.*

April 17-19, 1994. **International Symposium on Volatile Organic Compounds in the Environment**, Montreal, Quebec, Canada. Sponsored by ASTM Committee E-47 on Biological Effects and Environmental Fate. Contact: symposium chair Dr. Wuncheng Wang, U.S. Geological Survey, WRD, P. O Box 1230, Iowa City, IA 52244, 319-337-4191, fax 319-354-0510.

August 22-25, 1994. **Healthy Buildings '94**, Sponsored by CIB, ISIAQ, and HAS, and co-sponsored by the World Health Organization, ASHRAE, and other international organizations. Budapest, Hungary. President, Professor László Bánhidi, Healthy Buildings '94, Technical University of Budapest, H. 1521 Budapest, Pf. 91, Hungary, 361 1812 960, fax 361 1666 808. *The official language will be English. Discounted advance registration fee is $450, $150 for students.*

September 5-9, 1994, **Ventilation '94**, The Fourth International Symposium on Ventilation for Contaminant Control, Stockholm, Sweden, Sponsored by Swedish National Institute of Occupational Health. Contact Ventilation '94, National Institute of Occupational Health, S-171 84 Solna, Sweden, +46 8 730 9448, fax +46 8 275 307.

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