Indoor Air BULLETIN™ *Hal Levin, Editor*

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Specifying Low-Emitting Materials

The desire to control sources of indoor air pollutants has led designers and building owners to write specifications that restrict building materials and products to those with low emissions. In some cases, they write letters or make phone calls before finalizing construction documents. In other cases, they write restrictions directly into the specifications requiring submittals for the potential indoor air pollutant sources.

We've used both approaches. Our method depended on the timing of our involvement in a project and the type of construction contract (bid, negotiated, or design-build). In this article, we review our experience in getting emissions data and specifying materials. We also discuss the lack of adequate standards for emissions data and how different agencies and researchers have approached this need.

Our Experience

In the past, getting good information from manufacturers was problematic. However, the number of manufacturers willing to respond to requests for emissions data has increased. The responses have become much more detailed and informative. The type of information requested has also changed.

Varied Responses

In the early to mid-1980s, we asked for the contents of products, some production information, and other data that would help us assess potential emissions. This approach was imprecise and imperfect at best; however, we did discover which manufacturers were willing to discuss their ingredients.

When working on large projects for concerned owners, we first conducted emissions testing and then discussed the results with the manufacturer's technical staff. Sometimes we recommended important improvements in the products — often at little or no additional cost to the manufacturer. Many manufacturers were very cooperative, although some were not and remain so.

We used the scant published emissions testing information to identify products of concern and roughly estimate emissions. During the early 1980s, researchers extensively tested particleboard and other pressed wood products that use formaldehyde resins. Otherwise, little published data on emissions was available. There simply were not enough manufacturers from whom we could directly solicit emissions data.

The Situation is Changing

The situation is now changing very rapidly. More research and industry scientists are testing products, and emissions data is becoming more available. Some manufacturers within a given industry are willing to provide detailed emissions test reports. However, some will provide only test results, and some will not provide any test information. Until recently, some asserted that their products emitted nothing (or nothing harmful).

The improvement is also largely due to the economic pressure of consumers. Architects and owners bring pres-

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sure to bear in large projects or when their institutions and clients are large purchasers. Major consumers of building products such as carpet, paint, ceiling tile, adhesives, and other identified sources of indoor pollutants use their large purchasing power to require that manufacturers be responsive.

The federal government alone can exert tremendous pressure because of the scale of its construction and renovation activities — roughly ten percent of U.S. construction. A provision in the House version of the indoor air legislation now in Congress would require emissions testing for all products used in federal building construction and renovation. The General Services Administration is developing standard requirements for such testing.

We are involved with some private clients that consume very large quantities of building products annually. They negotiate purchase contracts by the year, not by the building. Manufacturers who want their business are quite willing to cooperate.

Emissions data informs product developers and those concerned with liability. Product manufacturers have been defendants in several well-publicized IAQ lawsuits; the awareness of liability has been a very strong motivator.

Standard Emissions Test Methods Are Needed

The absence of standardized VOC emissions testing led ASTM Subcommittee D22.05 on Indoor Air to develop a guide. It is designated ASTM D5116-90, "Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions From Indoor Materials/Products." This work is based largely on work done at EPA's Indoor Air Branch. It became the basis for a carpet emissions test method developed by Air Quality Sciences, Inc. for the Carpet and Rug Institute in 1990. That method was modified to test other carpet assembly products such as cushions (pads) and adhesives.

The Carpet and Rug Institute and other carpet product industry associations are now involved in testing programs to fulfill an agreement with EPA. These tests are for total volatile organic compounds (TVOC) and do not require identifying or quantifying individual chemical compounds.

TVOC Versus Individual Compounds

Substantial controversy surrounds the usefulness and reliability of TVOC data for determining the potential health and irritation effects of emissions. Emissions testing for TVOC costs less and does not provide complete information. Assessments of health and irritation potential are necessary prior to regulation; therefore, industry tends to favor TVOC testing as less costly and less threatening.

Accurate and reliable testing for individual compounds is complex and more expensive. Risk assessment is not simple either, partly due to the lack of health effects information for so many substances. Nevertheless, an EPA contractor has recently developed a method for risk assessment based on emissions data for individual compounds from SBR-latex-backed carpet. The assessment by Research Triangle Institute was limited to an analysis of styrene and 4-phenylcyclohexene (4-PC) and was hampered by the paucity of data available on 4-PC health effects. The results did not indicate any serious hazard.

EPA's Phantom "VOC Emissions Standard"

We have heard several times that EPA has a "Standard" for VOC emissions of 0.6 milligrams per hour per square meter (mg/h per m^2). Sales representatives claim that their products' emissions meet an "EPA standard," and we see the assertion more often now that manufacturers are testing their products' VOC emissions.

EPA has not established a standard. The erroneous belief is based on misinterpretation of a paper that W. Gene Tucker presented at Indoor Air '90 in Toronto. Tucker is chief of the Indoor Air Branch at EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, North Carolina. His paper was presented in a session we chaired, and we are anxious to clear up this matter. Although Tucker works for the EPA, his paper was for informative purposes only and was not by any means an EPA- or government-sanctioned standard.

Tucker's paper was titled "Building with Low-emitting Materials and Products: Where Do We Stand?" He pointed out that one way to ensure good IAQ was to build with low-emitting materials. Specifically, he recommended using "materials and products with low emissions of substances." The paper presented three approaches to using low-emitting materials.

Tucker's Approach One approach, then being considered for new and renovated EPA buildings, was based on work at Tucker's laboratory. It involved requiring emissions-rate testing reports from prospective manufacturers. It also called for setting maximum emission factors for the five major organic compounds and any irritating or toxic substances. The total from all products must be less than a calculated maximum air concentration of 5 mg/m^3. A designer could either "reject or evaluate conditioning of materials or products that are likely to increase organic vapor concentrations by 0.5 mg/m^3 or more...."

State of Washington Approach The second approach, used by the State of Washington, establishes emission limits based on air concentrations resulting from use of the product. The limits are as follows:

- 0.05 ppm (60 $\mu g/m^3$) of formaldehdye.
- 0.50 mg/m^3 of total volatile organic compounds (TVOCs).
- 50 $\mu g/m^3$ of total particles.

The Washington approach also requires identifying, quantifying, and eliminating or meeting the maximum technologically feasible reduction of the following emissions:

- IARC category 1, 2, 2A, and 2B carcinogens.
- Compounds on the National Toxicology Program cancer list.
- Reproductive toxins in the latest edition of the Catalog of Teratogenic Agents.

The testing of "work station set-ups is required...." A six-week test period is required to obtain data on changes in emission rates. Then, "an appropriate IAQ model" is used to predict indoor pollutant concentrations based on the building and ventilation rate design. Compliance is based on the air concentrations predicted by the model. Actually, the State of Washington is now using on-site testing of the completed building after a 90-day ventilation period to determine compliance.

Critics of this approach say the particle emissions standards are unnecessary, the six-week period is unnecessary and simply guarantees more fees to the test lab, the requirements are hard to enforce, and that the procedures provide an increased market for the services of the firm that wrote the requirements. The costs of testing are paid by the manufacturers, and some we know have complained of being "captives" of the testing firm.

Private Sector Approach The third approach follows specifications we wrote for both public and private building projects. It attempts to place the burden on manufacturers to address IAQ considerations. It requires submitting information on material contents and emission tests and identifying carcinogens and teratogens where such data are available. It also addresses the quantity of materials such as adhesives, specifying that the smallest quantity suitable for the function shall be used. Installation procedures, including ventilation during and afterwards, are also covered.

Tucker's Proposed Classification Scheme

Tucker's basic philosophy was that absent other criteria, selecting low-emitting materials was a reasonable approach. Many people asked what he defined as low-emitting. To help readers, IAQ consultants, and the building industry understand what a "low-emitting material" is, Tucker presented a classification scheme from which the erroneous notion of a "standard" has been derived.

The scheme provides default limit values for emissions of total organic vapors as shown in Table 1.

Material or Product	Maximum Emissions (TVOC in mg/h per m^2 unless otherwise noted)*
Flooring materials	0.6
Floor coatings	0.6**
Wall materials	0.4
Wall coatings	0.4**
Movable partitions	0.4
Office furniture	2.5 mg/h per workstation
Office machines (central)	0.25 mg/h per m^3 of space
Ozone emissions	0.01 mg/h per m^3 of space
Office machines (personal)	2.5 mg/h per workstation
Ozone emissions'	0.1 mg/h per workstation

* This column lists default values for use where predictive modeling of IAQ impacts is not done. For specific indoor situations, modeling is generally preferable to using these defaults, and may yield very different values for maximum emissions. Values for particularly noxious compounds will also be lower than those shown.

** Many varnishes, paints, waxes, and other wet coatings have emissions factors substantially higher than this immediately after application. These coatings might still be considered "low-emitting" if their emission factors drop below this level within several hours. However, the presence of other surfaces that adsorb coating vapors and subsequently re-emit them complicates the classification of coatings.

Basic Assumptions: Indoor air is well mixed; ventilation rate is 0.5 exchanges of outdoor air per hour; maximum prudent increment in indoor concentration of organic vapors from any single source type is 0.5 mg/m^3; maximum increment of ozone is 0.02 mg/m^3 (0.01 ppm); and volume of concern for dispersion of emissions from furniture and machines at workstations is 10 m^3.

Table 1 - A Classification of Low-Emitting Materials and Products.

Tucker told us his VOC limits were based on the best available data at the time on the effects of exposure to common indoor concentrations and mixtures. Since that time EPA has done further work on VOC and human responses, but there have been few discussions about establishing guideline levels in the United States. Lars Mølhave of Denmark, who did the early pioneering work both on emissions testing and on establishing the levels of TVOC that caused adverse human responses, continues to explore this approach.

Industry Wants Standards

We think that some of the misinterpretation of Tucker's classification scheme results from a reasonable need of industry to understand targets or limits. Currently, there are no clear, consensus guidelines, and we do not believe they are imminent. Partly for that reason, we believe that standards and guidelines will ultimately be based on individual substances and their potential health effects.

Independent of total or individual VOC emission discussions, there is a consensus that carcinogens, and, in most cases, teratogens should be identified. Therefore, emissions testing must identify and quantify individual compounds. Then health scientists will conduct risk assessments. The current EPA regulatory approach is based on compound-by-compound analysis, and that is not likely to change, regardless of how much more widely recognized the importance of indoor air exposure might be in the future.

References:

ASTM, 1990. Standard D5116-90, "Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions From Indoor Materials/Products." *Annual Book of Standards, Vol. 11.03*, pp. 480-491. Philadelphia; American Society for Testing and Materials. Available from ASTM, 1916 Race Street, Philadelphia, PA 19103. (215) 299-5400.

W. Gene Tucker, 1990. "Building with Low-emitting Materials and Products: Where Do We Stand?" in Walkinshaw et al., (Ed.), *Indoor Air '90, Volume 3*. Pages 251-256.

Productivity Revisited

Wyon Comments on December *IAB* Article

Much of our December ***IAB*** feature article on IAQ and Productivity was based on comments by David P. Wyon made during his talks at ASHRAE's "IAQ '91 - Healthy Buildings" (September 1991) and at the Winter Cities Biennial in Montreal (January 1992). We based our comments on notes taken during the talks and a tape recording of Wyon's Montreal presentation. Thanks to alert readers and active fax machines, we quickly received some reactions to the article. Obviously we misunderstood Dr. Wyon and are grateful to him for the correction regarding his work. We welcome all contributions from our readers: corrections, suggestions, knowledge, and appreciation.

Letter from David Wyon

Dear Hal:

Thanks for a very extensive review of several aspects of my work. I have only two quarrels with it, namely your point about openable windows, and the controversy you seem to think must exist on humidity perception. Preller et al. made very little of their result [on openable windows], for very good reason that it was borderline significant: the 95% confidence limits of the odds ratio had an upper limit of 1.0, i.e. of no effect at all.

Concerning humidity, I am now sending you ... my 1975 report, recalculating published data to show that work from Fanger's laboratory in 1971 indicates clearly that people *sometimes mistake the direction of a humidity change* in climate chamber experiments (although the author's interpretation was merely that they were insensitive to humidity).

Our field work then went on to show that people are in fact very sensitive to humidity in practice, and that the effect of air temperature is unexpectedly large: this was both for humidity perception and for air quality, as you can read for yourself in the excerpt. These results are of course supported by Jaakola's subsequent work, and by the very new Volvo Truck Corporation results I showed for the first time in Montreal.

A possible explanation for the discrepancy between my results and those of Fanger (Rasmussen) and of Andersen (who had shown that 9% RH for 72 hours caused no distress in a climate chamber) was that their subjects were exposed to chemically clean and filtered air, while mine were breathing office air, presumably containing potential allergens and dust. In 1975 the situation was that these laboratory studies claimed to show that people were almost totally insensitive to humidity, and that it was therefore OK to save energy by not humidifying. I disagreed, and showed the opposite. It is therefore disconcerting to find that you seem to think Berglund's

1989 work contradicts my conclusions! I maintain, however, based on my re-analysis of Rasmussen's data, that people do sometimes mistake the direction of a humidity change, especially when not sweating.

Regards,
David P. Wyon

IAB Reply and Comments

With respect to the Preller et al. finding on openable windows, we wrote the following to Dr. Wyon:

Dear David:

You are correct, I have not mentioned the 95% confidence limit range of 0.67-1.00. This shows a problem with summarizing technical and scientific work — if one fails to give all the details, important information can be lost. I personally believe that openable windows should improve health and, perhaps, did not want to ignore contrary evidence. On the other hand, it may be possible that opening windows did create operational problems for the HVAC system or resulted in intake of contaminants from outdoors, thereby actually causing some increased exposures and increased SBS. I hope others will study the effect of openable windows, and I hope they will characterize the physical environment as well as study occupant responses.

Sincerely,
Hal

Swedish Humidity Study

Dr. Wyon sent us the 1975 study mentioned in his letter and the data in question from his re-analysis of the Rasmussen study. The relevant data are shown in Table 2 and in somewhat aggregated form in Figures 1 and 2.

Relative Humidity	Air Temp (°C)	Response 1	2	3	4	5	Total Responding
30 %	21.1	-	10	21	1	-	32
	23.3	2	13	15	2	-	32
	25.6	3	15	13	1	-	32
	27.8	3	19	7	3	-	32
70 %	21.1	2	4	23	3	-	32
	23.3	-	9	19	4	-	32
	25.6	-	15	12	5	-	32
	27.8	3	7	4	13	5	32

Table 2 - Frequency of Responses on Humidity Perception Scale.

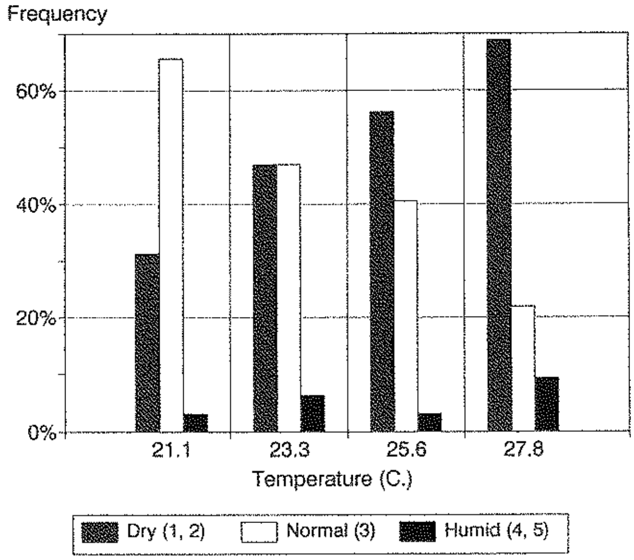

Figure 1 - Responses at 30% RH Plotted as Percentages.

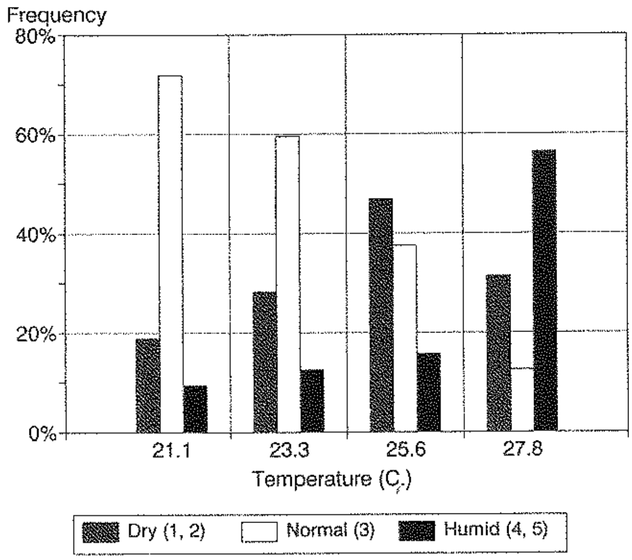

Figure 2 - Responses at 70% RH Plotted as Percentages.

It is interesting that the percentage of those who found the relative humidity of the air "normal" at both 30% and 70% RH was highest at the lowest temperature (21.1 °C - 70 °F) and decreased as the temperature increased through two intermediate temperatures to 27.8 °C (82 °F). At 30% RH, those who found it too dry increased from about 30% to almost 70%. At 70% relative humidity those who found it too humid increased from less than 10% at 21.1 °C to more than 50% at 27.8 °C. Interestingly, at 70% RH, more subjects found it too dry as the temperature increased to 25.6 °C (78 °F), and even at 27.8 °C, more than 25% of the study subjects found it too dry.

Swedish Building Research Results

The Swedish work was done in office buildings whereas the Danish work that was re-analyzed had been done in laboratory settings. Four humidity conditions were tested in the Swedish work: elevated humidity, intermittent humidification for two hours each day, intermittent humidification for four hours each day, and constant low humidity achieved by not humidifying. A total of 630 interviews were conducted in the four office buildings where the work was conducted. All interviews were held during the winter.

Wyon found that the optimum temperature for thermal comfort was 21 °C, although only a small portion of the measurements showed temperatures that low. The authors concluded that "office workers can detect even quite small differences in humidity, and that the air temperature is critical for complaints of dryness."

While varying the humidity by intermittent humidification produced a satisfactory overall response, "the most rational solution is to ensure that temperatures do not exceed the 20-22 °C range. Within this range, a greater proportion are thermally comfortable, and the naturally occurring low humidity gives rise to fewer complaints than the higher levels produced by artificial humidification." However, where humidity was intermittent, "neither temperature nor humidity sensation was sensitive to temperature changes within the 21-24 °C range studied."

For more information:

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References:

L. O. Andersson, P. Frisk, B. Löfstedt, and D. P. Wyon, "Human Responses to Dry, Humidified and Intermittently Humidified Air: An Experimental Study in Large Office Buildings." Report D11:1975. Stockholm: Swedish Building Research Institute. (Also published in Swedish as Report R63:1975.)

J.J.K. Jaakola, O.P. Heinonen, and O. Seppanen, (1989). Sick Building Syndrome, sensation of dryness and thermal comfort in relation to room temperature in an office building: need for individual control of air temperature. *Environment International*, Vol. 15, pp. 163-168.

L. Preller, T. Zweers, B. Brunkreef, and J. Bolej (1990). "Sick leave due to work-related health complaints among office workers in the Netherlands. *Indoor Air 90* Vol. 1, 227-230.

Productivity Revisited

Hedge Comments on December *IAB* Article

In the December *IAB* feature article on IAQ and Productivity we included a graph on self-reported estimates of the effect of the work environment on productivity (December 1991 *IAB*, Figure 4 on page 5). This graph was based on our misinterpretation of data presented in the paper by Raw et al. Professor Alan Hedge of Cornell University writes that our graph showed a much greater effect on productivity associated with higher SBS symptoms than actually was found.

Hedge's Letter

Dear Hal:

I think the graph which you show on page 5 of the December 1991 *BULLETIN* is misleading. It looks as though what you have plotted is the % change in ratings as a function of the average # of symptoms, whereas I think that you should plot mean productivity ratings. This gives the impression that there is greater loss in productivity than was found.

The data plotted should be those from Table 2 from Raw's paper, which is simply a secondary report of the survey data which Sheena Wilson, Sherwood Burge, Alastair Robertson and I collected several years ago in the UK. Below is the correct graph [Figure 3] relating symptoms and productivity. It must be emphasized that all data were self-ratings and no objective productivity measures were taken.

I hope that you will clarify this in a future issue of the *BULLETIN*.

Alan

Hedge is right: we plotted the relative percentage changes in the scores on the scale 1 through 9 rather than the percentages just above them that they represented. Table 3 shows the original question asked in the study. Just below each percentage is a numerical value which the authors used in their analysis. Since workers responding to the question were responding to the percentages, we should have plotted those rather than the scores immediately below them.

The summary results from Raw et al. are shown in Table 4. The incorrect graph in our last issue shows how published reports can be misinterpreted; our error resulted

"Please rate how much you think the physical conditions at work influence your productivity."

Conditions increase this effect by								Conditions decrease this effect by
40%/more	30%	20%	10%	0	10%	20%	30%	40%/ more
1	2	3	4	5	6	7	8	9

Table 3 - The Original Question as Asked During the Study.

Symptoms	Number	Mean WEP*
0	831	4.42
1	552	4.93
2	602	5.07
3	571	5.28
4	544	5.54
5	455	5.80
6	355	5.94
7	210	6.12
8	147	6.05
9	63	6.52
10	39	6.90

* WEP is Worker Evaluation of Productivity.

Table 4 - Mean Worker Evaluation of Productivity (WEP) by Number of Symptoms Reported in the British SBS Study of S. Wilson, A. Hedge, S. Burge, and Others.

from the way Raw et al. presented their analysis. Clearer presentations will minimize these kinds of mistakes.

Figure 3 shows our corrected plot of the data as suggested by Hedge.

Importance of the Study

The original study by Hedge and his colleagues is one of the largest multi-building SBS studies published to date. It is often used to support the view that buildings with natural ventilation have lower SBS symptom prevalence rates than ones with mechanical ventilation. Not all the data gathered in the study have been analyzed and published. Hedge is planning to complete some of the remaining work soon.

Additional Analysis

Hedge sent *IAB* the raw data and suggested a couple of additional plots. He pointed out that we can also plot the number of SBS symptoms reported as a function of self-estimated productivity. The plot of this relationship is shown in Figure 4. Remember that a self-reported productivity rating of 5 corresponds to no effect of the work conditions on productivity, a value of 1 indicates the most positive effect, and a value of 9 represents the most negative effect.

Figure 4 shows that for those with a self-reported productivity rating of 1 (corresponding to +40% impact of the work conditions), the mean number of symptoms corresponds to an average of 3 SBS symptoms. The number of symptoms decreases until the productivity rating of 4 (+10% impact), then begins to climb again fairly steadily to the value of 9 (-40% productivity impact).

We might conclude from this that those with more symptoms report a greater work environment effect on productivity: either positive or negative. Those who report fewer symptoms, say those with about two symptoms, report less of an effect of the building on their productivity. Nevertheless, there is a more dramatic increase to the right of the plot from a self-reported productivity rating of 5, or no effect.

Figure 4 shows average data from all of the buildings and types of building ventilation systems. Hedge said: "When you look at this graph, you are looking at the average productivity from buildings with five different types of ventilation, and we know that buildings with different types of ventilation have different effects on symptom prevalence." He sent us the raw data for each type of building, and we have plotted the results in Figure 5.

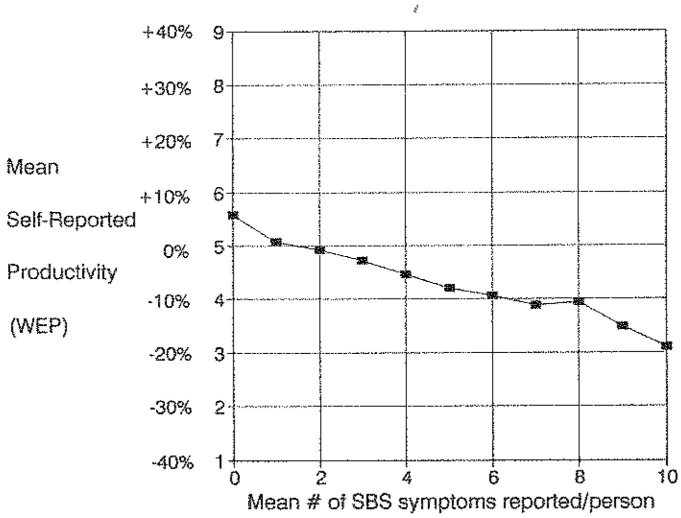

Figure 3 - WEP by Number of SBS Symptoms Reported.

While it is difficult to see the differences among buildings by ventilation type in this graph, partly due to the graphic limitations, there is a general trend similar to that shown in Figure 3. When we plot the overall average values for each type of building ventilation system, there are some differences among them as shown by the histogram in Figure 6. It appears that the estimates of the largest negative effect of the work conditions on productivity were for the two building ventilation types with either central or local fan coils. Naturally ventilated buildings appeared slightly better than mechanically ventilated buildings without fan coils, and VAV systems appeared slightly worse than mechanically ventilated buildings.

Many IAQ researchers have stressed the British finding that SBS prevalence rates are lower in naturally ventilated buildings and higher in air-conditioned buildings. Mechanically ventilated buildings without air conditioning are somewhere in between. We wondered how the British researchers defined the various building ventilation types. Hedge sent us the definitions and our brief summaries follow:

- Natural ventilation: Openable windows, no cooling or humidity control. (11 buildings).
- Mechanical ventilation: Openable windows, although some meant to be shut. Generally, room-based heating, ducted air, no cooling. (7 buildings)
- Local fan coil: Local air supply, water based heating and cooling. Sealed or locked windows. Heating, cooling, and air supply through unducted, perimeter induction units. (5 buildings).
- Central fan coil: central, ducted air supply of pre-heated or cooled air (some with terminal tempering). Generally humidified with spray or evaporative methods. (11 buildings).
- VAV systems: Central, all-air heating and cooling; all Variable Air Volume except two constant volume. Some local reheat. Two without humidity control, four steam humidifiers, and the rest spray or evaporative humidifiers. Two had openable windows not meant to be opened.

Conclusions

We asked Hedge what to make of all this data. He replied: "You don't know whether the people with a lot of health symptoms are reporting low productivity be-

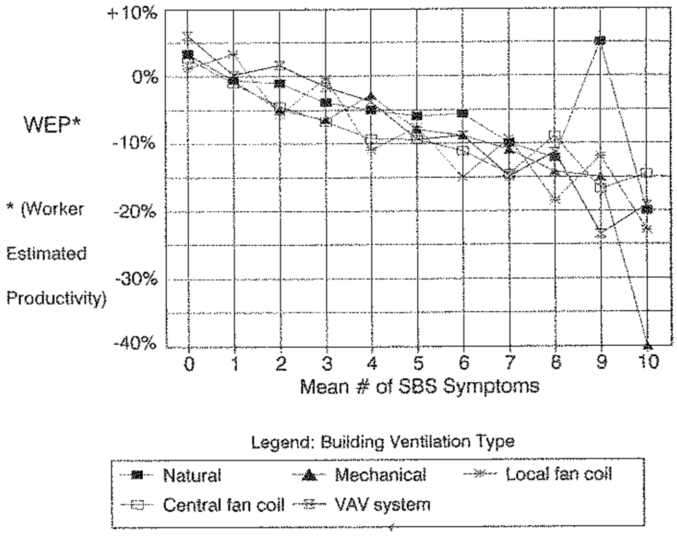

Figure 5 - WEP by Mean Number of SBS Symptom Reports and Ventilation Type.

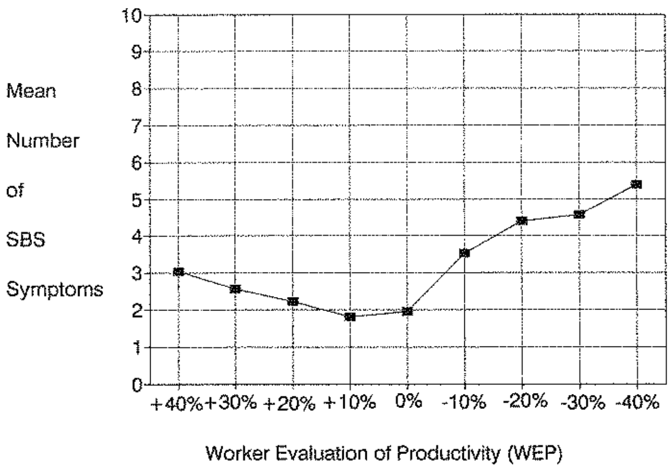

Figure 4 - Number of SBS Symptoms Plotted by WEP.

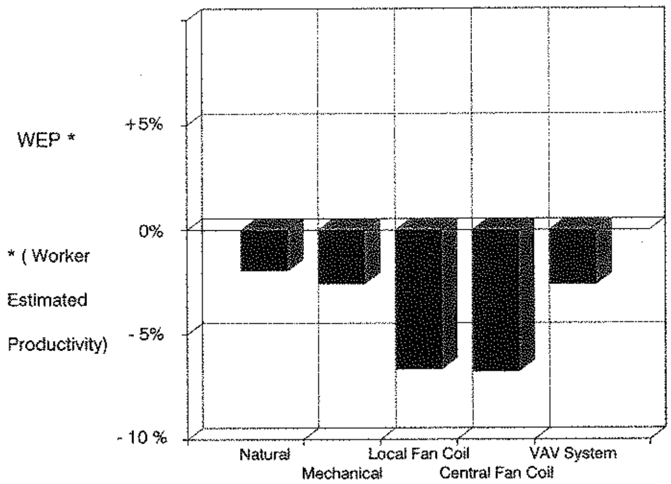

Figure 6 - Self-reported WEP by Building Ventilation Type.

cause of their ill health, or whether the people who are reporting low productivity are the ones that report a negative view of all aspects of their environment, their health, and their productivity."

We have always lamented the absence of more detailed environmental data for the large British studies since there is so much data on so many occupant responses. We are particularly concerned about lumping buildings together by building HVAC system type since, in our opinion, the quality of the design, construction, and operation could be more important than the system type for indoor environmental quality. Hedge told us he has a considerable amount of data that have not yet been published, and he intends to write it up during his imminent sabbatical. We look forward to the publication.

References:

G.J. Raw, M.S. Roy, and A. Leaman (1990). "Further findings from the office environment survey: productivity." *Indoor Air '90* Vol. 1, pp. 231-236.

For more information:

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Environmental Tobacco Smoke

IAQ "Experts" and the Tobacco Industry

Environmental tobacco smoke (ETS) may not be the sole or even an important cause of SBS. However, it is a health hazard and smoking-permissive building policies do not make public-health or business sense. In fact, ETS is one of the most obvious causes of real health concerns and probably contributes to many SBS complaints. It is also one of the easiest to eliminate by adopting no-smoking policies.

When a consultant repeatedly says that ETS is not a problem, it is logical to question whether the individual receives tobacco industry funding. Because of the consistency and frequency of Gray Robertson's ETS-is-no-problem message, many in the indoor air community have assumed that Robertson is a tobacco consultant. Until recently, his tobacco industry affiliation was little more than informed speculation and he denied it. Now, unequivocal evidence has been reported, and apparently Robertson has reluctantly acknowledged his tobacco industry ties.

Gray Robertson

Robertson has possibly been the most effective public tobacco-industry consultant. Appearing in person, on TV, and on radio, he seems to be more a businessman than a scientist or professional; it is not obvious to ask who pays for his appearances. He has also testified before Congress on IAQ legislation. He seems to simply drum up business for his firm; however, he also reports results from the numerous buildings his firm has serviced, and suggests that ETS is less of a problem than many scientists and consultants believe.

Robertson heads a firm, Healthy Buildings International (HBI, formerly ACVA Atlantic), that does building inspections, testing, and duct cleaning. In addition, he, his firm, and their public-relations agency deliver their message through radio and television appearances, on the firm's promotional video tape and newsletter, in scientific and professional meetings and journals, and directly to their clients on several continents.

Robertson's Message

His handsome appearance, British accent, and apparent business success give him a certain credibility in many quarters. Yet his message also serves the tobacco industry. The ETS-is-not-so-bad message in the written material we have seen is nicely couched among a lot of other, non-ETS-related IAQ messages. For example, in the first issue of HBI's glossy, eight-page newsletter, a one-page case study appeared addressing ETS in an office building. The newsletter was otherwise unconcerned with tobacco smoke. The article concluded that smoking could be permitted in portions of an office building without creating air quality problems in other parts of the building.

A common and frequent theme of Robertson and his staff at HBI is that ETS is not an important IAQ problem. The message usually is that smoking in a building where air is recirculated does not dangerously elevate concentrations of ETS constituents or cause excess health and comfort complaints. Often the identified causes of IAQ complaints are the ventilation system, especially microorganisms in the ductwork. Not surprisingly, duct cleaning and more ventilation are recommended.

The firm does a building investigation and recommends remedial action to its building operator clients. The costs of HBI IAQ assessments are low compared to some of the best known IAQ investigation firms. But the cost of the duct cleaning, when recommended, may be considerably more. After the recommendations are followed, the firm issues a certificate to the building operator stating that the building is healthy. Robertson says his firm has investigated many million square feet of office space.

The Smoking Gun

Robertson made remarks at a recent Los Angeles press briefing which were reported by Myron Levin, a *Los Angeles Times* staff writer [no relation to ***IAB*** Editor Levin]. Robertson said the briefing was to drum up business for his firm. According to the February 25th *Times*, Envirosense, "a coalition of a dozen businesses including the world's largest tobacco firm, Philip Morris," was sponsoring Robertson's west-coast press tour.

When the reporter asked Robertson "....if he had received tobacco-industry funding, Robertson initially said he had merely inspected a few tobacco company buildings as he had for dozens of clients." "He denied being a tobacco industry consultant," the article said.

However, in an internal 1987 memo from the industry's lobby group, the Tobacco Institute, Robertson was listed as "one of the consultants and allies we use to refer reporters to." Responding to the memo, he said: "If I've made appearances for people...I don't necessarily say I'm their consultant." The *Times* article also reported that itineraries prepared by the Institute showed Robertson on media tours to more than twelve cities in eight states that year. A former tobacco official reportedly said that Robertson's audiences typically did not know who his sponsor was.

Implications

To diminish attention to ETS, many tobacco industry consultants point to other causes of occupant IAQ-related complaints. A former tobacco industry official, interviewed by the *Times* writer on the condition of anonymity, said: "Out of all the arguments they [the anti-smoking groups] have going, this is probably the best one....There are real problems in sealed buildings."

Robertson is not the only tobacco industry consultant to convey similar messages; many tobacco industry consultants are active in most indoor-air-related professional, technical, and scientific groups. They are also active internationally, frequently organizing or speaking at conferences and symposia in Europe and elsewhere.

ASHRAE's Standard 62-1989, "Ventilation for Acceptable Indoor Air Quality" is perhaps the most important single document in the indoor air field — at least in the United States and Canada. At a recent meeting of the newly formed ASHRAE committee to revise Standard 62-1989, more than half the numerous observers identified themselves as tobacco company or Tobacco Institute representatives or are known to us as tobacco industry consultants (although they do not identify themselves as such).

IAB Comments

From a public health perspective, the question is whether there is any good reason to permit smoking in buildings. From a tobacco industry perspective, the question is whether there is any good reason to ban it. Over the years, the evidence has steadily grown in one direction: toward the harmfulness of ETS, just as it did with tobacco smoking before. The EPA's Science Advisory Board will soon recommend a position on the ETS question that will guide public policy for some time to come. They are expected to recommend that EPA list it as a carcinogen.

It is not necessarily so that because ETS is easy to avoid, smoking indoors ought to be banned. But the preponderance of evidence points to adverse effects, and the benefits are questionable, especially to the growing majority of people who do not smoke.

Duct Cleaning

How Clean Is Clean?

Ventilation system ductwork can become very dirty as buildings age. Even brand new buildings can have dirty ducts from initial installation or from leftover construction debris. However, duct cleaning is a controversial subject.

There is no available guidance on duct cleaning services, and there is little published information on how well duct cleaning operations work. Yet millions of dollars are spent each year on this service. Building owners often place themselves at the mercy of duct cleaning contractors without independently assessing qualifications, work quality, or costs. To be fair, duct cleaning is not much different from many other professional service activities; most people cannot evaluate the competence of their physician to diagnose and remedy illness.

Concerns about duct cleaning stem from several quarters. There have been reports of building contamination after duct cleaning, allegations that materials removed during duct cleaning are improperly disposed, and concerns about related activities performed by duct cleaning companies. There are no standards for how to clean ductwork, how to evaluate the quality of duct cleaning, or how to determine whether ductwork needs to be cleaned in the first place.

Duct Cleaning Methods

Ducts are cleaned either by blowing air through a duct and then into some appropriate filtration system or by mechanically scrubbing surfaces. Various firms have different approaches to the forced-air cleaning procedures; the forced air can create significant differences in interior duct pressures and air velocities. The equipment used and length of duct treated at a single time determines the pressures and air velocities that can be achieved in any given duct system.

High-pressure, forced-air cleaning forces air through at higher velocities that may, along with brushing the surfaces, remove contaminants that otherwise might be stripped off surfaces at normal (lower) velocities and pressures. However, there is more to it.

Besides air pressure or velocity, moisture, temperature, and chemical conditions may also determine the removal or "stripping" rate of particles from surfaces. Duct vibration might also play a role. The turbulence patterns near duct walls that are generated at higher velocities may also be different from those generated under "normal" or "typical" operating conditions.

The Need for Standards

With a growing number of new firms offering services, established companies are concerned about poor quality work damaging the reputation of duct cleaning. Some firms offer more than duct cleaning: they apply encapsulants to seal in dirt and microbial growth, provide anti-microbial treatments, and they perform duct repair and other tasks.

Some of the problems stem from a lack of standards for performing duct-cleaning services and for evaluating the effectiveness of the services. There is a very large difference between the cleaning of metal ductwork without internal linings and cleaning those that are lined with acoustic or thermal insulation. Various duct liners have different types of barriers protecting the surfaces of the liner materials, usually fibrous glass, from erosion or contamination. There are also ducts made from fibrous glass boards. When fibrous glass is exposed inside ductwork, duct cleaning has caused fiber release.

Proposed Standard

Davidge Warfield is president of the National Air Duct Cleaners Association (NADCA) and owns his own firm, Rite-Way Company, Inc., in Cheverly, Maryland. Warfield has worked hard to develop standards for duct cleaning that would provide guidance to the industry and allow customers to understand the procedures. One of Warfield's proposals is that there be a standard for evaluating duct-cleaning services.

At a recent ASHRAE seminar, Warfield said: "If I clean a surface, I want to know how clean the surface is." He sees this as the appropriate way to evaluate duct cleaning operations. He proposes using a vacuum test which would collect material over a defined duct interior surface area. The particulate matter collected would then be weighed to determine the amount of collected material in the specified area that could be removed by vacuuming.

Warfield proposes a 100 cm^2 area comprised of two 2 cm by 25 cm slots at least 2.5 cm apart. A template would be applied to the surface, and a calibrated vacuum would draw a sample onto a pre-weighed filter cassette. The cassette would be analyzed at a qualified laboratory.

This procedure applies to non-porous surface ducts and is not applicable to porous duct surfaces such as fiberglass board or lined ducts. No procedure is proposed for ducts lined with porous materials. Warfield is fairly clear about his belief that such materials simply do not belong inside ductwork.

Warfield's approach is embodied in a draft standard prepared by the NADCA. The draft standard is likely to go out for public comment at the end of March.

Bud Offermann Dissents

Francis J. "Bud" Offermann, PE, CIH, of Indoor Environmental Engineering in San Francisco, does not think the NADCA test is an acceptable evaluation tool. Offermann says: "I'm not interested in how clean the surface is; I want to know what comes out of the duct."

He made his comments at the ASHRAE seminar on the role of the industrial hygienist. His view is that the only way to know if the duct is clean is to test what comes out of it. Sampling the air upstream and downstream of the cleaned duct will allow evaluation of the duct's contribution to air contamination. Offermann says that owners need to know if the duct is causing contamination problems, not if the surface is clean enough to eat from.

IAB View

We think both Warfield and Offermann are correct. The owner is concerned about the building's air quality. Assessing that is a job for an industrial hygienist with IAQ expertise, an engineer, chemist, or other IAQ professional. But the duct-cleaning company can only be evaluated on the task it is hired to perform. Duct-cleaning companies do not generally have industrial hygienists or other IAQ professionals on staff. Their work is specialized and focused.

An owner with IAQ concerns beyond the presence of visual soiling on duct surfaces needs to engage the services of a qualified IAQ professional to determine whether duct cleaning is necessary, to oversee the selection and direction of the contractor, and to evaluate the efficacy of the work.

We don't know the reliability of surface vacuum testing as a predictor of duct contributions to air contamination. Research should be done on this and other topics in order to improve the contribution of duct cleaning to good IAQ.

For more information:

If you wish to obtain a copy of the public review draft for information or to comment, call NADCA; there is a $5 charge for review copies. NADCA can be contacted at 1518 K Street, N.W., Washington, DC, 20005. tel (202) 737-2925, fax (202) 638-4833.

ASTM Modeling Symposium

ASTM Workshop and Symposium on Modeling Indoor Air Quality and Exposure

Studies of indoor air contaminant concentrations are far more useful when we can use the results in other contexts. This can only happen if the critical variables that determine the concentrations and their relationships are understood. The most useful way to do this is by modeling the critical variables — ventilation, sources, sinks and other removal mechanisms and environmental variables such as temperature, humidity, and air flow.

Modeling can also help predict the impact of changing variables on indoor air concentrations. For example, using measurements in an accurate model will help determine the effectiveness of increasing ventilation to reduce formaldehyde concentrations in a newly furnished office containing lots of particleboard-based furniture. If we want to project the impact of installing new carpet and we know the source strength of the carpet assembly, we can predict the concentrations.

Researchers from Lawrence Berkeley Laboratory measured VOC concentrations and ventilation rates in a new federal office building. They found the major component of the indoor air VOCs came from wet-process photocopiers and plotters. The source was the fluid used in these machines. By consulting with the purchasing department, they obtained data on monthly use of the fluid. Then, they predicted the airborne concentration based on the assumption that virtually all of the fluid would vaporize. Their predictions were reasonably accurate and a lot less costly and time consuming than making lots of measurements.

IAQ Modeling

IAQ modeling is the process of creating physical or mathematical (symbolic) representations of the relationships between important variables and factors. For example, the most basic IAQ model is the relationship between pollutant source strength, ventilation, and indoor air concentrations usually modeled by a fairly simple mass-balance equation. The basic assumption of the mass-balance equation is that everything must be accounted for.

To a reasonable first order approximation, the concentration of a substance from an indoor source is a function of the emission rate divided by the ventilation rate if there are no outdoor sources. So, a simple model for an indoor air contaminant source is that generation rate, or source strength, divided by ventilation rate equals concentration.

$$Concentration = \frac{EmissionRate}{VentilationRate}$$

To be more accurate, we must account for sinks and chemical transformation that may remove (or contribute) some of the substance to indoor air. Finally, the outdoor air may be a source, and that must also be accounted for.

Results from measuring IAQ can be compared with expected values in order better to understand their meaning. They also can be used to understand the relationships between various factors believed important in determining indoor air concentrations of the measured substances. The results from either exercise can contribute to an understanding of environments and conditions other than those measured. By these means, we can characterize IAQ reasonably well in most indoor environments without having to make many detailed measurements.

Modeling lets us establish basic principles that apply outside the context of a particular environment or set of environments where measurements are made. Fundamental relationships are set up, such as the famous mass-balance equations that are at the heart of many IAQ models.

ASTM Symposium and Workshop

On April 26-29, ASTM Subcommittee D22.05 on Indoor Air will sponsor a workshop and symposium on modeling IAQ and exposure. The event will take place in Pittsburgh, Pennsylvania. The workshop will include an introduction for those not familiar with modeling, then hands-on demonstrations by many of the people who will present papers. This will help those without modeling experience to learn the basics so that they can apply them in their own work. It will also let all participants observe the operation of many of the models that are the basis of papers in the symposium.

Workshop

The workshop will take place Sunday, April 26. The purpose of the workshop is to provide symposium attendees who are unfamiliar with models, but have some background and knowledge in indoor air, with an understanding of IAQ models. The workshop will enable attendees to gain familiarity and some hands-on experience with IAQ models. The workshop will help attendees to better understand symposium presentations and to derive more useful information from the symposium sessions.

The Workshop and Symposium on Indoor Air Quality Modeling and Exposure will be different from most indoor air conferences. The purpose is not primarily to present data, but to present and explore the problems and issues involved in modeling. Since modeling is so critical to the expansion of knowledge, we think the symposium will make in important contribution to the indoor air field.

The symposium begins Monday morning and runs for two days. The morning session is on modeling exposure followed in the afternoon by one on sources and sinks. Tuesday morning's session is on model validation and applications. The closing session continues on applications. Researchers from Europe and the United States are presenting papers in what we expect to be a very interesting meeting.

For more information, see the listing in the Calendar section.

Conference Announcement

National Coalition on IAQ Sponsors First Conference

The National Coalition on Indoor Air Quality (NCIAQ) is expecting about a thousand attendees at its "First Annual IAQ Conference & Exposition" to be held April 30 to May 2 in Tampa, Florida. Organizers are promoting the conference as "the nation's largest indoor air quality conference and exposition," and, indeed, it is likely to be just that.

The organization is multi-disciplinary and provides an opportunity to address technical issues. Fifty speakers from government, industry, and academia will present talks on issues ranging from IAQ-related products and services to regulatory issues and perspectives. An exhibit of approximately 100 firms will present their products and services.

The Coalition's press release says the conference is targeted at "building owners, contractors, environmental testing companies, architects, IAQ product manufacturers, and anyone else with an interest in indoor air quality."

What is the NCIAQ?

The NCIAQ is an association of three important industry/trade groups involved in products and services related to IAQ. Ken Sufka serves as executive director for NCIAQ as well as for the three original member trade associations. The member groups that formed NCIAQ when it began in 1991 are the Associated Air Balance Contractors (AABC), the National Air Duct Cleaners Association (NADCA), and the National Air Filtration Association (NAFA). Each of these has a different IAQ-connected interest, but the common theme is the ventilation system.

Now the organization has expanded its scope by adding board members from a variety of professions, organizations, and companies. The Board of Directors includes representatives from the three founding groups as well as a physician and an engineer representing the Carrier Corporation, among others.

Burroughs Chosen First NCIAQ President

Barney Burroughs has been chosen as the first president of the Board of Directors of NCIAQ. Burroughs formerly worked in the filtration industry and is a past president of ASHRAE. He operates his own consulting firm, Indoor Air Quality and Building Wellness Consultancy (IAQ/BWC), in Alpharetta, Georgia.

Conference Registration Information

The conference registration fee is $450 for attendance at all technical sessions, exhibits, a copy of the proceedings, and the reception and luncheons. A separate admission fee of $25 is available for those wishing only to view the exhibits during the three days. Additionally, there will be two concurrent four-hour workshops on Wednesday, April 29. One is on "How to Market IAQ Services," the other is "How to Market a Healthy Building." There is a separate $75 fee for attendance at the workshops.

For more information:

To register, or for further information on the conference or NCIAQ, contact the Coalition at 1518 K Street, N.W., Washington, DC, 20005. tel (202) 628-5336, fax (202) 638-4833.

EPA IAQ Firm Survey

Firms Asked to Complete Questionnaires

EPA is conducting a "voluntary" survey of IAQ firms offering IAQ diagnostic and mitigation services for residences, offices, schools, and other non-industrial buildings. EPA is interested in finding out about available IAQ services and will also use the data to characterize and analyze the IAQ service industry.

EPA is updating its previous survey, results of which were published in November 1989 as *Survey of Indoor Air Quality Diagnostic and Mitigation Firms* (EPA400/1-89/004). The publication is a directory of firms to provide public and private users with a resource for finding IAQ services.

To obtain a copy of the questionnaire, without obligation, call (800) 452-9561, or write to EPA Indoor Air Quality Survey, c/o ICF Incorporated, Room 1073, 9300 Lee Highway, Fairfax, VA, 22031-1207.

Publications

EPA Releases Vols. 3 & 4 of Headquarters Study and Final Report on Carpet Dialogue

After much delay, EPA has released the last two of the four-volume EPA Work Environment Study. This completes the study; the field work was conducted during February and March of 1989. The release came with a glaring absence of fanfare considering that this was probably the most expensive published building environment study in the US.

Perhaps the low-key treatment is because the study's findings were a disappointment to many involved, or perhaps because of the lawsuit pending against the owner of the Waterside Mall by a number of EPA employees. In either case, the last two volumes address the relationship of employee questionnaire responses to environmental measurements (Vol. 3), and statistical analysis of health, comfort and odor perceptions related to personal and workplace characteristics (Vol. 4).

We described some of the findings in the August 1991 ***IAB***. We reported there that "Dust...contributed most strongly to comfort and odor factors." A careful reader has pointed out that it was the occupants' perception of dust, not any physical measurement of dust that correlated to the comfort and odor factors.

The report's conclusions (Volume 4) did state that "persons in areas where new carpet had been installed in the last year were more likely to report sore throat, dry throat, and hoarseness. Dizziness was also increased among men in these areas." And later, these findings, taken as a whole "...suggest that carpet or the carpet installation process (ripping up old carpet and molding) can be associated with certain health effects among a substantial number of employees."

Carpet Dialogue Final Report Released

EPA's Carpet Policy Dialogue concluded in September, and the Final Report is a compendium of documents developed in the process. Most of the test results from test agreements made during the dialogue will not be available for some time. But the compendium constitutes a valuable resource for those interested in carpet and associated installation products.

To Obtain Copies

Copies are available from the National Technical Information Service (NTIS) at 5285 Port Royal Road, Springfield, VA 22161, (703) 487-4600.

Indoor Air Quality and Work Environment Study:

- Volume 3: Relating Employee Responses to the Follow-up Questionnaire with Environmental Measurements of Indoor Air Quality. 21M-3002, March 1991.
- Volume 3: Relating Employee Responses to the Follow-up Questionnaire with Environmental Measurements of Indoor Air Quality. 21M-3002, March 1991.
- Volume 4: Multivariate Statistical Analysis of Health, Comfort and Odor Perceptions as Related to Personal and Workplace Characteristics. 21M-3004, June 1991.

Carpet Policy Dialogue:

- Compendium Report, September 27, 1991. EPA/560/2-91-002, September 1991. Copies are $66.00 plus $6.00 shipping.

Awards

ASHRAE Honors Fanger

ASHRAE has awarded P. Ole Fanger of Denmark its highest award, the F. Paul Anderson Award. Anderson was a pioneer in the study of environmental conditions of comfort. It is fitting that Fanger be honored with the Anderson award since Prof. Fanger's contributions to the field of IAQ and climate were primarily in the establishment of thermal comfort criteria. His research in the 1970s comprises an important knowledge base, and his book, Thermal Comfort, is widely cited in the engineering and scientific literature.

More recently, Fanger has been working on what we might call "odor comfort," although Fanger himself does not use this expression. His new work established units of air pollution odor source strength and perception as well as a model for comfortable IAQ. The model Fanger has developed uses panels of trained observers to rate the odor in an environment or emanating from a source. The units are derived from the amount of ventilation required to achieve odor acceptability by 80% of the panelists. This is consistent with thermal comfort standards adopted by ASHRAE where Fanger has been active for many years.

Fanger's odor comfort concept and the units he has developed — the "olf" and the "decipol" — are not without controversy in the indoor air community. They address only perceived air quality and are limited in terms of assessing irritants; Fanger points out that they are not surrogates for health assessment. They cannot evaluate health risks per se. Nevertheless, Fanger is credited with drawing more public and engineering attention to the quality of indoor air. He is an effective spokesperson for designers and researchers who are committed to improving indoor environmental quality.

Calendar

March 23-24, 1992. **"How to Meet New Ventilation Standards: Indoor Air Quality and Energy Efficiency,"** San Jose Convention Center, San Jose, California. Sponsored by Association of Energy Engineers (AEE). Contact: AEE, 4025 Pleasantdale Road, Suite 420, Atlanta, GA 30340, (404) 447-5083, fax (404) 446-3969. *Fee is $685 for AEE members, $785 for non-members.*

March 23-24, 1992. **"HVAC Systems: Improving Operation and Maintenance,"** San Jose Convention Center, San Jose, California. Sponsored by Association of Energy Engineers (AEE). Contact: see above listing.

April 13-14, 1992. **"Indoor Air Pollution: Pollutants, Sources, Effects, Liabilities, Research and Control,"** University of Tulsa, Tulsa, Oklahoma. Contact: University of Tulsa, Division of Continuing Engineering Education, 600 South college Avenue, Tulsa, OK 74104. tel (918) 631-2347, fax (918) 631-2154. *Enrollment cost is $295 after March 23.*

April 26-28, 1992. **Symposium on Modeling Indoor Air Quality and Exposure**, Sponsored by ASTM Subcommittee D22.05 on Indoor Air, Pittsburgh, Pennsylvania. Contact: George Luciw, Staff Manager, ASTM, 1916 Race Street, Philadelphia, PA 19103-1187, (215) 299-5571 Fax (215) 299-2630.

April 29, 1992. **ASTM Subcommittee D22.05 on Indoor Air; Spring Meeting**. Contact: George Luciw, Staff Manager, ASTM, 1916 Race Street, Philadelphia, PA 19103-1187, (215) 299-5571 Fax (215) 299-2630.

April 30 - May 2, 1992. **The First Annual IAQ Conference and Exposition**, "Indoor Air Quality: Service & Technology," Tampa Convention Center, Tampa, Florida. Sponsored by the National Coalition on Indoor Air Quality. Contact: National Coalition on Indoor Air Quality, 1518 K Street, NW, Washington, DC 20005.

May 3-8, 1992. **"Measurement of Toxic and Related Air Pollutants"** (International symposium and course.), Omni Durham Hotel and Convention Center, Durham, North Carolina. Sponsored by Air & Waste Management Association and U.S. EPA. Contact A&WMA, P. O. Box 2861, Pittsburgh, PA 15230. (412) 232-3444, fax (412) 232-3450.

May 4-8, 1992. **"Improving Indoor Air Quality in Non-Industrial Buildings,"** Sponsored by EOHSI/CET, University of Medicine and Dentistry of New Jersey-Robert Wood Johnson Medical School and Rutgers, The State University of New Jersey. Contact: Centers for Education and Training (CET), 45 Knightsbridge Rd., Piscataway, NJ 08854-3923. (908) 463-5064. Course fee is $750 for five days.

May 7-8, 1992. **"Diagnosing and Mitigating Indoor Air Quality Problems,"** Omni, Georgetown, Washington, DC. Sponsored by American Association of Energy Engineers (AEE). Contact: AEE, P.O. Box 1026, Lilburn, GA 30326. 404-925-9633. Fax 404-381-9865. *Instructor is IAQ expert Francis J. "Bud" Offermann, PE, CIH. Fee is $685 for AEE Members, $785 for non-members.*

May 14-15, 1992. **"Indoor Air Quality" Professional Development Seminar**, Oklahoma City, OK. Sponsored by ASHRAE. Contact: Education Coordinator, ASHRAE, 1791 Tullie Circle N.E., Atlanta, GA 30329. (404) 636-8400, Fax (404) 321-5478. *Registration fee is $530 for ASHRAE members, $605 for non-members. Discount for early registration.*

June 18-22, 1992. **American Institute of Architects Committee on the Environment** (AIA COTE), Meeting in conjunction with the AIA Convention, Boston, Massachusetts. Contact: Kristine Dombrowski or Patrick Lally, AIA, 1735 New York Avenue NW, Washington, DC 20006, Tel. (202) 626-7400, Fax (202) 626-7518.

June 21-26, 1992. **85th Annual Air & Waste Management Association Meeting and Exhibition,** Kansas City, MO. Contact A&WMA at address above for May 3-8.

June 27-July 1. **ASHRAE Annual Meeting,** Baltimore, Maryland. Contact: ASHRAE Meetings Dept., 1791 Tullie Circle N.E., Atlanta, GA 30329, (404) 636-8400.

July 12-17, 1992. **"Asbestos Measurement, Risk Assessment, Laboratory Accreditation."** Johnson State College, Johnson, Vermont. Sponsored by ASTM Committee D-22 on Sampling and Analysis of Atmospheres. Contact: George Luciw, ASTM, 1916 Race Street, Philadelphia, PA 19103, (215) 299-5471.

July 14-15, 1992. **"Indoor Air Quality for Facility Managers."** Sponsored by International Facility Managers Association (IFMA), Boston, Massachusetts. Contact: Susan Biggs, IFMA, 1 East Greenway Plaza, 11th Floor, Houston, TX 77046-0194, (800) 359-4362, Fax (713) 623-6124. *Instructor is IAB Editor Hal Levin.*

August 30 - September 5, 1992. **"Achieving Technical Potential: Programs and Technologies that Work!"** ACEEE 1992 Summer Study on Energy Efficiency in Buildings, Asilomar Conference Center, Pacific Grove, California. Sponsored by The American Council for an Energy-Efficient Economy. Contact: ACEEE 1992 Summer Study Office, 2140 Shattuck Avenue, Suite 202, Berkeley, CA 94704.

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.

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.

International

April 28-30, 1992. **"Quality of the Indoor Environment,"** Sponsored by The International Association for Indoor Air Quality, Athens, Greece. Contact: Conference Secretariat, Quality of the Indoor Environment, Unit 6, 2 Old Brompton Road, London SW7 3DQ, UK.

June 9-11, 1992. **Aerobiology 1992:** Symposium of the Pan-American Aerobiology Association, Scarborough College, University of Toronto, Toronto, Canada. Contact: Christine Rogers, Conference Organizer, Life Science, Scarborough College, University of Toronto, 1265 Military Trail, Scarborough, Ontario, Canada M1C 1A4. (416) 287-7421; Fax (416) 287-7642.

July 22-24, 1992. **1992 International Symposium on Ventilation Effectiveness,** Tokyo, Japan, sponsored by the Institute of Industrial Science, The University of Tokyo. (co-sponsored by ASHRAE). Contact ASHRAE in the US.

September 2-4, 1992. **Roomvent '92, The Third International Conference on Air Distribution in Rooms**. Aalborg, Denmark. sponsored by Danish Association of HVAC Engineers. Contact: Danish Association of HVAC Engineers, Ørholmvej 40B, DK-2800 Lyngby, Denmark.

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.

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. *Abstracts of no more than 300 words are due by August 15, 1992. The official languages will be English, French, and Flemish.*

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