July 4-8, 1993

THE 6TH INTERNATIONAL CONFERENCE ON INDOOR AIR QUALITY AND CLIMATE

INDOOR AIR '93

Workshop Summaries

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The 6th International Conference on Indoor Air Quality and Climate

Workshop Summaries

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INTRODUCTION TO WORKSHOP SUMMARIES

The twenty workshop summaries that follow provide an excellent overview of the many aspects of indoor air quality addressed at The 6th International Conference on Indoor Air Quality and Climate, Indoor Air '93. The results generally represent the consensus of the leading international authorities on indoor air quality, and they can be relied on to guide research and regulatory activities in the topic areas covered.

There were 690 papers presented at Indoor Air '93 held in Helsinki, July 4-8, 1993. The authors came from 38 countries and all six continents. The papers covered a very broad range of indoor air topics organized in 29 technical and scientific sessions of both oral and poster presentations. Conference participants came from 50 countries representing all disciplines involved in indoor air research and technology.

Twenty organized workshops were conducted during the Conference. The workshops provided a forum for conference participants to discuss the state-of-the-art and to work together on focused problems of common interest. The topics and the tentative questions to be addressed in the workshops were coordinated by me, and by Jorma Säteri, the Scientific Secretary of Indoor Air '93. Some of the workshop topics were developed by the conference organizers together with co-sponsoring organizations and invited experts. The final program and questions addressed in the workshops were the responsibility of the workshop chairpersons.

Most of the workshops followed a similar format: they began with introductory presentations followed by general discussion. The number of participants at the workshops ranged from 30 to 100, or more. The workshops were from one and one-half to two hours long. In most workshops the specified topics were covered rather well. The workshop chairpersons prepared the draft summaries during the Conference. The drafts were edited by Hal Levin with some follow-up clarification and preparation of the final versions in the month following the Conference.

I would like to extend my thanks to all chairpersons for the excellent work done organizing and conducting the workshops during the Conference and for preparing the summaries on a very tight schedule. All twenty summary drafts were completed by the end of the Conference.

The expertise of Mr. Hal Levin was invaluable during the process of editing the workshop summaries. My sincere thanks to him and the other experts who made the workshops and summaries that follow possible.

Professor Olli Seppänen
President, Indoor Air '93

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W1 INDOOR AIR QUALITY AND ENERGY

Kevin Teichman, USA, Eduardo de Oliviera Fernandes, Portugal, Martin Liddament, UK, Chairmen

Peter Wouters, Belgium, Philomena Bluyssen, Netherlands, Speakers

Co-Sponsors: American Society of Heating, Refrigerating and Air- Conditioning Engineers, the Commission of European Communities, and the International Energy Agency

INTRODUCTION

Although the impetus for much of the concern about indoor air quality began with efforts to reduce ventilation rates to conserve energy, when properly designed, constructed, operated and maintained, energy efficient structures can provide acceptable indoor air quality. Moreover, energy efficient buildings can offer more and better opportunities to improve indoor air quality than energy inefficient structures. The purpose of this workshop was to promote discussion of how to ensure that the goals of indoor air quality and energy efficiency are not only compatible, but even complementary.

QUESTIONS

To validate the above premises three questions were posed. These questions and the discussion and conclusions they promoted are summarized below.

Are decreased ventilation rates to conserve energy the primary cause of IAQ problems?
Energy efficiency is essential for the rational use of environmental resources. Therefore, building energy conservation is an important energy conservation target. When space heating or refrigerative cooling is needed, outside air ventilation and infiltration result in energy loss. Much discussion focused on the role of ventilation in controlling indoor air quality. Examples of poor IAQ arising through inadequate ventilation and of poor IAQ that did not respond to ventilation were presented. It was concluded that while it is not appropriate to provide less ventilation than is needed for occupant health and comfort and for the dilution and removal of unavoidable pollutants, low ventilation is not the primary cause of IAQ problems.

The quality of supply air was also addressed. By not addressing the quality of air used for ventilation, many designers misapply ventilation standards, focusing only on providing adequate quantities of ventilation air. This can lead to the misperception that inadequate quantities of ventilation is the cause of most IAQ problems. Inadequate ventilation is not a source of indoor contamination, but rather allows the pollutant levels from indoor sources to increase in concentration.

Increased ventilation (and the attendant increases in energy consumption and costs) beyond that which is needed to provide occupant health and comfort must be balanced

against the removal of the offending pollutant source responsible for the increase. There was no consensus on how much ventilation was needed.

What are the most energy and cost effective techniques for controlling indoor pollutant sources?
The most cost effective controls depend on many factors including climate, pollutant source, and occupancy pattern. When pollutants are unavoidable, local pollutants are best extracted at the source. Typical examples in this category include cooking and local moisture generation. When pollutants are widely distributed, for example emissions from building fabrics and furnishings, control would need to be removal by dilution ventilation.

Source control or elimination was generally thought to be most acceptable approach for avoidable pollutants. For the building owner or occupier, some workshop participants regarded source control as the lowest cost option. Where individuals were collectively content to smoke, smoking areas or lounges (with extraction and no air return to other spaces) was considered the preferred strategy for the control of environmental tobacco smoke.

Outdoor pollutants cannot be effectively controlled by ventilation. In residences, for example, the first step to radon mitigation is to tighten the building shell and foundation to prevent radon ingress. In office buildings, air intakes should be located away from polluting zones such as traffic areas and adjacent exhaust points. Other controls include filtration and air cleaning.

What are the most energy and cost effective techniques to provide adequate building ventilation?
It was agreed that intentionally provided ventilation was essential for good IAQ; reliance on uncontrolled air infiltration was deemed unsatisfactory. However, systems should be as simple in design as possible. In moderate climates, intentionally provided natural ventilation, based on vents, stack effects, and atria design may be appropriate. In severe climates, or in buildings subjected to high heat loads and population densities, mechanical systems combined with air conditioning and heat recovery are important for both comfort and energy efficiency.

It was stressed that ventilation systems should tolerate inaccuracies in design, construction, and use. Particularly important is the distribution of outdoor air to occupants, but it can be especially difficult in large and heavily partitioned spaces. The role of ventilation should be separated from that of cooling, perhaps by the introduction of chilled ceilings. A further suggestion was the introduction of high efficiency fans combined with careful sizing that could lead to a new generation of low cost mechanical systems for both the office and the home.

Systems must also cope with seasonal and daily variations in climatic conditions. Specific problems include humid outdoor air, dry air, and high diurnal temperature variations.

The performance of heat recovery devices and mechanical ventilation systems can be destroyed by air infiltration. Therefore, when completed, the building must be of airtight construction. This is being addressed by an increasing number of codes and standards.

W2 CRITERIA FOR CODES AND STANDARDS OF RESIDENTIAL VENTILATION

Klaus Endrullat, Germany, Robert Axelrad, USA, Kevin Teichman, USA, Chairmen

PROBLEM STATEMENT

Ventilation is required mainly to dilute and exhaust human effluent and chemical and biological pollutants from a variety of indoor and outdoor sources. Ventilation rates should be as low as possible to conserve energy while also providing a healthy and comfortable environment.

To achieve an acceptable residential ventilation standard which reflects the accessible knowledge, we must 1) identify the pollutants and pollutant mixtures of concern in residents, 2) characterize the pollutant sources contributing to these exposures, and 3) choose among potential control options, including source control and ventilation.

QUESTIONS TO BE ANSWERED

1. What are the appropriate bases for residential ventilation rates?
2. As criteria for setting ventilation standards for the residential environment, how feasible are: a) Pollutant specific numeric health-based standards? b) Emission rates? c) Indicator parameters, such as total volatile organic compounds (TVOC) or carbon dioxide CO_2?
3. Is mechanical ventilation necessary to provide adequate ventilation in the indoor residential environment?

DISCUSSION

What are the appropriate bases for residential ventilation rates?
There appeared to be a consensus among workshop participants that ideally, residential ventilation standards (i.e., minimum requirements for ventilation) should be based on the need to protect the health of building occupants in both developing and industrialized countries. In attempting to develop a health-based ventilation standard, it is important to take into account several factors. First, ventilation should not be used as a cure-all in lieu of appropriate source management but should be used to address those contaminants that cannot be controlled through source management. Second, a range of ventilation rates will be required to account for different climactic conditions, degrees of building tightness, sources of potential contamination from both indoor and outdoor sources, and the need to address both continuous and intermittent sources of indoor and outdoor pollutants. Third, ventilation rates should vary depending on pollutant loading, which should increase efforts on the part of manufacturers to reduce pollutant emissions.
It was suggested that minimum performance guidelines for ventilation equipment be specified to ensure adequate performance.

For developing countries, the issue of appropriate ventilation is made more complex by economic, social, and other factors. It was noted that solid combustion fuels are a major

indoor air contamination problem in developing countries requiring modification of the source to eliminate such fuels.

As criteria for setting ventilation standards for the residential environment, how feasible are:
a) Pollutant specific numeric health-based standards?
There appeared to be consensus that sufficient data to establish health-based pollutant-specific standards which could be used to calculate ventilation rates will not be available any time in the near future.
b) Emission rates?
The methodology for calculating emission rates is fairly well developed, although specific sources will require modifications in the testing protocol. Because emission rates are not directly correlated to health data, the use of emission data as a health basis for ventilation rates is questionable. However, it was noted that as a tool for encouraging pollution prevention/exposure reduction strategies, increased use of emission data by manufacturers of products used indoors is desirable.
c) Indicator parameters, such as total volatile organic compounds (TVOC) or carbon dioxide CO_2?
Most participants appeared to believe that TVOC and CO_2 were not appropriate bases for setting residential ventilation standards. TVOC is too imprecise a measure of toxicity and CO_2 is more appropriate in office environments where human occupancy rates are higher than in most residential settings.

Is mechanical ventilation necessary to provide adequate residential ventilation?
There is a difference of opinion regarding whether mechanical ventilation is necessary. There is consensus that in moderate climactic zones controlled natural ventilation is also possible. In climates where certain hot and cold conditions exist, it may be appropriate under some circumstances to require different types of mechanical ventilation, particularly to control moisture and other pollutants with known health effects for which source control is inadequate or inappropriate. Independent of climate, natural or mechanical ventilation should be required for kitchens and bathrooms to control moisture.

CONSENSUS

The available research results are not yet usable for establishing health-based ventilation requirements or for standardizing ventilation requirements. There is a need to move toward health-based ventilation rates that are able to take into consideration multiple factors related to the country, climate, building tightness, pollutant load, usage and occupancy, and social and economic factors.

RECOMMENDATIONS

Research into appropriate residential ventilation rates must be continued and perhaps expanded in order to provide policy makers with sound criteria for residential ventilation codes and standards.

W3 NEW CRITERIA FOR VENTILATION: SENSORY EFFECTS

William S. Cain, USA, and Thomas Lindvall, Sweden, Chairmen

Co-sponsor: International Society of Indoor Air Quality and Climate (ISIAQ)

BACKGROUND

Irrespective of any other criteria, such as health, used to decide the habitability of an indoor space, the criterion of whether human beings perceive the atmosphere as acceptable stands as key. Perceptual attributes of relevance include odor, irritation, and the thermal dimension. Chamber experiments have previously offered guidance about the amount of clean air that visitors to a space will consider acceptable by sensory criteria. Various questions arise from such experiments.

QUESTIONS AND SOME CONSENSUS ANSWERS

Do the recommendations from chamber experiments converge with other criteria, e.g., consensus of ventilating engineers, regarding fresh air rates for acceptable air quality?
From one decade to another through the 20th century, recommended ventilation rates, which have been set principally by consensus of ventilating engineers, have varied by a factor greater than five. Required minimum ventilation rates for offices (in L/s m^2 floor) even now range between 0.7 and 1.4 from organization to organization. In Europe, there is fairly good agreement: 1.1 to 1.4. The large variation illustrates in and of itself only weak convergence on any particular criterion. We may, however, have moved beyond the day when very low rates will be recommended. Some data from field studies imply that below 10 L/s p symptoms may begin to accelerate. Chamber data imply much the same. In any case, better articulation of the reasons for particular recommendations seems called for.

Do chamber tests with visitors alone give an adequate indication of fresh air requirements, or should chamber tests with occupants supplement those with visitors?
It is useful to distinguish between two kinds of sensory effects. One comprises environmental perceptions, e.g., odor, and the other concerns body perceptions, symptoms, e.g., eye irritation. Both are important, but require different protocols for investigation. Assessment of odors can use visitors whereas assessment of body perceptions needs to use persons who would be exposed over time. Irritation, like odor, is a time-dependent effect. It includes, for example, a component of temporal summation.

What percentage satisfaction should form the customary criterion for acceptability?
There is no a priori reason to permit great dissatisfaction. In the WHO air quality standard for Europe, for example, the nuisance threshold level has been placed at dissatisfaction by 5 % of persons not more than 2 % of the time. This is a relatively stringent criterion, but would have merit indoors if economically and practically feasible. The European guidelines for indoor air quality require a conscious decision about how

much dissatisfaction to allow, with a range from 10 to 30 %. Ventilation requirements will of course vary inversely with the amount of dissatisfaction decided upon.

Should we devise a uniform sensory protocol for chamber tests to decide acceptable rates?
This is a rather technical question and one for which a simple "yes" may be given, but coming to agreement about what protocol would work best would taken considerable time and effort. Fundamental issues, such as what sensory dimensions to measure and whether to use trained or untrained panelists, might require some comparative tests as well as discussion.

Should field tests verify rates recommended by chamber tests and should air quality standards require field tests as part of compliance?
For various reasons, chamber tests may fail to provide complete enough data. Ventilation rates need to satisfy at least five criteria simultaneously: a) minimum rates based on health effects, b) minimum rates based upon satisfaction, c) choice of optional ventilation air above the minimum, d) ventilation efficiency and various other characteristics of the ventilation system, its design, operating characteristics, and maintenance, d) definition of various loading factors, positive and negative, that may exist only in the field, e.g., contribution to load by the building itself and its furnishings, interactions between contaminant sources of any kind, control of sources. It becomes relevant within this context to define a "load max." Some field studies are needed.

What contaminants matter the most and do enough data exists to decide fresh air rates to control those contaminants?
This question raises the fundamental issue of whether and when to use humans. For materials of unknown composition or toxicity the use of humans may be ethically indefensible. If humans are to be used to screen materials, they should serve only after animal toxicity tests have been run and toxic properties characterized. Indeed, if bio-responses are to be used, they should preferably come from animals. Such bio-responses as the negative mucosal potential may offer considerable sensitivity to screen irritation. In any case, there was little consensus about what contaminants matter the most.

W4 MAINTAINING CLEAN HVAC SYSTEMS

John R. Girman, USA, Richard Truter, South Africa, John McCarthy, USA, Chairmen

BACKGROUND

In buildings served by mechanical ventilation, maintaining a clean heating, ventilating, and air conditioning (HVAC) system is a key to providing adequate ventilation and good indoor air quality. Yet little guidance based upon the results of actual studies is available and many questions exist. Some of the important questions are: What are the major contaminants of HVAC system? Are biocides necessary? What standards or guidance can be applied? What precautions are necessary? What are the benefits/risks of duct cleaning? What studies are necessary to address any remaining issues? Despite the fact that duct cleaning is a relatively new practice and appears to be most common in North America and northern Europe, most of the discussion by workshop participants appears to assume that it was an appropriate practice under some circumstances and the discussion below reflects this assumption.

MAJOR CONTAMINANTS

A large number of contaminant types were identified: microbials; dust, including dust mites, heavy metals, construction residue (sheet rock dust, manufacturing oils on ducts); ETS and carbonaceous material; biocides; fibers (from construction or from HVAC system linings); water treatment materials such as glycols and amines; and water from humidifiers, cooling coils and inadvertent intrusion. Of these, most participants agreed that microbials and, therefore, also water, should receive top priority. Consistent with this, much concern was expressed about duct systems lined with fibrous materials because of the difficulty of cleaning such systems and the potential for accumulation of contaminants and water. Additional concerns were expressed about the presence of any organic material in HVAC systems.

Some participants believed that biocides are useful in poorly designed systems and could even be used on a regular or intermittent basis in condensate drain pans. Biocides which leave no residue are used in Germany (hydrogen peroxide) and in the USA (chlorine dioxide). Other biocides, though not approved, are also used in the USA. However, in many countries including Sweden, they are not used due to strong ethical considerations. Most participants expressed a strong view that biocides should not be used because solving one problem has high potential to create another. A far better approach is to have a properly designed system tjat does not have water in inappropriate parts of the system. Many technical options for achieving this were presented. There was divergence about whether it was truly possible to have such a system. The majority believed that it was an appropriate goal but in practice, under some conditions, problems with water were likely. Some of the difference in opinion may be due to conditions imposed by different outdoor climates.

CLEANLINESS

HVAC systems should be clean but need not be spotless. Adequate filtration reduces the need for cleaning but the return ducting from the occupied space will contain some contamination. This is not a problem unless contamination is extreme or air flow is

impeded. Reduced air flow in any part of the HVAC system because of contamination is a signal to clean the appropriate sections of the system. However, air supply ducts should be held to a higher standard of cleanliness because of the potential introduction of contaminants into the occupied space. Filtration is the principal tool for control of dust. Monitoring the pressure drop across filters was advocated as more appropriate than visual inspection or periodic replacement. While the need for objective standards for cleanliness was recognized, many difficulties were identified. In Sweden the guideline is 1 g/m^2 and it is believed that the NADCA (North American industry guideline) is 0.1 g/m^2. This difference illustrates the lack of consensus on this issue. In addition, an adequate standard should acknowledge the many types of contaminants possible. Guidance in the form of a single number does not appropriately account for these differences.

BENEFITS/RISKS OF DUCT CLEANING

Consensus was strong that biocides are used too frequently and that risks from their use was poorly understood. Proper design to include good access for inspection and servicing is the more appropriate solution and will diminish the need for duct cleaning. Barriers to accomplishing this received much discussion. These barriers include emphasis on first costs (construction and equipment costs) at the expense of overall costs which include equipment replacement costs, maintenance and servicing costs, diminished marketability and productivity losses. It was pointed out that design engineers do not have incentives to account for long term, overall costs. A possible solution to this problem is to use market forces through education to motivate medical and commercial insurance carriers regarding reduced liability because of better HVAC design. An additional barrier is proper training of maintenance personnel to protect the capital investment and to reduce maintenance costs. Several precautions should be taken when ducts are cleaned. Occupants should not be present and should receive notification of the work to be done. The space should be isolated from the rest of the building. Duct cleaners should wear appropriate protective equipment. Coarse filters should be installed on supply registers and care should be taken not to damage the ducts or any linings. The HVAC system will probably require rebalancing.

REMAINING QUESTIONS AND ADDITIONAL STUDIES

Some participants called for regulations of HVAC system cleanliness and maintenance. However, there are difficulties with this approach. Existing data are inadequate to address differences in contaminant types and amounts, especially for different indoor environments (office, school, hospital, or residence). While there appears to be qualitative consensus on what cleanliness means, the knowledge base for establishing quantitative standards is inadequate. Additional information is needed about the accumulation of contaminants in HVAC systems including time profiles and the types of contaminants. Information is needed relating contaminants in the HVAC system to concentrations in the occupied space and to the impact on occupants' health and productivity. Current information is insufficient to develop numerical standards, especially for microbials, based upon health effects. Better guidance is also needed for HVAC system design for improved maintenance and service access and for filter selection based upon the type of indoor environment.

W5 EVALUATION OF BUILDING MATERIALS

Bernd Seifert, Germany, W. Gene Tucker, USA, Hal Levin, USA, Chairmen

BACKGROUND

Similar to the situation in other environmental areas, the "end-of-pipe" strategy is not the most appropriate strategy to guarantee good indoor air quality. Rather, it is more effective in most cases to use source control as a tool to exclude that elevated levels of air contaminants occur. This statement is especially important for all kinds of building materials and products which not only cover a high percentage of the surface area in a room, but also cannot be removed easily by the occupant in case they are discovered to be important pollutant sources.

The Commission of the European Communities, in 1989, has issued a directive on construction products which prescribes that buildings - among other requirements - be built so that they will not be a threat to health and hygiene due to, in particular, the giving-off of toxic gas and the presence of dangerous particles or gases in the air. The requirements of this directive which reflects also the needs seen in many countries outside the EC, i.e. to select the most appropriate materials for construction, call for procedures to evaluate building materials. Such evaluation needs to include both an analytical part to determine the emissions from building materials and an effect-oriented part.

Conduct of the Workshop:
For the discussion, building materials were defined as follows:

- materials used in or on floors, walls, and ceilings;
- materials used in the air handling portions of HVAC systems;
- materials used for maintenance of floors, walls, ceilings, and HVAC systems.

Before the start of the workshop participants (who were not necessarily experts in the area dealt with at the workshop) were asked to answer the questions in a prepared questionnaire according to their actual state of knowledge and own judgment. After having listened to "yes" and "no" arguments prepared by invited speakers, the audience discussed these arguments. Following this exchange of ideas, each question was answered again by everybody to see if the arguments made during the discussion had convinced people to change their first judgment. A total of 82 questionnaires were completed and summarized in the remainder of this report.

QUESTIONS AND DISCUSSION AND RESULTS:

Question 1: Do we have adequate techniques to characterize chemical emissions of building materials? While some participants supported the idea that we can measure emissions and that modeling techniques are available to predict the resulting indoor concentrations, others did not fully support this judgment and came to a "yes, but" conclusion; these participants, however, mentioned especially the still poorly understood sorption effects and the fact that not all compounds are easily determined correctly. Answers were distributed quite evenly between "yes" and "no" and did not change much:

BEFORE		*AFTER*	
Yes	*No*	*Yes*	*No*
55 %	45 %	52 %	48 %

Question 2: Do we have adequate techniques to characterize comfort effects of building materials? Even the officially appointed advocate of the "yes" had to admit that "yes" is not realistic today. However, it may become valid within 10 years from now.

The question was found to be too complex to be answered by a simple "yes" or "no". In the discussion it was also advocated that the definition of the words "adequate" and "characterize" in the question could be the subject of a longer debate. Answers remained fairly stable and were distributed as follows:

BEFORE		*AFTER*	
14 %	86 %	13 %	87 %

Question 3: Which is the better way to predict potential adverse effects of building materials (check A, B, or C): A. Measure emissions, then use available toxicological information to predict adverse health effects. B. Test biological responses to human, animal or in vitro test methods to emissions from materials, then predict adverse health effects. C. Combination of A and B
For this question, a selection between answers A, B and C had to be made. Today, A seems to be the only reasonable approach, but B may become possible in the future if more information is available. The difficulty of detecting long-term effects (especially on humans) via B was emphasized. In addition, ethical considerations would also have to be considered if biological responses of humans were to be investigated. As shown by the percentages, trust in the validity of predictions based on procedure B alone diminished after the discussion:

A: 19 % vs. 16 % (before/after) B: 4 % vs. 0 % C: 77 % vs. 84 %

Question 4: Is ranking of building materials for the same use an appropriate procedure of evaluating them? The major debate was on the nature of the parameters to be considered in the ranking procedure. Emission rates and toxicological considerations must be part of the ranking and life-cycle emissions need to be considered. The majority of the participants were in favor of developing a ranking procedure and not much change in opinion could be observed:

66 %	34 %	69 %	31 %

Question 5: Do you agree that low-quality building materials be on sale provided that their use is restricted to specified conditions? There were mixed feelings concerning the fact that low-quality products may be admitted to the market. People have a tendency not to follow instructions that would have to be linked to such products. Low-income people would probably not be protected sufficiently. The sale of low-quality products would contradict the attempts to control sources as much as possible. A noticeable shift in opinions could be seen after the discussion:

54 %	46 %	45 %	55 %

Question 6: Do current evaluation techniques provide a satisfactory basis for labeling building materials? It was mentioned that either positive or negative labeling is possible. Positive labeling seems to be preferable. It was emphasized that if ranking is possible (see question 4), then labeling follows automatically. There was a clear "no" majority which, however, decreased after the discussion:

30 %	70 %	38 %	62 %

N.B. The organizers of the workshop would like to emphasize that the numbers given above are not representative and should not be used as such. Their scientific value is questionable for a number of reasons which were discussed in detail at the workshop. However, they may give a first impression of where we stand today.

W6 TLVs AND IAQ GUIDELINES: RESOLVING THE AMBIGUITIES

Richard B. Gammage, USA, and John A. Tiffany, USA, Chairmen

Michael Hodgson; Ed Light; and Claudia Miller; Workshop Speakers

Co-sponsor: American Industrial Hygiene Association (AIHA)

PROBLEM STATEMENT

For the past fifty years, the American Conference of Governmental Industrial Hygienists (ACGIH) through its Threshold Limit Value (TLV) Committee has been setting numerical guidelines for single compounds produced or inputted into industrial processes. Additionally, the American Industrial Hygiene Association (AIHA) has a Workplace Environmental Exposure Level (WEEL) Committee that develops guidelines for industrial chemicals lacking a TLV. The TLVs were first proposed in 1946 for 146 chemical substances. In 1991, there more 650 substances for which a TLV was assigned, and the concept had been expanded to physical and biological guidelines. Until recently, some traditional industrial hygienists have been skeptical concerning the need for alternatives to the TLVs and WEEL's in the non-industrial environment. The Indoor Environmental Quality (IEQ) Committee of the AIHA, on the other hand, has come to favor alternative approaches (generally non-numerical criteria) for helping to resolve IAQ complaints.

At this workshop, organized by the IEQ Committee, comments were unanimous that TLVs are generally inappropriate for resolving IAQ problems. Sentiment was also expressed that there exist no real ambiguities between TLVs and IAQ guidelines. TLVs and non-numerical IAQ guidelines are addressing different circumstances in the workplace. A TLV is intended to provide a healthy worker with adequate protection against individual compounds predominating in the industrial processes. IAQ guidelines aim at protecting all types of individuals working in office environments who are exposed to lower concentrations of complex mixtures of chemicals and other office environmental factors that TLVs were never intended to address. The speakers also expressed the belief that any effective numerical comparison with regard to air concentrations should be done on a relative basis. This can include a temporal and spatial comparison of levels at different times in the same locations, or by comparing the levels to the airborne concentrations outside the location.

Five basic criteria for setting IAQ standards were discussed. Firstly, an appropriate outcome must be used for setting the standard. Second, the effects of multiple components found in the environment be taken into account. Third, the question must be answered whether representative measurements can be taken of the specific contaminant(s) being considered for a standard. Fourth, is the frequency of outcomes predictable, and are they general for the population at risk? Specifically, has the intensity of each of the predicted outcomes been addressed? Fifth, are the dose/response relationships adequately worked out? Currently, no TLVs, or any other IAQ guideline, can meet these criteria. Alternatives must be considered, such as non-numerical guidelines, or ALARA (as low as reasonably achievable).

QUESTIONS ASKED BY THE WORKSHOP PARTICIPANTS

The scope of the questions asked by the workshop participants were twofold: the concept of standard setting as a matter of public policy; and the use of objective versus subjective criteria for the setting of standards or guidelines. The workshop participants and the speakers agreed that the makers of public policy must take action sooner rather than later with regard to standard setting. They must react to the public's perception of risk and act accordingly. The "social amplification" of risk perception was discussed and it was noted that this is driving the IAQ field and is probably a factor in the increased number of complaints of chemical sensitivity. There was also a discussion of "blue collar versus white collar" workers and if it is appropriate for the setting of different standards for these different work environments and populations. It was agreed that these different settings may require different guidelines and methods of addressing the different perceptions of risk and the chemical sensitivity of the two populations. However, the concept of higher levels for blue collar workers was not considered acceptable; perhaps the TLV review process should be reconsidered.

RECOMMENDATIONS

Basic understanding of the etiology of syndromes such as Sick Building Syndrome (SBS), Multi Chemical Sensitivity (MCS) and hypersensitivity are largely lacking. The hypothesis of "kindling" of the limbic system of the brain expressed as neurological impairment is one possible starting point for research. Dealing with these syndromes on both a pragmatic and policy decision basis needs to be based on good science. Strong sentiment was voiced by the participants for various national public health agencies to conduct a broad range of medical studies, especially human challenge studies, aimed at shedding light on the underlying mechanisms causing these problems.

W7 ASKING THE RIGHT QUESTIONS: OCCUPANT HEALTH SURVEYS

Michael Hodgson, USA, and Gary Raw, UK, Chairmen

BACKGROUND

This workshop addressed the use of appropriate questionnaires in building surveys. Four questions were posed as follows:

What is to be measured?
For what purpose?
By what methods?
With what reliability and validity?

QUESTIONS ASKED

For what purpose are we measuring?
Participants suggested the following goals: 1) surveillance of buildings (longitudinal measurement), 2) screening for problems (cross-sectional approaches), 3) outbreak investigations, and 4) formal research on the SBS. Each may require different specific questionnaires. Surveillance and SBS research may use a standardized questionnaire. Outbreak investigations and problem screening may each require specific instruments. Such investigations may also constrain questionnaire structure. For example, intervention studies require short-term symptom descriptions, based on intensity measures, whereas as others may use symptom frequency definitions. Outbreak investigations must establish a clinical case definition, develop a questionnaire to capture that definition, and validate the questionnaire. Conversely, they may use a previously validated questionnaire, although even then, the questionnaire responses may be influenced by other factors within the building. Specific conditions and symptoms may be related to exposures in a certain temporal relationship. The questionnaire must be structured in a way that it can reflect those characteristics. For example, current (at the time of investigation) and recent (over the last hour, day...) symptom responses may need to be offered.

For some screening and problem investigations, a building walk-through or engineering review may formulate hypotheses that can be tested with a questionnaire. These may include occupant perceptions of their environment (too hot, too cold, stuffy, dusty...). Finally, when we use questionnaires, we should have clear goals in mind. Occupants must be aware of those goals. Otherwise, they may respond inappropriately.

Although the questionnaires that have been used appear reasonably robust, they do have poorly developed test characteristics, i.e., we do not know how accurate or precise they are.

What is to be measured?
The actual content of the questionnaire must address the topic of interest. Broad-based research on the SBS may use a standardized questionnaire, as may surveillance. The questionnaires currently in use are likely to provide useful information. On the other hand, additional information besides presence or degree of symptoms and discomfort is

often necessary. This may include information on environmental conditions, on work-place issues such as work stress or labor-management problems ("political" topics), spatial comfort and privacy, and personal medical aspects. One participant emphasized that we should distinguish between factors that can only be identified through questionnaires or interviews, such as the presence of medical symptoms or perceptions of the environment, and information that can be more easily or accurately obtained through direct observation, such as distance from windows.

The phenomenon of "work-relatedness" of symptoms was discussed at some length. Symptoms and this temporal characteristic must be measured in two separate questions. Including or excluding this criterion in analyses is not likely to make a difference in building rankings in the experience of most investigators. Nevertheless, individuals may have symptoms that do not resolve away from buildings because their disease is more severe. Such questions therefore may have limited usefulness in problem solving, research, and individual assessment and screening.

Specific characteristics and qualities within individual symptom categories do not appear to distinguish individuals and buildings, as they "converge." That is, irritation, dryness, and tearing of the eyes cluster strongly. They do not always correlate well with other symptom groupings.

By what methods?
Several participants pointed out alternative ways of examining questionnaires. Plotting spatial characteristics in a two-dimensional format (Orebro work) may identify etiologies. Alternative approaches to questionnaires include recording sickness absence, as validation or as a second measure.

Open-ended questions may be useful in allowing individuals to vent their opinions.

With what reliability and validity?
Reliability has been examined in a number of investigations. At least one questionnaire appears to have re-test validity. On the other hand, response frequency does appear to decrease with repeated administration so that control groups or other measures to control for this are necessary.

External validity consists of face, construct, and predictive reliability. The first two appear to exist. Work by Franck and Skov and by Wyon strongly support this. On the other hand, the failure to document previously documented measures of validity (tear-film break-up time and eye irritation) may be related to missing validity or to other study factors (failure to characterize tear stream or blink frequency).

Interventions may lead to questionnaire-dependent response changes so that accuracy may change over time.

Several problems were raised such as that of small sample sizes. Manual diaries or computer-based, self-prompting automated record keeping may be useful strategies.

The predictive validity of questionnaires remains to be defined.

W8 EVALUATION OF MICROBIAL CONTAMINATION OF BUILDINGS

Aino Nevalainen, Finland, Brian Flannigan, UK, Chairpersons

BACKGROUND

Over the past few years, evidence has accumulated that there is a link between health and exposure to fungi and bacteria in indoor air. In most cases the exact cause of ill-health cannot be pinpointed. While the physician can diagnose illness, the microbiologist cannot adequately characterize the exposure(s) or provide him with the information he needs for treatment of the illness. The investigating team can advise the physician whether the patient can be returned to his home or workplace. Currently, such advice can only be based on unequivocal evidence that all fungal contamination has been removed, that the building surfaces cleaned appropriately to remove particulate matter, and that the situation is under control.

STANDARDS

Unlike other contaminants of indoor air, indoor sources of fungal growth can be prevented and eliminated through appropriate design and maintenance. In addition, inappropriate use of building space can be a source of microbial contamination (e.g., storage of firewood indoors, inappropriate handling of dirty laundry, high densities of poorly maintained potted plants). There are considerable difficulties in developing risk assessments for exposures to indoor-source molds and their products. Regardless, it is difficult to defend unnecessary exposures to fungi and bacteria.

In outdoor air above ground, variable concentrations of phylloplane (plant associated) and Basidiomycete (mushroom/bracket) fungal spores are present worldwide (except during snow cover). As a general principle, the airborne mycoflora should therefore be similar inside and outside. In buildings with HVAC systems incorporating filters, the airborne fungal burden should be lower indoors compared to outdoors.

Bacteria in indoor air are mainly gram-positive cocci that arise from occupants and should be managed by appropriate occupancy and ventilation. HVAC systems and domestic water supplies should be designed to prevent the growth of Legionella and gram-negative bacteria that are a source of endotoxin.

METHODS

Some methods exist for characterizing exposures to fungi and fungal products in buildings. At present their use requires a high level of training and experience. None is adequately quantitative; they probably also inadequately characterize the fungal populations present and do not characterize their allergens, toxins, volatiles and other products. Individual exposures to fungi vary considerably in buildings and are a function of proximity to the amplifiers and reservoirs. Hence determination of "average exposures" is of limited use. The presence of fungal spores and volatiles varies according to the amount of water in the amplifier. Distribution of fungal particles varies according to the

activity within the buildings, pressurization/depressurization of wall cavities and HVAC system operation.

In terms of defining the qualitative nature of the airborne mycoflora, the only useful approach is to attempt to culture living spores. This is complicated by the use of inappropriate air samplers, problems in collecting representative dust or other surface samples, the choice of culture media, and difficulties in fungal identification and taxonomy. Management of the airborne mycoflora requires the power to determine whether the indoor mycoflora is quantitatively similar to outdoor air. Consistent detection of pathogenic fungi such as Aspergillus fumigatus and toxigenic molds such as Stachybotrys atra and Aspergillus versicolor that produce potent toxins requires that special attention should be given. The techniques used must be able to determine their relative presence or absence with certainty.

New, robust chemical techniques for assessing microbial contamination are being researched, e.g., ß-1,3-glucan in fungal cell walls, molecular methods of identification (e.g., RAPD) and fungal volatiles. The need for these techniques is apparent, but they will not be available for several years yet.

Newer techniques for the determination of Legionella (e.g., PCR) and endotoxin are more accessible but are still in a state of flux.

TRAINING

The techniques for characterization of the status of the airborne mycoflora are difficult and inexact. A high degree of training and interdisciplinary cooperation must also be used to manage these microbiological problems. Informed inspection of buildings for water and microbial damage should be made by trained engineers familiar with building and HVAC design and maintenance. This is the first step in evaluating the microbiological status of the building. Visible signs of microbial damage should prompt involvement of a mycologist trained in the investigation of microbial problems in buildings. The failure to find an obvious cause of indoor air quality complaints should also trigger the involvement of mycological expertise at an early stage. Many studies have shown that some kinds of fungal contamination cannot be easily detected.

Expertise in management of Legionella and endotoxin should be sought from specialists.

The most important finding of the workshop was that there is an urgent need to develop state-of-the art-training programs for engineers, occupational health practitioners and mycologists. Some agencies, e.g., Public Works Canada and the American Industrial Hygiene Association, have begun a process to accredit investigators in this area. The workshop recognized the urgent need to pursue this course.

W9 NUMERICAL PREDICTIONS OF AIR QUALITY AND THERMAL ENVIRONMENT

Peter V. Nielsen, Denmark, Shuzo Murakami, Japan, Chairmen

PREDICTION OF EXPOSURE AND PRESENTATION OF COMFORT PARAMETERS

A short introduction by Peter V. Nielsen showed how the flow in a room will be locally modified by the presence of a person. This makes it difficult to predict exposure and actual thermal comfort at a given location.

S. Murakami continued the introduction by showing a Computational Thermal Mannequin that calculates the combined effect of convection and radiation in a specific place. The mannequin 'walks around' in the solution domain of a CFD prediction and it changes color according to the level of comfort. Measurements and predictions of the flow and heat transfer around a mannequin were also introduced.

The topics of environmental stability and flow after persons have moved around was discussed. It was concluded that it usually takes about 10 minutes to re-establish the prior (stable) condition in the case of mixing ventilation. If displacement ventilation is used, the thermal stratification will stabilize the temperature field and, although less rapidly,the concentration field as well.

It was concluded that exposure modeling is very important. Especially the measuring of the actual exposure due to breathing needs to be properly handled. Often there are many assumptions that result in an insufficient determination of the real exposure.

It is important to use the most advanced prediction methods when the contaminant source is small and located close to the breathing zone because measurements from industrial environments show that small changes in the location of measuring equipment significantly impact the results. Contamination from large area sources (e.g., a carpet in a room) does not necessitate the use of an advanced method for exposure prediction.

A certain gap between the crude 'total mixing' assumption and the rather detailed CFD predictions was found. There is a general need for 'toolboxes' to bridge the two different ways of treating the problem.

Finally, in the first part of the workshop, the need for 'engineering intuition' and understanding of the basic physics was emphasized.

THE ART OF MAKING BOUNDARY CONDITIONS FOR CFD WITH RESPECT TO IAQ CALCULATIONS.

The governing equations used for numerical prediction were presented by Dr. A.J. Baker, USA. It is the task of the HVAC-engineer to specify the boundary conditions (BC). It is associated with considerable difficulties as the detailed information is often not available - we are usually dealing with fuzzy data.

A.J. Baker demonstrated the importance of BCs by an example of thermal-driven flow in a cavity. Minor differences in BCs were occasionally reflected in substantially deviating solutions.

These remarks initiated the discussion. Emission for some materials is controlled by interior diffusion, while the boundary layer flow is controlling the emission in other situations. It was stressed that the physical processes of fluid flow and desorption are incompatible due to different scales in time and space. Diffusion in materials takes hours and days while diffusion in air is almost instantaneously. Dealing with particles the length scales are in the order of microns and the boundary layer thickness in air flow predictions is typical centimeters.

It was recognized that numerical computations and experimental investigations are usually carried out in empty rooms under steady conditions. The presence of occupants affects the flow field and in principle transient phenomena are important. Due to the difficulties connected with unsteady (transient) behavior, a statistical approach was recommended.

The procedure of validating the models was addressed. The aim of validation is mainly to test the models capability in terms of applications to 'real' cases and not only to verify the performance in mathematical sense.

A three step procedure is used in general. The first step is to make predictions according to a known answer. The next step is to make tests on relevant cases which checks the mathematics and physics (benchmark tests). The third and last step is the validation where different types of physical experiments are compared with CFD-results.

CFD originates from mechanical engineering where forced flow is of primary interest. However, in residential buildings (without mechanical ventilation) natural convection is dominant. Radiation phenomena, improved turbulence models for natural convection, and a better description of natural convection at surfaces are topics needing further development.

Parallel to increasing available computer power the CFD programs become more complicated and more time is spend on creating input and evaluating the output - this is not necessarily the best way of using the limited resources.

W10 RADON POLICIES AND SCIENCE

Susan L. Rose, USA, Michael Suess, Israel, Matti Jantunen, Finland, Chairpersons

Co-sponsors: World Health Organization (WHO), US Department of Energy

PROBLEM STATEMENT

Various countries treat the radon problem in different ways. They also have different economies, national problems priorities, and different radon issues. Several international radon meetings have recently been convened, much radon research is on-going, and many national and international bodies come up with radon statements. This workshop was planned to facilitate discussion on radon issues of interest to attendees at the Indoor Air Conference, many of whom are part of these other efforts and could contribute to the collective knowledge.

Michael Suess and Tony Nero talked about the EPA-WHO radon meeting in Eilat, Israel, in March and explained consensus recommendation on a risk-based criterion for indoor radon of 10^{-3} *per annum.*

Phil Hopke and others talked about the radon meeting in Rimini in June and highlights of the new ICRP document were presented. This document, still in draft form, recommends an action level of 200/Bq m^3 for dwellings and a level of 1000 Bq/m^3 for occupational settings. Another part of the ICRP report that drew comments was a recommendation that those areas or countries with 1 % over the action level of 200 Bq/m^3 be "priority areas." This makes the entire world a "priority area." Some discussion also arose on occupational versus residential differential recommendations.

QUESTIONS ANSWERED

What is known about the health effects of low level radon exposures and what needs more knowledge?

- Joint pooling of uranium miner studies discussed (Samet)
- Status of residential epidemiologic studies discussed (Samet, Stolwijk, Swedjemark)
- It was acknowledged that we have no knowledge of low level effects. We only extrapolate from uranium mines. Epidemiology will not answer these questions.
- Cellular and molecular studies were discussed and it was suggested that only they will provide information on the low level effects. Epidemiology can not provide information on low level effects or mechanisms of action.

Scientifically sound cost/benefit aspects of radon policy choices:

- No scientific basis for excess risk to children was discussed Politics, not science.
- Finding high risk homes and persons appears to be a priority in most countries.
- Long term testing best for exposure information/technology limits and radon variability.
- Who should pay for testing and mitigation? Several countries and several parts in the US do. Examples were given on help to citizens and policies of cost.
- Radon preventable deaths (very few) versus attributable deaths (risk numbers from epidemiology), are very different issues
- Need to provide sound information to all citizens, also express uncertainty.

W11 DESIGN OF SBS RESEARCH

Erhard Mayer, Germany, Philomena Bluyssen, The Netherlands, Gary Raw, UK, Chairpersons

Co-sponsor: CIB

PROBLEM STATEMENT

In the past a lot of research on SBS has been done. On the other hand many questions still are unsolved. One conclusion of that might be that we need to develop further the interdisciplinary research and international collaboration.

Inge Kirchberger presented an example of an interdisciplinary study in Germany and stated that there is a need for more studies of this kind, but also pointed out the difficulties you might encounter setting it up. Some effort must be put into understanding the basic concepts and methods employed in different disciplines. There can also be problems obtaining funding since the usual funding routes followed within each discipline may not apply to a interdisciplinary study.

Douglas Walkinshaw presented some examples of the benefits of interdisciplinary and international working from his own experience.

Philo Bluyssen presented the reasons for starting the "European audit project to optimize indoor air quality and energy optimization in office buildings." First, a standardized European method to investigate problem buildings would make comparison of results from different studies in different countries easier and more convenient. Second, this project will provide information for the European IAQ database.

Gary Raw presented a report being prepared for the European Collaborative Project on Indoor Air Quality. The report will provide guidelines for the design of intervention studies to address sick building syndrome. The idea is not to set out a standard research design, but to provide a common logic and methodological framework that links the best advice from different disciplines together in a single source document.

QUESTIONS TO BE ANSWERED

Should we standardize the design of studies of SBS?
In the "Audit project" standardization is definitely necessary, but for research projects, there is a demand only for guidelines, as described by Gary Raw. However, to make sure that specialists of different disciplines can understand each other, a certain agreement on the definitions, e.g., of SBS, must be reached.

Comparison of results among countries can only be possible if one has a representative sample of buildings from each country. The "Audit project" is not designed to do this.

always know what we are measuring. Until we have a better idea of what we are measuring, it is still better to have a common element in methodologies. Guidelines would help.

One disadvantage of standardizing SBS studies is that such standardization could suppress creativity and could result in channeling research funds to those who use the standardized approach.

Should we conduct mainly intervention studies?
Intervention studies are strong designs for the identification of cause-effect relations, but cross-sectional studies are useful when it comes to identifying new parameters and generating hypotheses.

Not every potential cause can be studied by an intervention study. For example it may be impractical to replace all the windows in a building, and it could certainly not be done double blind. In some instances, e.g., cases of Legionnaires' disease, an immediate solution must be sought.

Is there a demand for the above-mentioned European guidelines for SBS research?
SBS research guidelines are useful, not only in Europe but definitely in countries which do not have such a long history of SBS research.

Guidelines should be flexible enough to allow individual research teams to develop their own detailed approach and to make future adjustments possible.

Good guidelines should take a modular approach. For example, in the case of a questionnaire, a standard core of questions could be recommended, with other sets of questions being available.

CONCLUSIONS

There is a demand for guidelines that can provide basic definitions and recommendations for design and measurement.

It is recommended to carry out intervention studies where this is feasible.

W12 CHALLENGES AND OPPORTUNITIES OF CHAMBER EXPERIMENTS

Lars Mølhave, Denmark, and Hillel Koren, USA, Chairmen

Co-sponsor: US Environmental Protection Agency

EXPERIMENTAL DESIGN PRINCIPLES OF CONTROLLED EXPOSURES

The advantages of controlled experiments versus. other types of investigations (such as epidemiological or field studies) is that they can be used to establish causality as most variables affecting the outcome of the exposure can be controlled. Epidemiological and experimental investigations are complementing each other in establishing a dose-response relationship. Controlled experiments are further used for developments of analytical methods and for diagnostic exposures of patients (e.g., in asthmatic subjects) and for providing data for modeling of "real world" scenarios.

Generally, repeated exposures of the same person can be used to increase the experimental sensitivity of the design. However, effects of training may affect the subjects performance in behavioral tests.

Bias caused by perceptions of the exposures or the effects on the body caused by the exposure may be a problem in many experimental designs. This bias may also occur at exposures below sensory thresholds e.g., in the form of perceived changes in physiological functions.

One way to maintain double-blind conditions despite the bias is to use masking, e.g., with an odorant. When using masking exposures, the possibility of effects caused by the masking agent need to be considered. Double-blind test conditions are not always needed or may even conflict with the purpose of the experiment, e.g., when dealing with questions of acceptability of the exposures. It is, however, important that subjects stay as blinded as possible for the duration of the exposure.

For economical and practical reasons the researcher is limited to the use of as few subjects as possible and to do as few repeated measurements as possible. The optimal number of subjects depends on the desired sensitivity of the experimental and statistical analyses and the representativeness of the panel needed for extrapolation of the results to the general population. Appropriate statistical design and procedures are available and should be applied to estimate the optimal size of the panel.

Psychological characteristics of the subjects are legitimate experimental variables in parallel with other biological variables if they are influencing the effects of the exposures. Psychological factors may be used as selection criteria but can cause selection bias of the panel. Psychological changes may be effect variables or co-variables that need to be controlled for in the experimental design.

BIOMARKERS AND OTHER RELEVANT MEASURES OF EFFECTS

The measures of effects which are relevant for IAQ research may be immunological, physiological, neurobehavioral, etc. The relevant measures depend on the hypotheses tested and should include all variables needed to confirm or reject the hypotheses.

Objective measures of biological effects relevant for SBS are still lacking. Measures should be developed and documented with respect to accuracy, reproducibility, etc. Such markers can be developed in the lab (controlled exposures) and validated in the field.

Generally, subjective measures are the most sensitive measures of effects. In some applications they are the only alternative (e.g., acceptability, god/bad air quality). If possible they should be supplemented with objective measurements to reduce the possibility of biasing effects.

RELEVANT EXPOSURES

The relevant variables in the experiment are all those environmental and biological factors or variables which can not be excluded as potential influences on the biological system or function under investigation. All these variables except the exposure variable should be controlled, held constant, or balanced in the design.

Experiments dealing with the effects of multifactorial exposures may include tests of single compounds from which the effects of the combined exposure, subsequently, may be calculated through toxicological models. If the exposures include many compounds and the possibility of interactions between or among the compounds exists, this toxicological modeling may turn out to be too inaccurate. Consequently, tests of mixtures may be more accurate and economical.

The exposure ranges used in the design should be selected considering both the relevance of the exposure for real life situations; the ethics of the exposure; and, the fact that only documentation of significant effects of the exposure allows the researcher to draw any conclusions. Therefore, at least one exposure level must be selected at a sufficiently high level to ensure a positive response to the exposure. This exposure level then serve as a reference or calibration exposure level.

Ethical considerations should include both protection of high-risk groups such as pregnant women or children, and should ensure exposure levels which are realistic in comparison with real life exposures. The ethics of IAQ exposures are still an open question.

RELEVANT POPULATIONS

Humans may be experimentally exposed both as test or control subjects in controlled experiments, or as patients in diagnostic tests. The relevant populations to investigate in IAQ experimental research should represent the general population including the hypersusceptible part and other high risk groups (e.g., due to high exposure or sensitivity). However, the hypersusceptible part of the population has not yet been defined.

THE STRUCTURE

It is proposed that a Consortium be created among a group of leading universities to support the legal and administrative frame of the school. So far, 24 leading universities are considering joining the group. There are 10 from Europe, seven from North America, two from Asia, and two from Australia. Support will be also considered by other institutions. Other relevant partners can enter the Consortium at a later stage. The administrative secretariat will be provisionally provided by the University and the Politecnico of Milan, Italy.

Targeted funds will be asked from the European Community, the Nordic Council of Ministers, North American institutions, and any other public or private sponsor whose support will not be in conflict with the trust of the School.

THE STARTING PROGRAM

It is proposed that the triennium 1994-1996 be devoted to:

- offer Summer Courses
- consolidate the existence of the Consortium
- prepare a suitable teaching program.

A report on these activities will be provided at Indoor Air '96 in Japan.

The summer courses could be offered for a 2-week period each year based on the concept of having four groups of students - architects, engineers, medical, chemist/biologist - with a first week of common program and a second week specific for each group. Availability of scholarships to ensure the participation from various countries would be highly desirable and will be sought. A steering group of faculties will organize the course each year.

An educational committee will prepare the teaching programs and the educational curricula for the specialists in indoor air sciences, which will then be discussed by all the participant faculties. The constitution of the Consortium will be drafted by the secretariat and discussed and approved by correspondence.

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W13 CREATION OF THE INTERNATIONAL SCHOOL OF INDOOR AIR SCIENCES

Marco Maroni, Italy, Demetrios Moschandreas, USA, Chairmen

BACKGROUND

Indoor air sciences encompass several disciplines from hygiene and medicine to architecture, physical engineering, chemistry, microbiology, environmental sciences, etc. Currently, teaching programs on indoor air are offered in technical universities -schools of architecture and schools of engineering - and in medical schools either at Public Health level or as post-graduate program for physicians and hygienists.

The development of indoor air sciences in recent years has shown that this field of knowledge is vast and complex, requiring contributions from many disciplines and an integrated approach among them. However, it is necessary that each discipline supports its specialized contribution while understanding the basic common principles that constitute the core problems of the indoor environment.

Such an integration has proved to be difficult because the different disciplines use diversified technical methods, different languages, various cultural references and non-uniform scientific approach. The forums provided by the triennial scientific indoor air conferences as well as the multidisciplinary meetings organized by the International Academy of Indoor Air Sciences and the Intentional Society of Indoor Air Quality and Climate offer opportunities to overcome these limitations.

In order to foster the development of a harmonized international culture on indoor air sciences where the various disciplines can cooperate, exchange experience and transfer the best scientific messages to an international scholarship, a group of leading educational institutions are exploring the creation of an International School of Indoor Air Sciences supported by the experience of faculties specifically involved in this field.

THE MISSION

The *International School of Indoor Air Sciences* aims at developing and promoting high quality education of students, teachers and professionals in the field of indoor air sciences.
The purposes of the school are:

- to offer teaching programs at international level
- to develop educational curricula to be adopted worldwide
- to promote exchange of faculties and students at international level.

The educational mission of the International School of Indoor Air Sciences includes training of trainers, continuing education, and formal programs for graduates and post-graduate students.

The educational programs offered by the School will be based on essential, integrated knowledge as a basic common element for all the different professions; in addition, specific teaching modules can be developed to deal with the specific expertise to be conveyed to the different professional users.

W14 TOTAL EXPOSURE TO AIR POLLUTANTS

Demetrios J. Moschandreas, USA, and Michael Lebowitz, USA, Chairmen

Co-sponsor: International Society of Exposure Analysis (ISEA)

PROBLEM STATEMENT

There is no uniform employment of the concept of total exposure to air pollutants by the indoor air community. Additionally, there is insufficient understanding of the role of indoor air pollution as a component of total exposure to air pollutants. The workshop formulated and addressed the following three issues for discussion by the participants of the workshop:

Challenges in estimating exposure to organic compounds (predicting the trends in exposure assessment for the 1990s).

Benefits of estimating distributions of exposures to bioaerosols.

Current capabilities to obtain information on time activity patterns.

These topics provided the basis for generalizing the discussion on total exposure assessment.

QUESTIONS ASKED BY THE WORKSHOP PARTICIPANTS

The participants asked questions mostly concerning clarification of time and place, and how these factors in different settings contribute to total exposure assessment. The two major topics were: what were the distributions of time spent in each microenvironment and what were the distributions of air pollutant concentrations in the microenvironment. Considerable time was spent on discussion of population exposures versus individual exposures. It was agreed that certain individuals, such as sensitive ones, should have individual exposure assessments, but that populations exposure distributions are required as well.

Another major discussion issue was the accuracy needed in determining exposures; that is, what is the time unit for determining mobility patterns to be used in exposure estimation. It was concluded that there are two criteria involved: the time period required for health responses being measured, and the accuracy of techniques for measuring pollutant concentrations. It was also agreed that the time frame critically depends on the pollutant considered, and it is different for, say ozone, VOCs, CO, fine particulate exposures, and so on. When modeling was discussed, it was agreed that pollutant concentrations selected either from an appropriate average or from a distribution of concentrations should be the basis for exposure distributions in different microenvironments. In addition to statistical approaches for developing exposure models, it was suggested that using inputs and knowledge of the chemical and physical properties of the pollutants and their sources in conjunction with models will help in the formulation of exposure distributions. It was emphasized that understanding the chemistry of indoor

air, especially for new compounds, is essential for developing time-space specific exposure distributions. Uncertainties involved include: instrument calibration, detection limits, primary and secondary compounds associated with specific sources, and the impact of the indoor conditions on the chemistry of the pollutants.

It was pointed out that different groups (such as different cultures, sensitive individuals, age groups) spend their time differently and that their microenvironments may be quite different. The question of whether exposure distributions generated within one nation can be generalized in another was discussed. It was agreed that exposure distributions cannot be transferred across cultures and nations. Yet, the intriguing possibility of transferring microenvironmental differences of exposure distributions was brought forward, and was discussed with interest. Clearly, research is needed on this subject.

The question was raised whether distributions of exposure would be possible for all agents. It was pretty much assumed that one could determine such distributions for chemical pollutants, but there was a question if one could do so for biological agents. Such agents have very specific diurnal and seasonal periodicity, and the production of these agents is very specific to other conditions in each microenvironment. In addition, there are not source usage patterns that would affect concentrations of these agents. It was decided that we can determine exposure distributions for biological agents, the above constraints notwithstanding.

Further discussion focused on specific needs in exposure assessment. For long-term exposures, it was decided that better study designs were necessary to obtain information on retrospective exposures, and that more research was required to develop long-term bioindicators. In addition, further discrimination of confounding exposures, such as effects of biological agents (internally and externally) would influence the relevant characteristics of chemical exposures. A comment was made that adding more reality to exposure
assessments would improve evaluation of exposure-response relationships. It was also stated that time-specific exposure gradients were necessary for various types of studies.

RECOMMENDATIONS

The major recommendations were:
1. Time-activity determinations should be consistent with the specific pollutants and the associated health effects of concern.
2. Exposure distributions are specific for the nation in which they are formulated. Differences should be explored through modeling such that generalized exposure distributions can be considered. Likewise, differences in exposure distributions for sensitive individuals, different age groups, and cultures should be explored.
3. Finally, exposure assessment should include the impact of the indoor environment and its relative contribution to total exposure to air pollutants.

W15 CHARACTERIZATION OF VENTILATION IN LARGE ENCLOSURES

Claude Alain Roulet, Switzerland, Peter Wouters, Belgium, Chairmen

BACKGROUND

Large enclosures considered here are factory halls, open office buildings, staircases, atria, sport and assembly halls, large commercial complexes, and airport buildings.

The assessment of ventilation in such large enclosures is more complex than in smaller ones for several reasons:

- the dimensions of the large enclosure itself usually require more measurement points, larger amounts of material, and, often, more powerful instruments;
- the characteristics of the air (temperature, density, contaminant concentrations) are not homogeneous within the enclosure. Measurement techniques assuming homogeneous characteristics cannot, therefore, be used without modifications.

On the other hand, the analysis of non-homogeneities could be an important scope in studying ventilation in large enclosures. Adapted ventilation systems, taking into account that the enclosure can be divided into occupied and unoccupied zones, can provide high indoor air quality in the occupied zone without requiring high flow rates or high energy consumption.

The issue of 'energy, air and contaminant flow in large enclosures' is studied in the framework of ECBCS Annex 26 of the International Energy Agency. In total, about 8 countries are involved.

DISCUSSION

What are the parameters to be used in characterization of ventilation?

The parameters to be used in the characterization depends on the type of problem to be studied: thermal comfort problems (overheating, zones which are too cold, stratification), draught problems, pollution levels for normal occupancy schemes, pollution levels when accidents occur (e.g., in industry), infiltration through the building envelope, energy consumption predictions, and design of ventilation and heating systems.

How to apply CFD and other calculation methods to interpret results?

CFD simulations should be seen as a tool for the designer and the consultant. The powerful and impressive presentations of the results that often accompany such simulation tools should not mislead the end-user of such tools. There is a general consensus that CFD must be used in combination with practical experience of the designer and the consultant. Essential in CFD simulations are good input data (especially for boundary conditions) and skill of the user.

Validation of the use of CFD is still very limited, especially for large enclosures. Therefore, the CFD methods are probably more appropriate to detect serious problems (e.g., dead zones, excessively high contaminant concentrations) than to prove that the design criteria are met (e.g., air velocities).

In order to increase confidence in simulation results (or to detect serious divergence in the results), a sensitivity analysis in which certain input data and modeling approximations are changed is strongly recommended.

The k-ϵ models are the most used. However, one should be careful when applying them to large enclosures where stratification effects are expected.

There was a consensus that CFD should not be seen as the only tool for predicting ventilation related parameters in large enclosures. Zonal models may be useful when time dependency and thermal coupling with the structure are important. Moreover, they are cheaper in use and require less input data.

How to select the strategy for tracer gas injection and sampling

In general, the measurement strategy largely depends on the information required: e.g., multi-point, constant concentration tracer gas can be used if the total air change rate is sought, while homogeneous emission techniques are more appropriate to assess the local mean age of air.

In order to optimize the experiments, a combination with other techniques might be envisaged. CFD simulations and smoke visualization can help in selecting the injection and sampling points as well as other measurement points (e.g., temperature).

W16 GOVERNMENT POLICY OPTIONS

Sigurd Hoelsbrekken, Norway, Ewa Rydén, Sweden, Chairpersons

Co-sponsor: Nordic Committee on Building Regulations (NKB)

BACKGROUND

The different national building codes apply to the construction and certain material requirements for buildings and civil works with the objective to secure conformity regarding certain overall requirements for health, safety, environmental protection and economy. The requirements set up in the building codes are based on the knowledge existing at the time the building codes were formulated. Recently we have gained better knowledge of the relations between health, the use of building materials, and technical solutions. This knowledge enables the national authorities to set up some requirements with the goal of securing a healthy indoor environment. Still we lack medical knowledge of the relations between health, the use of materials in buildings, and technical solutions. Such knowledge might not be available for a long time. This means that we do not have a sufficient basis for setting up complete requirements for all aspects of a good indoor environment. Until this can be done, we have to inform the users of the relationships between the use of materials, the technical solutions, and the health aspects in buildings. This most likely means that we need to use a combination of regulatory codes and voluntary actions from the users in order to secure satisfactory indoor air quality.

A satisfactory indoor environment depends not only on the use of materials and technical solutions but also on how the buildings and installations are designed, operated, and maintained in order to obtain and keep good performance throughout the period of use. Today's building codes give no mandate to state requirements for securing correct operation and maintenance.

When requirements are set up in the regulatory codes, the requirements must be verifiable and controllable. This means that we ought to have sufficient tools to verify that the requirements are fulfilled. Harmonized standards and guidelines will be such tools.

QUESTIONS ASKED OF THE WORKSHOP PARTICIPANTS

Should authoritative or voluntary methods be used to control IAQ?

What type of regulations are needed from authorities?

What standards are needed for IAQ control?

New and existing buildings need to be addressed separately. New buildings will be addressed through building codes, but existing buildings will need a separate regulation. We agree that existing buildings should not have a lower standard than new buildings, but they may need more time to meet those standards.

The participants agreed on the idea of creating different categories of buildings. If a building is to be used for a new purpose, it must first meet the IAQ standards for that purpose. (As an example, we discussed an office building that might be converted to a day-care center.)

The participants do not believe it is feasible to establish government regulation for all products brought into buildings. For example, companies should seek to reduce the emissions of VOCs from their products in advance of the governmental demands, instead of governments setting requirements for maximal levels for NO_2, VOCs, etc. The most practical approach will be to establish minimum ventilation rates. It was agreed that a combination of establishing minimum ventilation and filtration requirements (depending on the outdoor air quality) together with voluntary action to achieve "better" materials might be the most practical approach today.

Voluntary actions are needed for some subjects with individual sensitivity, (e.g., emissions, lighting) and require knowledge among the users with regard to the relation between the use of materials, technical solutions, and the health aspect in buildings, good product information, labeling and declaration (disclosure of contents).

Compulsory methods are needed for ventilation and thermal climate. The governmental demands should be given as functional requirements in order not to impede further development of construction and technical solutions that are controllable and verifiable.

Standards are needed for several indoor air parameters. In different classes of the standards one must consider the emission of harmful substances from furniture, textiles etc., and the intended use of the building. After weighing all the parameters, demands can be made.(ASHRAE has standards; WHO provides guidelines.)

- Standards are needed to state the different "security levels" for indoor air quality.
- Standards are needed for control and verification that the "security level" is obtained.
- Standards are not only needed to control and verify regulatory codes. Standards are also needed to consider emission from furniture, textiles and other interior materials not classified as building materials.

This means that we need standards for the following:
- defining different levels of IAQ
- testing materials (lining, covering, furniture, textiles etc.)
- quality assurance

The questions were discussed regarding the outcome of planning, materials, air and water quality, noise, light, radon and thermal comfort. The conclusion ended in the statemetns given above .

The working group totaled 50 participants arranged in smaller discussion groups around five tables. The following countries were represented: United Kingdom, France, Australia, Canada, Italy, Germany, USA, The Netherlands, Finland, Denmark, Norway, and Sweden. Many participants expressed their appreciation of the opportunity to work and exchange experiences with each other in this way.

W17 OCCUPATIONAL RESPIRATORY ALLERGIES

Kari Reijula, Finland, Sherwood Burge, UK, Chairmen

Co-sponsor: International Commission on Occupational Health (ICOH)

BACKGROUND

The title "Respiratory allergies" was changed to "Occupational respiratory allergies" in order to keep the topic focused on the problems which could all be discussed during the limited time of the workshop.

The number of new cases of occupational respiratory allergies has increased during recent years. At the moment, occupational respiratory and dermal allergies represent approximately 15 % of all occupational diseases e.g., in Finland. Most of the causative agents of occupational respiratory allergies can be detected in the indoor air of the workplaces and most of the new cases of these diseases could be prevented by eliminating the harmful exposure to inhalant allergens.

QUESTIONS ASKED

Altogether 21 persons from 11 countries attended the workshop. The workshop on the "Occupational respiratory allergies" was focused on the following questions:

What is the prevalence and incidence of
- **occupational asthma (OA)**
- **occupational rhinitis (OR)**
- **hypersensitivity pneumonitis (HP)**
- **(extrinsic allergic bronchioloalveolitis)?**

What are the causative agents of the above mentioned diseases in different countries?

What are the clinical diagnostic criteria of these three occupational diseases?

QUESTIONS ANSWERED

There were three introductions by Drs. Reijula, Burge, and Nordman before the discussion:

Dr. Reijula introduced the data which was collected from the Registers of Occupational Diseases in Finland (from the Institute of Occupational Health, Helsinki, Finland). According to the Register, there has been a significant increase in the prevalence and incidence of OA and OR in 1981-91 whereas the number of new cases of HP has decreased after 1988. In 1991, the total number of new cases with OA was 352 and there has been a 2-fold increase in the number of newly detected cases with OA during 1981-91. Number of cases with OR increased from 61 to 318 during 1981-91. In 1988, there were 298 and in 1991 there were 85 new cases with HP in Finland. Almost all cases of HP were patients with farmer's lung

The main causative agents of OA and OR are cow epithelium among farmers and flour dust among bakery workers representing more than 55% of all cases of OA and OR in Finland

Dr. Burge introduced the prevalence and incidence of OA in the UK. The most common causative agents of OA in the UK. have been isocyanates, flour dust, and colophony. In the West Midlands of the UK. the incidence of OA has been 1800/million/year among paint sprayers (isocyanate), 1000 in electric platers (chromium), 500 in bakery workers and 50/million/yr among farmers. The incidence of isocyanate OA has increased during recent years in the UK.

Dr. Henrik Nordman presented the figures with the incidence of OA in Finland: According to the Register of Occupational Diseases, the incidence of OA among patients exposed to flour dust was 4000/million/year, to isocyanates 3100, to cow epithelium 1400 and to welding fumes 1200/million/yr in 1991 in Finland.

Dr. Nordman presented the clinical diagnostic criteria of OA. The challenge test with a relevant allergen is practically always needed before the final diagnosis of OA.

DISCUSSION AND CONCLUSIONS

In the discussion, some data could be collected from different countries of the causative agents of OA:

The most common causative agent of OA is isocyanate in the UK and Italy, flour dust in Germany, wood dust in Australia and aluminum in Norway

As a conclusion, the occupational respiratory allergies are preventable diseases the number of which has been remarkably high in many countries especially in Finland. The incidence of OA and OR in Finland is obviously the highest in the world. This can be explained partly by the fact that there is a well organized registration of occupational diseases in Finland, and because insurance companies pay the cost of the clinical examinations which leads to an improved clinical activity among patients with work related diseases.

The methods of collecting data of occupational respiratory allergies in the UK. have the advantage that the diagnosis of OA does not depend on the final decision of the compensation.

Further information on the epidemiology of occupational diseases, causative agents, and diagnostic methods should be collected from different countries. A collaboration between physicians and occupational hygienists should be improved in the investigation of the causative agents of work related diseases. The present information increases the need to improve the methods to measure relevant allergens in the workplaces and to protect the workers against exposure to allergens in their workplaces.

W18 CONTROL OF MOISTURE PROBLEMS AFFECTING INDOOR AIR QUALITY

Brian Flannigan, UK, Philip Morey, USA, Chairmen

Co-sponsor: International Society of Indoor Air Quality and Climate (ISIAQ)

BACKGROUND

This workshop considered control of moisture problems affecting indoor air quality especially in relation to microorganisms and microbial contaminants. As water is required for the growth of microorganisms the workshop initially discussed the following:

QUESTIONS ASKED OF WORKSHOP PARTICIPANTS

How to predict critical moisture levels of materials? What are appropriate indices to be used?

Microorganisms grow in moisture films on surfaces and within porous materials. The amount of free water available to them for growth in a substrate is best described as water activity (a_w), the ratio of the vapor pressure of water in the substrate to the vapor pressure of free water (equivalent to equilibrium relative humidity or ERH). Most bacteria have a minimum a_w for growth >0.95 and many fungi (including molds and yeasts) >0.88, but xerophilic fungi can have a lower limit of 0.65-0.70. Reducing the RH of the indoor air to $<70\%$ will not prevent mold growth if there are cooler surfaces in the environment, as the RH at the surfaces will be $>70\%$ and moisture absorbed by a porous material will raise its a_w to >0.70. Where the surface temperature is below the dew point temperature, condensation will occur and mold growth will be profuse. The minimum a_w for growth is increased at lower temperatures, and raised by rich nutrient supply. Nutrients are available in dust and in complex materials such as wood, paper and paints, which are enzymically broken down by microbial contaminants. Microorganisms can therefore cause considerable damage to structural/interior construction materials and furnishings.

A consequence of these variable a_w and nutrient conditions is that different species of fungi will occur. For example, wet cellulose-based materials are colonized by fungi such as Stachybotrys atra and Chaetomium globosum that are highly adapted to such conditions. Molds such as Aspergillus versicolor can be isolated from organic materials at moderate a_w values. Knowledge of the fungal species present in air or dust can therefore provide useful clues as to the nature of the "amplifier/reservoir". As noted, the presence of S. atra indicates very wet cellulose-based materials (and sometimes contamination through drains with faulty traps); fungi such as Fusarium moniliforme indicate stagnant water in HVAC or perimeter heating/cooling units; some species of Penicillium and Aspergillus indicate chronically damp carpets or other materials.

While a_w is the preferred index for assessing the critical moisture levels necessary to support the growth of various kinds of microorganisms, research is needed to develop techniques that can readily be used by investigators in the field to predict if an interior construction or finishing material contains sufficient "free" moisture to support growth.

The measurement of a_w and ERH of common interior construction or finishing materials in the laboratory, and the correlation of these laboratory measurements with moisture content readings (e.g., by conductivity meters) can provide the engineer or field investigator with a predictive method for determining if the growth of microorganisms can occur. Research is needed on direct-reading techniques to estimate a_w.

Under what conditions do harmful microorganisms survive, grow, and aerosolize in building materials and systems?

The chronic presence of water in interior construction materials and HVAC systems is almost always associated with the growth of microorganisms or the occurrence of microbial reservoirs and amplification sites buildings. Stagnant water in ventilation systems and humidifiers, floods in occupied spaces, and condensation on or in ceiling, wall, and floor systems are examples of conditions in buildings that can result in growth of microorganisms. The relative humidity in the air in the middle of the room is of far less importance than the a_w in the microenvironment (interior construction or finishing material) where actual microbial growth can occur.

Fleecy materials such as porous insulation, carpet, ceiling tiles, and upholstery may become sinks or reservoirs where microorganisms accumulate. The presence of dirt and debris in fleecy microenvironments provide extensive adsorptive or absorptive surfaces for uptake moisture that can support growth. The growth of microorganisms on surfaces both within HVAC systems and in interior surfaces in occupied spaces almost always results in the aerosolization of microbial particulate (e.g., spores) or microbial VOCs.

What methods are feasible to control microbial problems in buildings?

Control of microbial contamination problems in buildings is largely dependent upon preventing moisture from rising to levels sufficient to support growth. Control of moisture in building systems is primarily a function of attention to proper design, operation, maintenance and cleaning. Some of the more important aspects of microbial control in buildings are:

Prevent the accumulation of water in HVAC system components (e.g., drain pans).

Prevent entrainment of water droplets (e.g., from cooling towers) into HVAC system outdoor inlets. The emission of water droplets from wet surfaces within air handling units must also be prevented.

Prevent condensation on cold surfaces in all wall, ceiling, and floor systems.

Reduce microbial nutrients in buildings by installation of more efficient filtration and by more efficient cleaning devices (e.g., vacuum cleaners).

Initiate research programs to promote the use of interior construction and finishing materials that are hydrophobic and thus will not contain critical moisture levels necessary to support microbial proliferation.

While antibacterial biocides in humidification systems have a useful role, proper design and maintenance should obviate the need for antifungal biocides in most cases.

W19 INDOOR AIR QUALITY INVESTIGATIONS

Jan Sundell, Sweden, Ed Light, USA, Chairmen

Co-sponsor: International Society of Indoor Air Quality and Climate (ISIAQ)

PROBLEM STATEMENT

While the sharing of research information on IAQ between countries has become routine, little is known internationally about how IAQ complaints are investigated in non-research projects. Furthermore, there has been virtually no attempt to validate the investigation protocols currently in use by field practitioners.

This workshop represented the start of an ISIAQ Task Force dedicated to addressing these questions. Preliminary objectives of the task force are to:

Identify public and private organizations active in responding to IAQ complaints.

Compile available protocols applicable to practical IAQ investigations.

Develop an assessment tool to evaluate the success of IAQ complaint investigations.

Solicit voluntary cooperation of IAQ investigators to collect follow up data.

Write a generally applicable strategy for the resolution of IAQ complaints.

IAQ complaints require diverse investigation approaches. One category involves situations of comfort concerns only. Another involves cases where a specific illness or source problem is understood at the outset. Finally, there is the more common "sick building syndrome", where there are health concerns and the cause is not clear . The type of investigation conducted will depend on the complexity of the problem and the resources available.

Two practical IAQ protocols were briefly introduced at the workshop: "Investigations and remedial measures" by the Nordic Ventilation Group and "Building Air Quality " by U.S. EPA and NIOSH. Interesting similarities and differences were noted.

QUESTIONS TO BE ANSWERED

Three basic questions were asked of the Workshop participants:

What protocols exist?

How can we validate IAQ complaint investigations ? and

Who will volunteer to help in the ISIAQ Task Force?

A number of protocols exists. Most recommend a stepwise, interdisciplinary method from simple "walk-through" inspections, via the use of standardized questionnaires or interviews, simple indicator measurements up to "detective-work". The Canadian Government has an interdisciplinary team to investigate public buildings. Jim Woods summarized his publications on IAQ diagnostics and noted the availability of some U.S. follow-up studies on buildings with microbial contamination. The availability of ASTM protocols and procedures was stated. There was discussion of the potential problem of ignoring other indoor environmental factors just because the complaints originates as "air quality..".

There were many questions and few answers regarding how to validate an IAQ complaint study. Any follow-up must recognize the dynamic nature of the building and its occupants. It must also account for the psychosocial factors. What, if the building owner does not implement the investigators recommendations ?

The availability and limitations of questionnaires were reviewed. It was pointed out that perceived IAQ problems cannot be resolved by technical means. Other measures of change might involve building conditions or interviews with primary complainants.

Participants noted that this was a start toward informal networking between practical investigators. More than 30 individuals volunteered to work with the ongoing ISIAQ efforts.

For further information on this ISIAQ task force, please contact:

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W20 TRACER GAS MEASUREMENTS IN LARGE MULTI-ROOM BUILDINGS

Francis (Bud) Offerman, USA, Jorma O. Säteri, Finland, Chairmen

Co-sponsor: The Nordic Building Research Cooperation Group (NBS-I)

INTRODUCTION

Ventilation is one of the most important determinants of sick/healthy buildings. Experience of field surveys from various parts of the world show that assessing ventilation rates in individual buildings is almost impossible without experimental data on the very same building. Thus, ventilation measurements have an important role in building surveys. Ventilation measurements are often neglected due to lack of money, time, knowledge, or other resources. The aim of this workshop was to map available methods for including ventilation parameters in large scale field surveys in multi-room buildings (offices, blocks of flats).

WHAT ARE THE PARAMETERS OF INTEREST?

Ventilation is too complex a phenomenon to be characterized with only one parameter. The one most usually used is the flow rate of fresh air into a given space. This parameter is important in the assessment of energy consumption due to ventilation. It is also the basic physical quantity with which other parameters can be derived. In health investigations the capability of the flow to dilute the contaminant concentration (purging flow rate) is of primary interest. The distribution of air and contaminants within the enclosure can best be assessed using the age of air concepts. Both short and long term measurements of the mentioned parameters are needed.

HOW TO ASSESS THEM?

In energy-oriented surveys, it is usually enough to measure the air flows at the air handling unit(s) using traditional mechanical flow measurement techniques. These measurements provide information regarding the amount of outside air brought into the building but provide no information regarding the distribution of this air to the occupied zone. In health surveys, the distribution of outside air through the building is of primary interest as it is an important parameter in determining the contaminant concentrations in the occupied zone. Tracer gas techniques are used to determine the flow rate of outside air in the occupied zone. Tracer gas step up, step down (decay), and constant concentration are three commonly employed techniques. These methods are typically used to measure outside air ventilation rates over relatively short time periods (e.g., 3-4 hours).

Measurement of ventilation rate over longer periods of time (e.g., one week) are of interest in health related building investigations. While the more complex tracer techniques may be repeated to provide this longer term information, they are very costly. Passive tracer gas techniques have been successfully used in residential buildings to

provide long term information. These techniques are, in principle, feasible for application in larger, multi-zone buildings such as offices and apartment complexes.

Another approach to assessing the distribution of outside air in large buildings introduced at this meeting is the concept of homogeneous emission of tracer gas by a large number of small, passive sources. This approach involves distributing sources on a volume basis through the building. The relatively inexpensive samplers used with this approach allow for a higher density measurement grid than is feasible with more traditional tracer gas techniques. This method can be used to assess the local age of air in large enclosures.

A new concept involving the homogeneous emission of tracer gas in large, multi-zone buildings is the Pollution Control Index. In this concept the tracer gas sources are used as simulated contaminant sources and the concentrations measured provide information regarding the dilution power of the ventilation system.

In buildings such as offices where there are occupied and non-occupied periods of time, there is the problem of acquiring data just for the occupied period of time. Research is currently under way looking into sources and/or samplers with programmable start/stop times to overcome this difficulty.

Thus there are a number of different tracer gas techniques which may be used to measure ventilation in large multi zone buildings. Different techniques provide different information at different costs, and it is important for the building investigator to know what information is desired.

INDOOR AIR CONFERENCES

FIRST INTERNATIONAL INDOOR CLIMATE SYMPOSIUM
The 1st International Conference on Indoor Air Quality and Climate
Copenhagen, Denmark, August 30 - September 1, 1978
President: P. Ole Fanger

INTERNATIONAL SYMPOSIUM ON INDOOR AIR POLLUTION, HEALTH AND ENERGY CONSERVATION
The 2nd International Conference on Indoor Air Quality and Climate
Amherst, USA, October 13-16, 1981
Co-Presidents: Craig D. Hollowell, Demetrios J. Moschandreas and John D. Spengler

INDOOR AIR '84
The 3rd International Conference on Indoor Air Quality and Climate
Stockholm, Sweden, August 20-24, 1984
President: Thomas Lindvall

INDOOR AIR '87
The 4th International Conference on Indoor Air Quality and Climate
Berlin (West), Germany, August 17-21, 1987
President: Bernd Seifert

INDOOR AIR '90
The 5th International Conference on Indoor Air Quality and Climate
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President: Douglas S. Walkinshaw

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The 6th International Conference on Indoor Air Quality and Climate
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