Indoor Air BULLETIN™ Hal Levin, Editor

Technology, Research, and News for Indoor Environmental Quality

Volume 3 Number 4

Sensory Evaluation of Indoor Air

More and more investigators are using sensory evaluations of indoor air in their work. Ole Fanger and his colleagues at the Technical University of Denmark are among those who have stimulated a renewed interest in using sensory evaluation of indoor air. Chemical measurements alone apparently do not consistently predict occupant responses, and some studies have failed to find a correlation between ventilation rates and occupant responses. Furthermore, Fanger and many others have found that ventilation system designs and ventilation rates based on human occupancy alone are simply not adequate to provide comfortable and, in many cases, healthy indoor environments.

However, research reported at Healthy Buildings '94, held August 22-25 in Budapest, Hungary, indicates that there is little to no correlation between certain sensory evaluations of IAQ and occupant satisfaction or symptom reports. There is also an apparent lack of consistent correlation to chemical measurements and ventilation rates. Preliminary reports from the European Audit Project failed to show correlations between sensory evaluations, olf/decipol ratings, chemical measurements, ventilation rates, and SBS symptom reports.

Background on Sensory Evaluation

Sensory evaluation of IAQ is certainly not new. In the mid-19th century, the first building ventilation standards were developed to control odors indoors. These odors were primarily from people themselves. Before the advent of frequent bathing and commercially available soap, personal hygiene was quite different. Controlling odor was a need obvious to most building occupants, and ventilation was an obvious solution.

Early ventilation standards used carbon dioxide as an indicator for human bioeffluents since there was an appreciable correlation between odorant production and respiration or metabolism generally. It's no surprise that efforts to specify ventilation requirements are tied to the occupant density and use of a space; these are major determinants of occupant-related carbon dioxide and other bioeffluents. However, eliminating human odor is no longer the dominant need for ventilation, and there are many views as to what should be the basis for ventilation rates.

Questions

Sensory evaluations seem logically related to occupant responses to IAQ, and they are relatively fast and affordable compared to many types of chemical measurements. On the other hand, they are not uniformly reliable for identifying health hazards, and some non-odorous pollutants such as radon and carbon monoxide are simply not detectable based on odor. Furthermore, enormous variations among people make predictions of occupant responses based on odor valid only for statistical predictions applied to large populations. They may not be useful for individual cases.

It is widely acknowledged that using sensory evaluations alone cannot ensure healthy indoor air, but it is often stated or implied that controlling factors affecting perceived air quality is an adequate surrogate for IAQ. This is an attractive and even seductive idea. But, in the end, important questions remain:

- How important is odor for building occupants' comfort and health?
- How useful are sensory evaluations of IAQ in predicting occupant responses?

Inside This Issue:

Many of the Budapest conference papers shed some light on this, and we have chosen several to discuss here.

British Research Finds Conflict Between Odor and Dissatisfaction

A paper by Nick Parine and Tadj Oreszczyn of London described their investigation into the relationship between perceived odor, perceived air quality, and occupant satisfaction. The paper states that "...perception of human odor (bioeffluent) has been used [historically] to set standards for ventilation rates in buildings." Early standards (Yaglou, 1936) were based on human occupant density. In recent years, Ole Fanger has questioned this approach by arguing that building fabric and contents are important sources of pollutants. Berglund and Cain (1989) showed that temperature and humidity influence individuals' judgments of air quality. Mølhave (1993) reported that temperature affects volatile organic compound (VOC) pollutant impacts on human physiological and neurological responses.

European Ventilation Guidelines (1992) state that health risks should be negligible and that air should be pleasant rather than stuffy, stale, and irritating. Recommended ventilation rates depend on which of three levels of dissatisfaction (10, 20 or 30%) the owner or designer deems "unacceptable." The number of people predicted to be dissatisfied is based on the olf/decipol scale (Please see our discussion of olf/decipols at the end of this article.). The olf/decipol scale itself is derived from a two-point acceptability scale and knowledge of the amount of odor present judged by untrained visitors within two minutes after entering a space.

The Study

The Parine-Oreszczyn study compared the results of a questionnaire survey involving 300 office workers in two air-conditioned buildings in the UK. Both buildings had ventilation rates in excess of the 8 l/s/p rate recommended by the Chartered Institute of Building Service Engineers (CIBSE). Questions on odor and air quality were just four among a much larger number of questions contained in the survey. Ventilation and other indoor climate factors were also measured. The measurements are shown in Table 1.

The values reported in Table 1 show that thermal conditions were well within accepted guideline values and should not have produced occupant discomfort. They also show that there was an adequate ventilation rate in Building A and a rather high one in Building B.

The results of the questionnaire survey (see Figures 1, 2, and 3) does not show the expected correlation between dissatisfaction with air quality (Figure 1) and occupants' perception of odor either at the time of the questionnaire (Figure 2) or over time (Figure 3). In fact, the occupants reported the building lacked smell both at the time of the questionnaire administration (Figure 2) and over time (Figure 3).

Both buildings satisfied the WHO requirement that less than 50% of occupants be able to detect odors. Yet occupants perceived both buildings as having poor air quality and both buildings failed to meet the ASHRAE Standard 62 criterion of not more than 20 percent dissatisfied (PD).

Using Yaglou's criteria for satisfactory odor environment, only 3% and 1% of occupants respectively of Building A and Building B were "dissatisfied" based on their votes of "strong odor," "very strong odor," or "overpowering odor." Considered as "satisfied" were indications of "moderate odor," "slight odor" or "no odor." Thus, the researchers suggested, dissatisfaction with air quality in these buildings has little to do with perception of odors.

Based on the ventilation rates and occupant densities, the researchers calculated a predicted percent dissatisfied according to procedures outlined in the European Guidelines (European Concerted Action, 1992). Using the mean value of 0.3 olf/m^2 and the actual occupant densities, they calculated an expected dissatisfaction level for Building A of 47% and for Building B of 22%. Their measured values from the questionnaire results were 72.6% dissatisfied (voting "dissatisfied" or "very dissatisfied" on a five point scale) in Building A and 85.5% dissatisfied in Building B.

Table 1 - Measured Indoor Climate Parameters.

	Building A	Building B
Mean air temperature	22.1 ºC (71.8 ºF)	23.1 ºC (73.6 ºF)
Mean relative humidity	35%	47%
Mean air movement	0.072 m/s (14.2 fpm)	0.066 m/s (13.0 fpm)
Outside air ventilation/person	10.8 l/s/p (23 cfm/p)	59.0 l/s/p (125 cfm/p)
Outside air ventilation/area	0.66 l/s/m^2 (0.13 cfm/ft^2)	2.11 l/s/m^2 (0.415 cfm/ft^2)

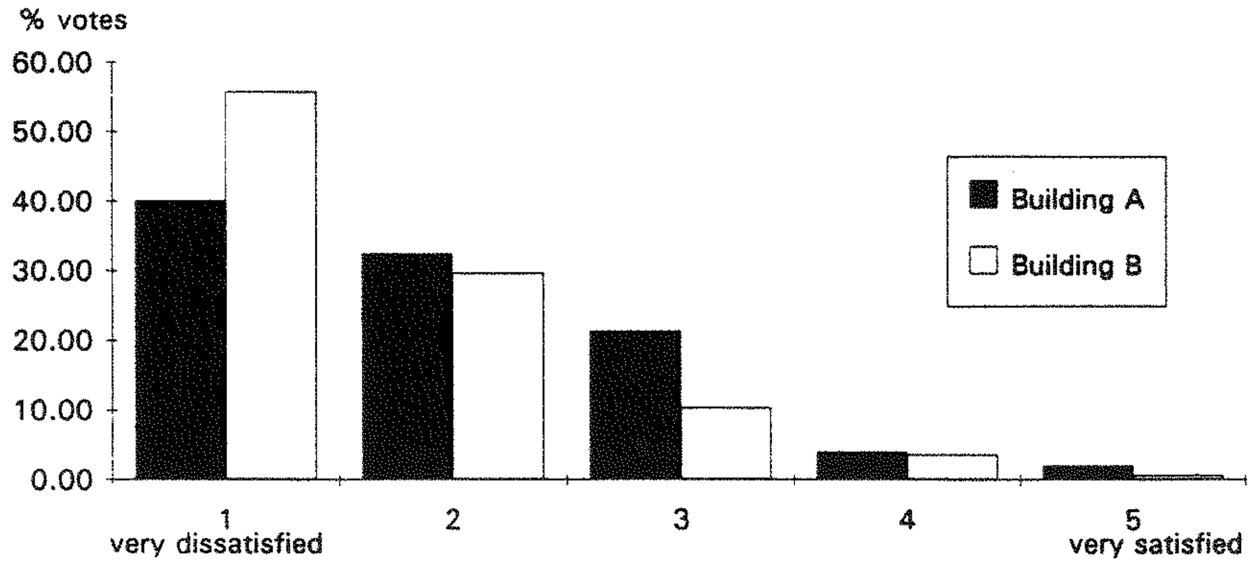

Figure 1 - Occupant's dissatisfaction with their air quality – distribution of votes on the "very dissatisfied" to "very satisfied" scale.

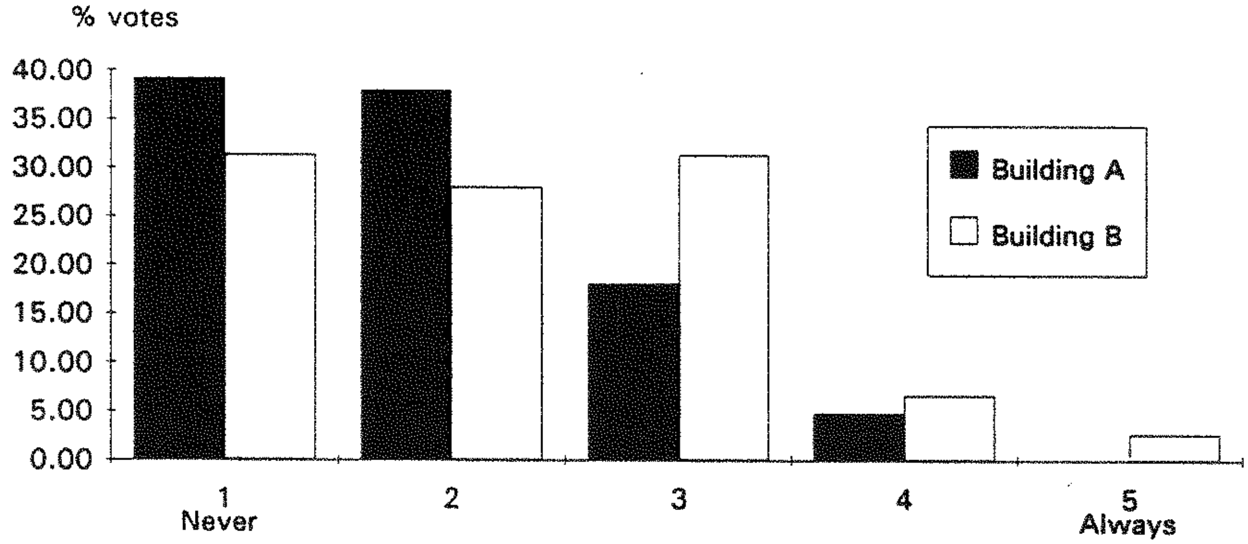

Figure 2 - Occupant response to smells over time – distribution of votes on the "never smelly" to "always smelly" scale.

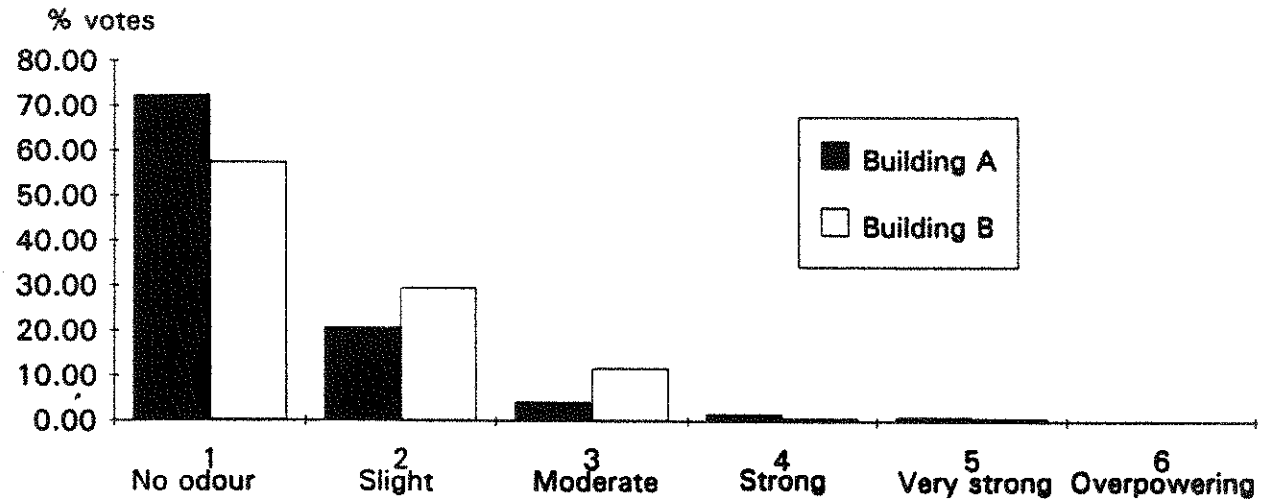

Figure 3 - Occupant response to odor at the time of the questionnaire – distribution of votes on the "no odour" to "overpowering odour" scale.

Conclusions

The researchers concluded that there "appears to be no single measurable definition of acceptable indoor air quality." Various factors including odor character and intensity as well as other sensory perceptions combine to affect the occupants' air quality perceptions. In spite of very high dissatisfaction levels with the air quality, the occupants of the two study buildings did not find their workspaces to be "odorous" or "smelly."

The researchers also concluded that using visitors' judgments to evaluate air quality will generally predict a higher level of dissatisfaction with odor than by using occupants' judgments, and, therefore, they questioned the relevance of this technique. They also point out that "Fanger refers to his system as measuring 'air quality' despite the original work using an odor acceptability scale." They acknowledge that taking the mean value of olf levels in office buildings results in PD values that are too low, and that buildings do in fact have much higher levels. But, they argue, "...if this were true, it would surely be reflected in the occupant votes on the 'smelly' scale as they are 'visitors' at the beginning of each new day." We would argue that people become accustomed to the odors at their workplace, and other research has shown that familiarity with odors results in rating them more pleasant. (Engen, 1984)

IAB Comments

Does this study simply tell us that air does not have to be smelly for occupants to be dissatisfied with it? Or does it also tell us that odor perception is an inadequate predictor of the acceptability of IAQ? More studies will be required to answer the question, but it is clear that odor perception (as measured in this study) was not a predictor of air quality acceptability (also as measured in this study) in the two study buildings.

Clearly, visitors' and occupants' evaluations of IAQ are not likely to agree. If that is the case, then what value do visitors' judgments have? Certainly for improving air quality for visitors, occupants' judgments are less valuable as well. In buildings where visitors are a normal part of the building function, both visitor and occupant judgments are important. Furthermore, visitors' judgments can be more sensitive and help identify sources of pollution that occupants might not be able to identify. Certainly more research, as Fanger often suggests, is necessary.

In fact, Fanger tells us, researchers are finding that buildings supplied with recommended amounts of outside air (according to ASHRAE or other guidelines) are full of people complaining about air quality. This, he points out, means we simply have not adequately accounted for the non-people sources of pollution. We agree with his observation, but we have not yet been convinced that predicting dissatisfaction based on trained olf/decipol panels is the answer.

Japanese Emissions Study

Japanese researchers Go Iwashita and Ken-Ichi Kimura reported a study that investigated the effect of surface air velocity on surface emission rates (SER) of perceived air pollutants. They said they initiated the study to complement chemical emission tests such as those done by the US Environmental Protection Agency with emission rate information on "perceived air pollutants, *e.g.*, Fanger's olf, from building materials and products."

By varying the air velocity from 0.05 m/s to 2.0 m/s at a ventilation rate of about 0.46 l/s, [1 m/s ~ 197 feet per minute, fpm; 1 l/s ~ 2 cubic feet per minute, cfm), the researchers were able to obtain emissions under a very wide range of conditions. They used 12 trained panelists to evaluate emissions from four materials. They used human sensory evaluations to determine air speed effects on the emissions of "perceived air pollutants" based on the olf/decipol system.

They found that the higher the air speed the greater the surface emission rate based on the mean perceived air pollutants. A forty-fold increase in air speed from 0.05 m/s to 2 m/s resulted in increases from 50% to more than 100% for the four materials. The results show that the effect of surface velocity within the range studied is relatively small. A forty-fold increase in surface velocity produced approximately a doubling of surface emissions of odorants perceived as air pollutants. Other investigators have reported a ten-fold increase in air velocity (from 0.2 to 2.0 m/s) increased VOC emissions from carpet by 30%, a value consistent with the current study results.

An increase of surface air velocity from 0.05 to 2.0 m/s increased perceived air pollution emissions from chipboard by 86%, from carpet by 73%, from rubber by 73%, and from straw mat by 39%, according to the Japanese researchers. [Our computations based on their data produced slightly higher values.] Figure 4 shows a plot of the results for the four materials in olf/m^2 for the four surface velocities.

The increase was the greatest for carpet, although the absolute emission values were lowest for carpet of the four materials tested. Emissions from the rubber sample were the highest and increased by about the same amount as the carpet. The other two materials, chipboard and straw-mat, had intermediate strengths and their increases were consistent with those from carpet and rubber.

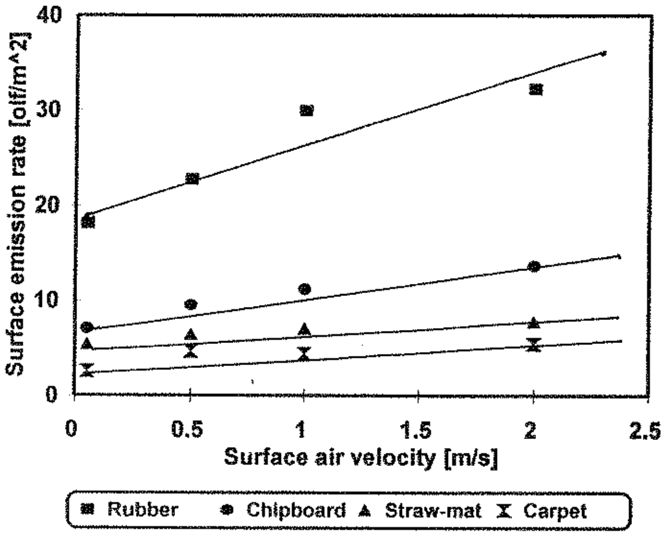

Figure 4 - Surface emission rate versus the surface air velocity.

Conclusions

The authors concluded that using realistic air velocities is important to avoid overestimating surface emission rates (SER) of perceived air pollutants. They cited the work of Tom Matthews who measured typical velocities in six houses of 0.07 median and 0.05 mean m/s (13.8 and 9.8 fpm respectively). We have found "typical" air velocities in mechanically ventilated buildings ranging from less than 0.03 m/s up to 0.3 m/s and above.

IAB Comments

It is worth noting that the researchers used no instrument chemical measurements but only sensory evaluations for the study. A similar approach was reported at the recent ASTM Symposium on "Characterization of Indoor Sources and Sinks" to evaluate test chamber surface air velocities. Similar research methods have also been used at the Danish Building Research Institute and collaboratively with the Danish National Institute of Occupational Health. The appeal of sensory measurements is their low cost and immediacy. However, we are concerned about excessively relying on sensory validation methods without validation by chemical testing methods.

It is also interesting to note that the slopes of the curves for the different materials are not parallel; this is consistent with the work reported by Knudsen as discussed below.

Danish Technical University Study

A paper by Henrik Knudsen (with Geo Clausen and Ole Fanger) of Professor Fanger's laboratory at the Danish Technical University reported results of a study to determine the effects on perceived air quality of diluting building material emissions with unpolluted air. The emissions studied were from linoleum, carpet, paint, and a mixture of emissions from the three materials. Researchers varied the dilutions to study the relationships between five concentrations of the emissions and perceived air quality judged by a trained panel. They varied the concentrations by a factor of fifteen within a range "typical for the application of the materials in real spaces."

Figure 5 is a pair of graphs from Knudsen's paper showing the results for four pollution sources: human bioeffluents, paint, carpet, and linoleum and the mixture of the three materials. The relative concentration is determined as the actual concentration divided by the concentration at a calculated theoretical 20% dissatisfied.

The researchers investigated the effect of dilution on the four types of sources by adding varying proportions of "unpolluted" air to the emissions before panelists' exposure. The plots in Figure 5 show the impact of the dilutions on "predicted percent dissatisfied" (ppd),

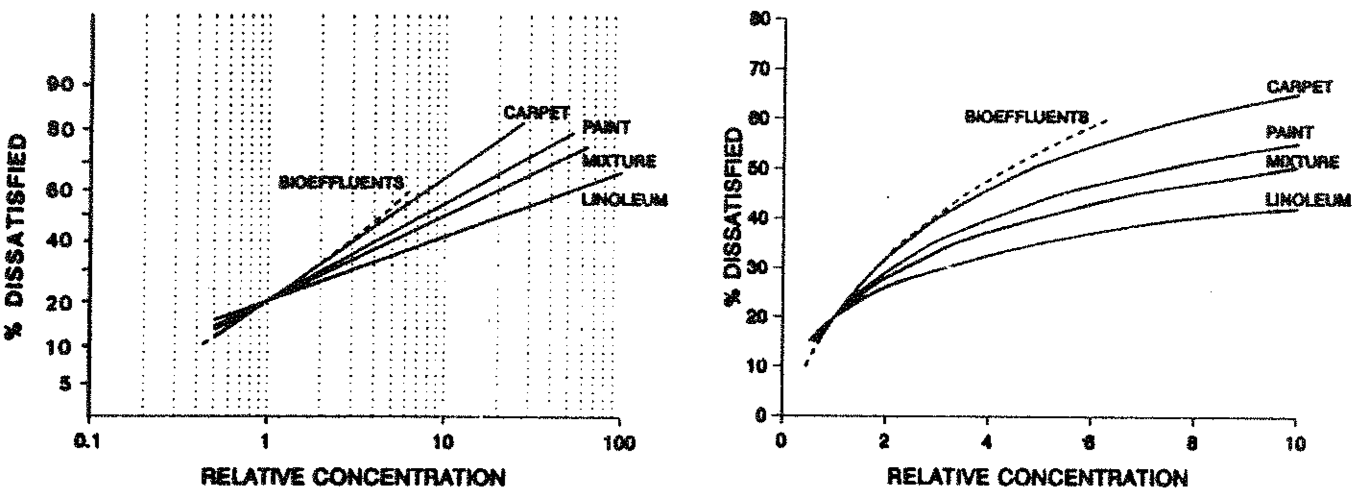

Figure 5 - The percentage of dissatisfied as a function of the relative concentration, defined as the actual concentration divided by the concentration at 20% dissatisfied, for the materials and for bioeffluents.

which is a derived value based on the decipol rating. They found that the changes in perceived air pollution varied for the different materials. (This also appeared to be a trend, although perhaps more subtle, in the Japanese study described above.) Thus, olf/decipol values used to predict human responses in a building or laboratory must be modified to reflect these findings.

The authors noted that the curves for the materials and the mixture are less steep than the curve for bioeffluents. They also pointed out that the differences in the slopes in Figure 5 show that it is "...more difficult to improve the [perceived] air quality when the air is polluted by the studied materials than if the air is polluted by bioeffluents." [We question whether this is really true or is simply an artifact of the use of the particular gas (2-propanone) chosen to calibrate the panelists' judgments of perceived air pollution.]

Adjusting Olf/Decipol Values Required For Different Materials

The slopes and locations of the plots are different depending on the type of source being evaluated. Thus, the researchers wrote, "...the sensory emissions rates for the materials are not constant but vary with the pollution concentration."

Therefore, a set of constants were derived by statistical methods to be used when making calculations predicting percent dissatisfied based on olf values for individual materials. Table 2 shows the constants for the four materials and the mixture.

Finally, the authors conclude from Figure 6 that the previous finding that a simple addition of the loads form individual pollution sources may reasonably approximate the total sensory pollution load. They state that this is so because the curve for the mixture of materials is close to the average of the three curves for the individual materials.

IAB Comments

This research seems extremely complicated and, perhaps, convoluted in its methodology. What was originally a rather simple idea, that one could use odor judgments as an effective tool for predicting occupant satisfaction with air quality, is being refined to the point where its simple elegance has vanished.

As we understand it, this study tells us that not all olfs are equal. Olf values must be adjusted according to the type of source when the results are being used to predict occupant satisfaction for different source strengths and ventilation (dilution) rates. Two derived constants were developed for each source type. These constants can then be applied to produce a more reliable prediction of the percent of building occupants likely to be dissatisfied with a given environment.

Table 2 - The constants a and b characterizing the materials and the mixtures of materials.

Material	a	b
Linoleum	5.52	0.28
Carpet	5.91	0.54
Paint	5.25	0.42
Mixture	5.32	0.37

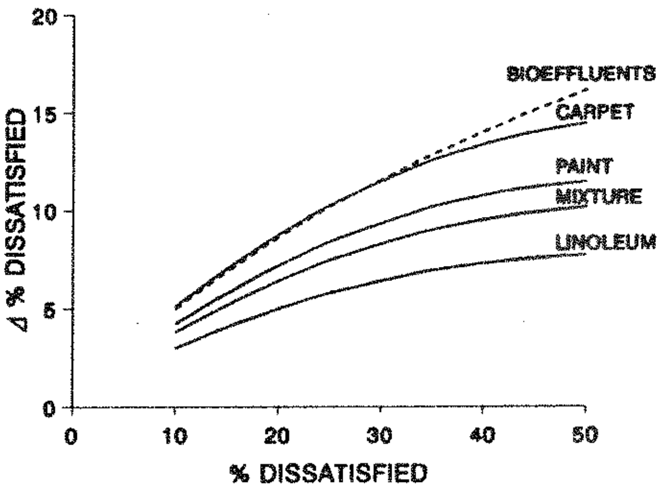

Figure 6 - The decrease in % dissatisfied when the ventilation rate is doubled as a function of % dissatisfied before the change of the ventilation rate.

Olf/Decipol Units

The increasingly widespread use of sensory evaluation was evident at Healthy Buildings '94, but there was more discussion of the limitations and shortcomings of its most popular form, the olf-decipol units. Developed by Ole Fanger of Denmark, Philo Bluyssen of the Netherlands, and others, olfs are units used to quantify emission source strengths, and decipols are the units of perceived intensity. One olf is the emission from a "standard person" and one decipol is the intensity of perceived air pollution when the olf is diluted with an air exchange rate of 10 liters per second (~ 20 cfm). Note that by definition, a standard person is one with normal hygienic practices who bathes every 1.6 days.

General Problems with Sensory Evaluation

Evaluations of odor or perceived IAQ are not always very specific as to what is being evaluated and how. Odor and irritation are closely related but different. People do not perceive pungent chemicals the same ways as they do other chemicals. Are judgments strictly about odor strength, or are they about acceptability *per se*, or pungency/irritancy, comfort, or what? Preferences, likes, and dislikes vary greatly within a population and reflect prior experiences as well as physiological differences. Reported odor thresholds in the scientific literature cover as many as seven orders of magnitude for the same substance. The variations are attributed both to individual human differences as well as to differences in the methodologies used to determine them.

We find it increasingly difficult to understand the meaning of the values given by sensory evaluations due to the proliferation of their use often with little or no description of exactly what is being evaluated. At the same time, more and more investigators use them to evaluate IAQ. A plethora of variations have simply compounded the problem of insufficiently detailed descriptions of methodology in many study reports and papers. Among the variations are different ways of posing questions about sensory evaluation on questionnaires, different scales, conversions to different units, and several others.

Direct Criticism of Olf/Decipol Units

Nigel Oseland of the Building Research Establishment (BRE) in Coventry, UK, raised several questions about the use of the olf/decipol units in his paper (co-authored with C. Aizelwood and G. Raw, also of the BRE). Oseland and Raw had previously published a critical discussion of the olf/decipol units. (1993)

The BRE investigators participated in the European Audit Project, a study by researchers in nine European countries of no less than six buildings in each country. All participants in the study followed the procedures in the project manual assembled by Philo Bluyssen.

Oseland was direct and explicit in voicing his criticisms. He started with the theoretical basis for the olf and decipol system. The theoretical foundation, according to Oseland, assumes a linear relationship between odor perception and chemical concentration. In fact, Oseland said, odor intensity is a power function of the source concentration.

Oseland reported that in BRE's work to replicate the method published by Bluyssen, Fanger, and others, many modifications had to be made for safety and the reliability of the experiments. He said that the suggested procedure involving calibration beforehand, which was to simply remove the caps from the test jars 10 minutes before the training, resulted in incorrect concentrations.

He also indicated that the training of the panel members was impractical in the setting at the BRE. He cited research by Parine that found the concentrations of acetone used in the training were below the thresholds for most people. He quoted thresholds at concentrations up to seven times higher than those used in the training. However, he noted that none of the 50 people tested had trouble detecting concentrations of 50 ppm or above. The selected panel members were capable of detecting and rating very low concentrations of acetone.

He also said the visits to the buildings were not well structured to make efficient use of panelists' time. More fundamental criticisms related to finding access to fresh air for the panelists to clear their noses between judgments. Because most large office buildings in the UK are mechanically ventilated and sealed, it is difficult to get panelists to fresh air to "clear" the nose before the next rating after being inside for a prior one.

Oseland *et al.* also criticized the method for the lack of consideration of the impact of 12 people walking in and out of a space to make the ratings. They suggested that the presence of 12 people is still a significant source of olfs.

Revising the Training for Olf/Decipol Ratings

Philomena Bluyssen and Lars Gunnarsen, both formerly in Fanger's lab, presented a paper comparing the performance of trained and untrained panels. Bluyssen is one of the pioneers in the use of the olf/decipol system and is responsible for the standardized approach used in the European Audit Project. The researchers concluded that if untrained panels are used, they should consist of 50 members when "perceiving air quality in the typical range of 0 - 10 decipol" to be as precise as a trained panel of 12 members. Furthermore, trained panels must pass through a quality-assurance program. Such a program is under development. Bluyssen said that there needs to be a tightening up on the training and quality control for the panels.

Practical Advice Based on Odor Detection

Tom Follin of BARAB, an IAQ consulting firm in Sweden, uses odor as a major clue in his investigations and remediations of contaminated houses and sick buildings. He presented three sequential papers delineating his approach and offering some very practical advice based on his experience. His papers were a refreshing relief from the research focus of most of the other presentations. His were more in keeping with the intended theme of the Healthy Buildings 'XX conference series. On the other hand, his advice was based on anecdotal evidence and at times seemed insufficiently supported for generalization. Nonetheless, he has used sensory evaluation in a practical context and others can learn from and build on his approach.

IAB Comments

Our own preliminary analysis of results of the European Audit Project indicates that there is no apparent correlation between the results of the decipol evaluations and the other standard audit project measurements. That is, for each of the buildings studied in a given country, the decipol values did not appear to correlate with the other measured values including SBS symptom index, ventilation rate, VOC concentration, or even sensory evaluation.

We do not know how the sensory evaluations were performed, but we find it significant that there is no correlation between sensory evaluation and the predicted percent dissatisfied based on the decipol values.

Why is there no apparent correlation between olf/decipol evaluations (and their predictions of potentially dissatisfied occupants) and the other measures of IAQ or of occupant and visitor responses to it? Which are the most valuable predictors of occupant symptoms and health complaints? Why don't decipols correlate with other measures?

One of the frequently offered explanations is that the decipol ratings are based on the responses of visitors (trained panelists) made within 15 seconds or even two minutes after entering a space. Odor perception diminishes as exposure time increases while for many substances irritation responses increase with exposure time. Since occupants are in a space far longer than the panelist making the decipol ratings, the opportunity for irritation to occur is obviously greater for occupants than it is for panelists or visitors. Irritation is rarely a quick response except for extremely strong substances or for highly sensitive individuals.

The Need for Better-Quality Research

One of the things we have found most difficult about reading or listening to papers reporting studies using sensory evaluations is that the methodology is often not very fully described. This shortcoming is not limited to sensory evaluations, of course; many reports of VOC measurements or of many other study parameters are frequently inadequate. Unless and until there are universally accepted, standardized measurement methods for studying indoor air, this problem will continue. More care in describing study methods will improve understanding and enhance the usefulness of the work that is being done.

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Microfungi

A new book, *Microfungi,* has just been published by Munksgaard. The book is about filamentous fungi, the molds. It is unquestionably the most beautiful and, one of the most useful publications we have seen for indoor air researchers and related professionals. Credit is given in the acknowledgments to Margaret Flannigan, who edited the text to produce an eminently readable book. Written by Suzanne Gravesen, Jens C. Frisvad, and Robert A. Samson, this 168-page hard-bound monograph is exquisite.

The book is generously illustrated with normal or life-size color photographs as well as electron micrographs. There are photos of culture plates showing the appearance of the fungi in laboratory growth media; drawings and diagrams to complement the photos; photos of plant and animal organisms that are infected by fungi; and, photos of many common objects of daily human life that are made with the aid of fungi, subject to damage from them, or both.

The text is clear and well-written and comprehensive in its treatment without being excessively technical. The book is intended to assist various groups of people. The authors focused the book on the most common molds in daily life; it does not include mushrooms or other fungi that occur as diseases on plants and animals.

Some Pearls of Wisdom from *Microfungi*

From Chapter 2, Biodeterioration - spoilage moulds: "Old dirty wall-to-wall carpets placed in service buildings such as schools, kindergartens and offices offer an excellent substrate for growth of deposited mould spores if the carpets are supplied with adequate moisture, either due to accidental water damage e.g. in winter when people will walk in with wet shoes or boots, or on purpose. The latter could be the result of cleaning procedures which use shampoo and water or prevention of static electricity with humidification of carpets, as is sometimes recommended by authorities."

"Mould growth in dwellings is often discovered because of the emission of characteristic musty or earthy odours produced by the mould during growth. One of these heavy musty odours is 2-methyl-isoborneol produced by *Penicillium commune*. Other volatiles often encountered in damp houses are ethanol and acetaldehyde."

"As is the case with the production of mycotoxins, water availability may have a considerable influence on volatile production by moulds. Experiments with growth of moulds on agar have led to the assumption that production of volatiles is inversely related to water activity (a_w) and that the volatiles are accumulated during stress periods in which they fulfill an osmoregulatory function, after which they can be released. However, it is also known that fungal volatiles have a strong ecological effect: e.g., 1-octen-3-ol is an attractant for certain mites and insects."

"Most odours in damp buildings are caused by mould growth and in some cases by bacteria, especially actinomycetes but rarely by wood-rotting fungi."

From Chapter 4, Mycotoxins and mycotoxicoses: "In nature, living organisms protect themselves, thereby protecting their genes, in many different ways. This can occur by colonising habitats through extremely quick growth, as is done by bacteria and some moulds; by emission of unpleasant and smelling volatiles; by production of toxic substances; or even by attracting other organisms for effective dispersal."

The Audience

Microfungi has useful information for architects, engineers, and builders regarding the destruction of building materials and the moisture requirements for mold growth in houses. Chemists may find it useful for the information on specific metabolites produced by the individual mold species it covers. It contains information on the serious health effects of metabolites from molds that should be useful to people working in the areas of health and medicine. It is likely to be of value to nearly everyone interested in indoor air.

The authors organized the book in chapters that discuss the basics of fungi ecology; biodeterioration - spoilage molds; molds in biotechnology (what we might call economic molds); mycotoxins and mycotoxicoses; allergy and other adverse health reactions to molds; and, fungal infections. This (last and longest) chapter is divided into descriptions of common microfungi organized alphabetically. A specific organism is presented in each two- to four-page section. There are sections containing a description, ecology, practical application, damaging effects, and specific metabolites.

For some fungi, where relevant, (e.g., *Aspergillus terreus, Cladosporium herbarum,* and *Stachybotrys chartarum*) there are sections on medical aspects and infection. Also, where relevant, there are sections on building damage and agricultural aspects. There is a photo of the organism grown in laboratory culture media and one or more additional photos including electron microscopic views of the organism or its component parts.

A publication note of interest: Munksgaard is the publisher of the journal *Indoor Air*, the most credible and valuable scientific and technical journal devoted to indoor environment issues.

To Obtain a Copy:

Microfungi is available from Munksgaard for DK 320, about US $50 at the time of this writing. Contact Munksgaard International Publishers, 35 Nørre Søgade, Postbox 2148, DK1016 Copenhagen K, Denmark, +45 33 12 70 30, Fax +45 33 12 93 87.

Publications

Protecting the Built Environment: Cleaning for Health

Rarely does a clear, well-written, technically sound, practical book on IAQ appear. Even rarer is good information on the importance of cleaning indoor environments for health. Michael A. Berry, Ph.D., has beaten these odds with a comprehensive, 274-page book, *Protecting the Built Environment: Cleaning for Health.*

Berry works at EPA's Office of Research and Development in the Environmental Criteria and Assessment Office. He used to be responsible for EPA's indoor air research budget. His interest in indoor air related not only to his professional responsibilities and qualifications, but his wife was in the building cleaning business. So, when he commanded the funds for indoor air research, he began funding efforts to understand cleaning and its relationship to building environments and health.

While there is a great deal written about the whys, whens, and hows of duct cleaning to maintain good IAQ, there is next to nothing readily available on the cleaning of floors, walls, ceilings, furnishings, and other important indoor surfaces – especially with an emphasis on health. Even if you do not clean buildings yourself, if you own them, operate them, run them, or occupy them, this book is a valuable tool. IAQ consultants will benefit from a careful read of the book and will probably want a copy to give to each of their clients.

Comprehensive Contents

The book covers the topic of cleaning for health the way one hopes a building is cleaned: thoroughly, from top to bottom. There are introductory chapters on professional cleaning and environmental health, environmental management, health and the building environment, environmental impacts on people's health, and pollutant sources and effects. Then the book lays out principles for environmental management and cleaning and environmental guidelines for cleaning.

The chapter on buildings and cleaning is where the rubber meets the road. Berry describes all the parts of a building relevant to the cleaner, how things get dirty, and how to clean them. He discusses building inspection for cleaning and provides a six-page checklist for inspectors. In the chapter on basic cleaning, he discusses general housekeeping, carpet cleaning, fabric cleaning, and the control of "biopollutants."

Carpet Cleaning

"More and more indoor cleaning problems are related to dirty carpets," Berry writes. "Most can be solved through cleaning, mainly through maintenance and restoration." He tells us that clean carpet does not promote the growth of microorganisms, but dirty carpet does allow bacteria, fungi, and mites to proliferate.

"Even in ideal circumstances, carpet constantly takes in and releases gas phase organic compounds at various emission rates. Research with dry cleaning brought into houses shows that perchloroethylene (PERC) used in dry cleaning is released for days from clothing brought home from the cleaners. "This gas penetrates carpet and wall surfaces and is released back into the air. The cycle goes on for days."

Berry tells us that neglected carpets pose a health hazard and that carpet should not be installed in any building unless its owners plan to clean it frequently using an external extraction method. Later he writes, "From a public health perspective, it is difficult to justify indoor carpet unless a routine and effective cleaning program can be assured. Such a program calls for properly trained personnel applying appropriate cleaning methods and using environmentally-sound cleaning technology." We see this as good advice for designers, building owners and managers, and occupants as well.

There is a myth in the design and building professions that it is cheaper to maintain carpets than it is to maintain hard-surface floors. Research by Thomas Schneider and others at the Danish National Institute of Occupational Health in Copenhagen has shown clearly that it takes the same amount of maintenance to achieve a comparable level of residual dust on carpets or on hard-surface floors.

Specialty Cleaning

A separate chapter on specialty cleaning discusses restoring damaged environments including odor-source identification and control. Here too he provides a check list and then follows it with a catalog of techniques for controlling odor. The methods he includes are removal, diluting with ventilation, sealing and containing, gas-phase reactions, oxidation, adsorption and absorption, digestion, and masking and pairing.

He even discusses the problems relating to AIDS and HIV including a "safe approach to cleaning up blood." He discusses medical and infectious waste disposal, water-damage prevention and management, and fire restoration. He only briefly treats duct cleaning, a subject that remains controversial as the field evolves and data is gathered on its performance.

Marketing Building Cleaning

He has a chapter on marketing building cleaning services using a "total quality management" approach. This is something of an overworked buzzword these days, but for the entrepreneur in search of a product or service, building cleaning may be a worthwhile endeavor.

Qualified Praise

We have to qualify our praise for Berry's book on two grounds. First of all, it stops short of directing the reader to specific proven equipment. It stays fairly general, but does provide enough advice for the reader willing to pursue finding equipment that conforms to his guidance. It would have been far more useful if the section on extraction equipment, for example, had been more detailed and even contained brand-name guidance.

Secondly, this is not the first book on cleaning buildings. The Danish company ISS, a major building cleaning and maintenance contractor, published a comprehensive guide to IAQ with a very significant emphasis on cleaning. Unfortunately, the ISS book *Indelklima* is, except for one page written by ***BULLETIN*** editor Hal Levin, written in Danish. We can't read Danish, but the pictures make it look extremely useful and well-done. We have visited the ISS headquarters in Copenhagen and discussed IAQ and building cleaning issues with company representatives interested in expanding their activities. They are involved in some very useful studies of cleaning and indoor environment. Some of them involve collaboration with the Danish National Institute of Occupational Health.

IAB Strongly Recommends this Book

We strongly recommend the book to our readers, but we hasten to warn that it may not always provide all the details you want or need. Perhaps this is a function of the complexity of IAQ issues; maybe it's just too large and complex a topic to treat comprehensively and in detail in a single volume. Let us know what you think of the book and what questions you most want answered. We will try to address your comments and questions in a future issue of the ***BULLETIN***.

Reference:

Michael A. Berry, (1993), *Protecting the Built Environment: Cleaning for Health*, Chapel Hill, NC: Tricomm 21st Press.

To Get a Copy:

Order from Tricomm 21st Press, P. O. Box 349, Chapel Hill, NC 27514, 800 424 2178, Fax 919 933 5542. The cost is $50.00 plus $3.00 shipping and handling. Discounts are available for quantity orders: 6-10 copies are $45 each, and 11 or more are $40 each.

__Letters__

Mike Hoag on *IAB* Emissions Testing Article

Dear Mr. Levin:

Thank you for the complimentary copy of the most recent edition of the ***Indoor Air BULLETIN*** (Vol.3:3). In regards to your report on the particleboard and MDF emissions testing, work done by NPA and Geomet, there are some errors in the ***IAB*** article and apparent oversights in the interpretation of the results. Errors such as these can usually be avoided if the papers and articles reported in the ***IAB*** are reviewed by the original authors, prior to publication.

First of all, the ***IAB*** article "Particleboard and MDF Emissions Test Results", fails to identify the role of Geomet Technologies, Inc. as the NPA contractor, providing the chamber testing for the study and Don Cade of Geomet, as co-author of the report presented at the 28th International Particleboard/Composite Materials Symposium.

Also, in the preceding ***IAB*** article "Industry Product Testing - Leveling the Playing Field" you suggested that NPA has begun a comprehensive program to test VOC emissions from industry products. Contrary to this perspective, the NPA study of particleboard and MDF VOC emissions testing was a pilot effort to 1) evaluate a selection of industry products of known origin for comparison to VOC emission data already reported in the literature; 2) gain experience with VOC emissions test procedures; and 3) evaluate typical VOC emissions, and their variability between product types for selected particleboard and MDF materials. There are other, more comprehensive VOC studies underway, however, NPA's involvement in these is primarily advisory.

In the *IAB* article, "Particleboard and MDF Emissions Test Results", Table 3 and Figures 1 and 2 indicate that multiple unfinished MDF materials were tested. This is incorrect. The first six materials identified as MDF in Table 3 were all particleboard. These represent 2 samples from each of three particleboard mills. The two materials identified simply as MDF are correctly identified. This mis-representation carries into Figure 1, which suggests that multiple MDF "species" were tested and Figure 2, which again lists four unfinished MDF materials.

Referring again to Table 3, the *IAB* article includes a column identifying the age of the materials when tested. Although this is accurate, it should be noted that all test specimens were maintained in aluminized PET specimen bags up until the time they were inserted into the chamber for testing.

In interpreting the NPA study, the *IAB* article states that this testing "... demonstrate[s] the value of detailed emissions testing" and later "[T]his suggests the importance of product selection based on emissions test results." NPA did not conclude this from the product testing. Instead the variability from material to material and even within a single material type, clearly suggests a need for a much more comprehensive evaluation of the test procedure itself. The NPA/Geomet test protocol followed ASTM 5116-90, Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Material/Products. As you know this is only a guide and does not include specific criteria for test conditions and material handling. This testing suggests that for wood-based composites one must take particular care in sample selection and preparation and that chamber conditions, including loading should be evaluated carefully to identify the optimum settings to achieve repeatable results.

The *IAB* article appears to support this view in stating, "[T]hese results suggest the need for more careful control of the samples specimens before testing, possibly involving a lengthy conditioning process to achieve reasonably stable conditions." Interestingly, the particleboard industry has followed just such a protocol for the past 8 years now in its large chamber testing program, characterizing formaldehyde emissions from particleboard and MDF materials.

NPA's study of product VOC emissions represents an effort to better understand this phenomenon in industry products. Wood products professionals and others have long known that wood products emit VOCs. By and large these emissions are accepted as a fundamental positive characteristic of wood and in many cases even represent a desirable characteristic, such as cedar closets. It is my view that VOC emissions from wood-based composites is largely a wood raw material phenomenon. Furthermore, the results of the NPA pilot study suggest that many of the most commonly used laminating materials - thermofused melamine, high pressure laminates, low basis weight papers and veneers are effective barriers, significantly reducing VOC emissions from finished products.

I am enclosing some additional information on the presence of naturally occurring VOCs in wood products and raw materials, presented by Sundin, *et al.*, at the 27th International Particleboard/Composite Materials Symposium (copy enclosed). In this study some of the highest VOC concentrations measured were associated with planed pine lumber and a mix of residual shavings and sawdust from spruce and pine (material often used to manufacture particleboard).

NPA will continue to support efforts to characterize the naturally occurring VOCs as well as those that may be manufacturing process related. However, without adequate test method standards in place, it makes little sense at this time, for specifiers to request VOC information when using particleboard and MDF materials.

If I can answer any questions please call.

Sincerely,
Michael Hoag, Technical Director

IAB Replies

We thank Mr. Hoag for writing to correct our errors and omissions. We regret failing to credit GEOMET for its contribution to the study and Don Cade for co-authorship of the report, and we apologize for the oversight. We also regret any errors in the article published in *IAB* Vol. 3, No. 3. We trust that readers will now review that article in light of the comments in Mr. Hoag's letter.

We may have been optimistic in saying that NPA had begun a comprehensive program of emissions testing. The report itself did represent the study as a "pilot," as Mr. Hoag's letter states. But the significant emission factors reported indicate further testing is warranted, and we certainly hope the industry will continue its own testing (regardless of whether testing is being conducted by others). The 120 hr TVOC emissions were generally high ranging from around 75 $\mu g/m^2$ hr for thermofused melamine on southern yellow pine particleboard to more than more than 1 mg/m^2 hr [for] 6 mil vinyl adhered with epoxy to southern yellow pine particleboard. The test results showed significant variations among product types and even within a single product type (i.e., Medium density fiberboard). Clearly the number of product types and number of samples of each product type were too limited for generalization, and the large variations in results within products also suggests the need for further testing.

Mr. Hoag does not agree with our interpretation that the results suggest the value of emissions testing and the importance of products selection. He believes the results show the need for improving the test methods themselves. There are two important but distinct issues here, as we see it. One is whether the test methods themselves are reliable. The second is how many tests are required to obtain useful information.

In the article, we stated that the test methods need to be refined for this type of product, possibly by including a conditioning period or other means of controlling sample specimens. Only after implementing such careful control will it be possible to determine whether the large variations in the reported emissions are artifacts of the test methods, test implementation, or the actual materials tested. Specimen selection and preparation is an important aspect of any product emissions test procedure. No standards exist for making such selections, and any statistical analysis would support the need for running much larger numbers of tests. Due to the costs of these tests, it is unlikely the necessary increase in testing will occur.

The results, even though they are from a pilot study, do indicate such large differences among various similar and dissimilar products' emissions that we would hope industry leaders and the NPA staff would want to conduct further testing to determine the critical factors that determine VOC emissions. A paper recently presented by James Strobridge of Steelcase Inc. at ASTM's "Symposium on Characterization of Indoor Sources and Sinks" reported large differences in formaldehyde emissions from similar pressed wood products from different manufacturers. In general, emissions from US-made products were half those from foreign sources, but the ranges from both domestic and foreign products were large enough to justify testing before product selection/ specification.

Even if the VOC emissions from composite wood products are predominantly from the raw wood materials themselves, the strength of the emissions reported by Hoag and Cadet were sufficient to warrant further inquiry. Since many researchers, problem-building investigators, and even experts in lawsuits are prepared to argue about the significance of total VOC emissions and concentrations, it behooves the composite wood products industry to demonstrate that the emissions from their products are not important from a health or irritation perspective. There are very few buildings built in industrialized countries that do not contain some of these products. In some cases, very large quantities of these materials are used. In these cases, the VOC emissions as well as the formaldehyde emissions are likely to comprise a significant fraction of the total sources for these pollutants in the building. A great deal more understanding of the contribution of pressed wood products to indoor air pollution would be quite valuable to nearly everyone concerned about IAQ.

Letters

Karl Guttman on Hospital Environments

Dear Hal,

I am still reading your bulletin! And as usual, feel compelled to add my two bits worth.

[Re:] Volume 3, No. 3, page 9 - Hospital Environments. This is a subject very familiar to me. I have designed hospital environments since the early '60s; there is hardly a hospital in northern California I have not done some work in. As you probably know, I am also very close to OSHPD and the regulatory climate in California for Health Care Facilities, having served 8 years as a member of the Hospital Building Safety Board, and much longer as a member of the Mechanical/Electrical Committee for that board. I was a member of the Ad Hoc Committee writing the new TB Environmental Control regulations, which went into effect in California May 17, 1994.

1. Construction Zones

In my 30 plus years dealing with hospital construction, I have never come across a single case of a patient's infection being traced to inadequate separation of occupied zones, not to speak of "large scale" outbreaks. I would appreciate some data as to where and when this occurred.

2. Sealed Windows in Patient Rooms

In air conditioned hospitals, operable windows are a disaster. Because wind will destroy any air movement control within the hospital, I would not use them even in not air conditioned hospitals. The California code allows fixed windows as long as they can be opened with tools for cleaning and emergency control.

3. Relationship of supply to exhaust (return) air

You quote Andy Streifel of the University of Minnesota as recommending 10% excess air supply to produce a positive pressure in a room in which fungal spore concentrations are to be controlled. That 10% is a hangover from an old ASHRAE guide; in reality, maintenance of positive pressure is much more difficult and requires a careful design approach. To start with, I would question positive pressure to control fungal spore concentrations - would this not lead to "exporting" the problem to adjacent spaces?

To design for stable and significant air pressure differential between rooms, one has to:

–use constant volume terminals on both supply and return/exhaust.

–assign supply and return/exhaust cfm, taking into account air transferred to the room from adjacent rooms, as well as air leaking into (negative) or out of (positive) the room. To do that, we prepare air balancing drawings, and move air around between rooms. In reasonably tight rooms, the main source of air interchange are doors; we allow 75 cfm for a three foot wide door (25 cfm per ft. width). This is a tricky game, as there are other openings, such as pass through windows, etc.

4. George Kubica (Dunwoody, Atlanta) likes UV lights to control TB. My advice to your readers is to go slow! The jury is still out on the use of UV radiation for germicidal control.

a. In the 1960's, UV lights were proposed for this purpose. Early studies showed that:

–Because of the rapid decay of the UV intensity with distance, ceiling mounted lights are effective only for a very short distance.

–The effectiveness of UV radiation is also proportional to dwell time, i.e. the time the air is within range of the radiation source.

–To take advantage of the above limitation, Robbins Manufacturing Company produced a patented unit in the 60's, consisting of an array of tubes, each containing a UV lamp with a spiral around it, forcing the air passing through it into a longer dwelling time.

The unit was not successful because it had a relatively high pressure drop and the decay of UV intensity with time (another limiting factor) required frequent replacement of tubes.

–American Ultraviolet Company currently offers a duct mounted unit, which, however, consists of a tube bank perpendicular to air flow, and while it brings air into fairly close proximity, depending on the size of the duct, it does not address the problem of dwell time. We have never used it and I can not assess its effectiveness.

b. I have conducted a quickie literature search with the help of the UC Medical Library computer, and found only one recent study relative to this subject[1]. The author comes to the cautious conclusion that, while theory seems to indicate that UV radiation might be useful in the control of TB, there are no clinical field trials to bear this out. How does this square with Mr. Kubica's statement that "The only demonstrably effective means of controlling TB is UV light..."?

c. The new State of California "TB Environmental Control Regulations", which became effective on May 17, 1994, do not mention UV radiation at all. They mandate negative air pressure in TB Isolation Rooms, and propose methods to achieve this. We have followed these regulations, which have existed for some time as emergency regulations, and found them to be implementable. How effective they are, only time will tell.

Hal, I hope this is of some help.

Very truly yours,
Karl Guttmann

[1] Nardell EA., Environmental Control of Tuberculosis. Medical Clinics of North America, 1993 Nov, 77(6):1315-34.

IAB Replies

The documentation of hospital contamination during construction is from Andrew Streifel at the University of Minnesota. He has published numerous papers and has been very helpful to those I have referred to him. He can be reached at 612 626 5804.

The Healthy Buildings 'XX Series

More than 300 people attended Healthy Buildings '94, the third in the conference series that began six years ago in Stockholm. Held in Budapest in late August, it was the first Healthy Buildings 'XX conference to be held in the former eastern-bloc country. Overall attendance was lower than at past "Healthy Buildings" conferences. Relatively few participants came from outside of Europe compared with other recent, major international indoor air conferences. Perhaps this was because the location is less well known to non-Europeans as an attractive, interesting city. Or, perhaps, as some participants suggested, there are just too many indoor air conferences.

The quality of the papers varied greatly, as it has at many of the past international conferences. Conference organizers are under pressure to extend participation in order to ensure adequate attendance and the related financial success of the conference. They also try to extend the boundaries of standards for quality to those not previously part of the indoor air community.

Communication to authors prior to the conference was difficult due to slow mail service and limited telephone/fax access to the organizers. Assignment of papers to sessions was not thematically consistent making it difficult to follow the program, especially during the concurrent sessions. This problem was exacerbated by numerous no-shows resulting in divergence between the printed program and the actual session sequences. Nevertheless, there were many interesting and valuable papers and some interesting workshops as well.

Thomas Lindvall and Birgitta Berglund of Sweden organized the 1988 conference to develop and communicate scientific indoor air quality and climate knowledge to a broad audience including professionals and lay people as well. Their intention was that each year following the triennial international Indoor Air 'XX conference, there would be an international meeting that would translate scientific content of the past year's Indoor Air 'XX conference into practical, useful information for public policy, professional, and commercial applications.

Healthy Buildings '88 included a series of structured workshops designed to elicit the state of knowledge on IAQ and climate. The 1988 meeting workshops were well-structured and produced focused discussions and recommendations. Organizers of "Healthy Buildings '91" in Washington attempted to follow the Swedish model, but pressures existed to make the conference more like the annual ASHRAE IAQ conference series. The workshops were useful, but overall the conference did not have the quality of its 1988 model.

Overall, the themes of Healthy Buildings '94 were similar to those of the triennial Indoor Air conferences such as that held in Helsinki last year and the five previous ones. It did not distinguish itself from Indoor Air 'XX conferences the way the 1988 conference did. Some attendees remarked that the conference was too similar, after all, and that indoor air conferences did not need to be held each year. We would argue that these are separate issues. There is lots more work on indoor air and climate now, but the structure and format of the conferences might need to be more distinct. Alternatively, all major international conferences might follow similar formats but not focus on the same topics each time.

Healthy Buildings '94 lacked the organizational strengths of its predecessors and attracted a smaller audience. Perhaps there are just too many indoor air conferences now, and researchers have many outlets for presentation of their work. With another Healthy Buildings conference scheduled for 1995, it remains to be seen whether this is the case. The organizers face a real challenge to produce a conference that is both of high quality and distinct from the many other recent conferences.

Healthy Buildings '95: Call for Papers

Another Healthy Buildings conference is now planned for September, 1995, in Milano, Italy. Professor Marco Maroni is the conference president. The Preliminary Announcement and Call for Papers has been issued, and Abstracts are now invited. For more information, contact Dr. Maria Grazia Colombo. (See Calendar for details.)

Copies of the Proceedings of Healthy Buildings '94

There were extra sets of the two-volume Proceedings available from the organizers of Healthy Buildings '94 at the end of the conference. Copies, as long as they remain available, can be purchased through the conference president, Professor Laszlo Banhidi, for approximately US $50 (at this writing). Send requests for specifics regarding purchase of the Proceedings to Dr. Laszlo Banhidi, Department of Building Services, Technical University of Budapest, Budapest, Hungary, telephone and Fax 361 1812 960 or 361 1666 808.

Calendar of IAQ Events

October 29 - November 1, 1994. **ASHRAE IAQ '94**, Hyatt Union Station, St. Louis, Missouri. Contact: ASHRAE, Meetings Department, 1791 Tullie Circle NE, Atlanta, GA 30329, 404 636 8400, Fax 404 321 5478.

November 6-9, 1994. **First International Conference: Sustainable Construction,** Hyatt Regency, Downtown Tampa, Tampa, Florida. Organized by Center for Construction and Environment, University of Florida. Contact: Dr. Ronald Nutter, Division of Continuing Education, 2207 N.W. 13th Street, Gainesville, Florida 32611-5709, 904 392 1701 ext 240, Fax 904 392 6950. *Registration fee is $350 on site. There will be an exhibition of products and services in conjuction with the conference.*

November 14-16, 1994. **Bioaerosols: Health Effects, Exposure Assessments, and Control,** Ann Arbor, Michigan. Contact: University of Michigan Center for Occupational Health & Safety Engineering, 313 936 0148, Fax 313 764 3451.

January 26-27, 1995. **Fundamentals of Indoor Air Quality**, sponsored by Association of Energy Engineers. Contact: AEE, 4025 Pleasantdale Road, Suite 420, Atlanta GA 30340, 404 447 5083 ext. 210, Fax 404 446 3969. *Course registation fee is $795, $695 for AEE members.*

January 28 - February 1, 1995. **ASHRAE Winter Meeting and Exhibition**, Palmer House Hotel, Chicago, Illinois. Contact: ASHRAE, Meetings Department, 1791 Tullie Circle NE, Atlanta, GA 30329, 404 636 8400, Fax 404 321 5478.

January 30 - February 1, 1995. **International Air Conditioning, Heating, Refrigerating Exhibition**, McCormick Place, Chicago, Illinois. Contact: International Exposition Co., 14 Franklin Street, Westport, CT 06880, 203 221 9232, Fax 203 221 9260.

April 3-5, 1995. **ASTM Subcommittee D22.05 on Indoor Air, Spring Meeting,** Denver, Colorado. Contact: George Luciw, Staff Manager, ASTM, 1916 Race Street, Philadelphia, PA 19103, 215 299 5571, Fax 215 299 2630. *Attendance at meetings of the committee are open to the public and there is no cost to attend. Membership is required to vote and costs $50 per year.*

International Events

November 27-December 1, 1994. **Indoor Air: An Integrated Approach**, Gold Coast, Queensland, Australia. Sponsored by Australian and international organizations. Contact: Indoor Air - An Integrated Approach, PO Box 1280, Milton Qld., 4064 Australia, 07 369 0477, Fax +617 369 1512.

February 6-8, 1995. **The 1st International Congress on Intelligent Buildings**, Tel Aviv, Israel. Contact: Secratariat, c/o Stier Group Ltd., 28 Hayezira St., Ramat-Gan 52521 Israel, +972 3 7516422, Fax +972 3 7516635. *The offical languare of the Congress is English.*

May 10-12, 1995. **Indoor Air Quality, Ventilation and Energy Conservation in Buildings; 2nd International Conference**, Montreal, Canada, Organized by Centre for Building Studies, Concordia University. Contact: Fariborz Haghighat, Centre for Building Studies, Concordia University, 1455 de Maisonneuve Blvd. W., Montreal, Quebec, H3G 1M8, Canada, 514 848 3200, Fax 514 848 7965.

June 19-21, 1995. **International Symposium: Indoor Air Quality in Practice; Moisture and Cold Climate Solutions**, Oslo, Norway. Sponsored by Norwegian Society of Chartered Engineers and International Society of Indoor Air Quality and Climate. Contact: Norwegian Society of Chartered Engineers, attn: Ms. Lise Olaussen, P. O. Box 2312 Solli, N-0201 Oslo, Norway. *A call for papers has been issued; Abstracts are due December 1, 1994, papers will be accepted by 1 January, 1995, and papers are due April 1, 1995.*

August 30 - September 1, 1995. **Annual Conference of the International Society of Environmental Epidemiology and the International Society for Exposure Analysis**, Leeuwenhorst Conference Center, Noordwijkerhout, The Netherlands. Contact: Susan Peelen, Msc, Department of Epidemiology and Public Health, University of Wageningen, P. O. Box 238, 6700 AE Wageningen, The Netherlands, +31 8370 84124, Fax +31 8370 82782.

September 11-14, 1995. **Healthy Buildings '95**, Milano, Italy. Contact: Dr. Maria Grazia Colombo, Via Magenta 25, 20020 Busto Garofalo, Milano, Italy, +39 331 568091, Fax +39 331 568023. *A call for papers has been issued. Abstracts are due January 31, 1995. The official conference language is English.*

July 17-19, 1996. **Roomvent '96, The 5th International Conference on Air Distribution in Rooms**, Yokohama, Japan. Contact: Dr. S. Kato, Murakami and Kato Laboratory, Institute of Industrial Science, University of Tokyo, 7-22-1 Ropponi, Minato-ku, Tokyo 106, Japan, +81 3 3402 6231 ext. 2575, Fax +81 3 3746 1449.

July 21-26,1996. **Indoor Air '96, The 7th International Conference on Indoor Air Quality and Climate**, Nagoya, Japan. To receive a copy of the Call for Papers, Contact: Dr. Koichi Ideda, Secretary, Indoor Air '96, The Institute of Public Health, 6-1, Shirokanedai 4-chome, Minato-ku, Tokyo 108, Japan. +81 3 3441 7111 ext. 275, Fax +81 3 3446 4723. *The pre-conference announcement has been issued for those who wish to receive the first announcement and Call for Papers. The Call for Papers will be issued November 15, 1994, Abstracts will be due November 30, 1995, Authors will be notified of acceptance January 15, 1996, and papers will be due March 31, 1996.*

Indoor Air BULLETIN

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Editorial Office: 2548 Empire Grade, Santa Cruz, CA, 95060, 408 425 3946, Fax 408 426 6522.
Subscription Office: P.O. Box 8446, Santa Cruz, CA, 95061-8446, 408 426 6624, Fax 408 426 6522.

Subscriptions: $195 per year (12 issues) in the US, $235 per year (12 issues) outside the US.
Discounts available for multiple subscriptions within one organization.
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Indoor Air BULLETIN sincerely invites letters or any comments you may have on either the topics presented within or on other indoor environmental issues of interest.
Printed in Santa Cruz, California, October 1994.