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Ventilation Protection Found Limited Against Airborne Tuberculosis

At low ventilation rates, a small increase in ventilation can greatly reduce the risk of airborne infection. However, increasing ventilation at higher ventilation rates reduces risk much less. Furthermore, when concentrations of infectious agents are elevated, even very high ventilation rates do little to protect occupants against infection.

Those are the findings of researchers at the Massachusetts Department of Health who studied office workers in a building where a case of tuberculosis (TB) had occurred. The researchers, led by Dr. Edward Nardell, observed that the role of building ventilation in preventing person-to-person disease transmission has received little attention in the recent medical literature – even though the importance of airborne microbial infection has long been recognized.

Most recent literature on microbial illnesses and indoor air deals primarily with the fungal and bacterial contamination of ventilation systems. However, people, not buildings, are the primary source of indoor airborne infection, according to Nardell. Influenza, measles, tuberculosis, and other infections caused by airborne agents continue to occur in a wide range of indoor environments including offices, schools, nursing homes, prisons, hospital intensive-care units, and other building types. Numerous cases of tuberculosis resistant to conventional antibiotic therapy have been reported among human immuno-deficiency virus (HIV) infected patients. Many procedures used to manage patients with AIDS may also increase the risk of tuberculosis transmission.

The Study

Nardell's study took place in a building that had been the subject of occupant complaints for over two years. The on-going complaints resulted in extensive air-quality investigations for possible causes. One investigation which measured CO_2 allowed researchers to estimate the outdoor air ventilation based on CO_2 concentrations and occupant densities. Because they could estimate ventilation rates, researchers were able to construct a mathematical model to analyze the results of their clinical tuberculosis study.

The study included 67 office workers exposed to a TB-stricken co-worker for four weeks. The 30-year old woman (index case) had apparently contracted the illness while on vacation abroad. Upon her return she experienced progressively worsening symptoms, but she remained at work for four weeks before her illness was diagnosed. In the meantime, recirculated ventilation system air exposed the office building occupants to concentrations of the infectious agents throughout the building – even in locations distant from the infected worker.

Skin Tests

Investigators administered Mantoux skin tests four months and one week after the index case was diagnosed. [The Mantoux skin test involves the intracutaneous injection of a solution containing tuberculin.] "Conversion" in the test identifies recent infection. A positive skin test result is defined as one where induration (hardening) of an area around the site of an injection increases signifi-

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cantly. The 67 workers included in the study were those who showed no signs of infection (negative) at the time of the first skin test and were available for the second round. Of these, 27 (40%) converted (were positive) when re-tested after four months.

The average age of the 27 converters was 41.1 years, and their mean increase in induration was 16.2 mm. These data indicate that the high conversion rate was most likely not brought about by the two-stage testing. The fact that there was no evidence of other sources of tuberculosis transmission in the office building or among study subjects' family members suggests that the most likely source of infection was the work environment. Only one of the 27 positive tests who had decided against preventive therapy developed clinical tuberculosis, and this individual was subsequently successfully treated.

The investigators considered the 40% conversion rate an underestimate. There were 16 workers with positive skin tests who were tested only once and, therefore, were not included among the 67. Some of these may have been infected through their exposure at work.

Model Analysis

Researchers calculated a theoretical value for the airborne concentration of the infectious agent for TB. They were then able to model the impact that changes in outdoor air ventilation rate might have on the percent of occupants that would have been infected. They were also able to model the impacts ventilation would have had under conditions of higher or lower airborne concentrations of the infectious agent.

For the 67 study subjects, researchers estimated average exposure duration at four weeks. Assuming that exposure at work averaged 40 hours/week, they estimated total exposure at 160 hours. Based on research done previously in several settings, they calculated an estimated average airborne concentration of 12.7 quantum per hour (qph).

The unit "quantum" is an arbitrary unit based on calculation. It indicates the relative number of an infectious agent added to the air during a unit of time. Another way of expressing it is as the "infectiousness" of the index case. It is calculated based on the Soper equation for airborne transmission which relates the number of new infections to several important variables. The Soper equation is as follows:

$$C = S(1 - e^{Iqpt/Q})$$

where

C is the number of new infections.

S is the total number of susceptible individuals.

I is the number of infectors.

p is the volume of air sampled per minute per occupant.

t is the exposure time.

Q is the volume of outdoor air building ventilation per unit time.

q is the number of quanta of infection added to the air per unit time (infectiousness of the case).

See the Soper citation at the end of this article for more details of this method.

Rearranging the equation, the authors calculated an exposure concentration of 12.7 quanta per hour. Based on work done elsewhere, they had empirically derived values for other exposure situations.

Plotting their results and the others on a graph, they showed the theoretical impact of ventilation rate changes on percent of occupants infected (Figure 1) and on the predicted number of the 67 susceptible subjects that would have been infected (Figure 2).

From these analyses, the authors found the following:

- Had the ventilation rate been reduced from 15 cfm/p to 5 cfm/p, the infection rate would have nearly doubled to 78%.
- An increase in the ventilation rate from 15 cfm/p to 25 cfm/p would have reduced the infection rate by only a third to 26%.
- A further ventilation rate increase to 35 cfm/p would have reduced the theoretical infection

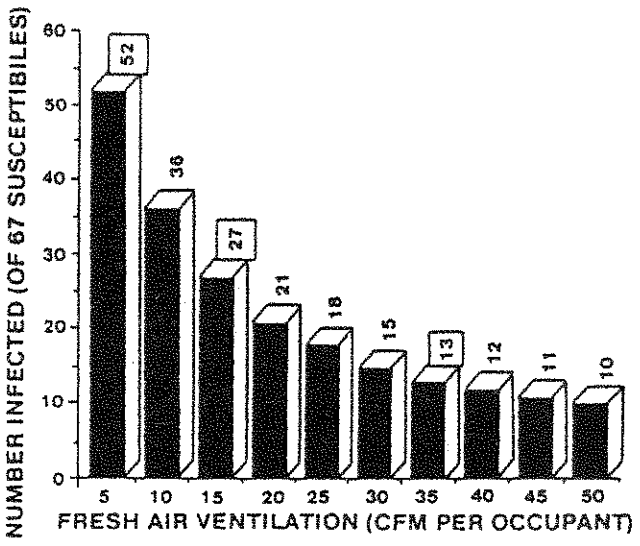

Figure 1 - Predicted Number of Workers Infected at Various Levels of Outdoor Air Ventilation.

rate an additional 7% to 19%, just under half the actual rate of 40%.

While the authors commented that further increases in ventilation rates were not practical, they "would be predicted to result in progressively smaller reductions in infection" as shown in Figure 2. See our comments on "Outdoor Air Amounts and Economizers."

Work done by others provided additional data covering a very wide range of the airborne infectious agent concentrations. These data are included in Figure 2 which examines the theoretical impact of increased or decreased ventilation over the full range of concentrations. Riley *et al.* reported that the average tuberculosis patient generates 1.25 qph. This is only 10% of the infectious particles calculated for the office building. The plot in Figure 2 shows that at 1.25 qph and 15 cfm/p outdoor air ventilation, only three of the 67 workers would have been infected over a four-week exposure. Figure 2 also shows that at reduced ventilation rates, theoretically several more individuals would have been infected. However, increasing ventilation would not have provided much additional protection, according to the figure.

At 60 qph, a value also from Riley, this time of a laryngeal case, the theoretical probability of infection would have been quite high at 15 cfm/p. A ventilation rate of 35 cfm/p would reduce it, but it would require something like 80 cfm/p outside air to reduce the theoretical infection rate to the level achieved by 15 cfm/p with only 12.7 qph in the air.

In one unusual situation, during an intubation and bronchoscopy, 250 qph was the calculated tuberculin level. At that level, virtually all occupants would be predicted to be infected, according to the model, even at 100 cfm/p outside air ventilation.

Outdoor Air Amounts and Economizers

Under various design assumptions commonly used for offices when an economizer or other all outdoor air ventilation mode is provided and operating, an office worker with 140 sf (15 m^2) of office space would receive as much as 70 to 140 cfm/p outside air ventilation. We base these numbers on the usual range of total supply air volume of 0.5 to 1 ft^3/ft^2 of floor area.

This design is common in temperate climate zones. All outdoor air supply is a common and economical, energy-efficient operating mode when outdoor air temperatures are between 10 and 30 degrees less than indoor air temperatures. This provides so-called "free cooling" because the natural temperature differential is used to provide the cooler air needed to provide thermal comfort in the office. Obviously it is not free since fan energy is expended to move the air, and fan energy can be as much as half the energy consumed by the HVAC system in temperate climates. Nevertheless, it is economical to use outside air for cooling when the temperature warrants it.

Figure 3 shows the predicted infections prevented by increasing outdoor air from 15 to 35 cfm/p and from 15 to 125 cfm/p as a function of infectiousness (q). The assumptions for the plot are 67 susceptibles exposed to one source generating 1.25 to 250 infectious quanta per hour for 160 hours. Infections prevented are expressed as a percentage of the 67 exposed persons.

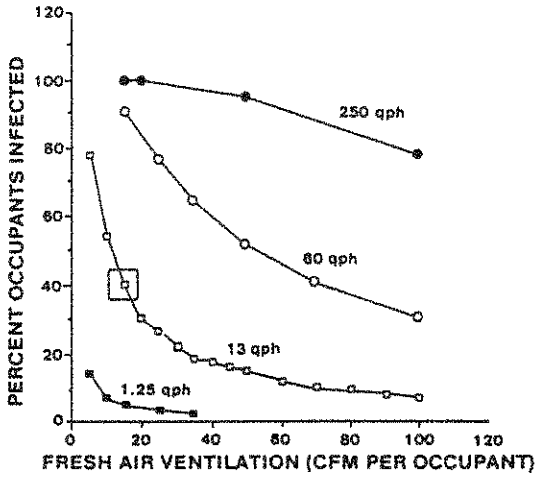

Figure 2 - Predicted Percentage of 67 Exposed Workers Infected at Various Levels of Outdoor Air Ventilation.

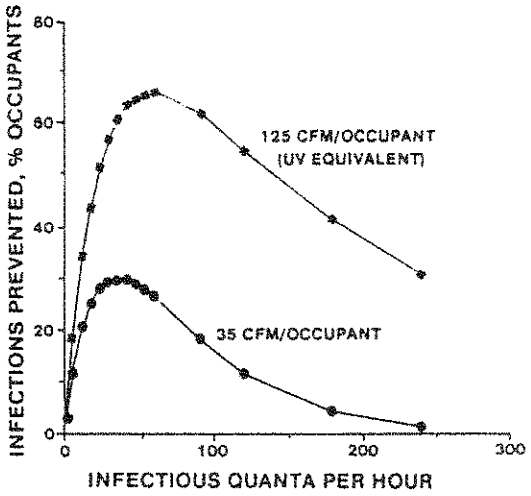

Figure 3 - Predicted Infections Prevented by Increasing Outdoor Air Ventilation.

Conclusions

The authors conclude that "outdoor air ventilation that may be adequate for comfort may contribute to airborne infection but that the protection afforded to building occupants by ventilation above comfort levels may be inherently limited, especially when the level of exposure to infection is high." The authors based the main conclusion from their theoretical analysis on the fact that the "relationship between ventilation and risk of airborne infection is a logarithmic curve."

An interesting finding of the research is that exposure to tuberculosis occurred throughout the building from the recirculating ventilation air. The outdoor air ventilation rates (therefore, air recirculation rates) varied in different parts of the building (based on calculations from the CO_2 measurements). Infection rates in various areas on the same and other floors throughout the building varied from 25% to 53%. Although 52% of the susceptible individuals in the same work area as the index case converted (were infected as revealed by Mantoux tests), similar infection rates occurred in two areas neither adjacent to the index case nor downstream to its ventilation. This, the authors state, demonstrated that the impact of proximity to the index case was neutralized by the recirculation of air throughout the building. It indicates to us that the ventilation system did not itself effectively remove the infectious agent from the recirculating air.

Implications

The work of Nardell and his coworkers presents yet another example of the importance of source strength in determining the required ventilation rate to achieve a specific exposure level. Ultimately, it is far more effective to remove the infected individual than to try to provide protection at any of the concentrations modeled and plotted in Figure 2. A dedicated employee who comes to work sick is often endangering the organization and his coworkers. In the long run, employers will benefit by discouraging such behavior – it is effective source control.

References:

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Ventilation

Readers Comment on April *IAB* Article on European Ventilation Guidelines

In the April ***IAB*** we discussed the new European Ventilation Guideline. We sent copies of the article to several Europeans involved in European Community (EC) indoor air activities and to several members of the ASHRAE committee revising its ventilation standard (62-1989). Following are the letters and comments received from four respected colleagues.

Bernd Seifert

The first response is from the European IAQ committee chairman, Bernd Seifert, of Germany's Institute for Water, Soil and Air Hygiene in Berlin. Seifert has been in the forefront of developing criteria for screening building materials and furnishings based on a comprehensive evaluation of the health and comfort impacts of their chemical emissions.

Dear Hal,

As the chairman of the Steering Committee of the European Collaborative Action (ECA) "Indoor Air Quality and its Impact on Man" (formerly COST 613), I would like to take this opportunity to thank you for the interest that the ***Indoor Air BULLETIN*** edited by you has shown with regard to our work. We very much appreciate that you draw the attention of our colleagues worldwide to our publications. Concerning your invitation to comment on your review of Report no. 11 in the ***Indoor Air BULLETIN's*** April issue, it is my pleasure to react positively.

Reports of the ECA generally have two different objectives: while some are compilations of existing knowledge for the benefit of readers not fully familiar with the respective subject, others are of technical nature giving more or less detailed descriptions of (analytical) procedures. Report no. 11 on ventilation requirements in buildings is of a different nature as it contains both elements and in addition is not "complete." However, the members of the Working Group chaired by Ole Fanger and backed by the Concertation Committee which reviewed and approved the report thought that the text

should be published even with not all desired information available in order to stimulate (a) discussion, and (b) the generation of more data (as an editor you are certainly aware of a fundamental rule in writing scientific texts: Rarely a scientific reviewer can refrain from completing a text when he believes to have more data than the author).

While Ole Fanger in his comment addresses some of your technical remarks, I would like to limit myself to one fundamental aspect.

It is not by chance that the chapter "Health Aspects of Indoor Air Quality" (4 pages) was put in front of that entitled "Perceived Air Quality" (3 pages). This indeed has been the result of intensive discussions in the Concertation Committee where we felt that although perception often may be the driving force for complaints, it should not and cannot be the only effect governing ventilation requirements.

Unfortunately, our knowledge with regard to the composition of products/materials and the health effects of indoor air pollutants at the levels generally encountered is still so poor that we have problems in defining "permissible" emission factors which one would need to prescribe "precise" ventilation requirements. Without further incentive this situation will probably not change very rapidly, as you know. You also know that this is — among others — the reason why I am much more in favour of ranking products for the same use and only take the best.

Under these circumstances we felt appropriate to point at some possibility likely to at least reduce the percentage of complaints triggered by perception. When giving the imprimatur we were aware that important data are still missing. I firmly trust that discussions like ours here will stimulate the generation of such data. So: thank you for your critical comments and for providing the opportunity to reply.

Yours sincerely,
Bernd Seifert

Ole Fanger

Professor P. Ole Fanger of Denmark was chairman of the working group and we invited him to comment on our article. He replied and his letter appears below. Ole Fanger is Professor at the Laboratory of Heating and Air Conditioning, Technical University of Denmark, Lyngby.

Dear Editor:

In the April issue of the ***Indoor Air BULLETIN***, the Editor reviews the new *European Guidelines for Ventilation Requirements in Buildings* and he has kindly invited me to comment on his views. I am indeed pleased to accept the invitation.

The Guidelines were inspired by the "air quality procedure" which has been adopted in the ASHRAE 62 ventilation standard since 1961.

This procedure is used throughout the document. The idea is to design for a certain desired INDOOR AIR QUALITY. While the aim of ASHRAE 62 is to make the air acceptable for 80% (20% dissatisfied), the European Guidelines make it possible to choose between three quality levels corresponding to 10, 20 or 30% dissatisfied. Levin sees this as the most unique aspect of the Guidelines. I rather see it as a natural extension of ASHRAE 62, offering several air quality levels to the building owner to choose from. But the major new idea in the Guidelines is that all the pollution sources in a space are acknowledged. The pollution load from the building is added to the pollution load from the occupants. Levin claims that this may be in contradiction to Cain's studies on addition of odor intensities.

It is not. It is well-known that intensities cannot just be added, not even intensities of the same pollutant (Stevens Law). Still sources can, as a reasonable first approximation, be added (in olfs) as can sound sources (in watts), light sources (in lumens) and heat sources (in watts).

Levin claims also that it is a weakness of the Guidelines "that there may be no relationship between perceived air quality and human health effects from harmful pollutants." I think we all agree with this statement, but it is certainly not a weakness of the Guidelines. Again and again it is emphasized in the Guidelines that pollutants may have an effect both on human health and on comfort. It is therefore prescribed that ventilation rates be calculated separately for health and for comfort and that the highest value be applied.

In the end of his review Levin grows pessimistic about the practical application of the Guidelines: since there is not at present sufficient data available on building materials, such "quantitative methods of building design are beyond current capabilities and feasibility."

I am not so worried about such pessimism. Throughout the history of engineering, pessimism has frequently been expressed when new methods were introduced. When rational methods were first introduced for designing sound or light in buildings, pessimism was also expressed: no data on noise or light in building materials etc. were available. Still rational methods and new sensory units proved to be most useful for proper design of light and sound in buildings. Designers began demanding data for sources and materials, test methods were developed and the manufacturers quickly began to supply the data.

A similar development was seen when rational methods for the thermal design of buildings were introduced.

The data to calculate heating or cooling loads were not available, thermal data on the many building materials were lacking. Today, data are there and thermal design is routine. In the beginning and still today, rough estimates of the heating or cooling load expressed as W/(m^2 floor) are in many cases sufficient for a proper design.

A similar rough estimate of the pollution load of the building per m^2 floor is exactly what is proposed in the new European Guidelines. Field data from around 50 buildings are already incorporated in the Guidelines as a basis for design today and this is illustrated by numerous practical examples in the Guidelines. But further data would certainly be useful and they are planned for: a major research project financed by the European Community will now begin a systematic collection of data on chemical and sensory pollution loads in buildings located in different parts of Europe.

Recognition in the Guidelines of the building as a polluter is a very important step: you get credit for designing a low-polluting building by a modest required ventilation and low energy consumption. On the other hand you get punished by a high ventilation rate and energy consumption if you do not care about the pollution caused by building, furniture, and HVAC system.

The alternative to the Guidelines is to continue ignoring the building as a pollution source and use the primitive "ventilation rate procedure:" just prescribing a certain ventilation rate per person, independent of the building materials, etc. If a similar primitive procedure existed for providing thermal comfort in buildings, one would just prescribe a certain cooling power (e.g. 100 Watts) to be supplied per person for office buildings, independent of season, of building and orientation, of geographical location and ignoring all heat sources except the persons. Such a "supply rate procedure" has of course never been applied. Instead it was obvious to define thermal comfort in relation to the temperature of the space etc. and the thermal design of building and HVAC system was done to provide that temperature level.

In the new European Guidelines we have tried to establish a similar, rational design methods for indoor air quality. Today we can predict temperature, sound and light in a building. We thought it was time to begin predicting indoor air quality as well. We know that the method may not be perfect, we know that the data base on pollution sources is modest. But we think that the publication of the Guidelines will encourage designers to demand pollution data for materials, HVAC components, etc. We expect that many manufacturers will be eager to supply such data proving that their product is low-polluting. We hope to generate a snowball-effect and the support of the ***Indoor Air BULLETIN*** would be essential. We are optimists!

Ole Fanger

Michael Hodgson

Michael J. Hodgson, M.D., M.P.H., is Associate Professor at the University of Connecticut School of Medicine, Section of Occupational and Environmental Medicine, Farmington Connecticut. Hodgson is a member of ASHRAE's ventilation standard committee (SSPC62) and former chairman of its Environmental Health Committee.

Dear Hal:

Positivism has its place in the world, even if we in the U.S. experience it as "uncritical." And progress has only rarely occurred because of the naysayers and skeptics. Still, some scientists and professionals have too much fun and may simply not be cynical enough for their work to be taken seriously in the U.S. This may be because philosophy of science has driven us to seek out type I errors. That is, we formulate a hypothesis as its converse, the null hypothesis, and if we fail to disprove it, we deny that an effect, measure, or idea is important or scientifically valid. The short form is "prove it."

Public health, on the other hand, is driven by type II errors. What is the best way of doing something? How do we protect the most people? What happens if we are wrong? True scientists view those of us in public health as "chicken littles."

In my view, The European ventilation guidelines represent a leap of faith that is exciting and important. Your own work has supported such a theoretical approach. But the science must catch up at some point, if a similar procedure is to be implemented in this country.

The olf method is certainly interesting although its scientific underpinnings may yet be shaky. Much of the background literature is unavailable to those of us who do not read Danish. Questions that have been legitimately asked, in the ASHRAE ventilation standard committee (62-89R), on the subcommittees on the use of environmental criteria and the air quality procedure, in the ASHRAE Environmental Health Committee, and in the research community address both the internal and external validity of the method.

We do know that odor thresholds vary substantially among individuals. How large a panel, then, must be used to provide what level of confidence that ratings are within which percentage of the initial evaluations? Does the same panel rate spaces similarly over several evaluations?

Do different panels rate conditions similarly on the same or on different days? How legitimate is the screening and selection procedure of individuals as olf-raters? If in fact less than 25% of a screened population is able to serve on panels using the method, can the results be extrapolated to the rest of the potential exposed population?

A second question concerns the relationship between odor and irritation. The literature on irritation thresholds without odor is only now growing, through the work of Drs. Cain and Cometto-Muñiz. This may provide important insights into odor-irritation interactions. There is irritation without odor. Psycho-social aspects of subjective discomfort may not be adequately addressed by the method.

Such methodological concerns have not been addressed in the English, German, or French literature with which I am familiar. Casual discussions with professionals from Dr. Fanger's lab have not provided substantive answers to those legitimate concerns. Perhaps it is time that some agency in the U.S. funded the basic methodological work. Alternatively, ASHRAE could hold a seminar inviting individuals using the olf technique to present the data.

Still, Dr. Fanger makes a exceedingly legitimate point in his letter. Levers of progress are often rough. His, or some similar procedure is conceptually the only way of addressing the issues. Whether ASHRAE should adopt the technique in its current form or support some similar technique based more on chemical quantification remains to be seen.

Michael J. Hodgson

John R. Girman

IAB spoke with John R. Girman, Chief of the Analysis Branch of EPA's Indoor Air Division, and formerly at Lawrence Berkeley Laboratory of the University of California and at the California Department of Health Services. Girman is a keen observer of the indoor air scene and plays an important role in formulating U. S. policy.

According to Girman, one problem with Fanger's olf/decipol approach to IAQ is that too much focus can be given to subjective aspects; this has the potential to lessen the focus on serious health effects. An example of a misplaced focus is the use of CO_2 as a surrogate for indoor air pollution, which has tended to lessen the focus on other factors contributing to poor IAQ.

Like Michael Hodgson, Girman raised several questions about the subjective evaluations required for application of the Fanger approach. "Is it sufficiently precise to be used in this way? We need to know about the precision across different groups using the olf/decipol approach. Is this an approach one can read about and then apply? Or must all practitioners be trained by one trainer? If it's the latter, then we have an application of art, not technology. We need a round robin or some other sort of study to learn more about the performance of this approach when applied by different groups before its use can be recommended. In essence, we need inter-laboratory comparisons before this can be accepted as a validated method."

Commenting on Fanger's analogy to noise and light, Girman said: "These are inappropriate analogies because they are physically measurable. Fanger's olf is a subjective value based on the responses of a certain population to some odors; the instrument is the human being."

He also said that looking at cooling loads for the design of equipment is a poor analogy because it ignores the fact that there is a sensor, a thermostat, that allows the cooling of a space to be moderated up to the limit of the cooling capacity. "You don't have that aspect of control for odors; no odor sensor is available to moderate ventilation systems to control odors."

Finally, Girman said: "I agree that subjective responses to IAQ are important, but I am uncomfortable incorporating a subjective response into guidance with only limited validation of the approach."

IAB Comments

We would like to add a few comments to those of our colleagues above. First, Fanger says after "[d]esigners began demanding data for sources and materials" that manufacturers "quickly began to supply the data." This is true only of a very tiny fraction of manufacturers and is, therefore, misleading. Most manufacturers have not tested their products' emissions and do not want to do so. The pressure on them is coming from designers and others making purchasing decisions, but at such a slow pace that it does not allow designers to rely on such data to implement the guideline. This is a critical gap that we believe will be bridged quite slowly unless and until regulatory actions mandate testing.

Second, Fanger's comments on estimating pollution loads in buildings and the European Community financed study do not address our point that there is a very wide range of values within the buildings already studied and a wider range is anticipated as more buildings are studied. Values in the Guideline table vary by 10x for assembly halls and nearly 20x for offices. Designers cannot use the empirical data from such studies as design assumptions for determining required ventilation.

Finally, we strongly endorse the proposals of Dr. Seifert as embodied in the ventilation guideline. We have long advocated developing adequate data on both the health effects of exposure to indoor air contaminants and the odor/irritation impacts of exposure to emissions from indoor pollution sources. To the extent that the European ventilation guideline stimulates those activities, we are very pleased it has been published. But until its provisions are incorporated into laws, regulations, or standards, it will serve only as a useful stimulus and guide for those most devoted to improving indoor air quality. Its application in an actual building design is simply impractical at the present time.

Copies of the European Ventilation Guidelines

Readers can obtain complimentary copies of the European ventilation guideline by writing to the Commission of the European Communities, Joint Research Centre Environment Institute, Ispra 21020 (Varese) Italy. The Indoor Air Programme can be reached by fax at +39 332 78 50 22 or +39 332 78 92 22.

Reference:

CEC, 1992. *Guidelines for Ventilation Requirements in Buildings.* Report No. 11 European Concerted Action: Indoor Air Quality and Its Impact on Man. (EUR 14449 EN), Commission of the European Communities, Directorate General for Science, Research and Development, Joint Research Centre - Environment Institute, Ispra, Varese, Italy.

Materials

Summary Guidance on Material Selection

Architects, engineers, interior designers, and other professionals increasingly try to select building materials and furnishings (sources) that contribute as little as possible to indoor air pollution. There are many ways to collect information and make informed product selections, and the best method for any particular project depends on many factors including project size, timing of decision-making, the roles of the designers and the contractors, and the importance of IAQ to the various key parties. In this article we discuss different methods available and the criteria for selecting them.

In our fourteen years of specializing in IAQ and over thirty years in designing and constructing buildings, we've learned that there are rarely simple answers to the really tough questions – and choosing healthy building materials presents some very tough questions. Selecting "clean," "safe," or "healthy" building materials is extremely complex. It involves trade-offs between short- and long-term health effects, between more- and less-costly or time-consuming choices, and between different levels of certainty about the consequences of our decisions.

In most cases we can identify some candidate products or materials as strong sources of odors, irritants, or toxins. However, usually we don't have enough information to thoroughly evaluate the likely impacts of our choices. Frequently we choose between alternatives that will have disparate values for other aspects of material/product performance such as durability, acoustic control, aesthetic quality, ease of installation, and many others.

Our usual approach is to look at generic product types that merit consideration based on the most important selection criteria other than IAQ. Then we examine the meritorious candidate products and materials based on IAQ criteria. The following is a general, step-by-step process for selecting materials and products to meet your IAQ requirements.

Steps to Selecting Clean Building Materials

Below we outline the steps for selecting building materials and furnishings to improve building IAQ. This is not a rigid procedure but merely a suggested sequence for most situations.

Identify Critical Materials and Products

Examine the building design and the various materials and products that will affect IAQ. A major factor is the total quantity of a material to be used; this will fundamentally determine its contribution to IAQ. For example, if we are using lots of solvent-based adhesive for installing a floor or wall covering, some minor use of the same solvent elsewhere should only be a concern if we will reduce or eliminate the more quantitatively important source. Therefore, focus on the materials with the greatest surface area and the materials with the largest concentration of volatile materials in them when they are installed in the building.

Consider the timing and location of a material's use in terms of the potential for occupant exposure to emissions. Materials located near the occupants and their breathing

zone or exposed directly to supply or recirculating ventilation air will have high exposure. Materials encapsulated within walls or other construction assemblies will have low exposure.

Materials installed in the building in wet form will generally emit much of their content in the short term. How long will it take for the product to cure? What will be the physical characteristics of the product after the initial curing process is completed? Will significant emissions occur for days, weeks, months, or years? Short-term, strong emitters might be better than long-term, weak emitters depending on the use patterns of the building, the potential to use ultra-high ventilation rates when materials are newly installed, or when strong emitters are used for maintenance or replacement activities.

Identify Candidate Products

Limit the IAQ analysis to those products and materials that will satisfy functional performance, aesthetic, cost, and durability requirements. Keep in mind that impact on IAQ is rarely the most important materials-selection criteria. Apply the extensive amount of work involved in a thorough IAQ evaluation to realistic alternatives. Develop a list of candidate products for each potential use.

Screen Candidate Products

Using published information, prior experience, expert advice, and common sense, narrow the field of potential products to an even more manageable number. Some general information exists on many building products and materials. Occasionally, information is available on a wide range of product choices, and there are published data from credible scientists and laboratories. We published a compilation of most such data that now exists in the November '91 *IAB*.

However, don't expect to find enough information to make "perfect" IAQ choices. Sufficient data are rarely available to evaluate thoroughly the IAQ impacts of alternative products and materials. Even when reliable data are available on the complete chemical emission characteristics of a product, definitive data on all the potential health effects of the individual chemicals are lacking. Data on the effects of the complex mixtures emitted by most products are virtually non-existent.

Odor detection and recognition thresholds reported in the scientific and technical literature are often ambiguous. They are usually based on varied findings of different tests using different test methods or types of subjects. Irritation response data are even more scarce than odor data. Variations in individual human sensitivity and in the methods, quality, and interpretation of odor tests have produced an extremely wide range of reported thresholds. Reported thresholds for specific chemicals that have been tested span three to four orders of magnitude (factors of 1,000 to 10,000) or more for some chemicals.

Communicate IAQ Requirements

Communicate the IAQ criteria to the manufacturers of all the candidate products. Send a letter notifying each manufacturer of the importance of IAQ in the project. Indicate that the owner, architect, occupants, or other parties are committed to providing good IAQ, and that you are requesting their cooperation and assistance. Advise them that you want products that have minimal emissions of odorants and irritants and that you will avoid products that emit toxins and carcinogens. Require the identification of all carcinogens, teratogens, or mutagens used in the manufacture of the product or that may be emitted by the completed product.

Advise that you will only specify products from manufacturers that provide enough information on their product to assure the architect, owner, or other interested party that the product will not have significant negative impacts on IAQ. This will require submittals that include the complete chemical contents of the product, the appropriate means and materials for maintaining the product, and, if tests have been conducted, reports describing its emissions. For some products, testing should be required. For other products, testing is not standardized within the industry and results are difficult to interpret even if they are available.

Seek Out Technically Competent Manufacturer's Staff

We often find that a particular person in a manufacturer's organization can identify the best product for our application. Most manufacturing companies have chemists and engineers on staff to deal with product development, process engineering, quality control, environmental compliance, or other company functions. When we discuss our air quality concerns with the right person in the company, we often receive frank and extremely useful advice about the manufacturer's best product for our application. Furthermore, these individuals can discuss various considerations in the specification, installation, and use of their products to improve IAQ.

Review Submittals

Determine the completeness and responsiveness of the submittals. Notify the manufacture of any missing components and establish a deadline for complete, acceptable submittals.

In some cases you will have to identify the person or office within the manufacturer's organization that is able to respond to your requirements. This is sometimes diffi-

cult. Sales personnel for most building products and furnishings are not able to respond to indoor air concerns. Therefore, you must ask them to help you find the appropriate individuals at the manufacturing facility or company headquarters. Most often the individuals responsible for environmental compliance or for directing the manufacturing and quality control operations can provide the available information. More importantly, these individuals can often tell the specifier which of the company's products are most appropriate for both functional and IAQ performance. Especially among some of the larger manufacturers, we have found conversations with these individuals extremely helpful in selecting products from their line that will comply with our criteria.

Evaluate Candidate Products

Using the criteria outlined below, you can review all the information you have obtained on candidate products and select those that appear most likely to serve your needs.

1. *Quantitative emissions* – the overall emission potential based on the quantity of material to be used in the building and the fraction of its constituents that will be emitted during its useful life. The lower both of these, the lower the product's impact on IAQ.

2. *Qualitative emissions* – the characteristics of a material's expected emissions including major compounds and classes of compounds. Are the compounds more or less volatile and, therefore, likely to dissipate more or less slowly? While volatile compounds may leave the products and the building very quickly, large quantity emissions may adsorb on sinks and continue to be present for a long time. Less volatile compounds come out at low rates, but their emissions decay very slowly. Therefore, they are around for a long time.

3. *Timing and duration of emissions* – will the decay be slow or rapid? Short term or long term? Affected by temperature and humidity? The more emissions are affected by changes in environmental conditions, the more likely large exposures will occur.

4. *Health and comfort impacts* – the significant effects of emissions including toxicity, irritancy, and odor. In particular, carcinogenic or teratogenic potential are considered especially unacceptable. Odor is more or less acceptable depending on the application and the strength of the odor relative to its detection threshold. Irritation and toxicity are unacceptable, of course, but concentrations resulting from a single product rarely reach levels that will cause these effects by themselves. Here it is simply a matter of degree.

5. *Sink potential* – the tendency of a material to act as a sink and, subsequently, a secondary emission source. This is based on surface area and material characteristics. The higher the surface area, the greater the sink potential. While few data are currently available on sink effects of various materials, you can safely assume that the rougher the surface texture, the greater the sink potential of the material. Glass is low, textiles are high. Wood and plastic are intermediate.

6. *Maintenance requirements* – the frequency of required maintenance, the nature of materials and processes required to perform maintenance, and the impact on IAQ of the expected maintenance routines. The ideal is no maintenance. Maintenance by water or dry cloth is also benign. Products requiring the frequent use of solvents are the least desirable.

7. *Availability of information* – the degree to which products have been tested by manufacturers and test results can be compared. Examples of tested products are particleboard and other pressed wood products and carpets. Where testing has been standardized, we do not consider products for which the manufacturer does not provide complete emission test reports. Where testing is not common or standardized, we require complete disclosure of the product's contents and a description of the manufacturing and treatment that is likely to impact its emissions.

8. *Manufacturer IAQ program* – whether a manufacturer has or is willing to take steps to improve a product's IAQ performance characteristics. Discuss the possibility of pre-treating solid materials such as carpets or furnishings before they are installed in the building. Cooperative manufacturers will usually be able to improve considerably their product's performance once they understand your concerns.

Comment

Don't expect the choices for IAQ to be easy. Difficult trade-off decisions are characteristic of design choices, and IAQ is no different in this respect. Even if a material emits what are seemingly relatively benign chemicals, the durability of the material may suggest that it will degrade rapidly in use and, therefore, require frequent maintenance, refinishing, or replacement. Seemingly harmless materials such as cotton and wool must receive biocidal treatments to resist microbial contamination.

Always do the easy things that can reduce known emissions. If you use a substantial amount of particleboard bonded with urea-formaldehyde resin as an underlayment for flooring, don't spend much time considering the selection of one table that might be

constructed with a particleboard substrate for a laminated or veneered finish. On the other hand, you can simply reduce formaldehyde emissions from the table by fully encapsulating the particleboard with laminate on all edges as well as the entire underside leaving no direct pathway from the particleboard into the air. Barriers of this sort have been shown to be more than 90% effective in reducing formaldehyde emission rates, although over the very long term virtually the same total quantity of formaldehyde will be emitted (at least in theory).

Be prepared for higher costs and more time-consuming selection and implementation procedures. Most of the best material choices we've found often involved more time, cost, or care than is typical in building design, construction, operation, maintenance, housekeeping, or

Four Types of Emissions

There are essentially four types of emissions to understand when selecting materials from an IAQ viewpoint. The four types are based on the nature of a product and its use in the building. Each type of emission can be limited by careful consideration during a building's design phase.

1. "Wet" Product Emissions Directly Into Building Air

Wet products usually emit solvents, water, and other substances during installation. Paints, sealants, adhesives, caulks, and sealers are excellent examples of these types of products. While most of the emissions occur during the first few hours or days after installation, many of these products continue to emit at far lower levels, perhaps 1000- or 10,000-times lower, for weeks, months, and even years. These emissions might also include solvents used to clean or process products during the manufacturing process.

2. "Dry" Product Emissions Directly Into Building Air

Dry products may emit solvents used in manufacturing the product or its constituents. There is usually an initial burst of emissions when the product is first exposed. This may be because the product was packaged soon after its manufacture and more volatile substances could not escape. Or, changes in the product may have taken place during storage, transport, etc. The initial burst may be ten- or even a hundred-times higher than the emissions a week or a month later. An excellent example is carpet backed by styrene butadiene rubber latex (SBR) which tends to emit significantly higher quantities of a substance (4-phenylcyclohexene — 4-PC) during the first day than at the end of a week and continues to emit at low levels for several weeks or more. Particleboard and other composite wood products made with formaldehyde-based resins emit formaldehyde for months or even years before even half the total formaldehyde is emitted.

3. Emissions of Adsorbed Substances From Building Surfaces Into Indoor Air

All surfaces adsorb molecules of chemical substances and compounds or particles that are in the air. Adsorption is a chemical-physical bonding that may be permanent or reversible. The degree to which a substance is sorbed is a function of the volatility and polarity of the chemical and of the virtual surface area of the sink material. Generally, the rougher the surface, the more sorption is possible. Glass and stainless steel sorb relatively low quantities compared to textiles, wood, and paper. Nearly all surfaces serve as sinks, and the sinks get loaded, in part, in proportion to the concentration of one or more substances in the air. The higher the airborne concentration, the greater the sorption rate. Sinks can get very loaded during periods of elevated concentrations and then release (re-emit) the substances later when the air concentration is lower. This is why a room where smoking occurred still smells hours or even days later. The higher the ventilation rate during the periods of elevated airborne concentrations, the less material will end up in the sinks.

4. Emissions of Materials Used for Maintaining Building Surfaces and Equipment

Materials such as waxes, polishes, cleaners, and disinfectants are not part of the original construction but are determined in large part by the design. Therefore, it is essential to select materials with due consideration to the emissions necessitated by the design and specifications. For example, specifying a linoleum flooring instead of carpeting will mean regular emissions from cleaning and waxing chemicals. The janitor's five-gallon can of floor cleaner comes in full and leaves empty. The contents of the can may originally be applied to the floor, but most of it ends up as vapors or particles as the floor maintenance product dries and wears. Maintenance products that have strong odors or irritating constituents should be avoided wherever possible.

use. There are exceptions, but many choices involve carefully considering life-cycle rather than just initial costs. In the United States (and many other capital intensive economies), long-term considerations are of little present worth (current economic value) due to the high value placed on capital. Private organizations as well as governments are rarely motivated to make larger investments on the basis of expected or promised future returns.

References:

"New Carpet Odor and Carpet Backing," "Carpet Installation Product Studies," and "EPA Carpet Policy Dialogue," ***IAB***, Vol. 1, No. 4, August 1991.

"Controlling Sources of Indoor Air Pollution," and "Material Emission Rates," ***IAB***, Vol. 1, No. 6, November 1991.

"Specifying Low Emitting Materials," ***IAB***, Vol. 2, No. 1, January 1992.

H. Levin, "Building Materials and Indoor Air Quality" In Cone, J., and Hodgson, M., (Eds.) *Problem Buildings: Building Associated Illness and the Sick Building Syndrome.* Philadelphia: Hanley & Belfus, Inc. Vol. 4, No. 4, *Occupational Medicine: State of the Art Reviews.* This 227-page volume is available from the publisher, Hanley & Belfus, 210 South 13th Street, Philadelphia, PA, 19107, (215) 546-7293. Price: $32 in the US, $34 outside the US.

John R. Girman, "Volatile Organic Compounds and Building Bake Out," In Cone, J., and Hodgson, M., (Eds.) *Problem Buildings: Building Associated Illness and the Sick Building Syndrome.* Philadelphia: Hanely & Belfus, Inc. Vol. 4, No. 4, *Occupational Medicine: State of the Art Reviews.*

W. Gene Tucker et al., Eds, *Sources of Indoor Air Contaminants: Characterizing Emissions and Health Impacts. Annals of the New York Academy of Sciences, Volume 641.* 327 pages. Available from the New York Academy of Sciences, 2 East 63 Street, New York, NY 10021. Price: $65.

Hans Gustafsson, "Building materials identified as major sources for indoor air pollutants: A critical review of case studies." Document D10:1992. Swedish Council for Building Research. 72 pages. Available from Svensk Byggtjänst, S-171 88 Solna, Sweden. Approx. price: SEK 80.

Publications

IAQ Directory

IAQ Publications, Inc. has published a 375+ page directory of commercial, industrial, and residential indoor air contacts, contractors, products, and other listings. The listings in "The Indoor Air Quality Directory - 1992-1993" are organized geographically and alphabetically for many of the categories. A brief summary of the contents with the number of pages devoted to each topic in parentheses follows:

- Service firms (92 pp.)
- Product manufacturers and distributors (70 pp.)
- Support services (24 pp.)
- Training/workshops/courses (37 pp.)
- Federal government (8 pp.)
- State government (24 pp.)
- Professional associations (14 pp.)
- Publications (16 pp.)
- Glossary (11 pp.)

There is some paid advertising, but the directory consists largely of factual information. The products and services sections provide access to a large number of firms throughout the United States. There are also a few listings for Canadian and British enterprises.

Overall, the directory should be a useful tool to nearly anyone in the IAQ field. The publisher guarantees satisfaction, so there is not much to lose. Surely most of our readers will find some useful information.

However, we did find some inaccuracies such as outdated addresses or phone numbers, incorrect attribution of publications, and omissions of significant individuals and organizations. We also noted that neither the ***IAB*** nor any of the three other major indoor air newsletters were listed in the "Indoor Air Quality" publications section although IAQ Publications' newsletter was listed there.

The errors and omissions in the directory do undermine the value of the directory somewhat. We did not carefully review a large number of listings to evaluate their accuracy, but we did find enough errors to cause concern. We have observed a similar carelessness in the editing of the publisher's monthly newsletter suggesting that there is insufficient fact checking and editorial quality control.

At $75 per copy, the directory is not cheap. However, the publication might be valuable as a source of names for mailing lists considering commercial rates for such names run around ten cents each.

One competitor of IAQ Publications, Inc., Cutter Information Corp., is currently working on a directory project, and EPA has funded an update of its 1989 "Survey of Indoor Air Quality Diagnostic and Mitigation Firms." All such publications are helpful in such a new and rapidly changing field as IAQ.

For a $75 copy of the "The Indoor Air Quality Directory - 1992-1993," contact IAQ Publications, Inc., 4520 East-West Highway, Suite 610, Bethesda, MD 20814, (301) 913-0115, fax (301) 913-0119.

"Quality of the Indoor Environment"

The following special report on the "Quality of the Indoor Environment" conference, held in Athens, April 28-30, 1992, was submitted to the ***IAB*** by Leon Alevantis, P.E. We have edited Alevantis' original report to reduce its length. Alevantis is on the staff at the Indoor Air Quality Program in the State of California Department of Health Services Air and Industrial Hygiene Laboratory, Berkeley.

The conference was organized by Indoor Air International (IAI). IAI is a relatively new organization organized originally by British professionals with a global focus. The organization has sponsored several other conferences since its formation.

We have previously suggested that IAI is heavily supported by the tobacco industry. Although IAI officers deny this, IAI conferences and publications consistently focus on active and passive tobacco smoke. Their presentations and publications seem to consistently draw conclusions favorable to the tobacco industry. These observations strengthen our suspicions, and Alevantis' report provides additional evidence.

Alevantis' Report

My overall rating of the conference was that, scientifically, it was of medium quality. There were some good- and some poor-quality papers, with some of them clearly promoting the ideas of the tobacco industry. In my opinion, one of the few positive aspects of the conference was the fact that under-developed or developing countries are realizing the importance of air quality. Conferences hosted by these countries are a good way to bring researchers together.

I met several researchers from Europe, most of whom were unaware of the funding source of the conference organizers. All the researchers I talked to appeared to disagree with the way the tobacco industry was funding research on indoor air, and agreed that some, if not most, of the tobacco-related papers attempted to down-play the health effects of cigarette smoke. Of the 86 papers listed on the final program, 17 were directly related to cigarette smoke.

I spoke with Frank Lunau, retired Occupational Hygienist and currently President of Indoor Air International, about his organization and source of funding. He stated that the reason his organization was formed was to provide practical solutions to IAQ problems for under-developed or developing countries. Such solutions were not being provided by other organizations (such as ASHRAE) which publish highly technical and scientific solutions impractical for these countries.

Lunau also mentioned that last year's ASHRAE Indoor Air Conference in Washington, DC, was mostly an engineering meeting with very few papers on health effects and other aspects of indoor air. He said that his organization receives no outside funding and that their only source of income is membership fees (about 200 members) and conference fees. Even based only on these fees, IAI was able to make a profit. Half of the conferences are arranged by local organizations. Future plans of IAI are publications aimed at maintenance workers and building managers. Finally, they have no plans to fund research in the immediate future.

Some Papers Worth Noting

A paper presented by P. Binnie (Healthy Buildings International) promoted the Building Systems Approach. The speaker suggested that enough ventilation should be provided so that the following indoor pollutant levels are not exceeded: CO_2 (800 ppm), CO (9 ppm), RSP (100 g/m^3), and HCHO (0.06 ppm). He also said that acceptable IAQ can be achieved if adequate ventilation with proper filtration is provided and regular building inspections are conducted. I commented to the author that his pollutant guidelines ignored most of the indoor pollutants such as VOCs and biological contaminants. He responded that such standards do not yet exist in the US.

An excellent paper was given by Dr. [Nicholas] Ashford on scientific policy considerations of multiple chemical sensitivities. Dr. Ashford stated that there is enough evidence in the fields of occupational and environmental medicine to suggest a real medical problem. Dr. Ashford said that there is an initializing event during the lifetime of a chemically sensitive person, and that the process can be reversed by withdrawal for an extended time.

F. R. Rosendahl presented a paper on the credibility of the results of epidemiological studies. Rosendahl discussed bias in scientific studies (such as bias in data, in research, in journals, etc.). I commented to the author that researchers should also disclose their funding source since that may be associated with bias. I brought as an example the case of the tobacco industry funding research on health effects of ETS. Rosendahl disagreed and said that the pharmaceutical companies fund research on the health effects of their products. I replied that the funding bias will be eliminated if a public entity would act as a clearing-

house for distributing research funds on behalf of the various companies.

The "Anti-Tobacco War in the West"

One of the most controversial papers of the conference was by P. Skrabanek regarding the moral and ideological aspects of the "Anti-Tobacco War in the West." The author said that there is no clear evidence that ETS causes cancer or heart disease, and that all anti-smoking laws were written and passed by bureaucrats who "did not have anything else to do." The author showed a variety of anti-smoking articles and advertisements and criticized each of them. He also added that smokers were unfairly being discriminated against and that in the west it is politically wrong to be on the smokers' side. When I asked Skrabanek to disclose his source of funding he categorically denied that he was receiving funding from outside the university.

Another paper by J. McCormick that tried to minimize the relationship of ETS to coronary heart disease made some people I talked to very upset.

There were several papers on epidemiological studies of health effects of cigarette smoke compared to other indoor pollution sources such as combustion sources, building materials, and biological pollutants. All these papers seemed to down-play the health effects of cigarette smoke as being a smaller risk when compared to other sources.

Some of the papers presented from Greek researchers indicated that IAQ is a serious concern in Athens. One survey of managers' attitudes towards cigarette smoking indicated that 87% of the respondents were in favor of creating a smoking policy whereas 75% indicated that they would welcome more information on the health effects of cigarette smoking. Another survey indicated that there are serious IAQ problems in office buildings influenced by the poor outdoor air quality.

Y. Ait-Amara studied seven non-smokers who were supplied with personal nicotine samplers for two 24-hour periods while they were exposed to ETS either at home or at work. Based on the level of the 24-hour inhaled nicotine, the cigarette equivalent (one mg per cigarette) of the non-smokers was between 0 and 0.6 cigarettes. Based on our experience in a limited number of U.S. buildings (on-going study) we have found nicotine levels to be high in non-smoking areas and highly dependent on the number of cigarettes smoked, air-flow patterns from the smoking to the non-smoking areas, and ventilation rates.

S. Willers' paper on urinary nicotine excretion at work concluded that there is evidence of passive absorption of ETS at some work-places and that smoking should be allowed in well-ventilated workplaces.

S. Ghittori's paper described an analytical method for determining benzene in urine from indoor sources. Because ETS is the major contributor of indoor benzene, this method can be used to evaluate exposure to ETS of both smokers and non-smokers, Ghittori said. In my opinion, the exposure of smokers to ETS is quite obvious and voluntarily made. It is the involuntary exposure of non-smokers to ETS that we should be concerned about. Based on our group's experience analyzing VOC samples from several non-smoking US buildings (including outdoor samples) we have found that low benzene levels are present in some indoor and outdoor locations. I therefore disagree with the author that ETS is the major contributor of benzene, but certainly agree that it can be one of the major contributors in most cases where there is enough smoking.

Lead and Childrens' Health

A paper by A. Spurgeon on low-level lead exposure and childrens' health questioned the current evidence. It said that "at the present time there is a lack of evidence to indicate a consistent association between exposure and effect," and that "the effects of low-level exposure are questioned by many researchers." One of the members of the audience, who served on the EPA's advisory committee for reducing the concentration standard for ambient lead, was particularly upset because this paper appeared to discredit all the research upon which EPA based its decision. According to this committee member, Dr. Nicholas Ashford, all the research presented in this paper was supported by the lead industry. Ashford suspected that the lead industry may be supporting IAI.

Mouse Bioassay

R. C. Anderson's paper described her application of ASTM E981 to evaluate the irritant potency of indoor air. The test procedure involves exposure of Swiss-Webster mice to the test atmosphere and measurement of the decrease in respiratory rate of the mice which is proportional to the irritant potency of the air. I commented to the author that her technique has the same disadvantages as that of Ole Fanger's. Both methods give only an indication of short term respiratory reaction; they ignore any compounds which do not cause short-term discomfort but result in serious health problems after a long-term exposure.

For more information:

Leon Alevantis, State of California Department of Health Services Air and Industrial Hygiene Laboratory, 2151 Berkeley Way, Room 347, Berkeley, CA 94704-9980, (510) 540-2132.

Conference Announcement

Indoor Air '93 Deadlines Draw Near

Critical deadlines for the 6th International Conference on Indoor Air Quality and Climate, INDOOR AIR '93, are fast approaching. Paper abstracts are due October 1 and travel grant applications are due December 1. INDOOR AIR '93 will take place in Helsinki, Finland, from July 4-8, 1993. The official conference language is English.

The triennial series of Indoor Air 'XX conferences is the most important and most exciting of all IAQ meetings. Past conferences have not only been valuable in terms of the scientific and technical papers, but also as opportunities to become acquainted with researchers and professionals from all over the world. The attendance was over 1,200 people at the '90 conference held in Toronto, Canada. Authors presented over 500 papers published in five volumes distributed to registrants at the conference.

After the conference, authors will be invited to submit expanded versions of their conference papers for publication either in the *ASHRAE Journal* or in *Indoor Air*.

Abstracts for Papers

The deadline for submitting abstracts for papers to be presented at the INDOOR AIR '93, is October 1, 1992. Abstracts received after that date will be rejected, according to the Call for Papers. The abstract of no more than 300 words must be submitted with 3 copies. An individual may submit up to two separate abstracts (as first author) and must sign a statement that the paper covers original material not published or presented at other major meetings.

The abstract must contain

- A title using significant descriptive words
- The author's name(s) and affiliations
- Corresponding address including fax number
- Topic which best reflects the contents of the paper
- Mode preference for presentation (slide or poster)

The text should contain an introduction (objective), methods, results, and conclusions, including recommendations and practical benefits. The official Call for Papers states: "It is not adequate to state 'results will be discussed.'"

Conference organizers will notify authors of abstract acceptance by November 15, 1992. Submitted papers will be due February 1, 1993. Final papers may be no more than six pages long. After final review, the conference organizers will notify authors of paper acceptance and mode of presentation by April 1, 1993.

Travel Grants Available

Travel grants are available for authors of papers accepted for presentation to Indoor Air '93. Researchers and students from North America whose papers have been accepted for presentation at Indoor Air '93 are eligible to receive partial travel grants. Authors should send applications for travel grants to Demetrios Moschandreas at the address listed below. Applications must include a copy of the abstract, the prime author's full address, and the social security number.

Conference Contacts

Send abstracts and requests for conference information to Indoor Air '93, Professor Olli Seppanen, Helsinki University of Technology, SF-02150 Espoo, Finland, +358 0-451 3600, fax +358-0-451 3611. Send travel grant applications to D. Moschandreas, Indoor Air '93, Pritzker Department of Environmental Engineering, Illinois Institute of Technology, 3200 South State Street, Chicago, Illinois 60616, fax (312) 567-3548.

Calendar

Domestic Events

September 21-22, 1992. **"Indoor Air Quality"** Course, Madison Wisconson. Sponsored by the University of Wisconsin Department of Engineering, Professional Development. Contact Engineering Registration, The Wisconsin Center, 702 Langdon Street, Madison, WI 53706 (608) 262-1299, or (800) 462-0876, fax (608) 263-3160. *Registration fee is $585 for this two-day course taught by Charles Dorgan, James Woods, and Michael Hodgson.*

September 22-25, 1992. **International Symposium on Radon and Radon Reduction Technology**, Minneapolis, Minnesota. Contact: For registration information, Diana, Conference of Radiation Control Program Directors, Inc., (502) 227-4543, Fax (502) 227-7862.

September 30 - October 2, 1992. **"Lead-Tech '92: Solutions for a Nation at Risk,"** Hyatt Regency Hotel, Bethesda, Maryland. Sponsored by IAQ Publications, Inc. Contact: Mary Lou Downing, Conference Manager, Lead-Tech '92, 4520 East-West Highway, Suite 610, Bethesda, MD 20814. (301) 913-0115; Fax (301) 913-0119. *The sponsors say this is the first industry-wide lead detection and abatement conference and exposition. Registration fee is $525 per person . Conference topics include public programs and policy; lead detection and abatement; blood lead screening, diagnosis and treatment; occupational safety and health; and litigation and liability.*

October 6-7, 1992. **ASTM Subcommittee D22.05 on Indoor Air; Fall Meeting**, contact George Luciw, Staff Manager, ASTM, 1916 Race Street, Philadelphia, PA 19103-1187, (215) 299-5571, fax (215) 299-2630.

October 18-20, 1992. **IAQ 92 - Environments for People,** Golden Gate Holiday Inn, San Francisco, California. Sponsored by ASHRAE, ACGIH, and AIHA. Contact; Jim Norman, Manager of Technical Services, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle NE, Atlanta, GA 30329, (404) 636-8400. *The conference program appears packed with interesting, quality papers. We look forward to another excellent conference and published proceedings from ASHRAE. Registration fees are $450 ($400 for ASHRAE Members). Student registration fee is $25 but does not include a copy of the proceedings.*

October 19-21, 1992. **Indoor Air Quality Continuing Education Course**, American Industrial Hygiene Association, Salt Lake City, Utah. Contact: Continuing Education, AIHA, P.O. Box 8390, White Pond Drive, (216) 873-2442, fax (216) 873-1642.

October 28-30, 1992. **World Environmental Engineering Congress**, Sponsored by Association of Energy Engineers (AEE), Atlanta, Georgia. Contact: AEE, 4025 Pleasantdale Road, Suite 420, Atlanta, GA. 30340. (404) 447-5083, fax (404) 446-3969. *Registration fee: $550 AEE Member, $650 AEE non-member. Booths are available for $16.50 per square foot.*

November 13-14, 1992. **Indoor Air Quality Symposium**, American Institute of Architects Committee on the Environment, Los Angeles, California. Contact: Pat Lally, AIA, Washington, DC. 1735 New York Avenue NW, Washington, DC 20006, (202) 636-7449.

January 23-27, 1993. **ASHRAE Winter Meeting and International Air-Conditioning, Heating, and Refrigerating Exposition**, Palmer House, Chicago, Illinois. Contact ASHRAE Meetings Department, 1791 Tullie Circle NE, Atlanta, GA 30329, (404) 626-8400.

May 3-7, 1993. **Air & Waste Management Association Annual Symposium**, "Measurement of Toxic and Related Air Pollutants," Omni Hotel and Convention Center, Raleigh, North Carolina. Contact Martha Swiss, A&WMA, P. O. Box 2861, Pittsburgh, PA 15230, (412) 232-3444, fax (412) 232-3450. *Abstracts of 200 words are due by Nov. 30, 1992.*

June 26-30, 1993. **ASHRAE Annual Meeting**, Radisson Hotel, Denver, Colorado. Contact: See listing above under January 23-27, 1993.

International Events

October 7-9, 1992. **"Indoor Air Quality, Ventilation, and Energy Conservation in Buildings"** — 5th International Jacques Cartier Conference, Hotel Chateau Champlain, Montreal, Canada. Organized by Centre for Building Studies, Concordia University. Contact: Fariborz Haghighat, Centre for Building Studies, Concordia University, Montreal, Quebec, Canada H3G 1M8. (514) 848-3192, fax (514) 848-7965. *The conference preliminary program looks very interesting. Registration is $515 (CND) including a copy of the Conference Proceedings. Student fee is $50 (CND) but does not include lunch or a copy of the Conference Proceedings which may be purchased separately.*

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

December 1-3, 1992. **"Quality Standards for the Indoor Environment,"** Sponsored by Indoor Air International (IAI), Prague, Czechoslavakia. Contact Professor M. V. Jokl, c/o Secretariat: Quality Standards for the Indoor Environment, Society for Environmental Toxicology, CS 116 68 Prague 1, Czechoslovakia; Fax 42 2-2328611; or, Dr. L. S. Levy, Institute of Occupational Health, University of Birmingham, Edgbaston, Birmingham B15 2TT, United Kingdom, fax 21 471 5208.

February 17-19, 1993. **"Building Design, Technology & Occupant Well Being in Cold and Temperate Climates,"** Palais des Congrés, Brussels, Belgium. Contact: ATIC-CDH, chausee d'Alsemberg 196, B-1180 Brussels, Belgium. Tel. 32-2-348-05-50; Fax 32-2-343-98-42.

March 4-6, 1993. **Second Spanish and Interamerican Air Conditioning and Refrigeration Congress—CIAR '93**, Madrid, Spain. Contact CIAR '93, Parque Ferial Juan Carlos 1, 238067, Madrid, Spain. Tel 722-50 00. Telefax 722 57 90.

July 4-8, 1993. **Sixth International Conference on Indoor Air Quality and Climate, Indoor Air '93**, Helsinki, Finland. For more information, a copy of the conference announcement, or the call for papers, contact the confeence secretary at: Indoor Air '93, P.O. Box 87, SF-02151 Espoo, Finland. Fax +358-0-451-3611. *This most important indoor air conference is held every three years and is always a very exciting and rewarding event. Abstracts are due October 1, 1992. Do not hesitate to submit an abstract even if you are not yet certain you will attend.*

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

Indoor Air BULLETIN

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