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ASHRAE Standard 62-89R, Ventilation for Acceptable Indoor Air Quality: Public Review Draft

ASHRAE Standard 62 is arguably the most important single document on IAQ in the world — certainly in North America. Its revision, 62–1989R, began a formal 120-day public comment period with the issue of the Public Review Draft on August 15. Discussion is widespread, and much of it is critical. This is not surprising, since the standard's scope has been expanded considerably in the draft revision. And, unlike the existing standard, the revision is written in code language. This was done to facilitate adoption by the model building code bodies and state and local building code adoption agencies.

Major changes to the standard proposed in the draft include separate sections with vastly expanded discussions of design, systems, construction, operation and maintenance. Documentation requirements are quite detailed and specific. Several very detailed appendixes have also been added. Few changes have been made to the prescriptive minimum outdoor air ventilation rates, although there are some notable exceptions.

The clarity of the standard should make its interpretation and use less difficult for most users such as designers, contractors, building operators, and product manufacturers. Although the 62-89R draft is far more detailed and comprehensive than 62-1989, we believe that it will create less contractual difficulty and generate less litigation once it is adopted into codes. Even prior to its adoption into codes, after adoption by ASHRAE the standard becomes the clear state-of-the-art for ventilation, HVAC system design, and IAQ. As the standard of care for architects and engineers, it can do much to reduce poor indoor climate conditions that have generated many lawsuits in the past.

In this article, we discuss the most important changes in the revision, provide a list of comments from committee-chairperson Steve Taylor, and project what's next in the standard's adoption process. We've also included the Table of Contents of the current draft.

The Most Important Changes

The ***BULLETIN*** identified the most important changes from 62-89 to 62-89R based on comments from several members of the committee that drafted the standard. It is important to note that the ***BULLETIN*** editor is also a member of the committee and our views unavoidably act as a filter on what is reported in these pages. Our own professional IAQ work mostly involves consulting during building design. We have conducted many investigations of IAQ problems (fewer recently), and also participate as a litigation expert — obviously on buildings claimed to have caused their occupants harm.

Dave Grimsrud, a member of ASHRAE's Standing Standards Project Committee (SSPC62) revising standard 62 as well as the committee that wrote Standard 62-1989, believes that the 62-89R draft is a logical evolution. The core of the standard has not changed, but it has been expanded to reflect the increased understanding of the factors that frequently contribute to IAQ problems. Including detailed requirements for design, construction, operation, and maintenance is certain to drastically reduce IAQ problems where the standard is

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followed. This, Grimsrud says, will benefit all concerned: designers, constructors, operators, and occupants. Finally, he told us, the standard has been written by engineers, a fact that will make it far more practical and easier to implement than 62-1989.

The requirements of the 62-89R draft are intended to provide guidance on achieving "acceptable perceived indoor air quality" for 80% or more of the occupants.

Appendix A — 62-89R

Following are some of the most important changes as seen by several other members of ASHRAE SSPC62 that wrote the standard.

The basis for establishing ventilation rates is more clearly specified. It is generally the sum of occupant and building-based requirements to achieve acceptable perceived IAQ. No general claims about protection against health hazards are implicit in meeting the ventilation requirements of the draft standard. For occupants, the requirements are based on bioeffluent emissions and occupant-associated activities. Building-related requirements are based on emissions from the building and its equipment.

As a result of the draft's approach to setting ventilation rates and the values chosen for the separate building rates and people rates, ventilation rates for dense occupancies have been reduced. In spaces such as auditoriums, theaters, and classrooms, these reductions may be significant. In very sparsely occupied settings, some ventilation rates may actually be higher on a per-person basis than in 62-1989. This is due to the separate building-related rate that is independent of occupant density.

Some ventilation rate reductions resulted from considering contaminant removal where re-circulation through filters is assumed. Finally, for certain types of spaces where a moderate rate of tobacco smoking was assumed in 62-1989, lower rates were obtained by assuming that smoking will not occur. A separate appendix discusses the provision of acceptable perceived IAQ where smoking is to be accommodated.

Ventilation Minimum Requirements

The most widely discussed, disputed, and to many, most important aspects of past versions of standard 62 were the minimum outdoor air ventilation rates. Unfortunately, many (perhaps most) designers have relied on standard 62 for little else. Significant conceptual and numerical changes are contained in the Public Review Draft of 62-89R.

New requirements for a minimum supply rate (MSR) (outdoor air plus recirculated air) control exposure to biocontaminants. This is based on the SSPC62 health subcommittee's review of health effects data concerning exposure to infectious agents such as viruses that cause the common cold or bacteria that cause tuberculosis or Legionnaire's disease. A minimum rate of 15 cfm per person is proposed as the MSR. This rate is independent of the outdoor air supply rate and is an example of how considering the contribution of filtration has played an important role in the development of the proposed standard.

The committee extensively and repeatedly considered whether to establish ventilation requirements to satisfy visitors or occupants. Visitors are "unadapted" to the odors in a space when first entering, whereas occupants tend generally to be "adapted" to odors after spending a few minutes in a space. The available research indicates that it takes about three times as much ventilation for unadapted individuals as for adapted ones to express similar levels of odor acceptability.

One point of contention is that adaptation does not occur with irritants. In fact, irritation tends to increase with time whereas odor perception decreases. On the other hand, irritation thresholds tend to be considerably higher, perhaps three times or more higher than odor thresholds, for many substances that have been studied. In the end the draft is intended to provide guidance on achieving "acceptable perceived indoor air quality" for 80% or more of the occupants. This 80% figure, borrowed from ASHRAE's thermal comfort standard and part of Standards 62-1981 and 62-1989, is another contentious and important point in the draft standard. Many critics argue that the implied 20% dissatisfied is simply unacceptable. We believe the measurement of "dissatisfaction" in the background research leaves much to be desired and should be updated with a careful evaluation of the methodologies used.

The draft 62-89R contains major changes in the way prescriptive ventilation rates are determined using what was formerly the ventilation rate procedure. Rather than simply looking up a single value for minimum outside air ventilation rate, either per-person or per-unit area, the revised draft requires four components in determining minimum outside air ventilation rates. The new procedure makes more important the specific occupant density, the ventilation effectiveness, and the building and other sources.

Ventilation Rate Procedures

There are three basic procedures in the draft standard for obtaining design ventilation rates (DVR) for minimum outdoor air supply rates. These are the simple systems procedure, the prescriptive procedure, and the analytical procedure.

Simple Systems Procedure

The Simple Systems Procedure is intended for simple buildings with basically one ventilation zone or for simple systems serving a single, homogeneous zone within a larger building. It provides supply air rates per unit floor area and is the easiest to use. However, there are built-in factors to address ventilation effectiveness and system efficiency that will result in higher ventilation rates for most spaces than would be obtained by using one of the other design procedures.

Prescriptive Procedure

The Prescriptive Procedure is a more complicated method that results in a minimum outside air and total air flow into each space. It represents a fundamental change from the existing standard requiring the use of a multi-part calculation of minimum outside air ventilation rates. The major components of the prescriptive requirements are separate rates for people (per-person) and for the building (per-unit area), the ventilation system efficiency, and critical zone analysis. The minimum rate per occupant (R_P) is still expressed in cfm/p (l/s/p) while the rate for the buildings (R_B) is expressed in cf/ft^2 (l/s/m^2). This approach is intended to satisfy adapted people, not visitors initially entering a space. Important components in determining the design ventilation rate (DVR) are the occupant density, the "diversity factor" (a rough estimate of the percent of time the space is occupied at 100% of the design occupancy), and the ventilation efficiency.

The DVR is calculated as in equation 1 below.

$$\begin{aligned} DVR &= V_P + V_B \\ &= (R_P P_D)/D + R_B A_B \end{aligned} \qquad (1)$$

where

R_P = rate per person
P_D = design # of people
D = people diversity
R_B = rate/building area
A_B = building area

Thus, the DVR, (design ventilation rate) =
[(rate per person • occupants)/diversity factor] +
(rate per unit area • area)

The prescriptive procedure includes ventilation rates to address both occupant- and building-related emissions. These both vary depending on the type of occupancy. The ventilation rate components for emissions from building materials and furnishings (in cfm/ft^2 and l/s/m^2) are based on reports in the literature of emission rates and typical (and, therefore, presumably achievable) VOC concentrations (as discussed in ***BULLETIN*** Vol. 3, Number 5). The occupant-based ventilation rates in cfm/p (l/s/p) are generally based on results of various laboratory studies regarding the comfort and irritation requirements for adapted individuals exposed to human body odor (bioeffluents). Thus, like previous standards, per-occupant ventilation rates are intended to provide "acceptable" comfort and irritation from human occupancy rather than health effects.

Smoking is not accounted for in the rates in the draft's prescriptive ventilation rate tables.
Foreword — 62-89R

Among the noteworthy changes is the rate for classrooms: a rate of 6.0 cfm/p plus 0.14 cfm/ft^2 and 0.11 cfm/ft^2 of floor area for Kindergarten through grade 3 and grades 4 and above respectively. The guideline density values are 25 students per 1000 ft^2 in K to grade 3 and 35 students per 1000 ft^2 for grade 4 and above. The R_B values are 0.34 and 0.35 cfm/ft^2 for the two grade levels respectively under the simple systems approach. After correcting for overall system efficiency and ventilation efficiency in the room, grade 4 and above require a ventilation rate of 10.7 cfm/p. For the K through grade 3 classrooms, the rate is about 13.4 cfm/p. These compare to the 15 cfm/p usually used under 62-1989 which, if corrected for ventilation efficiency as indicated in the standard, would actually require 18 cfm/p at the air handler.

Smoking is not accounted for in the rates in the draft's prescriptive ventilation rate tables. This has been an assumption by the committee and has been reflected in the various progress drafts for several years. Of course, this has not pleased the tobacco industry representatives on the committee nor the several tobacco industry consultants and employees who attend all the committee meetings. The tobacco interests have repeatedly protested procedural matters and have also presented motions to change the draft. While most of their motions have failed, they all have received a few votes. These have tended generally to come from representatives of other industries who might also perceive the draft revisions as being contrary to their economic interests.

The ventilation rate section appears very complicated at first, especially to those accustomed to simply pulling a number out of Table 6.1 in the current standard. Both the prescriptive and the analytical procedures are more elaborate than in 62-1989. However, there is a good chance that a manual will be issued by

ASHRAE when the standard is adopted, and this will likely include some tables quite similar to the one in the existing standard for default ventilation rates based on typical occupant densities and other common assumptions.

Warden's Spreadsheet

A simple spreadsheet provided by SSPC62 member David Warden makes determining the minimum outside air ventilation rate and minimum supply rate (MSR) for multiple zone systems very easy. Warden, a practicing engineer and thoughtful contributor to committee discussions, assured the committee repeatedly that his firm uses such a spreadsheet to design systems under Standard 62-1989, and, by doing so, saves considerable expense in both the capital cost of HVAC equipment and in the energy costs required to run it. It essentially includes the multiple spaces approach that is in 62-1989 (equation 6.1) but expanded to include systems with multiple recirculation paths such as fan-powered mixing box systems and dual duct systems.

A copy of Warden's spreadsheet was supposed to be available with the draft on ASHRAE's web site, but somehow has not appeared. John Zierer of ASHRAE's Standards staff expected it to be available on the web site by September 25. Look for it there, or call Zierer at 404 636 8400.

A sample of the spreadsheet appears in Figure 1 below. Andy Persily is working on a Windows program for calculating both the DVR and doing the multiple spaces calculation.

Analytical Procedure

The analytical procedure allows designers to use lower outdoor air supply rates if low-emitting sources are selected or air cleaning is used to improve the quality of recirculated air. The procedure requires emissions data that are generally not yet available and establishment of acceptable concentrations that place the designer in a difficult and heightened position of responsibility. Few designers are likely to use the procedure in the immediate future, but it has enough potential to reduce ventilation requirements sufficiently to find more use in the future as the necessary data become available.

Documentation, Construction, and Commissioning Requirements

Among the most important of the draft standard's more detailed requirements are documentation and commissioning. The specific documentation requirements will improve communication and increase shared understanding within the design team, among the building designers, owners, and contractors, and ultimately, to those who will be responsible to manage, operate, and use the building.

There are new, separate sections containing many detailed requirements for design, for construction, and for operations and maintenance. Where standard 62-89

Inputs			
Units (Input SI or I-P)		I-P	units
Space air change effectiveness in the critical space	Eac	0.80	
Mixing efficiency of the primary air handling unit	Em	0.90	
Primary air fraction in supply air to the critical space	Ep	1.00	
Fraction of directly recirculated air which is representative of average building return air	Er	1.00	
Population density for building (Generally lower than Table 6.1)	Pdb	0.005	p/sf
Population density in the critical space (May be higher than Table 6.1)	Pdc	0.015	p/sf
OA requirement per unit area for building (Weighted average from Table 6.1)	Rbb	0.07	cfm/sf
OA requirement per unit area for critical space (Table 6.1)	Rbc	0.07	cfm/sf
OA requirement per person for building (Weighted average from Table 6.1)	Rpb	6	cfm/p
OA requirement per person for the critical space (Table6.1)	Rpc	6	cfm/p
Primary supply air to building per unit area	Vp	1.00	cfm/sf
Total supply air to critical space per unit area	Vsc	0.50	cfm/sf

Calculated Values				
Uncorrected OA requirement for building	Vou = RpbPdb+Rbb	=	0.10	cfm/sf
Unused OA requirement for critical space	osc = (RpcPdc+Rbc)/Ec	=	0.20	cfm/sf
Fraction of critical space supply not directly recirc. from space	A = Ep + (1-Ep)Er	=	1.00	
Fraction of critical space supply from fully mixed primary air	B = EmEp	=	0.90	
Fraction of critical space OA not directly recirc. from space	C = 1 - (1-Ec)(1-Ep)(1-Er)	=	1.00	
Uncorrected OA requirement as a fraction of primary SA	X = Vou / Vp	=	0.10	
Unused OA fraction required in supply air to critical space	Z = Vosc / Vsc	=	0.40	
Ventilation System Efficiency	Ev = (A+BX-CZ)/A	=	**69%**	
Total required OA intake to System	Vot = Vou/Ev	=	**0.14**	cfm/sf

Figure 1 - Outdoor air intake calculation for a VAV reheat system, interior room, using Warden's spreadsheet and adjusted R_B values.

had only one page (Section 5), to cover all of these topics, 62-89R contains 30 pages (23 pages for design, 3 pages for construction, and 4 pages for operating and maintenance procedures) with many detailed requirements.

Construction requirements address many sources of IAQ problems that occur during construction or renovation in partially occnpied buildings. Many of these requirements address the provision of clear and effective isolation of construction zones from occupied zones. Others address those problems that occur after completion of construction due to carelessness or improper attention to IAQ concerns during construction.

The commissioning requirements will ensure that newly completed ventilation systems perform according to design. If this is achieved, it will eliminate many IAQ problems that in the past have led to major disruptions of building occupancy and use, and, we believe, to far too much avoidable litigation based on problems during occupancy following new construction and major renovations.

The compliance requirements in the draft standard are written in mandatory building code language rather than advisory or guidance language. This, one committee member observed, forced committee deliberations to be more rational, minimized potentially ambiguous statements, and prevented "cop -out" positions on difficult issues. Where firm positions could not be taken, advisory or "informative" statements are provided rather than compliance requirements. But these informative statements are not a formal part of the draft standard's compliance requirements, and they will not be part of building codes that incorporate 62-89R's requirements. They will, however, be incorporated into a manual the standard's project committee recommended ASHRAE issue in conjunction with the standard when it is finally adopted.

The previous standard 62's were strictly design-oriented and didn't address what happened after design. The 62-89R draft requires the building to be run to deliver the designed ventilation. This has had a beneficial effect on the committee writing the standard by forcing a consistency between the design requirements and what is actually expected during operation. In the past, there have been many IAQ problems caused by a lack of concern by designers for a system's actual operation. In the worst instances, they simply design the system by sizing equipment and duct work, etc. without having any specific idea of how it will work. Then, the job is turned over to a controls contractor who tries to make it work. In the end, the building operator is stuck with whatever the controls contractor could figure out.

New Residential Section

There is a separate section for residential requirements. The proposed residential ventilation requirements consider dominant current practice as well as air quality needs. Natural ventilation is permitted if certain natural ventilation requirements are met. These are basically fulfilled by complying with the least current requirements in existing building codes for minimum operable window areas as a ratio to floor area. The draft also establishes minimal requirements for exhaust ventilation in bathrooms and kitchens. This will not only control odor, it will also reduce the accumulation of moisture inside the dwelling with the potential contribution to mold and mildew growth, the survival of dust mites, and the viability of bacteria.

Other Changes

Smoking is not included in the body of the draft (read, 'code provisions') of the standard. There is an appendix that provides guidance for addressing perceived air quality in smoking lounges. This has been an extremely contentious part of the standard through the participation of numerous tobacco industry representatives and consultants actively and vocally representing the interests of that industry throughout the standard development process.

The 62-89R draft requires the building to be run to deliver the designed ventilation.
Section 8 — 62-89R

Minimum filtration requirements and limitations on the extent of porous insulation materials are imposed in order to minimize microbiological contamination in ductwork. Concern over microbial growth on fiberglass acoustic and thermal duct liners or fiberglass ductboard resulted in considerable discussion by the committee with representatives of the North American Insulation Manufacturers' Association (NAIMA). A compromise was reached on the limitations the committee wished to impose on the use of fibrous materials in ductwork that focuses on liners in the immediate vicinity of the cooling coils where humidity levels will usually be quite high. NAIMA representatives argued that simply keeping the duct liners clean would prevent mold growth.

Classification of air according to its potential or expected contaminant content is part of the new standard. The permitted uses of exhaust air for recirculation, with or without air cleaning, are explicitly spelled

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Appendices

Only those appendices labeled "[Normative]" are a part of this standard. Those labeled "[Informative"] are provided for information only.

out. While this may at first appear more restrictive, the additional level of detail and specificity actually allowed the committee to provide lower outside air ventilation rates in some cases by permitting recirculation of specified classes of air for certain types of spaces. The five classes range from typical indoor air without unusual sources (Class I) to dangerous or strongly odorous effluent or exhaust air from sources such as combustion flues or cooling towers (Class 5). Class 1 air may be recirculated to spaces from which it is drawn whereas lower classes must either be cleaned to be re-used or must only be used in spaces from which even lower classes are drawn.

The standard sets upper limits on humidity to avoid microbial growth. 62-89R requires that in humid climates, where mechanical cooling systems are used, the humidity level be controlled independently of the temperature. The draft standard says humidity can be "...no greater than 60% during occupied periods, and no greater than 70% during unoccupied periods, in all occupiable spaces ...at expected full load and part load conditions." Informative language says that some means of measuring and controlling humidity may be required.

The scope of 62-89R covers both temperature and relative humidity, although only relative humidity is actually addressed in the draft.

The draft does not allow fans to cycle off and on in small buildings.

Section 8 — 62-89R

The majority of office and retail workers in the United States are not located in large buildings. Yet most committee discussion focuses on large buildings. Therefore, the committee did consider the small office building situation where a residential type thermostat is commonly used to control the HVAC system. These buildings may lack operable windows so that ventilation occurs either by operation of the HVAC system or when the doors are opened. These systems are usually switched on and off by the office manager or some other staff member in response to thermal conditions without regard for ventilation requirements. The draft does not allow fans to cycle off and on in small buildings.

62-89R Highlights from Steve Taylor, SSPC62 Chair

In a talk September 16th in Orlando, Florida, Steve Taylor, PE, presented his view of the most important changes in the draft standard. They are listed below, generally paraphrased from his talk.

1. The emphasis in the standard is on the acceptability of the indoor air, not the health components, as indicated by the definition of acceptable IAQ in the draft.

2. Section 4 contains a "road map" on how to comply with the standard. Since the committee wrote the standard in code language to enable adoption into building codes, it found it important to be clear about what would be required for compliance with its mandatory components.

3. According to Taylor, Standard 62-1989 gave guidance but "no one could understand or determine whether they complied with it or not." The 62-89R draft is clear about compliance requirements. For example, it is very specific about separation requirements between a flue top or other exhaust and the air intake on the roof. It is specific about the height of the exhaust outlet, the velocity of the exhaust, etc.

4. "We have to balance the enforceability with complexity. The standard might be too much for the typical building official to understand, but the average designer should not have trouble with it. It shouldn't, in my opinion, be written for the building officials, it shonld be written for engineers."

5. Taylor said that duct liners were the subject of lots of lobbying. Now, the draft's only restriction on duct liners is to prohibit them in the portiou of the HVAC system right near the cooling coils. No other restrictions survived the heavy lobbying mostly by the North American Insulation Manufacturers' Association (NAIMA).

6. CO_2 has been misunderstood, according to Taylor. He said that Standard 62-1989 deals with acceptable IAQ at 1000 ppm based on body odor only. CO_2 is not mentioned in the list of pollutants or in the body of the 62-89R draft except for its use in the application of demand-controlled ventilation. The draft permits demand-controlled ventilation (DCV). CO_2 can be used to trigger DCV. But this is the only place in the standard where CO_2 is mentioned except in the appendix. This is a major change from 62-1989 that the committee felt necessary due to widespread misinterpretation and misuse of CO_2 concentrations based on misreading 62-1989.

7. ASHRAE Standard 52.2 is out for a second public review. It is based on filtration efficiency as a function of particle size. At the bottom of the range of efficiencies are furnace filters which Taylor facetiously says are "...very good at filtering out furnaces, but not very good at filtering out anything else." The requirements of 62-89R will increase filtration requirements considerably, counting on newer, more efficient filters that do not increase pressure drop.

8. There are provisions for natural ventilation, but they are equivalent to the current minimum code requirements for natural ventilation — an opening area in the envelope of not less than 4% of the floor area served. There are limits, however, on how far the opening can be from the area served, so that spaces far from windows must have some ventilation provided by other means.

9. Taylor asks rhetorically, "Why did we not require the National Ambient Air Quality Standards (NAAQS) be met for outdoor air quality used for ventilation as was required in 62-1989?" And, he answers, "We decided this should be a societal problem. The engineer should not be responsible to clean up the outdoor air." Provisions are made to allow reductions of outdoor air supply volumes during periods of extreme outdoor air pollution, i.e., violations of the NAAQS concentration levels.

10. Humidity limits are now part of the standard, at least where air conditioning is used. When the space is occupied, relative humidity (RH) must be less than 60%; when it is unoccupied, it must be kept below 70% RH. The Building Owners and Managers Association (BOMA) objected that this was too stringent, but the committee felt it shouldn't let high humidities be sustained for long periods of time if the building is to limit microbial growth.

> *"[furnace filters] ...very good at filtering out furnaces, but not very good at filtering out anything else."*
>
> *Steve Taylor*

11. The ventilation rates can be determined in three ways. The first is called the "Simple Systems Procedure." By using it, the designer ends up with a per-square-foot ventilation rate requirement. Taylor opined that the rates are probably a little conservative, that is, the rates are a little higher than they would be if the prescriptive procedure were used. But the Simple Systems Procedure allows single zone, small building design without dealing with the more detailed requirements of the Prescriptive Procedure.

12. The second procedure, the most complicated and difficult, is called the "Analytical Procedure." According to Taylor, it is very much a theoretical procedure at this point. He says the data just don't exist to do it now. This refers to data on emissions of materials and other

sources that would allow the designer to calculate expected concentrations and, using some target concentration values, determine ventilation rates accordingly. The procedure is included, Taylor says, to encourage the generation of more emissions test data and development of rationalized target values. He believes that during the life of the standard, once adopted, such data will be available and the procedure will be more practical. Meanwhile, it is a "technology-forcing" concept.

13. The most familiar ventilation rate procedure is the Prescriptive Procedure. The procedure is revised from the existing standard. It includes rates (given in cfm/p and cfm/sq ft components) for both people (R_P) and the building (R_B), since the emissions of each are at least somewhat independent. Taylor says a lot of people ask a little too much of a standard of this sort and look for a single number for all spaces. The values that have been developed reflect the professional judgment of the committee as was the case for the previous standard as well. And, many of the values have been developed to be identical to the existing values for common spaces such as offices.

14. In contrast to 62-1989, which said to take ventilation efficiency into account but did not say how, 62-89R requires that ventilation efficiency be considered in determining how much air must be brought in at the air handler to deliver the required amount to the space.

The draft 62-89R requires regular inspection and maintenance, a considerable expansion of requirements from the existing standard, but requirements justified by a great deal of experience with "problem buildings."

Steve Taylor

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15. The values for ventilation rates needed to control the emissions from the building (R_B) were picked from the bottom of the range of values found in European studies. This, he said, was done on the assumption that if people did all the other things required by the standard, they would have a good, low-emitting building.

16. The ventilation rates are intended to provide acceptable perceived IAQ for occupants: individuals adapted to the air in a space, not unadapted visitors first entering a space. Much of the data reported in the literature on acceptable perceived IAQ makes the distinction between the reactions of adapted and unadapted individuals. Code is not for making a good first impression, Taylor said, "This is to be a building code, and the code shouldn't say how to make a good first impression; therefore, we chose a number for the adapted person, the occupant of the space."

17. What about building types other than offices and schools for which we have some data? The committee started with data from offices and schools, and judged other spaces relative to offices for which the most data exist.

18. Taylor gave a brief comparison of selected occupancies between 62-89 and 62-89R. He said offices and retail spaces stay the same as in 62-1989. Classrooms and conference rooms go way down; this, because the committee chose to use 5 rather than 15 cfm/p for the occupant component in these spaces.

19. The simple system approach requires a default filter efficiency of 60%.

20. Taylor commented on the inefficiency of systems that serve multiple spaces — various supply outdoor air rates are required for diverse spaces. Many people found this too complicated, so they simply used the rate for the space requiring the highest outdoor air supply rate for the whole zone. This resulted in over-ventilation in 62-1989. The draft 62-89R allows you to take credit for the re-circulation of filtered air, thus reducing the amount of outdoor air required in the multiple spaces situation. The spreadsheet prepared by Dave Warden should make it much easier to take advantage of the opportunity to save energy in these cases.

21. Section 7 of the draft 62-89R addresses construction. It requires the designer to isolate construction areas from occupied areas. Taylor says that many lawsuits have resulted from problems of construction with partial occupancy. Section 7 also requires a post-construction purge — 48 hours before re-occupancy. This was also opposed by BOMA as being too burdensome on building owners.

22. Section 8 addresses maintenance and operational requirements. It requires the identification of a "Responsible Party." This will, in Taylor's view, remove much of the ambiguity of who is in charge of IAQ. The section also says that the ventilation system must be operated when the building is expected to be occupied (leaving open the question of Saturdays, Sundays, and late-night work by cleaning people). The draft intends to exclude maintenance and clean-up people since they are "...more of an OSHA type exposure" than the regular building occupants. The section also requires regular inspection and maintenance, a considerable expansion of requirements from the existing standard, but requirements justified by a great deal of experience with "problem buildings." There is a

requirement to check supply and outdoor air flow rates every five years and to verify system balance.

Adoption Issues

This Public Review Draft is just that — a draft. A lot of discussion on various issues continues and much remains to be ironed out before adoption. Once adopted, the standard will probably be a powerful legal force — despite some obvious mitigation efforts.

Public Review Draft Not Necessarily Final Standard

Readers should bear in mind that the draft is subject to considerable change before adoption. During the committee deliberations, it has become clear that there are several members who strongly oppose certain elements. Further, it is apparent that some members who represent certain special interests are opposed to adoption of a revised standard either due to their preference for the existing standard or their objections to certain provisions. These members have been raising strong objections either to certain content or procedural matters during the committee's deliberations and, again, at the ASHRAE Standards Committee. Among these have been residentilal building interests, BOMA (a commercial building owners association), some but not all manufacturers of HVAC equipment, and tobacco interests as well as other manufacturers of indoor pollutant "sources."

Adoption Process

Following the receipt of the comments, SSPC62 will respond to the comments and determine what changes are warranted in the standard. Any substantive changes will require an additional public review before they can be adopted by ASHRAE. After ASHRAE's adoption, the American National Standards Institute (ANSI) will review the process and determine conformance to its consensus standards development procedures.

If approved by ANSI, it is then likely that some of the model building code organizations and state and local building code adoption agencies will incorporate some or all of the standard's provisions into its codes, either by reference or by inclusion of the actual code language of the standard. Instead of the ubiquitous "should" in the previous standard, 62-89R uses "shall." This has been done deliberately to facilitate adoption by code bodies. On the other hand, ASHRAE does not itself take the position that it is writing a code but rather a standard for professional practice.

Legal Implications of Public Review Draft Standard

The foreword to the draft states that the document is "a work in progress." Everything in the draft can be changed or deleted before final adoption. And, the document "...should not be relied upon as a standard in whole or in part..."

These words are intended to prevent the use of the draft as a "standard of care" in lawsuits. Since the ASHRAE committee consists of many leading IAQ authorities, many IAQ professionals and others (including attorneys) pay close attention to the draft's content — even though it is only a draft document for public review purposes. Since the committee has been meeting for over five years, and during the last couple of years met about seven times for two and one-half days each time, it is difficult to dismiss the review draft as carrying no authority in the field.

In the past, attorneys argued the Public Review Draft of Standard 62-1989 represented the standard of care for the industry because it was so widely discussed over several years' time. Certainly plaintiffs' attorneys are likely to try to hold architects, engineers, contractors, and building owners to a tougher standard in order to plead their clients' cases. Engineers and manufacturers as well as members of the committee are concerned about this, so the foreword's disclaimer represents an attempt to reduce reliance on the draft revision of the standard.

Clearly ASHRAE's Standard 62 has been the most recognized source for a professional "standard of care" for the last two decades during which IAQ problems have increasingly been the basis of lawsuits. In such suits, the responsibilities of design professionals and others are defined by the prevailing "standard of care" at the time the services were provided. When a revised standard is made available to the public, it logically begins to be the standard of care.

For a Copy of the Public Review Draft

The public review draft is available at no cost over the Internet at http://www.ashrae.org. A paper copy and diskette are available from ASHRAE publications: 404 636 8400. The cost is $25.

TVOC: Is It Dead?

There has been much talk about VOCs and microbial contaminants as probable causes of SBS symptoms and other health and comfort problems associated with poor IAQ. Much effort has gone into exploring the use of total VOC (TVOC) measurements to quantify air quality. However, a group of twelve highly-respected Nordic IAQ scientists has prepared a draft report raising serious questions about the use of TVOC as a health-effects indicator. Their report, prepared after reviewing the relevant literature, is unequivocal. It says that:

"...except in extreme cases, there is no scientific basis today for the use of TVOC as a risk index for discomfort or for health effects in buildings. This means that there is no basis for assessing measured values from buildings or for attempting to determine limit values."

In addition, the group noted that although the chemical composition of indoor air very probably is important for health and well-being, continued research should be concentrated on developing more relevant measures of both exposure and effects.

Among the authors of the report are Jan Sundell of Sweden, who chaired the Scientific Consensus Meeting at which the report was developed, Lars Mølhave, who has been the godfather (if not the father) of the TVOC concept, Peder Wolkoff of Denmark, a prolific author of papers where VOCs measurements are used, and a number of other well-known Nordic researchers. Carl Bornehag of the National Testing and Research Institute in Sweden served as secretary and prepared the draft. The group's work consisted of screening over 600 published papers, looking more closely at 117 of them, and finally selecting and reviewing 64 deemed to contain relevant, quality information.

A Selective History of TVOC

Several scientists at Indoor Air '90 in Toronto contributed work concerning TVOC including Mølhave, Bernd Seifert of Germany, and Gene Tucker of the US EPA.

Lars Mølhave's Indoor Air '90 Plenary Lecture

Mølhave has worked on VOC and TVOC issues for the better part of two decades. No review of the field would be complete without citation of many references from his published work — in particular, the Plenary Lecture he delivered at Indoor Air '90 in Toronto and now, the Plenary Lecture he delivered in Nagoya.

One section of the Toronto paper was titled "Tentative guidelines for VOCs in non-industrial environments (toxic)" (*Proceedings of Indoor Air '90*, Vol. 5 pp. 15-33). In that section, he presented the data summarized in Table 1.

In Nagoya, Mølhave gingerly tip-toed through the quagmire of issues but clearly indicated his agreement with the Nordic Scientific Committee report's conclusions (*Proceedings of Indoor Air '96*, Vol. 2, p. 37). In the abstract of his paper (co-authored by Geo Clausen of the Technical University of Denmark), he wrote: "TVOC should preferably be measured and calculated using GC-MS and identification of all VOC compounds." In a safe statement that is a clear but minor revision of his earlier writing, the abstract concludes: "The No Observed Effect Level (NOEL) for irritative or discomfort effects is expected to be below 0.2-0.3 mg/m^3 provided no highly reactive compounds are present in concentrations sufficient to provoke effects."

Table 1 - Tentative dose response relation for discomfort resulting from exposure to solvent-like volatile organic compounds. (Mølhave, 1990)

Concentration range	Irritation and discomfort	Effects
<200 μg/m^3	no irritation or discomfort	the comfort range
200 μg/m^3 - 3000 μg/m^3	irritation and discomfort possible if other exposures interact	the multifactorial exposure range
3000 - 25000 μg/m^3	exposure effect and probably headache possible if other exposures interact	the discomfort range
>25000 μg/m^3	additional neurotoxic effects other than headache may occur	the toxic range

Later, confirming his interest in compound identification, the paper says: "In most evaluations of IAQ, details are needed on individual organic compounds and the chemical mixture is, therefore, separated into its constituents." And later, "The best way of creating a TVOC value is to base it on identification of all individual VOC in the mixture, and use their own response factors to calculate a concentration." Where compounds cannot be identified, then the paper recommends using a single response factor, such as n-hexane or toluene, "...to estimate the concentration of unidentified compounds."

The paper includes "Recommended procedures for measurement of TVOC," shown in the sidebar on page 11 of this issue.

With respect to health effects, the Indoor Air '96 paper continues to recite dose-response relationships based on field and laboratory studies as described in a 1994 Mølhave paper (*Indoor Air*, Vol. 4, pp. 357-376). A concentration of 0.2 - 0.3 mg/m^3 is called "the low probablility range" for effects from exposure to VOCs. The "high probability range" is 1 to 5 mg/m^3, according to the paper. This would appear to be in conflict with his more recent position along with the other Nordic scientists. The problem, as we see it, is his tendency not to distinguish adequately between findings from his laboratory studies with the 22 compound mixture and field studies where VOCs are measured by a variety of methods and include whatever the measurement methods detected. In the paper the authors seem to blame the absence of a thorough, up-to-date review, citing a 1986 paper by Mølhave as the most recent available one.

After his talk, he was verbally attacked by several in the audience who felt that he was contradicting his earlier positions or that he had misled them by earlier guideline values. (See Table 1 on page 10.) Mølhave denied having reversed himself in spite of protests from commentors in the audience.

Recommended Procedure for Measurements of TVOC

In their Indoor Air '96 paper, Mølhave and Clausen describe a procedure recommended for measuring TVOC from the European Collaborative Action Work Group 13 (chaired by Mølhave). The steps in the procedure are as follows:

1. Use Tenax GC or Tenax TA for sample collection.
2. Use a non-polar GC column for analysis (column polarity index of <10). The system must permit a detection limit corresponding to three times the noise level for toluene and 2-butoxyethanol of less than 0.5 and less than 1 µg/m^3, respectively.
3. Consider only the compounds found in the part of the chromatogram from n-hexane to n-hexadecane. In this procedure, the WHO definition has been slightly modified by replacing the range of boiling points by a definition of the "analytical window" in terms of the two specific reference compounds.
4. Based on individual calibration, quantify as many VOC as possible, but at least those contained in a list of known VOC pollutants of special interest and those representing the10 highest peaks. Calculate the combined concentration Sid of these (mg/m^3). A list of compounds of interest in supplied in the report (EC-WG13 1996. The use of TVOC as an indicator in IAQ investigations. Report of working Group 13 of European Collaborative Action on Indoor Air Quality and its Impact on Man, JRC, Ispra, Italy.).
5. Determine C_{um} (mg/m^3) of unidentified VOC using response factor of toluene.
6. An acceptable level of edification has been achieved if S_{id} exceeds three times S_{um}.
7. The sum S_{id} and S_{um} is called the TVOC concentration or TVOC value.

Mølhave's Role

So, has Mølhave abandoned his earlier guidance? We think not. In fact, Mølhave may not have contradicted the letter of his earlier published work. He has, however, fueled the idea that there may be some valid basis for establishing TVOC effects threshold concentrations by his many years of research looking for such levels and by publishing his findings.. Both his laboratory studies as well as his literature reviews implied that such levels could be established. But his long series of laboratory studies were all conducted with a specific mix of 22 VOCs, and all conclusions from the work were tied to that mixture. In spite of many citations to the contrary, in fact, Mølhave only reported what he found without actually recommending "guideline" values.

We believe the problem is really that people have wanted to find such guideline values. In fact, there has been a lot of guidance developed and decisions made that claim to be based on Mølhave's earlier work. Guideline values of 1 mg/m^3 TVOC have been widely used including in state, national, and international standards. Others have cited values of 300 or 500 µg/m^3. Two of the more important of these are discussed below.

Nevertheless, Mølhave's position on the use of the values he developed remains ambiguous. In spite of himself, and perhaps because of his extended effort to develop a meaningful TVOC concept, his publications may have given TVOC more credibility than it deserves. His participation in the Nordic group questioning the use of TVOC is, therefore, extremely important.

Seifert's Lecture

Bernd Seifert recommended a "target guideline value of 300 μg/m^3 (sum of VOC)." But that 300 μg/m^3 value was the sum of the top ten individual VOC values in each of six specified chemical classes plus "other." Seifert's approach required that the TVOC total be determined by a gas chromatographic technique that allows separation of substances, not just by GC with flame ionization detector (FID) calibrated to toluene (or some other relevant compound). Seifert questioned the use of an integrated TVOC real-time signal from a monitor (FID or PID) as previously proposed by Richard Gammage. Instead, he proposed the following definition for TVOC:

"'Total volatile organic compounds' (TVOC) means the sum of individual VOC separated and quantified by gas chromatographic technique. To obtain the sum, the VOC belonging to one of the following chemical classes are ranked according to their measured concentration: alkanes, aromatic hydrocarbons, terpenes, halocarbons, esters, carbonyl compounds (excluding formaldehyde) and 'other.' The concentrations of the first ten VOC in each class are then summed up."

Seifert was really proposing a SumVOC concept for at least the most prevalent compounds. By requiring the first ten compounds in each class, he was very likely to be including the compounds comprising at least 90 to 98% or more of any class and of the total VOC present. [It is difficult to imagine a compound that is not in the top ten in one of these classes comprising more than 5% of any compound class let alone of the total VOCs present.]

Seifert then went on to propose a "target guideline" TVOC value of 0.3 mg/m^3. He went further to say that no single VOC class could exceed certain limits as shown in Table 2.

Table 2 - Seifert's prosed target guideline TVOC value of 0.3 mg/m^3.

Chemical class of VOC	Concentration μg/m^3
Alkanes	100
Aromatic hydrocarbons	50
Terpenes	30
Halocarbons	30
Esters	20
Aldehydes and ketones (excl. formaldehyde)	20
Other	50
Target guideline value (sum of VOC)	300

Seifert emphasized that the proposed target value was not based on toxicological considerations but, according to the author's judgment, was what was achievable. Furthermore, he indicated that specific guidelines for individual compounds could be set if needed.

Seifert characterized the values as representing "normal, long-term" conditions, not special conditions such as immediately following renovation. He suggested that after such special events, concentrations 50 and 10 times higher be accepted for up to 1 week and 6 weeks respectively.

Regarding the use of direct-reading instruments in the field for TVOC, Seifert said this "...may still be appropriate under certain circumstances, *e.g.*, to follow removal processes." He offered a rule of thumb that a result from a monitoring instrument might agree with gas chromatographic results within a factor of two or three. Given the dependence of the monitor signal on the type of instrument used and the actual mixture present in the room, he said, the value given by the direct reading monitor "...cannot be more than indicative."

In the end, we have not seen any field investigations or other studies that followed Seifert's recommendation. In fact, the cost and effort involved in doing the detailed chemical analysis he recommended has apparently discouraged its use. In the end, however, it still appears to us as a very sound approach upon which no one has yet offered any significant improvements (*Proceedings of Indoor Air '90*, Vol. 5, pp. 35-49).

Tucker's Classification Scheme

Gene Tucker presented a paper discussing a guideline TVOC concentration that has contributed to the confusion traced back to Mølhave. Tucker presented a classification scheme for low-emitting building materials and products as sources of indoor air VOCs. He specifically refers to "emissions of total organic vapors" without describing the measurement method or defining VOCs in any other way.

Citing a 1985 Mølhave paper, Tucker identifies a range of 0.16 to 5 mg/m^3 of total organic vapors as the threshold for mucous membrane irritation. He said: "Assuming 2 mg/m^3 to represent that range and accounting for multiple sources, a maximum contribution from any single source type of 0.5 mg/m^3 is used in...[the classification of low emitting materials and products]. This value incorporates a somewhat greater safety factor than the 1 mg/m^3 maximum contribution suggested [by Tucker] previously... and is consistent with the State of Washington criterion."

While Tucker was simply trying to provide guidance for the interpretation of emissions test results, his paper and the numbers given in it have been very widely and very incorrectly referred to as the "EPA guideline" or even "the EPA standard" for TVOC. And, again, all is blamed on Mølhave (*Proceedings of Indoor Air '90*, Vol. 3, pp. 251-256).

Problems with Using TVOC

Measuring VOC accurately is neither easy nor cheap. Often, more than a hundred different compounds can be identified in an indoor air sample and there are probably several hundred present at trace concentrations in most indoor environments. Some compounds also will be found that are difficult or impossible to identify.

Investigators have often chosen to measure VOCs as a single combined concentration (TVOC) because of this expense and difficulty of measuring and because of the lack of a satisfactory way to assess the significance of such mixtures once the measurements have been made. The measurement of this "simple" parameter — TVOC — is a very inexact science. The numbers generated by the various TVOC methods that are being used have large uncertainties.

Measurement Methods Are Critical

Measurement of VOC critically depends upon the method chosen. All VOC measurement methods are inherently selective, and no method can determine the presence or quantity of all VOC. Limitations include the boiling point range, the polarity, and the reactivity of the individual compounds that can be collected and detected by any particular measurement method. (See Vol. 3, No. 5 of the ***BULLETIN*** for a more detailed discussion of some of these limitations.) The relatively high cost of VOC measurements has resulted in the need for researchers and investigators to make choices resulting in implicitly partial characterization of the VOC present in any air sample.

Potentially important confounders are the TVOC measurements used in most studies. There are several problems with such measurements. Al Hodgson shows that measured TVOC may vary significantly among methods (*Indoor Air*, Vol. 5, No. 4). Charlie Weschler has written several papers, as have others, that show that indoor air chemistry may transform what is measured in deceiving ways, especially when viewed as TVOC or when higher molecular weight aldehydes (potentially irritating compounds) are not specifically measured.

Al Hodgson Sheds Some Light

To exacerbate the problems of dealing with VOCs, sampling and analysis methods strongly affect what will be found, and different methods give different (sometimes widely different) results. Al Hodgson compared three methods used to measure TVOC in indoor air investigations (*Indoor Air*, Vol. 5, No. 4, 247 - 257). The three methods were sorbent sampling with gas chromatography/mass spectrometry (GC/MS) analysis, sorbent sampling with flame ionization detection (FID), and a direct reading photo-acoustic/infrared (IR) gas monitor (Brüel and Kjær Model 1302).

Table 3 shows some of Hodgson's laboratory results. He created mixtures of 6 to 7 compounds in approxi-

Table 3 - TVOC mass concentrations measured by the GC/MS and FID methods and toluene-equivalent concentrations measured by an IR gas monitor for eight VOC mixtures. Numbers of compounds in each mixture are shown in parentheses.

		GC/MS		FID		IR Gas Monitor	
Mixture	Expected conc. mg/m^3	Measured conc. mg/m^3	Measured/ expected ratio	Measured conc. mg/m^3	Measured/ expected ratio	Toluene conc. mg/m^3	Measured/ expected ratio
Alkane HCs (7)	38.0	41.5	1.09	40.0	1.05	211	5.56
Aromatic HCs (6)	47.2	41.5	0.88	55.2	1.17	53.0	1.12
Misc. HCs (6)	41.7	28.8	0.69	36.2	0.87	204	4.89
Clorinated HCs (6)	38.3	25.9	0.68	10.3	0.27	2.4	0.06
Oxidized Compounds (7)	44.9	26.0	0.58	23.7	0.53	100	2.23
Common VOCs (13)	50.6	33.7	0.67	38.2	0.76	70.8	1.40
Human Exposure (12)	45.7	30.5	0.67	33.2	0.73	122	2.66
Carpet Mixture (4)	42.5	31.0	0.73	33.4	0.79	192	4.53
		Mean	0.75		0.77		2.81
		CV,%	22		37		71

mately equal concentrations from several classes of VOCs as well as a mixture of "common VOCs" derived from a national database of indoor air VOC concentrations, a "Human Exposure" mixture of 12 of the 22 compounds comprising 97.3% of the mixture used by Mølhave *et al.* in their human exposure studies, and a "carpet" mixture based on a set of four compounds recommended for calibration of the GC/MS or GC/FID analysis of TVOC emitted by carpets in EPA's Carpet Policy Dialog.

The performance of the GC/MS analysis of alkanes and aromatic hydrocarbons was reasonable compared to the expected values. This was anticipated since the method was calibrated with a mixture of these compounds. The response for all the other mixtures underestimated their values with a mean ratio of measured to expected concentrations of 0.75 with a coefficient of variance of 22 percent.

Hodgson commented that "...[a]lthough a FID is considered to be a universal detector, its response is strongly dependent upon compound structures and the presence of functional groups and heteratoms." Previous investigations showed low response factors for chlorine and bromine compounds. Hodgson reported that the lowest response ratios were obtained for the mixtures of chlorinated compounds (0.27) and oxidized compounds (0.53). Given the potential toxicity of chlorinated compounds, we suggest that this may be a matter of concern. Hodgson concluded that "...a FID can accurately quantify the concentration of carbon or the concentration of hydrocarbons in a sample but will substantially underestimate the mass concentration if the sample is dominated by chlorinated or oxidized compounds."

The IR monitor measurement results calibrated to toluene compared to the expected values varied by two orders of magnitude. Since toluene was used to calibrate the mouitor, accurate results were obtained for the aromatic hydrocarbons. But there were large discrepancies in the other mixtures. Alkane concentrations were overestimated by more than a factor of five. Chlorinated hydrocarbons were underestimated by a factor of approximately 16.

Conclusions

There is a growing consensus among the leading researchers in the field that TVOC is not a useful indicator of the risk of health effects in indoor air. It cannot continue to be used as it has in the past. It is not likely to be a fruitful tool in determining the causes of SBS symptoms. Nevertheless, it may have some use as a screening tool for both emissions testing and in buildings.

Maybe it is time to break VOCs down into logical groups in order to find correlations to reported symptoms. Perhaps by identifying important compounds and looking at them individually or in logical groups, investigators might find correlations to symptom reporting rates.

Clearly it makes sense to reduce VOCs to reasonably achievable levels as Seifert and others have suggested. We refer the reader to the values found in the EPA Base Study and the European Audit Project as indications of what is reasonably achievable in office spaces.

<u>Indoor Air '96</u>

More Highlights and Comments

As the conference recedes in memory, it is easier to gain some perspective on it and what it said about the IAQ field. Several people we spoke to expressed disagreement with Demetrios Moschandreas' description of IAQ as a mature scientific discipline (see ***BULLETIN*** Vol. 3, No. 7 for Moschandreas' Plenary Lecture). Many people feel that there is too much sloppy work and poor scholarship as well as a lack of accepted guiding principles for us to describe our discipline as such.

Overall, there was no sense of great strides or many new, exciting findings. Progress was incremental as usual, and on the same old fronts. There is still more noise and excitement about potential concerns than concrete evidence of real health problems. Other than a limited number of real concerns (e.g., CO poisoning, Legionella), there is not a lot of evidence demonstrating negative impacts of poor IAQ. There are, however, many more people talking about the importance of IAQ to the worldwide increase in the general population incidence of asthma.

On a different front, lots of the emissions work is still neglecting well-established theory and methodology from other fields, in particular chemistry and materials science. We call readers attention in particular to two papers by Andy Persily of NIST in the US. The first raised questions about emissions source strength calculations and measurements. The second focused on materials science as an important allied field that is under-utilized by indoor air researchers (*Proceedings of Indoor Air '96*, Vol. 2, p. 49, p. 109).

NIOSH and EPA Study Data

Mark Mendell from the US National Institute of Occupational Safety and Health (NIOSH) suggested that the EPA BASE symptom data by Howard Brightman (*Proceedings of Indoor Air '96*, Vol. 3, p. 1033) was "very important" and will likely be missed by most people because it was stuck in a session on Education. Mendell *et al.* presented (*Proceedings of Indoor Air '96*, Vol. 2, p. 877) NIOSH symptom data that were of interest also, not because of the NIOSH data themselves but because of the discussion of the uses and limitations of symptom reference data such as from the EPA BASE Study (shown in Figure 2 below).

In their paper, Mendell and his co-authors suggest that it is important to have symptom prevalence values for occupants of buildings that are not "problem buildings." He comments that while the EPA BASE study intended to exclude buildings with evident environmental problems, there are likely to be buildings in the BASE study with "symptom elevations from non-evident contaminants." Ideal epidemiologic baseline data would come not from general buildings, says Mendell, but from "healthy" indoor environments with minimal exposures, likely at the lower end of the symptom range among general buildings.

In the paper by Mendell *et al.*, results of NIOSH Health Hazard Evaluations of "complaint buildings" suggest what might be elevated symptom prevalences. The results of their study are shown in Figure 3.

Mendell and his colleagues say: "Buildings with minimal known risk factors for increased symptoms (*e.g.*, no mechanical ventilation, air-conditioning, humidification, or carpets; with adequate ventilation and thermal comfort... may best provide 'unexposed' baseline levels." These risk factors are some of those Mendell found in his 1993 meta-analysis of SBS studies (*Indoor Air*, Vol. 3, pp. 227-236).

While Mendell *et al.* have raised some important and difficult questions about obtaining "baseline" data, we wonder how they would suggest establishing SBS symptom baselines for the majority of commercial buildings in the United States that are mechanically ventilated, air-conditioned, or carpeted. It seems the buildings he would want baseline data from are not like the buildings most office workers inhabit. What, then, is a "baseline" and how is it to be used and interpreted? These, we believe, are important and unresolved questions.

Miscellaneous Comments

Mendell said the workshop on a standard questionnaire was "interesting and slightly controversial," due to limitations of the existing questionnaires that are likely to be proposed as standards.

Aino Nevalainen had some startlingly high numbers on the occurrence of Finnish homes with water problems – 52% (*Proceedings of Indoor Air '96*, Vol. 3, p. 421). Based on postal questionnaires, "[a]djusted odds ratios showed that exposure to moisture was significantly associated with sinusitis, bronchitis, nocturnal cough, nocturnal dyspnea, sore throat, and with increased number of common colds and tonsillitis."

Phil Morey's material on molds was, as always, entertaining and informative (*Proceedings of Indoor Air '96*, Vol. 2, p. 27). Kari Reijula's presentation on pathologic changes from stachybotrys atra induced lung mycotoxicosis toxin in mice was apparently quite important, people seemed to think (*Proceedings of Indoor Air '96*, Vol. 3, p. 639).

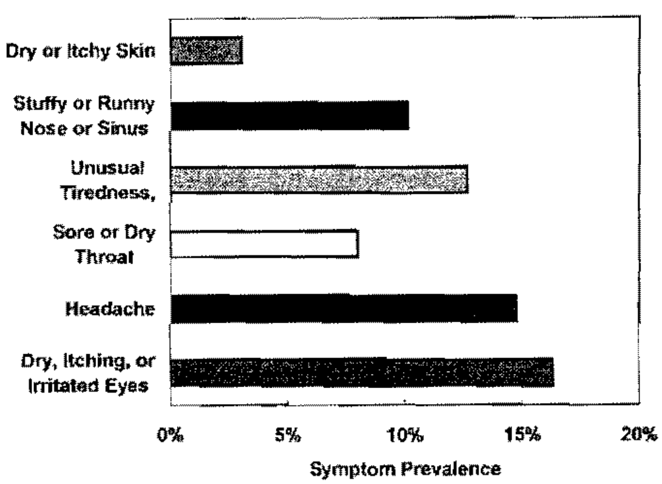

Figure 2 - SBS symptom prevalence data: overall means from 16 1995 EPA BASE study buildings (Brightman *et al.*, 1996).

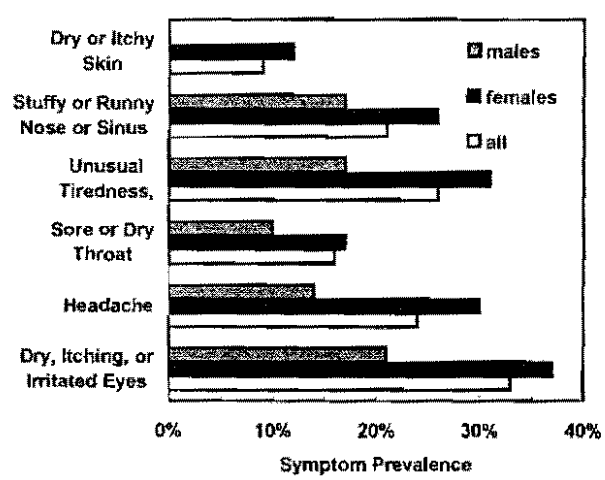

Figure 3 - Selected SBS symptom prevalence rates in 63 U. S. office buildings with complaints (Mendell *et al.*, 1996).

Calendar of IAQ Events

October 6-8, 1996. **IAQ '96, Paths to Better Building Environments**, Omni Inner Harbor Hotel, Baltimore, MD, sponsored by ASHRAE and several other organizations. Contact ASHRAE Meetings Department, 1791 Tullie Circle NE, Atlanta, GA 30329. 404 636 8400. Fax 404 321 5478. *There will, no doubt, be plenty of discussion of the public review draft of Standard 62R.*

October 13-16, 1996. **SMACNA 53RD Annual Convention**, Grand Wallea Resort Hotel, Maui, Hawaii. Contact: Rosalind Price Raymond, 4201 Lafayette Center Drive, Chantilly, VA 22021-1209, 703 803 2996, Fax 703 803 3732.

October 29-30, **ASTM Committee D22.05 on Indoor Air**, Hyatt Regency, New Orleans, LA. Contact George Luciw, ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959. 610 832 9710, Fax 610 832 9666, email gluciw@astm.org.

November 4-5, 1996. **Diagnosing and Mitigating Indoor Air Quality Problems**, San Francisco, California. Organized by Indoor Environmental Engineering. Contact: Pat Cleveland, IEE Seminars, 1448 Pine St., Suite 103, San Francisco, CA, 94109, 415 567 7700, Fax 415 567 7763. *Fee: $795 ($695 for members of ASHRAE, ABIH, AIHA, and BOMA.) Instructor is Bud Offermann, PE, CIH.*

November 14-17, 1996. **4th Annual Energy Efficient Building Association (EEBA) Excellence in Building Conference Program**, Minneapolis, Minnesota. Contact: EEBA, 2950 Metro Drive, Suite 108, Minneapolis, MN, 55425, 612 851 9940, Fax: 612 851 9507, Email: EEBANEWS@aol.com, http://www.eeba.org.

November 17 - 19, 1996. **Thriving in the Green Building Marketplace, 3rd Annual Conference and Trade Show**, San Diego, California. Presented by U. S. Green Buildings Council. Contact: USGBC, c/o Concepts Marketing and Trade Show Management, 6540 Lusk Blvd. Suite C-124, San Diego, CA 92121, 619 535 0050, Fax 619 535 8252, email planners@conceptsmeet.com. *Advertised as a conference for "all sectors of the building industry. Co-sponsors include NIST, American Institute of Architects, and the Construction Specifications Institute, among others.*

December 8-11, 1996. **Risk Assessment and Risk Management: Partnerships Through Interdisciplinary Initiatives**, sponsored jointly by International Society for Risk Analysis and International Society for Exposure Assessment. Fairmont Hotel, New Orleans, Louisiana. Contact: Society for Risk Analysis, 1313 Dolley Madison Blvd., Suite 402, McLean VA 22101, 703 790 1745. *Exhibitors contact Lori Strong or Sue Burk at 703 790 1745, Fax 703 790 2672.*

January 25-29, 1997. **ASHRAE Winter Meeting and Exposition**, Philadelphia, PA. Contact: ASHRAE Meetings Department, 1791 Tullie Circle NE, Atlanta, GA 30329. 404 636 8400, Fax 404 321 5478.

September 27 - October 2, 1997, **Healthy Buildings/IAQ '97: Global Issues and Regional Solutions**, Washington, DC. Organized by ISIAQ, ASHRAE, and Virginia Tech. Contact: Professor James E. Woods, Virginia Tech. Fax 703 698 4729. email: hbiaq.97@vt.edu. *Announcement and Call for Papers have been issued. Abstracts are due November 30, 1996.*

International Events

May 7-11, 1997. **Space design and management for place making; 28th annual conference of the Environmental Design Research Association**, Universite Du Quebec, Montreal, Montreal, Quebec, Canada. *A Call for Participation has been issued. Mail submissions by November 1, 1996, to EDRA, Business Office, P.O.Box 7146, Edmond, OK, 73083-7146. (Inquiries about forms and details for submittals: 405 330 4863, Email edra@telepath.com.)*

June 9-12, 1997. **Buildings and the Environment**, Organized by CSTB and CIB T18, Paris, France. Contact: Ms. Angela Ghivasky, International Affairs, CSTB, 4, Avenue du Recteur Poincaré, 75782 - Paris Cedex 16, FRANCE, +33 1 40 50 29 13, Fax +33 1 40 50 28 76, email ghivasky@cstb.fr.

August 30 - September 2, 1997. **Clima 2000**, Brussels. Organized by Belgian Royal Technical Society of Heating, Ventilation, and Related Technology Industry (ATIC), on behalf of Federation of European Heating and Air-conditioning Associations (REHVA). Contact: Clima 2000 '97, c/o SRBII, Ravenstein 3, B-1000 Brussels, Belgium, +32 (0)2 511 7469, Fax +32 (0)2 511 7597. *The conference language will be English.*

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