#6893

Some critics argue that the mice can easily be hurt as they struggle to get free from the restraint. Others suggest that the test, intended for respiratory irritancy, depends on exposing the mice to known, controllable concentrations of chemicals; the carpet and other product tests conducted at Anderson Labs characterize the *source* of the test atmosphere rather than the test atmosphere itself. Furthermore, Anderson is observing neuro-behavioral responses rather than the respiratory rate for which the standard test was devised. While the observations are based on a panel of factors used by EPA scientists, there is no standardized test methodology, and the use of the mouse bioassay to test carpets is not a standardized and validated test procedure. If EPA's tests do replicate Anderson's results, then it is certain that there will be efforts to validate the tests. For now, it is all something of a black box.

Difficulties in Interpretation

The chemical composition and concentration of Anderson's test atmospheres were not reported and that makes the results difficult to interpret. (The EPA protocol included measuring the test atmospheres and that should be helpful.) The carpets were not new: many of the carpets associated with the mouse deaths were taken from buildings where occupants had symptoms after carpet installation. If you test old carpet, you see lots of chemicals coming out that weren't in the carpet when it was new. Therefore, it is likely that used carpet emissions will be quite different from new carpet emissions. After all, the very large surface area of the carpets makes them excellent sinks — they act as a sample collection medium. Besides collecting air contaminants, the carpet also collects chemicals on tracked-in dirt and from spills.

All of these concerns notwithstanding, Dr. Anderson announced in late April that a mouse died when she tested a sample of new carpet. She collected the sample according to the Consumer Product Safety Commission protocol, the mouse was unrestrained, and the carpet was unheated. While this responds to some of the criticisms, the work (like nearly all of Anderson's findings) has not been reported in a scientific paper, and it is still not clear what it might mean. We do not expect the results of the EPA tests to explain why mice have died in Dr. Anderson's lab, even if EPA's mice die as well. The tests are not intended to provide that kind of information.

Conclusions

The EPA tests will likely show that indeed, both new and used carpets have substantial emissions. And, many will use the results to further their views on the health effects of new carpet installations. However, the EPA tests will simply replicate Anderson's tests, not establish health effects or why the mice died. To establish causation, we need to know the specific source(s) and identities of the chemicals causing the physiological and health effects; the emissions of such chemicals from carpets (if, in fact, carpets are the source); and, the pathophysiological mechanism by which the effects occur. To date, no one has provided very much evidence even to suggest answers to these questions.

However, it is clear that many people suffer from health and comfort effects after carpets are installed, and there is a variety of possible causes. We outlined many of those in the ***BULLETIN*** Vol. 2, No. 6. They include:

- The very easily detectable "new carpet" odor of 4-phenylcyclohexene emitted from SBR latex-backed carpets.
- The use of solvent-based adhesives in many installations.
- The potential emissions from carpet cushions.
- The possibility of some "bad batches" of carpets, and others.

The answers to the carpet issues are not close at hand. We have advised avoiding SBR-latex-backed carpets because of the odor, and we advise properly cleaning and maintaining carpets wherever they are used. Finally, we have advised using the low-VOC adhesives (non-solvent based) to avoid unnecessary solvent exposures. Beyond that, people will continue to wait for real answers to the carpet questions.

Ventilation

New ASHRAE Ventilation Standard Outline

In the last issue, we discussed the proposed outline for ASHRAE's revision of Standard 62-1989. This outline was approved by the committee at its January meeting in Chicago. The accompanying tables are the complete outline of the revised standard as presented to the committee by its chair, W. Gene Tucker of the US EPA. Tucker also compared the outline to the Guidelines for Ventilation Requirements adopted by the European Concerted Action Committee on Indoor Air Quality.

Comparison of 62-1989 and Proposed 62-199x

Standard 62-1989

Forward

1. Purpose
2. Scope
3. Definitions (incl. diagram)
4. Classification
5. Systems and equipment
6. Procedures
   - 6.1 Ventilation rate procedure
   - 6.2 Indoor air quality procedure
   - 6.3 Design documentation procedures
7. References

Appendices

- A Conversion factors
- B Positive combustion air supply
- C Guidance for AQ criteria
- D Rationale for CO_2
- E Procedure for cleaned recirculated air
- F Ventilation effectiveness
- G Rationale for lag or lead time for transient occupancy
- H Rationale for reducing outdoor air when loads unequal

ASHRAE policy statement on environmental impacts

Proposed 62-199X

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4. General requirements
5. Design procedures for comm-inst buildings
   - 5.1 Determining the design ventilation rate
   - 5.2 Procedure for minimum ventilation rates
   - 5.3 Procedure for additional ventilation rates
6. Design requirements for residential buildings
   - 6.1 Single-family residences
   - 6.2 Multiple-family residences
7. Documentation of design and op. guidelines
8. Operating and maintenance procedures
   - 8.1 HVAC system
   - 8.2 Other activities affecting indoor air quality
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ASHRAE policy statement on environmental impacts

Proposed 62-199x Changes from 62-1989

- Separate section for residential
- Separate section for design documentation
- New section for O & M
- Appendix: Method for determining OA
- Appendix: Example of calculations
- More explicit treatment of sources, air cleaning
- Ventilation rate procedure for minimum rates
- IAQ procedure explicit

Detailed Contents of Proposed 62-199x Sections 4 & 5

Section 4 - General Requirements

Combines Section 4 & 5 of 62-1989

Discusses general principles of ventilation

- Purposes
- Impacts on IAQ (+ & -)
- Dilution ventilation vs. exhaust ventilation
- Transfer air from low-conc. to higher-conc. spaces
- Operation for transient occupancy
- Operation during high-emission periods
- Meet Standard 55 (thermal comfort) conditions
- Prevent conditions that promote microbial growth
- Location of air intakes
- Etc.

Summarizes good engineering practice

Section 5 - Design Procedures for Commercial-Institutional Buildings

5.1 Design Ventilation Rate

DVR = Min VR + Add'l VR

= Sec. 5.2 + Sec. 5.3

5.2 Minimum Ventilation Rate

- Accounts for people and unique source
- Uses current Table 2 (Reviewed)
- Relates to floor area (e.g. LPS/M²)

5.3 Additional Ventilation Rate

- Accounts for strong non-occupant sources
- Tabulates factors for additional rates
- Tabulates default values
- Encourages evaluation of source mgt., air cleaning

Table 5.3A - Additional Ventilation Rates for Spaces with High-Emission Sources

Source Type*	Max. Emission Rate For Sec. 5.2 mg/h-m² (a)	Add'l Vent. Rate for High-Emission Spaces L/s-m² (b)
Floor coverings	Values in this column would be derived from concentration limits for contaminants, minimum ventilation rates listed in Section 5.2, and an assumption regarding mixing of air and contaminants. For assumption of complete mixing, $ER_{5.2}$ = C - MVR.	Values in this column would be derived from $AVR = DVR - MVR = \frac{ER}{C} - \frac{ER_{5.2}}{C} = \frac{ER - ER_{5.2}}{C}$
Total organic vapors		
Furniture		
Total organic vapors		
Office machines		
Ozone		
Particles (PM_{10})		
Total organic vapors		
Organic solvents		
Total organic vapors		
Smoking		
Particles (PM_{10})		
Unvented space heaters		
Particles (PM_{10})		
Sulfur dioxide		
Total organic vapors		
Wall coverings		
Total organic vapors		

* Types listed are illustrative only

Units

(a) Milligrams/hour (mg/h) per square meter of floor area (or certified low-emission product)

(b) Liters/second per square meter floor area, per mg/h-m² above the maximum ER for section 5.2

Detailed Contents of 62-199x Sections 4 & 5 - continued

Table 5.3b - Default Values for Additional Ventilation Rates *(Illustrative draft 1-24-93)*

Source Type	**Default Emission Rate (ER) mg/h-m² (a)**	**Add'l Vent. Rate for Default ER L/s•m² (b)**
Floor coverings		
Total organic vapors	Values in this column would be selected from emission rates found in the literature (high, but not extreme values).	Values in this column would be derived from $AVR_{def} = \frac{ER_{def} - ER_{5.2}}{C}$
Furniture		
Total organic vapors		
Office machines		
Ozone		
Particles (PM_{10})		
Total organic vapors		
Organic solvents		
Total organic vapors		
Smoking		
Particles (PM_{10})		
Unvented space heaters		
Particles (PM_{10})		
Sulfur dioxide		
Total organic vapors		
Wall coverings		
Total organic vapors		

Units
- (a) Milligrams/hour of contaminant per square meter of floor area
- (b) Liters/second of outdoor air per square meter of floor area

[Ed. note: The ventilation rates in 5.2 and 5.3 are calculated as described below.]

Minimum Ventilation Rate
- Select rates from Table [12] to ensure sensory comfort from occupant load
- Also covers unique sources (e.g., in kitchens, dry cleaners, swimming pools)

Additional Ventilation Rate
- Determine whether space has potentially strong sources [Table 5.3]
- For such sources in space, determine whether source strength greater than acceptable under MVR [Table 5.3l
- If not, use MVR
- If stronger, calculate AVR [Table 5.3]
- If unknown, use default value for AVR [Table 5.3]

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Furniture		
Total organic vapors		
Office machines	For assumption of complete mixing, $ER_{5.2} = C - MVR$.	
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Particles (PM_{10})		
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Organic solvents		
Total organic vapors		
Smoking		
Particles (PM_{10})		
Unvented space heaters		
Particles (PM_{10})		
Sulfur dioxide		
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Wall coverings		
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Detailed Contents of 62-199x Sections 4 & 5 - continued

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Total organic vapors	Values in this column would be selected from emission rates found in the literature (high, but not extreme values).	Values in this column would be derived from $AVR_{def} = \frac{ER_{def} - ER_{5.2}}{C}$
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Total organic vapors		
Organic solvents		
Total organic vapors		
Smoking		
Particles (PM_{10})		
Unvented space heaters		
Particles (PM_{10})		
Sulfur dioxide		
Total organic vapors		
Wall coverings		
Total organic vapors		

Units

(a) Milligrams/hour of contaminant per square meter of floor area

(b) Liters/second of outdoor air per square meter of floor area

[Ed. note: The ventilation rates in 5.2 and 5.3 are calculated as described below.]

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- Also covers unique sources (e.g., in kitchens, dry cleaners, swimming pools)

Additional Ventilation Rate

Determine whether space has potentially strong sources	[Table 5.3]
For such sources in space, determine whether source strength greater than acceptable under MVR	[Table 5.3]
If not, use MVR	
If stronger, calculate AVR	[Table 5.3]
If unknown, use default value for AVR	[Table 5.3]

European Guidelines

[Ed. note: For comparison, Tucker presented the methods used to establish ventilation rates in the European Ventilation Guidelines. Table references are to tables in the European guideline.]

Comfort

- Select perceived IAQ desired (A, B, C)
- Determine vent. rate (LPS/OLF) [Table 1]
- Select perceived outdoor AQ [Table 5]
- Estimate sensory pollutant load (OLF/M^2)
  - Occupants [Tables 3,4]
  - Non-occupant sources [Table 2]
- Select vent. effectiveness [Table 6]
- Calculate vent. rate for comfort

Health

- Identify most critical contaminant(S)
- Estimate source strengths
- Calculate vent. rate to meet permissible concentration(S)

Required rate

- Higher of rates for comfort or health

Ventilation

Corrected Ventilation Rate Table

In our Vol. 2 No. 8 issue we published a table of outdoor air exchange rates with a significant error throughout it. The table listed values of outdoor air in air changes per hour (ACH) based on percent outdoor air, ceiling height, and total air supply per square foot. The values we published were low by a factor of ten. We republish that table here with the correct values and apologize for any inconvenience or puzzlement we may have caused our readers.

We were encouraged to learn that some ***BULLETIN*** subscribers are careful readers and did try to use the table. We thank them for calling the error to our attention. If you ever see any errors or have any questions about what you read in the ***BULLETIN***, please do not hesitate to write, call, or fax us. We appreciate and value your comments and responses.

Outside Air as % of Total Supply Air		*Ceiling height (feet)*				
	8.0	*8.0*	*10.0*	*10.0*	*12.0*	*12.0*
	Total supply air (cfm/sf)					
	0.5	*1.0*	*0.5*	*1.0*	*0.5*	*1.0*
	AIR CHANGES PER HOUR					
10	0.4	0.8	0.3	0.6	0.3	0.5
20	0.8	1.5	0.6	1.2	0.5	1.0
30	1.1	2.3	0.9	1.8	0.8	1.5
40	1.5	3.0	1.2	2.4	1.0	2.0
50	1.9	3.8	1.5	3.0	1.3	2.5
60	2.3	4.5	1.8	3.6	1.5	3.0
70	2.6	5.3	2.1	4.2	1.8	3.5
80	3.0	6.0	2.4	4.8	2.0	4.0
90	3.4	6.8	2.7	5.4	2.3	4.5
100	3.8	7.5	3.0	6.0	2.5	5.0

Table 1 - Outside air exchange rate for three ceiling heights and two air distribution rates according to OSA% at air handler and distribution air volumetric flow rate in cfm/ft^2 of building area.

(Corrected version of ***BULLETIN*** Vol. 2 No. 8 Table 2.)

New England Journal of Medicine Ventilation Report — Good Research, Wrong Problem

What can happen when a good study design is poorly applied? The study can be seriously flawed and misleading results can be reported. When those results are inaccurately reported in a periodical like the *New England Journal of Medicine (NEJM)*, and then widely oversimplified by the media, lots of people can be misled. That is exactly what happened with a recent study of ventilation, IAQ, and symptoms of sick building syndrome (SBS).

The myth engendered by the article is that ventilation does not affect SBS symptom rates. By inference, therefore, any impacts it may have on IAQ are not important. In fact, several very large European studies have shown that lower ventilation rates do affect SBS symptom prevalence. Ventilation has a major impact on IAQ at the ventilation rates of interest for problem buildings.

Where did the Canadian researchers err? The study reported in the *NEJM* looked at ventilation rates that are virtually irrelevant to SBS symptoms, and the authors inaccurately reported what their study showed. Their study compared SBS symptom rates at 64 and 30 ft^3/min/person (cfm/p) of outside air; yet the range of interest for SBS symptoms is between 5 and 20 cfm/p, with 20 cfm/p widely believed to be sufficient to prevent an excess of SBS symptoms. In other words, the researchers completely missed the mark in their range of ventilation rates. {Note: To convert cfm/p to liters per second per person - L/s/p - multiply cfm/p by 0.47.)

The Menzies *et al.* Research Project

The recently published article by Richard Menzies, M.D., and several colleagues from various other relevant disciplines appeared in the March 25, 1993, *NEJM*. It describes a study of four Montreal, Canada, office buildings in a "randomized double-blind multiple-crossover trial... conducted to estimate the effect of changes in the outdoor-air supply..." on SBS symptom report rates.

The researchers studied the effect by manipulating ventilation in each of the four study buildings, two at a time. They reported changing ventilation from 64 to 30 ft^3/min/person (cfm/p) of outside air or 30 to 14.2 liters per second per person (L/s/p). The buildings were ventilated at the two outside air supply rates alternately for six one-week cycles each. Each week the study building occupants filled out questionnaires on their symptoms and their perceptions of the indoor environment, and researchers measured various building environmental parameters.

The researchers concluded that increasing the outdoor air supply "...did not appear to affect workers' perceptions of their office environment or their reporting of symptoms considered typical of the sick building syndrome." Their results did show clear impacts of the ventilation rates on indoor air pollutant concentrations although they did not stress these findings; apparently these results conflicted with their banner headline conclusion. They did report a correlation between perceptions of environmental quality and the number of SBS symptoms reported.

The researchers reported they did not achieve the ventilation rates they attempted to study but, rather, significantly higher rates (30 and 64 ft^3/min instead of the intended 20 and 50 ft^3/min).

The *BULLETIN* Comments

Several IAQ authorities told the ***BULLETIN*** that the ventilation rates actually achieved were not what was reported, and there was general agreement that the methodology for estimating the ventilation rates was seriously flawed. However, there was no agreement as to what the ventilation rates actually were in the study. In fact, the researchers did not report sufficient details of their ventilation rate measurements to allow reliable analyses of their estimates, and their reporting of their data collection was generally insufficient for a critical reading. We checked four published articles related to the same study and did not find any well-reported measurement methods.

We found other errors and sloppiness in the report. For example, citations were incorrect; and, different citations were referenced serially in making a logical argument where the actual studies cited differed enough to invalidate the explicit or implicit comparisons and logic. One of the four buildings permitted smoking, but this was only mentioned in passing and not discussed further.

The Damage

The researchers' conclusion that ventilation did not appear to affect SBS symptom prevalence has been reported widely in the popular press including such respected newspapers as the *Wall Street Journal* and the *Washington Post*. Many of our readers have expressed concern and even alarm at the widespread misinformation. One IAQ expert who works at an engineering firm said all his colleagues are using the study results to argue that outside air ventilation rates are not important.

The evidence does not support that conclusion, neither from this study nor from many others. There are several large-scale IAQ studies that did show a relationship between ventilation and SBS symptom reporting rates. A major difference is that these other studies looked at ventilation rates well below those reported by Menzies *et al.* Menzies should have reported that there was no apparent impact on SBS symptom rates at the very high ventilation rates studied, but that even the lower of these rates was well above those found in most reported problem buildings.

In fact, there is little concern about buildings with ventilation rates in excess of 30 cfm/p. The concerns tend to be about buildings with ventilation rates less than 20 cfm/p. Even the lower of the two ventilation rates they reported studying was well above the highest level at which any IAQ authorities have suggested SBS symptoms might occur except in cases of unusually strong contaminant sources. Again, the range of interest is primarily between 5 and 20 cfm/p, with 20 cfm/p widely believed to be sufficient to prevent an excess of SBS symptoms.

Study Full of Problems

To make matters worse, there were significant errors in the way the researchers measured the CO_2 levels and used the results to estimate the ventilation rates. Andy Persily and Stuart Dols at the National Institute of Standards and Technology have shown that there are many problems involved in the measurement of CO_2 concentrations in indoor air to estimate ventilation. Persily and Dols' work shows that CO_2 measurements made in the manner reported by Menzies *et al.* are an unreliable basis for estimating ventilation rates and that they usually overestimate the actual rate.

The estimates of ventilation rates using the CO_2 measurements were also flawed. Among the technical errors that appear in the *NEJM* article are the use of the wrong units for the per-occupant CO_2 generation rate (0.75 ft^3 per minute reported instead of 0.75 ft^3 per hour) and the use of an incorrect equation for the estimation of ventilation based on concentrations. The authors appear to have disregarded several assumptions required for tracer gas theory and ventilation rate estimation. These assumptions included steady state (equilibrium) conditions for occupant-generated CO_2, constant ventilation rate, and uniform CO_2 concentrations throughout the building.

Some Interesting Results Did Emerge

Although not emphasized by the Menzies article, the researchers' environmental measurements showed that there were significant differences in the environments at the different ventilation rates. For example, at the higher ventilation rates, mean VOC concentrations were only 36% (287 to 792 $\mu g/m^3$) of VOC concentrations at the lower ventilation rates. Also, mean formaldehyde concentrations at the increased ventilation rate were 62% of formaldehyde concentrations at the reduced ventilation rates — 24 ppb compared with 39 ppb.

While they reported differences in the IAQ at the different ventilation rates, their analysis of occupant questionnaire responses led them to conclude that the occupants did not perceive differences in the environment nor did occupant satisfaction with the environment change. But the data showed an overall increase in the inter-subject symptom reporting rates from about 40 to about 60 percent as a function of temperatures ranging from 21 to 24.5 °C. (See Figure 1.) Also, they found a decrease in the inter-subject number reporting SBS symptoms from about 60% to about 40% as air velocity increased from about 0.03 to about 0.17 meters per second (m/s), about 5.5 to about 35 feet per minute (fpm). (See Figure 2.) These are potentially important results that received far too little attention from the authors.

There was also a correlation between the number reporting symptoms and their "environmental satisfaction score." While this type of finding is not unique to the Menzies study, these findings suggest that ventilation is important. The researchers simply did not focus their report on the variables most affected by ventilation. No doubt it would have been less likely to receive publication in the *NEJM*.

Finally, the categorical reporting of symptoms is always a less sensitive tool than more detailed symptom questions. And, environmental measurements made remotely in space or time from the occupant questionnaire administration are always found less well-correlated with symptoms.

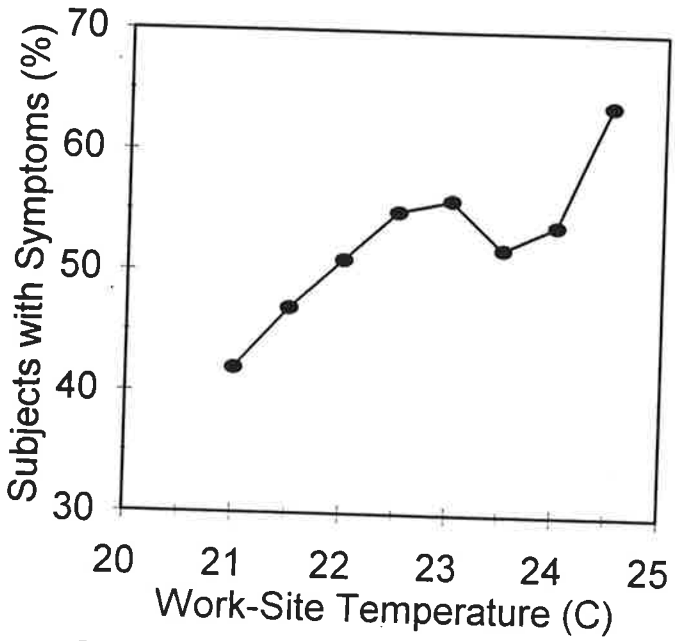

Figure 1 - Percent of occupants reporting SBS symptoms as a function of temperature.

This is surely not the first defective indoor air study that has been published. It is extremely difficult to control conditions in field studies of this type. But we can expect careful measurement work, studying variables that are relevant to the problem being studied, and sufficiently detailed reporting to allow careful reading and analysis.

Because the popular press and others have reported the publication of the study the way they did, it has been taken as evidence that ventilation does not significantly affect IAQ and IAQ-related occupant symptoms. The authors' conclusion totally ignores the relationship between typical contaminant concentrations and ventilation rates in office buildings. We have frequently published data and graphs to convey this relationship. Figure 3 illustrates this relationship again.

We call on the researchers to communicate to readers of the *NEJM* and the wider public that their study did not show what their published conclusion said it showed, to clearly qualify their previous conclusion, and to vigorously disseminate their revised conclusion to the media.

Ventilation and IAQ, Again

The relationship between ventilation rates and contaminant concentrations is not linear. At low ventilation rates, large contaminant concentration changes occur; and at high ventilation rates, small concentration changes occur, as seen in Figures 3 and 4.

Summarizing, for typical office building ventilation rates of 0.5 to 1.5 ACH, indoor source contaminant concentration plots are likely to go from a generally steep slope to a generally shallow slope. That is, the knee of the plot of a contaminant concentration curve is likely to occur within the range of ventilation rates often found in typical office buildings. The result is that at lower ventilation rates within this range, small changes in ventilation result in significant changes in contaminant concentrations. Figure 4 shows this relationship for VOC concentrations in the range of 0 to 5 ACH with various contaminant source strengths.

References:

Richard Menzies, Robyn Tamblyn, Jean-Pierre Farant, James Hanley, Fatima Nunes, and Robert Tamblyn, "The Effect of Varying Levels of Outdoor Air Supply on the Symptoms of Sick Building Syndrome." *New England Journal of Medicine*, Vol. 328, No. 12, March 25, 1993, pages 821-827.

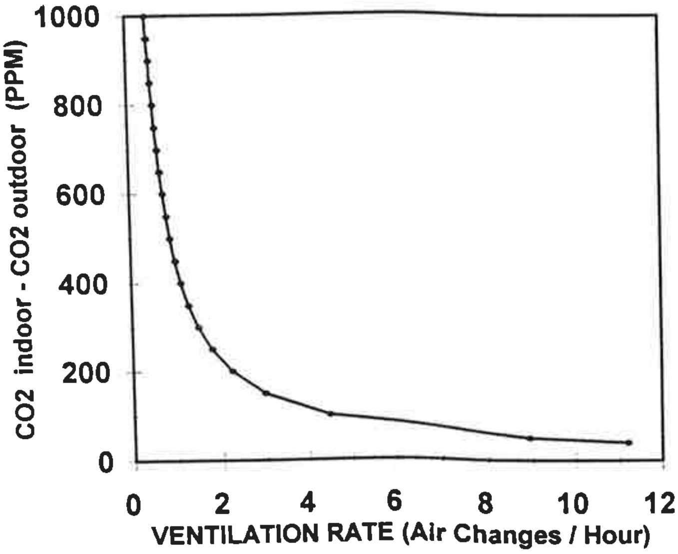

Figure 3 - Indoor CO_2 minus outdoor CO_2 vs. ventilation (ACH).

1 person/142 sq ft, 10 ft ceiling height. Outdoor CO_2 assumed to be 350 ppm. CO_2 generation rate = 0.0106 cfm.

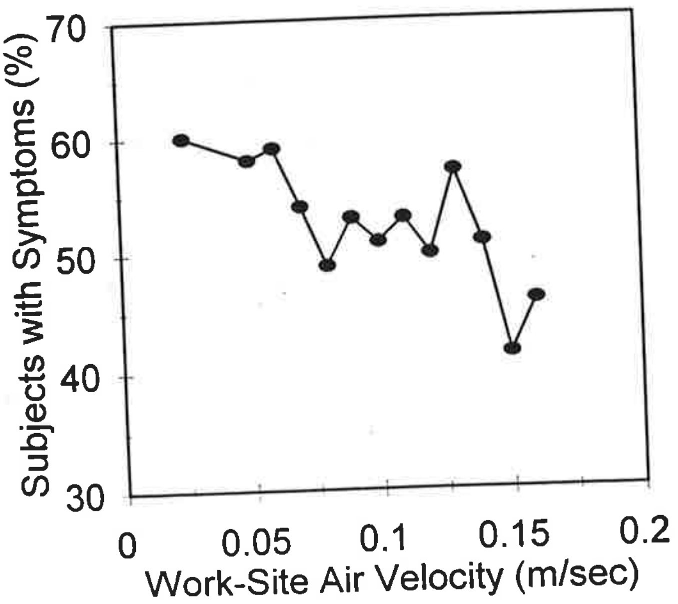

Figure 2 - Percent of occupants reporting SBS symptoms as a function of air velocity.

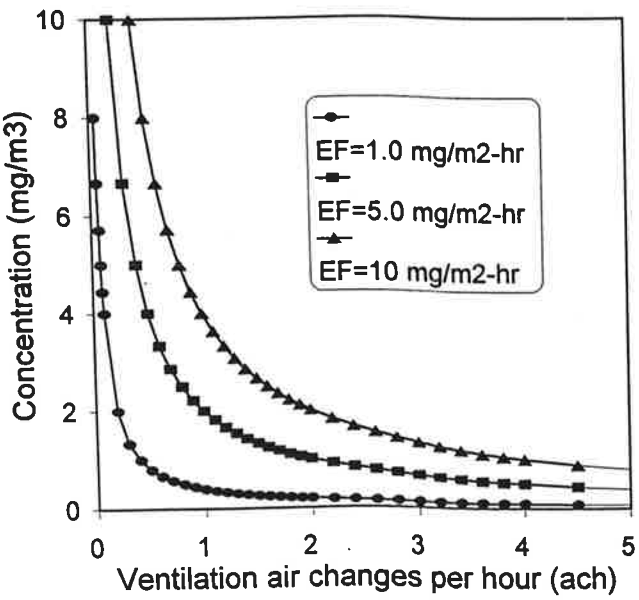

Figure 4 - VOC concentration as a function of ventilation rate.

Menzies *et al.*, "Sick Building Syndrome: The Effect of Changes in the Ventilation Rates on Symptom Prevalence: The Evaluation of a Double Blind Experimental Approach" in *Proceedings, Indoor Air '90*, Toronto, July 1990, Vol. 1, 519-524.

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VOC Sources

Toxic VOC Emissions From Correction Fluids

A recent study found that typewriter correction fluids available in Asia emit some very toxic VOC into indoor air. While the size of the little bottles characteristically used for correction fluid is rather small, more than 50% of the contents of most of these bottles available in Singapore, Indonesia, and Malaysia were organochlorine solvents.

Interest in testing correction fluids resulted from an observed increase in the use of correction fluids for "glue sniffing" by school children. The products are widely available in supermarkets and stationery shops in developing Asian countries. One of the most interesting aspects of these products for IAQ is that this type of product is often used, even properly, very close to the user's breathing zone. Thus, personal exposure is many times higher than what might be measured in typical indoor air sampling. Actual exposure of the individual, therefore, is not adequately characterized by most indoor air sampling protocols used in problem building investigations and in research projects.

California health department researchers investigated a popular correction fluid product in connection with the state's Proposition 65 requirements. They found that a single use of the product could result in significant day-long exposure at levels representing a potential health hazard. The result of the state's test was the substitution of a water-based fluid by the manufacturer to avoid labeling requirements under California state law.

Research Method and Results

Researchers from Singapore and Birmingham (UK) worked with "off-the-shelf" correction-fluid products commonly used by school children and office workers. They tested two-drop samples from the typical 20 ml. bottles using a headspace technique with GC/MS confirmation. Organochlorine compounds were the most commonly used solvent for the correction fluids. Trichloro or tetrachloro compounds were found in 14 of the 20 products tested.

The researchers also found that 9 out of 20 products contained between 26 and 95% 1,1,1-Trichloroethane. Among the other most commonly encountered solvents at significant concentrations were carbon tetrachloride, n-hexane, methylene chloride, and methyl cyclohexane. Methylene chloride (dichloromethane) was in 6 out of 20 of the brands, and 4 of them had concentrations greater than 20%.

The researchers said that the principal effect of organochloro compounds is central nervous system (CNS) depression. Addicted individuals with overexposure suffer dizziness, nausea, tingling, and drunkenness-like symptoms. Exposure to high concentrations can rapidly result in unconsciousness.

Two of the 20 products tested contained about 50% carbon tetrachloride (tetrachloromethane), potentially toxic to the liver in man. A single, high exposure can cause the development of a fatty liver and necrosis according to the ACGIH. Chronic, low level exposure can cause the same effect. Significant (17%) quantities of CFC-113 were found in 4 of the products.

Only 2 of the 20 products tested contained brief use warnings on the label. No ingredients nor the country of manufacture were on the label of 8 products. Product labels from European Community member states usually listed the major ingredient.

The researchers noted that water-based correction fluids are now widely available. They found ethanol to be the main component of the water-based correction fluid products.

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