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EPA Headquarters Buildings Investigated

There are two distinct approaches to understanding the effects of IAQ on occupant health and comfort. One is to intensively study one or more "problem buildings," where abundant occupant complaints and reported health effects suggest that environmental factors may be causing difficulties. With this approach, it's assumed one can compare a problem environment to non-problem buildings and find abnormalities. Epidemiologists tend to study a control building in order to develop a baseline for the frequency of occupant complaints and health effects reports. However, investigators usually do not study a similar population in a non-problem building as an experimental "control."

The second approach is to investigate a large number of occupants in a large sample of buildings, usually buildings without an excessive or unusually high rate of known problems or complaints. With this approach, researchers try to find causal factors by identifying the environmental conditions associated with elevated complaint rates where they do occur.

The EPA Headquarters Study

The environment at the EPA Washington, D.C. headquarters facility at Waterside Mall has received considerable publicity ever since numerous employees complained of health problems following the installation of new carpeting in late 1987 and early 1988. Actually, health and comfort complaints had been reported there for many years; complaints about the building environment were disclosed on National Public Radio broadcasts as long ago as 1981. The building received more national press coverage when employees publicly protested the building environment in the spring of 1988.

Background of the Study

In March of 1990, EPA studied the Waterside Mall facility and two other Washington-area EPA buildings. The investigators used a questionnaire survey of building occupants and extensive environmental measurements. About 5,000 EPA employees received the questionnaire, and 3,955 (81%) returned it. The results were organized in terms of either comfort and odor factors or in terms of health factors. The study was one of the most comprehensive building environment studies conducted in the United States to date. EPA conducted the study with the assistance of the National Institute for Occupational Safety and Health (NIOSH), Yale University, and private consultants. The manpower and financial resources expended on it were considerable.

Until recently, most of the reported results of the study have been disappointing relative to investigators' and occupants' expectations and the expense and effort spent. EPA has not yet released the complete results, but the *BULLETIN* has learned that it will release the remainder of the four-volume series of reports in the next few weeks. Earlier volumes reported the results of the questionnaire survey and the environmental measurements. Selected study methods, results, and data analyses are available through reports the investigators presented at the ASHRAE "IAQ '91 - Healthy Buildings" conference.

Inside This Issue:

Wallace Reports EPA Analysis

EPA's Lance Wallace, Ph.D., has long been a major contributor of knowledge on buildings and IAQ. His Total Exposure Assessment Method (TEAM) study of ten public buildings is an important body of research on the characteristics of volatile organic compounds (VOC) in large building environments. Wallace's paper was one of two analyses of the EPA work environment study presented at "IAQ '91 - Healthy Buildings." He concluded that "...the workplace variable affecting the largest number of health symptoms and comfort/odor concerns was dust. Perceptions of hot, stuffy air and the odor of paint and carpet cleaning and other chemicals were also associated with a number of health symptoms." Glare, noise, and nearby water leaks were also associated with comfort and odor.

The results did not implicate individual air-handling units. This is not surprising to us since we have heard that the number of air handlers serving EPA's portion of Waterside Mall is upwards of 50; some sources have said that there are more than 100 serving the entire building complex. Areas with new carpet did have higher incidences of reported throat problems. This is also not surprising, since so much has been made of the problems occurring after new carpet installations at the Waterside Mall facility.

The investigators concluded that "improved maintenance, better recirculation and filtration of air, and glare screens" could improve employee health and productivity. Again, the focus on maintenance problems is a frequent theme in reports of problem building investigations. In fact, it was probably the most common single theme at the ASHRAE "IAQ 91 - Healthy Buildings" conference.

Significance of the Study

According to Wallace, "[t]his is the first large-scale building study to employ an objective measure (PCA) [principal component analysis] to assess the way in which health symptoms cluster together." Wallace writes that authors of "[p]revious studies have subjectively grouped symptoms into clusters, which sometimes contain symptoms belonging to different factors as identified by the more objective PCA. The effect of lumping different factors would likely be to make it more difficult to detect associations."

Another important aspect of the study was that it attempted a census rather than a sample of all the occupants of all three buildings studied. The 81% coverage achieved allowed analysis of the effects of spatial variation including the effects of ventilation and carpet installation. According to Wallace, "These analyses have not been possible in most preceding studies because they typically have involved only a sample of employees from multiple buildings. The Danish [Town Hall] study was also a census, but measurements were made in only one room per building."

Finally, reported health complaints and IAQ problems at the Waterside Mall facility have been the subject of so much attention during the past four years that it is valuable to have the results of a fairly comprehensive study. We think that the most surprising study result is that the complaint rates at Waterside Mall were not terribly different from those at the other two facilities in the area.

Principal Component Analysis

An important element of EPA's analysis was the use of principal component analysis as a statistical method. If building-associated illness is truly a result of multifactorial causes, then effective analysis of investigation results requires methods capable of managing multivariate data. Such data can provide information about the relationships between the variables and about the subjects in the study.

According to S.S. Cohen in his book, *Practical Statistics*, variables can be either clustered or searched for combinations that as a single measurement account for a large proportion of the total variability in the sample. The linear combination that corresponds to the largest amount of variability is called the "first principal component." After removing the effect of the first principal component, the factor accounting for the most remaining variability is called the "second principal component," and so forth. There are as many principal components as there are variables, but the first few usually explain a significant portion of the total variance and the rest are ignored.

The principal component analysis tries to combine the variables in the data set into a smaller set of "derived measurements" that describe the most salient features of the sample. Each component assembles correlated variables and provides a single value to express their information content.

The Statistical Analyses

Specifically, the investigators analyzed separately 25 personal and psychological factors and 29 workplace factors included in the questionnaire. They also factored in new carpet and ventilation. They examined the effect of "coarse-grained" location (by building or major building sector) and "fine-grained" location (by 66 air handling unit/floor locations) in the three buildings.

They ran numerous statistical analyses on each of 22 health, comfort, and odor factors. The 32 health symptoms clustered into 12 factors, "largely by single body systems such as eye, nose, throat, chest, central nervous system, etc."

They ran all of their regression analyses separately for men and women. In all, then, they ran 68 separate regressions within each set of three linear regressions and one set of logistic regressions. Each regression contained between 20 and 120 personal and workplace characteristics, so thousands of associations were investigated. Since this approach increases the likelihood of "false positives," they considered effects significant only if there was no more than one chance in 100 ($p<0.01$) that the association was due to chance.

Results of the Study

The authors noted that headache is the single most common cause of absenteeism and lost work time. They also noted that glare appeared associated with headaches, and other ergonomic factors were associated with neck and shoulder pain. They suggested that improving the ergonomic design of work stations could be an effective means to improve productivity.

The eleven variables associated with at least four of the 12 health factors are shown in Table 1. Seven variables were associated with at least three comfort and odor factors. These are shown in Table 2.

Discussion

Various aspects of the study results repeatedly implicate maintenance issues directly or indirectly. Maintenance seems to be an issue in many buildings, yet there is very little published information on maintenance and IAQ; there simply isn't good guidance on the subject. We invite our readers to suggest sources of such information that we might evaluate and pass on to our readers.

Dust

Dust was the strongest contributor to reported effects. These included a wide variety of health, comfort, and odor concerns. The cause is not known, but it could be physical irritation, allergens, or endotoxins.

This finding is similar to one from the Danish Town Hall Study (DTHS) where dust was the most highly correlated variable to self-reported health symptoms. Another study, conducted in Sweden by Norback and Torgen, found a reduced number of health symptoms in an office environment following intensive cleaning of carpet and wet dusting. Hedge found that increasing recirculation and filtration (employing HEPA filters and charcoal) re-

Workplace characteristics	
Dust:	Headache; Nasal, chest, eye, throat symptoms; Fatigue; Chills and fever; Difficulty concentrating[a]; Dizziness; Dry skin; Contact lens problems.
Glare:	Headache; Eye Symptoms; Fatigue; Difficulty concentrating; Pain[b].
Personal characteristics	
Sensitivity to chemical fumes:	Headache; Nasal, chest, eye, throat symptoms; Fatigue; Pain; Chills and fever; Difficulty concentrating;. Dizziness.
Mold allergies:	Headache; Nasal, eye, throat symptoms; Fatigue; Pain; Dry skin.
No college:	Headache; Chest symptoms; Fatigue; Chills and fever; Dizziness.
Psychosocial characteristics	
Workload:	Headache; Eye symptoms; Pain; Difficulty concentrating; Dizziness.
Conflicting demands:	Nasal, chest symptoms; Chills and fever; Pain; Difficulty concentrating; Dizziness.
Comfort and odor characteristics[c]	
Hot stuffy air:	Headache; Nasal eye, chest symptoms; Fatigue; Difficulty concentrating; Dizziness.
Dry air:	Headache; Nasal, eye, throat symptoms; Dry skin.
Odor of paint, chemicals:	Headache; Nasal, chest, throat symptoms; Fatigue; Chills; Difficulty concentrating; Dizziness.
Odor of cosmetics:	Eye symptoms; Chills and fever; Pain; Difficulty concentrating.

[a] Includes difficult concentrating, difficulty remembering, depression, tension.
[b] Includes aching muscles, back pain, shoulder/neck pain, head/wrist pain.
[c] Significant at $p<0.01$ in at least two (of four) linear and logistic regressions.

Table 1 - Variables Associated* with at Least Four of the Twelve Health Factors.
* Significant ($p<0.01$) in at least two (of eight) linear and logistic regressions.

Workplace characteristics	
Dust:	All four comfort concerns and all six odor factors.
Glare:	Hot air; Dry air; Odors of paint; Cosmetics; Dampness.
Noise:	Hot air; Dry air; Cold air Odors of paint and cosmetics.
Use fan:	Hot air; Humid air; Cold air (negative); Odors of cosmetics.
Water leaks:	Odors of dampness; Cosmetics; Tobacco smoke.
Personal characteristics	
Sensitivity to chemical fumes:	Humid air; Odors of paint; Photocopying; New carpet; Tobacco smoke.
Conflicting demands:	Dry air; Cold air; odors of cosmetics; Photocopying; Dampness; Tobacco smoke.

Table 2 - Variables Associated* with at Least 3 of 10 Comfort and Odor Factors.
*Significant (p<0.01) in at least two (of four) linear and logistic regressions.

duced occupant symptoms on two floors compared with occupants of two untreated floors.(See the article on built-in filtration units in this issue.)

Dust also contributed most strongly to comfort and odor factors. Since dust particles may be generated by processes that create odors such as tobacco smoking, printing, or painting, the relationship between odors and particles may have physical causes, according to the authors.

The main odor factor with health associations was composed of the odors of paints, carpet cleaning, pesticides, and other chemicals such as glues and cleansers. Most of these odors are associated with maintenance activities in the building.

Health Symptoms Cluster

The 32 health symptoms clustered into 12 factors, "largely by single body systems such as eye, nose, throat, chest, central nervous system, etc." The authors thought this finding should be useful in designing questionnaires for future studies. This is an important issue not only in questionnaire design but also in analyzing the results. Other investigators have found that the way symptoms or complaints are clustered can affect the results of the studies. A notable example is the Northern Sweden Office Environment Study. Jan Sundell reported some of the results of that study at the ASHRAE "IAQ 91 - Healthy Buildings" conference.

Building Maintenance

We note that the original EPA report indicated that of 1,160 Waterside Mall occupants who wrote answers to the open-ended essay question, 233 mentioned maintenance first in their essay. This was the highest number for any topic and constituted 20% of Waterside Mall essay respondents. Only 8% and 5% of essay respondents from the other two EPA buildings mentioned maintenance first in their answers. Some respondents said the building was the worst place they had ever worked.

In the conclusion, the authors wrote: "The importance of dust, mold allergies, the odor of paints and other chemicals, and nearby water leaks in affecting multiple health symptoms and comfort/odor factors points to building maintenance or renovation as a possible factor in the complaints at the three buildings. Therefore, it is recommended that attention be given to ways of improving building maintenance, particularly to reduce dust, clutter, and conditions conducive to growth of mold."

They go on to say: "The design of new buildings should allow for adequate building maintenance and should reduce the likelihood of dust buildup. This could include decisions on the optimum extent of carpeting and fabric-covered partitions vs. other, more easily cleaned surfaces; the use of walk-off mats to reduce track-in dust and dirt; and techniques to allow for easy replacement of water-soaked carpet or cleaning and disinfecting water-stained surfaces."

Air Cleaning and Filtration

The authors note that many office tasks are associated with dust production. Therefore, they recommend consideration of "supplemental air cleaning and filtration." They note that this would require additional ventilation which might also reduce complaints associated with hot, stuffy air. Some means to achieve reduced dust levels include more frequent, more effective housekeeping, more efficient filters in HVAC systems, increased air circulation, or the use of local fans and filtration systems. We note that there are many vendors available to provide all of these, but it is essential to obtain competent professional assessment of equipment performance and cost and thorough evaluation of the alternatives.

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Carpet

New-Carpet Odor and Carpet Backing

Health and comfort complaints often arise shortly after new carpet installations; not surprisingly, building occupants often believe carpets are the root cause. However, it's not clear that new carpet itself is the primary source of IAQ problems - other contaminant sources include solvents used in adhesives, in seaming compounds, and in products applied to a subfloor or surface to prepare it for a better carpet installation. Also, there are usually other contaminant sources in buildings where new carpets have been installed. These sources may be paint, new furnishings, new mechanical ventilation system components, and or office equipment just to name a few. However, new carpet has a strong, recognizable odor, and therefore occupants tend to identify it as the IAQ culprit.

The recognizable "new carpet" smell often comes from 4-phenylcyclohexene (4-PC), a by-product of the styrene butadiene rubber (SBR) latex manufacturing process. According to the Carpet and Rug Institute (CRI), SBR latex is used as the primary and secondary backing in 94% of commercial carpets sold in the United States. Table 3 shows the market distribution of carpet products in the United States as reported by CRI to the EPA Carpet Policy Dialogue. (For details of the EPA Carpet Policy Dialogue, see page 9 of this issue.)

The manufacturers of SBR latex report that they have cut 4-PC emissions in half during the past two years, according to a study performed by the association of these manufacturers, the Styrene Butadiene Rubber Latex Manufacturers Council. However, 4-PC still dominates the VOC emissions from newly-manufactured carpets, according to a study presented at the EPA-A&WMA Symposium in May by Air Quality Sciences of Atlanta, Georgia.

Other types of carpet backing are available, but their use is limited for various reasons. Urethane foam (UF) backing costs about one dollar per square yard of carpet more than SBR latex. And, UF backing may emit more toxic compounds when it burns making it more dangerous in fires. Some manufacturers may be developing non-SBR latex backing products. We predict a large market for such products when they become available, and their

Fiber	Backing	Market Share (%)
Nylon	SBR[1] latex	70.20
	AR[2] Hardback	0.73
	Urethane foam	1.70
	PVC[3] hardback	1.30
	EVA[4] hardback	0.57
	Urethane Hardback	0.20
	Bitumen hardback	0.10
Olefin	SBR latex	14.90
	Urethane foam	0.88
	Urethane hardback	0.02
Polyester	SBR latex	8.70
Wool	SBR latex	0.70
TOTAL		100.00

[1] Styrene butadiene rubber
[2] Amorphous resin
[3] Polyvinyl chloride
[4] Ethylene vinyl acetate

Note: CRI determined that products with EVA latex-backing are no longer manufactured.

Table 3 - Roster of Carpet Product Types.
Adapted from Interim Report, Carpet Policy Dialogue - reference at end of article.)

success may drastically reduce the demand for SBR latex carpet backings.

4-PC Emission Rates

4-PC emissions from new SBR latex-backed carpets decline very rapidly during the first few days after installation according to measurements in environmental chambers and in buildings. 4-PC air concentrations decline more slowly over a period of weeks. This is perhaps due to the sink effect: the adsorption of chemicals on surfaces and their later re-emission into air.

Other Emitters

SBR latex is also used in most carpet adhesives. Adhesives are used minimally in residential installations, but their use is widespread in heavily trafficked, non-residential installations - offices, stores, schools, public assembly buildings, and others. Actually, the major emissions from adhesives come from the solvent used to carry the SBR into the adhesive. Adhesive manufacturers have moved to reduce the use of solvents for that purpose and virtually all manufacturers now make a non-solvent-based adhesive for carpet installations, although these low-emitting adhesives are not yet widely used.

Carpet Installation Product Studies

How much difference do low-emitting materials make in indoor air contaminant concentrations? A pair of studies reported last May provide valuable data on carpet product emissions. Using low-emitting carpets and carpet adhesives can result in dramatically lower indoor air VOC concentrations. This is the consistent finding from both field and environmental chamber measurements.

In the first study, EPA installed 3,462 ft^2 of new carpet in a room at its Washington, DC headquarters at the Waterside Mall. The use of low-emitting carpets and carpet adhesives resulted in lower room air VOC concentrations where the carpet was installed than in air 300 feet away in a corridor where custodians were cleaning the resilient tile floor.

In the second study, environmental chamber tests of styrene butadiene rubber (SBR) latex-backed commercial carpet and other carpet installation products revealed significantly lower emissions from the carpet than from carpet adhesives, seam sealants, and particleboard underlayment.

EPA Installs "Clean" Carpet Products

Jeff Davidson of EPA's Health and Safety Division reported the results of the EPA study at the May EPA-A&WMA "Symposium on Measurement of Toxics and Related Compounds." Due to a history of air quality complaints related to carpet installations at its headquarters in Washington, EPA selected "low" VOC-emitting products to minimize occupants' complaints.

The installation included a solvent-free adhesive (Envirotec Healthguard #2055 manufactured by W. F. Taylor Co. Inc. of Santa Fe Springs, California). The carpet was identified as "Scholar II" or "Acculon III" from Porter Carpet Mills of Cartersville, Georgia. Manufactured six weeks prior to installation, it consisted of a solution-dyed, charcoal gray, 28 oz. textured loop nylon face fiber with a woven polypropylene primary backing and a 100% urethane secondary backing with polyester scrim. EPA personnel aged the carpet before installation by rolling it out in a warehouse for approximately two weeks. [Davidson advised the ***BULLETIN*** that EPA's selection of certain products does not imply or express any endorsement or other evaluation. The names of the products used were provided in the interest of complete and accurate reporting.]

According to measurements made for EPA by Air Quality Sciences of Atlanta, total volatile organic compound (TVOC) levels in the air above the newly installed carpet were 116-243 micrograms per cubic meter ($\mu g/m^3$) one hour after installation began and 213-215 $\mu g/m^3$-hr five days later. Corridor TVOC air concentrations 300 feet from the room where the carpet was installed were 218 $\mu g/m^3$-hr during installation and 339 $\mu g/m^3$ five days later.

Table 4 shows TVOC concentrations in building air samples.

1,1,1- trichloroethane, a major component of the seam sealant, was the most significant compound measured during the installation. The reported trichloroethane air concentration during installation was 106 $\mu g/m^3$ during the installation and 1.5 $\mu g/m^3$ five days later. The adhesive emissions dropped significantly between 24 hours and 40 hours.

Chamber studies of the carpet, adhesive, and seam sealant measured separately and as a simulated installed assembly produced results that reasonably predicted the findings in the field. Table 5 shows the chamber test results. It appears that the aged carpet adsorbed a significant quantity of VOCs because its initial emissions were 50% higher than the new carpet. These VOCs may have been adsorbed during the airing out process in the ware-

Location	TVOC Concentrations (mg/m³) Before[1] Installation	During[2] Installation	After[3] Installation
Station 1 (corner alcove)	126	243	213
Station 2 (Center of room)	216	116	215
Average in Room	171	180	339
Control (Corridor, 300 ft away)	NA	218	339

[1] Immediately before installation began.
[2] Approximately one hour after start of carpet installation.
[3] One week after carpet installation.

Table 4 - Summary of Total Volatile Organic Compound (TVOC) Concentrations in Building Air Samples.

Product	Emission rate (Mg/m^3-hr)[1] Elapsed day (hour) 0(1)	1(24)	6(140)
Carpet ("new") only	0.062	0.035	0.006
Carpet ("aged") only[2]	0.098	0.026	0.020
Adhesive only	2.77	2.35	0.013
Installed carpet	0.411	0.202	0.111
Seam sealant only	2.96	0.249	0.010

[1] Emission rates obtained at exposure point in time.
[2] This sample was collected at the manufacturing point immediately after manufacture and placed in protective wrapping until tested.
[3] This sample was collected at the building site from the carpet actually being installed. This carpet had been rolled out in a warehouse for two weeks before shipment. The sample was placed in protective wrapping until testing at the laboratory.

Table 5 - Summary of Total Volatile Organic Compound Emission Rates in Environmental Chamber Test of Carpet Installation Products.

house. They were mostly emitted during the first 24 hours of the chamber test.

Modeling Emission Rates from Chamber Tests

Using a modified version of *Exposure*, a personal computer-based IAQ model by EPA (1990), AQS predicted a peak air TVOC concentration of 65 $\mu g/m^3$ at 4.5 hours of exposure after installation began. The predicted concentration after 24 hours was about 58 $\mu g/m^3$ and after five days about 25 $\mu g/m^3$. Figure 1 shows the results of AQS' efforts to predict the air concentrations for the carpet adhesive/assembly based on the emissions measured in the chamber.

The model does not account for sink effects. The calculation was based on an assumed ventilation rate of one ACH. The ventilation assumption was not verified in the field by measurement, but the design air flows in the space were 7.1 ACH total flow and 1.06 to 1.41 ACH outside air. The air handler ran continuously with a maximum outside air supply while the investigators were in the space. According to EPA's facility manager, it operated continuously from the start of the installation on Friday evening until 8:30 PM the following Monday. It normally operates from 6:00 AM until 8:30 PM daily.

Discussion

Low-emitting products can be selected ahead of time on the basis of their chemical constituents or composition and, in some cases, emissions testing. Avoiding 4-PC was probably an important criterion when EPA selected the carpet, although neither Davidson nor the AQS report said so. The absence of SBR latex most likely also influenced EPA since the odor from 4-PC may, by itself, indicate the presence of new carpet and therefore increase occupants' concern. Because of the history of carpet-related complaints about IAQ at EPA, there was substantial care taken to avoid anything that might increase the likelihood of adverse reactions both physiological and perceptual.

Many investigators feel that the heightened awareness of odor alone can strongly influence occupant perceptions of IAQ. This view was presented in the June *BULLETIN* by Alan Hedge of Cornell University. Hedge said that expectations can significantly affect occupants' reactions to their environment. Health effects studies of 4-PC are few in number and narrow in scope. However, 4-PC may be "unsafe" to use in buildings simply because its recognizable new-carpet odor heightens occupant awareness of a new carpet installation.

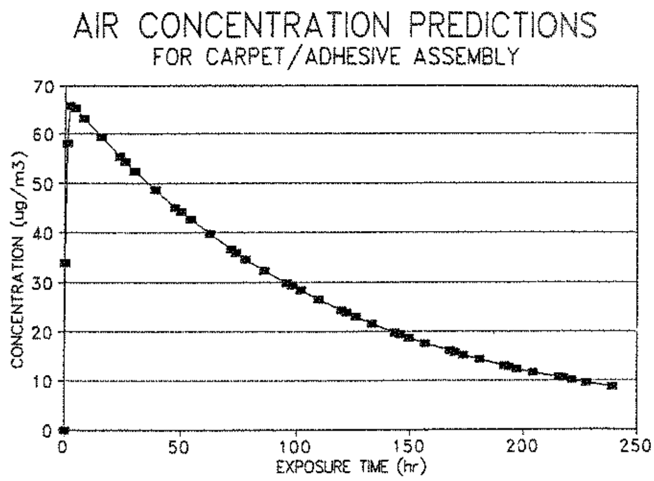

Figure 1 - Air Concentration Predictions for Carpet/Adhesive Assembly.

The adhesive was not solvent-based and this surely influenced its selection for the installation at EPA. Officials responsible for selecting it must have considered the occupants' awareness of the installation and potential adverse reactions as extremely important; they aired out the carpet for two weeks, studied the installation emissions extensively, and performed chamber testing.

Another lesson learned was that particleboard and seaming compounds can be much stronger sources of VOC than the carpet itself. Since many residential installations and some commercial installations are done without adhesives, care is warranted when selecting and applying seaming compounds. Most will be primarily solvent, so we recommend maximum ventilation during and after the installation regardless of the carpet and adhesive chosen. As far as we know, seam sealants lack low-emitting substitute products.

SBR Latex Carpet and Installation Product Emissions Compared

Total VOC and 4-PC emissions from styrene butadiene rubber (SBR) backed carpet are far lower than emissions from certain adhesives — even so-called "low-emitting" carpet adhesives. Reporting her laboratory findings at the EPA-A&WMA Symposium "Measurement of Toxic and Related Air Pollutants" in Durham, North Carolina last May, Dr. Marilyn Black of Air Quality Sciences in Atlanta, Georgia described her test methods and provocative results.

Dr. Black reported that VOC emissions from various SBR latex-backed carpet products varied little regardless of their face fiber type, dye process, or topical treatments. She reported an average 24-hour emission factor of 0.15 mg/m^2-hr for TVOC and 0.064 mg/m^2-hr for 4-PC. She said that these values resulted in a calculated potential VOC contribution of 61 $\mu g/m^3$ TVOC and 26 $\mu g/m^3$ of 4-PC. It appears that the air exchange rate used for the calculation was one ACH. According to Black, these emissions decrease to barely detectable levels (limit of detection was 2 $\mu g/m^3$ (0.5 ppb) for TVOC and 2 $\mu g/m^3$ (0.3 ppb) for 4-PC.

In contrast, Black said, carpet cushions, adhesives, and subflooring emissions were quite different. Table 6 shows a summary of the results she reported for those components of the carpet assembly. Adhesive emissions varied from 0.70 mg/m^2-hr to 120 mg/m^3-hr at a 24-hour exposure time. She reported a calculated TVOC contribution of 287 to 49,000 $\mu g/m^3$ from the adhesive products - considerably higher than from the carpets.

Product Designation	TVOC Emission Factor (mg/m2-hr)	
Cushions	24 hour[a]	144 hour[b]
P-1	0.123	0.059
P-2	0.240	0.012
P-3	3.36	0.11
Adhesives		
Ad-1	90.0	11.9
Ad-2	76.6	3.95
Ad-3	99.0	17.2
Ad-4	0.698	0.076
Subflooring		
Concrete	<0.005	<0.005
Particleboard	0.952	0.837

[a] Emission factor taken after a 24-hour equilibration period in the environmental chamber.

[b] Emission factor taken after a 144-hour exposure period in the environmental chamber.

Table 6 - Summary of TVOC Emission Factors for Cushions, Adhesives, and Subflooring.

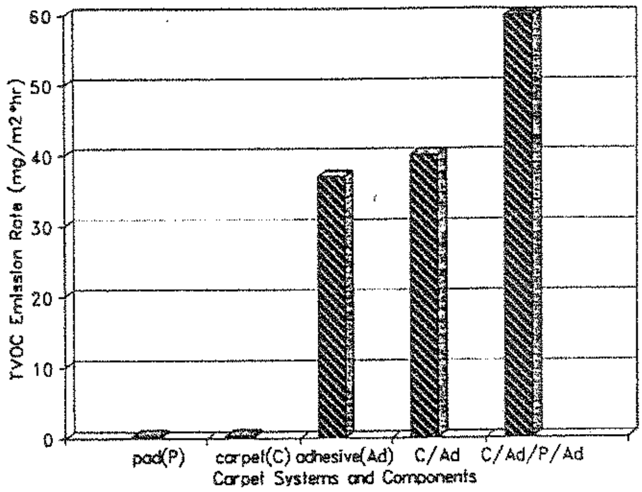

Figure 2 - TVOC Emission Factor Comparison of "Carpet System" and individual Contributors.

Black showed a chart comparing the relative contributions of pad, carpet, and carpet with pad and adhesive, and with adhesive with no pad. Figure 2 shows her results.

Discussion

Clearly, carpet is blamed in many cases where other sources of indoor air contaminants contribute much larger fractions. It is not possible to determine the relative contribution of carpet or carpet cushions and adhesives to people's complaints about IAQ or their adverse health effects. However, until further research links the products directly with the physiological and subjective responses, many will take the cautious approach of minimizing exposure by selecting low-emitting sources. The adhesive labelled "Ad-4" in Table 6 is the same product used by EPA in the installation reported in the previous article. It does not use solvent to carry the SBR latex into the adhesive; thereby, it reduces considerably the TVOC emissions.

The paper did not contain sufficient detail for a thorough evaluation of the reported methods and the results. Severe length limitations imposed on symposium papers precluded presentation of the level of detail we would have liked.

Also, the study did not evaluate non-SBR latex carpet products for comparison purposes. This would be interesting because, although SBR latex-backed carpet dominate the commercial market today, other products are used in about 6% of commercial installations. Even more important, other types of products may be developed or become more favored in the market if concern about the odor of 4-PC continues unabated.

Since AQS has done more testing for the Carpet and Rug Institute (CRI), there will be more detail available on carpet emissions when the EPA Carpet Policy Dialogue final report is released in October. See the Carpet Dialogue article below for more details.

References:

J. Davidson and M. S. Black, W. J. Pearson, L. M. Work, D. P. Miller (1991), Air Quality Sciences Inc., "Indoor Air Quality of Carpet Installation for United States Environmental Protection Agency," Report No. 01041-01, April 3, 1991. To obtain a copy, contact Jeff Davidson, U.S. EPA, 401 M Street SW, Washington, DC 20460. (202) 260-3640.

"Exposure," Indoor Air Quality Model, prepared by the U.S. EPA. To obtain a copy write Les Sparks, MD-54, EPA, Research Triangle Park, NC 27711.

M. Black, W. Pearson, and L. Work, (1991) "A Methodology for Determining VOC Emissions from New SBR Latex Backed Carpet, Adhesives, Cushions, and Installed Systems and Predicting Their Impact on Indoor Air Quality." [The paper will be published by A&WMA in the symposium proceedings. Contact A&WMA for information on obtaining a copy. Or, keep reading the *BULLETIN*; we will give details when they become available from A&WMA.]

Both the Davidson et al. paper and the Black et al. paper were presented at ASHRAE's IAQ '91 - Healthy Buildings. Copies are available from ASHRAE in Atlanta - (404) 636-8400.

For more information:

Dr. Marilyn Black, Air Quality Sciences, Inc. 1331 Capital Circle, Suite D, Atlanta, GA 30067. (404) 933-0638.

Envirotec Healthguard Adhesives: W. F. Taylor, 13660 Excelsior Drive, Santa Fe Springs, CA 90670, (213) 802-1896 or (800) 397-4583.

EPA Carpet Policy Dialogue

EPA initiated the Carpet Policy Dialogue as a response to a petition from its employees concerning carpet. The petition, submitted by the National Federation of Federal Employees (NFFE), asked that EPA regulate 4-PC, a by-product of the styrene butadiene rubber latex manufacturing process. EPA denied the petition on the basis of insufficient toxicity data on 4-PC. However, in announcing its decision, it initiated the dialogue to consider reducing the total volatile organic compound (TVOC) emissions from carpets. An interim report is now available that describes the dialogue's background, purpose, and progress.

The Carpet Policy Dialogue is scheduled to meet for the last time on September 27-28 in Washington. The dialogue, composed of representatives from the carpet industry, government, and other interested parties, has been meeting for 14 months to develop voluntary testing agreements for carpet and associated products such as carpet cushions and adhesives. The group has also identified potential control methods for carpet emissions and further research needs. A communications subcommittee has developed a pamphlet on carpet emissions and indoor air that dialogue participants and others will distribute.

The group will formally adopt its final report at the September meeting, although the report is not expected to be available to the public until several weeks later to allow for last minute changes and printing. We will report on the findings and other interesting products from the dialogue as they become available.

Future EPA Indoor Air Pollutant Source "Dialogues"

EPA officials indicated they may look at other indoor air pollutant sources after the carpet dialogue is completed. No official decision has been made that we know about. However, both the Office of Toxic Substances and the Indoor Air Division seem to have an interest in other products, and the Office of Research and Development continues to develop methods for source characterization. Our guess is that the next set of materials to be examined will be one of the "wet" product types such as adhesives, paints, caulks, or sealants. Measurement methods for these products are being developed, and exposure to their emissions, although relatively short-lived for many chemicals, may still be quite high. The adhesive emissions discovered during the Carpet Policy Dialogue along with emissions tests in the U.S. and abroad provide evidence of the relative significance of the "wet" products.

Reference:

"Carpet Policy Dialogue, Interim Progress Report." April 10, 1991. Prepared by The Carpet Policy Dialogue for the Office of Toxic Substances, U.S. Environmental Protection Agency, Washington, DC. Available from Environmental Assistance Division, (TS-799), Office of Toxic Substances, EPA, 401 M Street SW, Washington, DC 20460, (202) 554-1404, Fax (202) 554-5603.

For more information:

Phone Richard W. Leukroth, Jr., Carpet Policy Dialogue Coordinator, (202)260-3832.

Products

"Green" Products, "Green" Paints?

Green products are the rage; grocery and hardware stores, magazines, and catalogs are full of them. But what is a "green" product? Generally, the term refers to products claimed to be environmentally more benign. This means that they cause less environmental damage in their extraction, manufacture, application, use, and ultimate disposal. Some manufacturers are marketing products as green if they have minimal or reduced adverse impacts on IAQ. Manufacturers' claims abound, but no standards exist in the United States for assessing them.

Green products include carpets; porcelain paver tiles; ceramic tile and stone epoxy adhesive that might be made from recycled plastics; resilient flooring made from recycled tires; and, carpet adhesive made without solvents. Hardwoods from sustainable harvesting practices are also called green. The EPA has a "Green Lights" program that encourages the use of energy-efficient lighting sources.

Paint it Green

Paints containing radically lower amounts of petroleum-based products are now available in the United States as well as in Europe. According to David Dobbs, the "non-toxic" or "healthy" paints, like conventional latex paints, are basically suspensions of latex and pigment in water. Where a conventional latex paint uses petroleum-based solvents to disperse the latex in water and to improve workability and drying time, a less-toxic paint relies on natural ingredients such as plant-derived materials. This radically reduces a paint's total VOC content.

Typical ingredients used for emulsifiers are beeswax, linseed oil, citrus terpene (from citrus fruit) and turpentine (derived from conifers). Dobbs says that some paints do contain limited amounts of synthetic hydrocarbons to augment the natural ingredients. Nonetheless, they contain significantly lower levels of petroleum-based products. Generally they omit or use minimal amounts of the fungicides, mildewcides, and pesticides found in conventional latex products. Dobbs concludes that, overall, they contain far lower concentrations of known toxins.

However, since manufacturers market these products to the chemically sensitive population, we note that some of their ingredients might be irritating or toxic to sensitive individuals. While reliable estimates of the fraction of the population that is sensitive are not available, we have heard estimates ranging from a few percent up to 30 percent.

German companies manufactured the first less-toxic paints. While Americans can now buy domestic-made products, the German-made Auro, Biofa, and Livos brands still dominate the growing less-toxic paint market. Some of the American manufacturers have focused more on reducing odors from paints than on eliminating the synthetic ingredients. Their perspective is that the odor from natural products like turpentine might be more irritating than a synthetic substitute.

Test it Yourself

We always recommend that sensitive individuals test products themselves. Most of the suppliers listed below can send a free or low-cost sample for that purpose.

Prepare a test sample as closely as possible to the way it will be installed in the house or other building.

Use drywall, wood, or whatever other substrate will be painted. Try to leave only the surfaces exposed that will be exposed in the completed installation. Paint it and cure it as it will be cured in the actual project at hand. Then, either put it in your room overnight, or use the "clean glass jar test." Place a sample in a clean gas jar. Seal the jar using aluminum foil under the lid, dull side facing the sample. Let it sit overnight, then remove the lid and check your reactions to the vapors. Remember to conduct the test in an environment free of conflicting vapors and when you feel comfortable.

IAB Comments

Most of the less-toxic products have been around for a while, and we know people who have used them and like them. They are more expensive, yet they are probably friendlier to the environment because they use less petroleum-based materials and they emit less VOC. Ultimately, their performance (coverage, durability, cleanability, and resistance to microorganisms) will determine their long-term assessment. If more must be used over the life-cycle of the painted surface, that must be considered in assessing the total environmental impact. Also, the natural ingredients have their own environmental costs that should be figured.

Suppliers in the United States:

AFM Enterprises, Inc.
1140 Stacy Court
Riverside, CA 92507
(714) 781-6860
American-made low-toxic paints and other finishes.

Auro/Sinan Company - Natural Paints
P. O. Box 857
Davis, CA 95617-0857
(916) 753-3104
Imports Auro, a less-toxic paint from Germany

Bau, Inc.
P. O. Box 190
Alton, NH 03809
Imports Biofa, a less-toxic paint from Germany

Environmental Outfitters
Santa Monica, CA
P.O. Box 514
New Canaan , CT, 06940
(203) 966-3541
Imports a wide range of less-toxic products.

Livos Plant Chemistry
1365 Rufina Circle
Santa Fe, NM 87501
(800) 621-2591
Imports paints and finishes from Germany.

Miller Paint Company
317 SE Grand Avenue
Portland, OR 97214
(503) 233-4491
American-made low-toxic paints and other finishes.

References:

David Dobbs, "Paint it Green: Low-toxic choices for the chemically sensitive." *Harrowsmith Country Life*, September/October 1991. pp. 55-56.

"State of the Art: The Greening of Interiors," *Interior Design*, August 1991. [The entire issue is devoted to "green" interior design — products, resources, examples.] Available from Interior Design, Cahners Publishing Company, 44 Cook Street, Denver, CO 80206-5800. (303)388-4511, ext. 377 or (800) 542-8138. Individual copies cost $10; prepayment is required.

Researchers Evaluate Work Station Furnishings with Built-in Filtration

Professor Alan Hedge of Cornell University has evaluated the effects of a "furniture-integrated breathing-zone-filtration" (BZF) system manufactured by Centercore of New Jersey. In a paper published in the *Proceedings of IAQ 91 - Healthy Buildings*, Hedge, Michael Martin of Centercore, and John F. McCarthy of Environmental Health and Engineering in Newton, Massachusetts, report that the BZF system significantly reduces reported SBS symptoms as well as particulate concentrations.

The Centercore system uses a fan built into a workstation partition system to circulate air through a three-stage filter. The first stage is a polymer pre-filter to remove larger particles; the second stage is an activated carbon polymer filter to remove VOCs; and, the third stage is a high-efficiency particulate air filter (HEPA) rated to remove 99.97% of particulates 0.3 um or larger in diameter. The schematic design of the system and its operation are shown in Figure 3.

The units are intended to circulate room air through the filters between 7.5 and 13 times per hour depending upon the density of the installations, ceiling heights, and the fan speed setting, which is controlled by the occupants. Fan noise in an unoccupied office is 38 dBA at low speed and 57 dBA at high speed. The frequencies are in the range of speech, from 250 Hz to 4 KHz; the fan noise could be considered an advantage in terms of providing privacy in an open office or a hindrance in terms of interfering with communication.

While the researchers report fewer SBS symptoms and improved occupant evaluation of ventilation, thermal comfort, and IAQ, they state that the time elapsed between the pre-BZF and post-BZF installation studies was too short and that the changes in environmental conditions and the SBS symptom reports were not statistically significant. Particulate counts did decrease after installation of the BZF units.

IAB Comments

Based on its design and operating concept, a BZF unit certainly can improve air circulation and reduce particulate concentrations. We did not find any test data on the BZF unit's ability to remove VOCs, and we question whether the system can really be effective for that purpose without a very large quantity of carbon adsorbent.

We are concerned about relying on filters distributed throughout an office building to provide clean air. More specifically, we are concerned that filters will not be replaced as frequently as required. If they are not changed at appropriate times, they will become secondary sources of air contaminants. The filters are quite expensive, and management may not be inclined to replace them unless there are occupant complaints. In a discussion with Centercore's Michael Martin two years ago, we learned that filter replacement in the field does not usually occur as often as recommended.

Where BZF units are used to collect environmental tobacco smoke (ETS) constituents in or adjacent to designated smoking areas, the semi-volatile compounds in

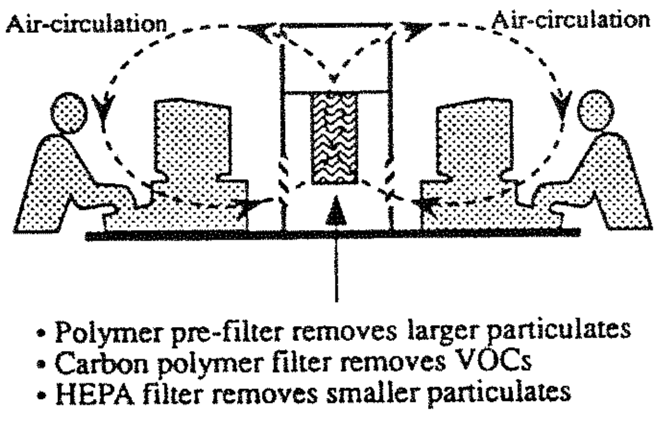

Figure 3 - Design of the Breathing-Zone Filtration (BZF) System.

ETS associated with carcinogenic and mutagenic activity may be adsorbed and re-emitted over time. Thus, the air may be clearer from the removal of particulate matter, but the vapors associated with some of the harmful and unpleasant effects of ETS may not be sufficiently controlled.

Reference:

A. Hedge, M.C. Martin, and J. F. McCarthy, "Breathing Zone Filtration Effects on Indoor Air Quality and Sick Building Syndrome Complaints," in *Proceedings of IAQ 91 - Healthy Buildings,* September 4-8, 1991, Washington, DC. Atlanta: American Society of Heating, Refrigerating, and Air-conditioning Engineers, Inc. pp. 351-357.

For more information:

Professor Alan Hedge, Ph.D., Cornell University Department of Design and Environmental Analysis, Ithaca, NY 14853-4401. 607 255-1957.

Emissions Testing

Danes and Swedes Develop New Small Test Device

Danish and Swedish indoor air researchers have successfully collaborated to develop a new small, handy emissions testing device called the "FLEC."FLEC is the acronym for Field and Laboratory Emission Cell. It will be useful for testing flat materials in both laboratory and field settings due to its portability. The researchers who developed it have already conducted round-robin tests to validate its performance.

The device is circular with an "active" diameter of 15 centimeters (about 6 inches). It provides for a test material surface area of 0.0177 m^2 (0.19 ft^2) and a volume of 0.035 liters (0.13 gallons). The loading factor is 506 m^2/m^3 — about a thousand times higher than that used in most small environmental chamber testing to date. The researchers have used an air exchange rate of 171/hour in the test cell compared with the usual rate of about 0.5 to 2.0 or 3.0 used in more traditional chambers.

The test specimen is installed directly in the stainless-steel housing becoming "a part of the test device itself." It can accommodate materials of uniform thicknesses of various depths by recessing thicker materials so that the exposed surface is flush with the housing. The design provides for evenly distributed air velocity over the test specimen surface.

At ASHRAE's "IAQ 91 - Healthy Buildings," Peder Wolkoff of the Danish National Institute of Occupational Health and Hans Gustaffson of the Swedish National Testing Laboratory presented findings from their separate comparison tests. They compared their independent results using the FLEC and also compared FLEC results to 234 liter test chamber results with a 0.41 loading factor. They report that the FLEC performed well in spite of the very high air exchange rate.

They also used the FLEC to field test emissions from vinyl floor covering. Equilibrium was reached in 20 hours calculating to an emission factor of 25 $\mu g/m^2$-hr of 2-ethylhexanol. Eight percent of the equilibrium concentration was reached after one hour. Using the chamber data, researchers calculated a room air concentration of 3 μg/m3 compared to a room air measured concentration of 2 μg/m3 2-ethylhexanol.

Implications

The FLEC report indicates that there are many potentially effective variations on the 50 to 500 liter environmental chambers that have been widely used to date to determine emission factors. It also demonstrates that independent tests using the same device and protocol can produce consistent results, that chamber testing can be useful for predicting room air concentrations, and that emissions testing is maturing. The device can be reconfigured to test rough-surface materials or liquids. The high air exchange rate results in a shorter elapsed time to reach equilibrium holding promise that emissions testing could become considerably cheaper with these and other modifications.

Reference:

P. Wolkoff, P.A. Clausen, P.A. Nielsen, H. Gustaffson, B. Jonson, and E. Rasmussen, 1991, "Field and Laboratory Emission Cell: FLEC." in Proceedings of *IAQ 91 - Healthy Buildings,* September 4-8, 1991, Washington, DC. Atlanta: American Society of Heating, Refrigerating, and Air-conditioning Engineers, Inc., pp. 160-165. Available from ASHRAE, 1791 Tullie Circle NE, Atlanta, GA 30329. (404) 636-8400.

For more information:

Contact Peder Wolkoff, Ph.D., Danish National Institute of Occupational Health, Parallé 105, DK-2100, Copenhagen, Denmark. Telephone: +45 31 29 97 11, fax +45 39 27 01 07.

Hans Gustaffson, Swedish National Testing Institute, Borås, Sweden. Telephone: +46 33 165266; fax +46 33 13 55 02.

Healthy Buildings '88 Proceedings Available

Four volumes are available from the 1988 Healthy Buildings Conference held in Stockholm, Sweden, September 5-8. The conference covered the usual range of IAQ conferences but also addressed energy efficiency, lighting, noise, moisture control, and a variety of other related indoor environment topics. The volumes are available individually or as a complete set.

The titles, descriptions, pages, order numbers, and prices are as follows:

Abstract Guide. A publication of abstracts (both in English and French) of papers accepted for the conference. 445 pages. (D14:1988). SEK 100.

Volume 1, State of the Art Reviews. Modern architectural design and dose-effect relationships; demands of allergic and hypersensitive populations; comfort equation for air quality and ventilation; moisture, condensation, and tight building envelopes; design criteria for heating, cooling, ventilating and filtering in buildings; building materials and pollutant predictions and interactions; quality assurance in materials, installations, design; and, regulation and strategies for healthy buildings. 210 pages. (D19:1988). SEK 90.

Volume 2, Planning, Physics, and Climate Technology for Healthier Buildings. Contributions on building location and planning, building physics, indoor air foundation, moisture and air tightness; thermal and climate technology for individual control and low-energy but healthy buildings. 734 pages. (D20:1988) SEK 150.

Volume 3, Systems, Materials, and Policies for Healthier Indoor Air. Contributions on indoor air quality technology for low energy but healthy buildings and individual control, human requirements and specifications on choice of materials; quality assurance in materials, designs, constructions, and maintenance; and, policy and regulation for healthy buildings. 754 pages. (D21:1988) SEK 150.

Volume 4, Conclusions and Recommendations for Healthier Buildings. Includes conference highlights, workshop summaries, and comments on the following topics: building location and planning; building physics; thermal climate technology; indoor air quality technology; choice of materials; quality assurance; and, policy and regulatory science. (D15:1991) SEK 100.

Special price for the set: Abstract Guide and Volumes 1-3, SEK 390 (a saving of SEK 100). As of this writing, SEK 1 was equivalent to approximately US $0.164. That would convert SEK 390 to about US $64, a real bargain. Adding SEK 100 for Volume 4 makes the complete set cost about $80. Please contact the distributor for availability and current price.

To order, send your request to Svensk Byggtjänst, S-171 88 Solna, Sweden.

Revised "Directory of State Indoor Air Contacts" Is Available

The EPA and the Public Health Foundation have published a revised version of their "Directory of State Indoor Air Contacts." The 149-page paperback lists state agencies and programs related to indoor air. It also lists contact individuals for various indoor air contaminants. One appendix contains a listing of the 18 federal government agencies and their representatives on the Interagency Committee on Indoor Air Quality. Other appendixes list contact information for the EPA and OSHA regional offices along with their respective jurisdictions. A final appendix lists the national hotlines and information services listed below and others.

The publication is available at no cost from the EPA Public Assistance Center, 401 M Street NW, Washington, DC 20460. (202) 260-2080.

National Hotlines and Information Services (updated from the Directory Appendix D).

U. S. Environmental Protection Agency

EPA Radon Hotline (toll free): 800-SOS-RADON or (800) 757-7236.

EPA Radon Public Information: (202) 260-9605

EPA Public Information Center: (202) 260-2080

National Pesticides Telecommunications Network Hotline (toll free):

(800) 858-PEST or (800) 858-7378

(800) 743-3091 (in Texas)

TSCA Assistance (Toxic Substances and Control Act) Information Service: (202) 554-1404.

Safe Drinking Water Hotline (toll free): (800) 426-4791.

U. S. Consumer Product Safety Commission

Product Safety Hotline (toll free): (800) 638-CPSC or (800) 638-2772.

U. S. Department of Health and Human Service

NIOSH Public Information (toll free); (800) 35-NIOSH or (800) 356-4674.

Indoor Air Quality Assistance: (513) 841-4382.

Letters

VAV Pinchdown

Dear Hal:

In the seminar on legal issues of IAQ at the ASHRAE meeting in Indianapolis, your presentation on behalf of Jim Woods developed into quite a discussion on ventilation airflow during VAV pinchdown. I am writing this letter to express my opinion on the subject.

When HVAC systems are not in economizer operation, ventilation airflows have traditionally been maintained by opening outside air dampers to a minimum position. While this minimum flow will be reasonably constant for a constant volume system, it will vary widely for a VAV system.

There are many factors that complicate the prediction of ventilation airflow for VAV systems, including:

1. Existence of, and control method for the return fan (by space static pressure, volume tracking, speed tracking, etc.).
2. Exhaust airflow and variability.
3. Damper selection, sizing, and sequencing.

The dominant factor that influences ventilation airflow is supply airflow. As the supply fan volume flow is reduced, the pressure difference between the mixing plenum and the outside decreases. Outside air dampers that are held at a fixed position will tend to provide fixed fraction rather than fixed volume flow of outside air. A similar result was found from simulations performed by Solberg et al. as reported in the January 1990 issue of *ASHRAE Journal*.

Thus, a VAV system that operates at 50-percent volume will provide half of the ventilation airflow that it did at maximum volume. This was one of the key assertions in the case discussed at Indianapolis, demonstrating that the occupants did not receive adequate amounts of ventilation air at all times.

Fixed minimum position control of ventilation air is not adequate for VAV systems. Closed loop control of the outside air damper based on a airflow measurement, is the best way to assure proper and continuous ventilation airflow.

I hope this discussion is useful in supporting the important point that you made at the seminar.

Sincerely,

Jarrell D. Wenger, P.E.
Senior Research Scientist
Johnson Controls, Inc.
Milwaukee, Wisconsin

Calendar

October 3-4, 1991. **"Diagnosing and Mitigating Indoor Air Quality Problems."** Chicago, Illinois. *Contact: AEE Energy Seminars, P. O. Box 1026, Lilburn, GA 30326 (404) 925-9633, fax (404) 381-9865. Instructor Francis J. Offermann provides hands-on demonstrations for using IAQ measurement equipment. Fee is $750, AEE Member $650.*

October 9-11, 1991. **Fifth National Meeting, American Assocation of Radon Scientists and Technologists.** Crown Plaza Holiday Inn, Rockville, Maryland. Contact: Harry Rector, 1991 Radon conference, MAC AARST, P. O. Box 1272, Germantown, MD 20575. (301) 428-9898. *Technical sessions and panel discussions to cover practical, scientific, and policy issues related to the discovery, investigation, and control of radon in buildings. A full program of continuing education and professional development courses will be offered October 8-9 and 12.*

October 22-25, 1991. **"1991 World Environmental Engineering Congress."** Sponsored by the Association of Energy Engineers. Georgia World Congress Center, Atlanta, Georgia. Contact: Association of Energy Engineers, 4025 Pleasantdale Rd., Atlanta, GA 30340. Phone (404)446-0007. Fax (404)446-3669. *Indoor Air Quality sessions Wednesday afternoon and Friday morning. Exhibits. Courses on Indoor air diagnostics, Corporate asbestos management on Tuesday afternoon. Conference registration fee: $495 for AEE members, $595 for non-members. Course registration: $395 each.*

October 28-November 1, 1991; January 6-10, 1992; March 2-6, 1992; 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 $700 for five days.

November 4-7, 1991. **ASTM Subcommittee D22.05 on Indoor Air.** San Diego, California. Contact: George Luciw, ASTM, 1916 Race Street, Philadelphia, PA 19103.

November 10-13, 1991. **IFMA '91, San Diego: "Improving the Environment."** Sponsored by the International Facilities Management Association (IFMA), San Diego, California. Contact: Christine Katnich, IFMA, 1 East Greenway Plaza, 11th Floor, Houston, TX 77046-0194. Fax (713)623-6124. *There are three sessions on IAQ at this year's IFMA meeting including two on Tuesday, the 12th and one on Wednesday, Nov. 13. Exhibition also: 200 exhibitors.*

November 14-16, 1991. **"Blueprint for a Healthy House Conference."** The Urban Center, Cleveland State University. Sheraton City Centre, Cleveland, Ohio. Contact: Barbara Benevento, The Urban Center, Cleveland State University, Cleveland, OH 44115. (216) 687-6947.

November 18-19, 1991. **"How to Meet New Ventilation Standards: Indoor Air Quality and Energy Efficiency.** Sponsored by the Association of Energy Engineers. Atlantic City, New Jersey. Contact: AEE Energy Seminars, P. O. Box 1026, Lilburn, GA 30326 (404) 925-9633, fax (404) 381-9865. *Instructors are Francis J. "Bud" Offermann, and Thomas Gilbertson. Registration fee $750; $650 for AEE Members.*

December 10-12, 1991. **Indoor Air Quality Program.** Harvard School of Public Health, Boston, Massachusetts. Contact: Mary F. McPeak, Office of Continuing Education, Harvard School of Public Health, 677 Huntington Avenue, Boston, MA 02115. (617) 432-3515, (617) 432-1969. *This course focuses on the health hazards of various indoor air pollutants, their physiological, toxicological, and perceptional aspects, and in-field monitoring strategies and instrumentation. Enrollment is limited to 50. Fee is $750.*

January 26-29, 1992. **ASHRAE Winter Meeting and Exhibition.** Anaheim, California. Contact: ASHRAE Meetings Department, 1791 Tullie Circle N.E., Atlanta, GA 30329 (404) 636-8400.

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. For Call for papers or to submit abstracts: Timothy M. Dyess, Radon Mitigation Branch, MD 54, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711

International

August 30th - September 4, 1991. **9th World Clean Air Congress & Exhibition: Towards the year 2000: critical issues in the global environment.** Montreal, Province of Quebec, Canada, Queen Elizabeth Hotel. Sponsored by the International Union of Air Pollution Prevention Association. Contact: The air pollution control association in your country.

September 9-13, 1991. **Clean Air At Work; New Trends in Assessment and Measurement.** Luxembourg. Sponsored by the Commission of the European Communities. Contact: Mr. D. Nicolay, Commission of the European Communities, DG XIII/C3 JMO B4/087 L-2920 Luxembourg. Fax: (352) 4301-4544.

September 22-28, 1991. **Fifth International Symposium on the Natural Radiation Environment.** University of Salzburg, Austria. Sponsored by the Commission of the European Communities, the U.S. EPA, and the U.S. Department of Energy. Contact: Dr. Martial Olast, DG XII D-3 (ARTS 3/51), rue de la Loi. 200, Brussels, Belgium. 32-2/235 07 23, Fax 32-2/236 20 06.

November 5-8, 1991. **1991 Far East Conference.** Sponsored by ASHRAE. Hong Kong. Contact: ASHRAE, Meetings Department, 1791 Tullie Circle N.E., Atlanta, GA 30329 (404) 636-8400.

December 3-7, 1991. **International Conference on Human - Environment System, ICHES '91.** Nihon Daigaku Kaikan, Tokyo, Japan. Contact: Yutaka Tochihara, Secretary General, ICHES, c/o Department of Physiological Hygiene, The Institute of Public Health, 4-6-1 Shirokanedai, Minato-ku,m Tokyo, 108 Japan. Tel. +81-3-441-711 Ext 240, (after Jan. 1, 1991, +81-3-3441-7111 Ext 240); Fax +81-3-446-4635.

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 Indooir Envirommnent, Unit 6, 2 Old Brompton Road, London SW7 3DQ, UK. *Call for papers has been issued; 200-300 word abstracts are due September 15.*

Indoor Air BULLETIN

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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.