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The Myth of Energy Conservation and IAQ

A popular myth holds that building energy conservation measures, implemented since the oil crises of the 1970s, cause indoor air pollution problems. This myth ignores the fact that most indoor air pollutant sources have little or nothing to do with energy conservation. Air studied inside buildings before 1973 was found to be more polluted than outdoor air even during severe air pollution events (Yocum, 1971). In fact, only two types of conservation measures directly increase indoor air pollutant concentrations: inappropriately reducing ventilation and using sealants and caulks that emit pollutants.

The myth ignores the fundamental responsibility (and ability) of architects, engineers, and building operators to create indoor environments that are both extremely habitable and environmentally responsible. Architects and other building design professionals must provide safe, healthy, and comfortable environments; minimize damage to the environment; and, conserve energy and other resources. Achieving good IAQ is as essential as providing comfortable, healthy thermal conditions and functional, aesthetically sound lighting and acoustical environments.

Reducing ventilation to conserve energy certainly increases concentrations of pollutants emitted from indoor sources. Adequate ventilation is essential to achieving and maintaining good IAQ. But there are many factors that determine IAQ and their interdependence is strong. And although ventilation is an important way to limit pollutant concentrations, limiting pollutant sources is more effective. Pollutants from indoor sources that cannot be eliminated should be minimized by careful planning, design, specification, and construction. The preventive approach costs very little; and, it saves energy.

How Ventilation Affects IAQ

Changes in ventilation rates generally affect IAQ only indirectly – it's the relationship between ventilation and pollutant sources that directly impacts IAQ. With the advent of larger buildings and variable air volume (VAV) systems, the role of ventilation has been shifted more towards thermal control and away from IAQ concerns. A discussion of these issues follows.

Ventilation Rates and IAQ

Reductions in outdoor air ventilation rates are commonly blamed for IAQ problems. However, consider the following three factors. First, there would be no indoor air contamination if there were no pollutant sources. The sources have changed in number and kind during the past forty-five years or so; abundant, harmful pollutant sources have resulted from new building materials, furnishings, equipment, and consumer products discussed later in this article.

Second, thermal control has become the dominant driving force in HVAC system design; the need to maintain good IAQ by adequate outdoor air exchange has become incidental. This shift began – long before the oil crises of the 70s – with the advent of VAV systems in the 1950s. The shift towards thermal control became more important as buildings became larger with more space remote from the envelope and concomitant lost access to daylight and ventilation through windows. In fact, ventilation rates sufficient to maintain good IAQ require very modest amounts of total building energy.

Finally, in the majority of buildings with IAQ problems, ventilation systems do not function as designed.

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Many of these failures result from problems in operation and maintenance. As many as 75% stem from design and construction flaws because designers simply did not place enough emphasis on IAQ. Table 1 shows the percentage of various deficiencies found in buildings with IAQ problems.

Ventilation and Indoor Air Pollutant Concentrations

Ventilation dilutes and removes indoor air pollutants. The amount of ventilation required depends on pollutant source strengths. The relationship is non-linear, best described by an asymptotic curve; a plot of the air concentration as a function of air exchange rate (a measure of building or space ventilation) is a smooth curve that approaches but never reaches either axis. Figure 1 shows the relationship between IAQ and air exchange rates based on contaminants from sources inside a building.

Problem Category	Physical Cause	Frequency (%)
Design	System problems	
	Inadequate outdoor air	75
	Inadequate air distribution to occupied spaces (supply and return devices)	75
	Equipment problems	
	Inadequate filtration of supply air	65
	Inadequate drain lines and drain pans	60
	Contaminated ductwork or duct linings	45
	Malfunctioning humidifiers	20
Operations	Inappropriate control strategies	90
	Inadequate maintenance	75
	Thermal and contaminant load changes	60

Table 1 - Frequencies of occurrence of physical causes of problem buildings. (Source: Woods, 1989)

The relationship between pollutant concentrations, source strength, and air exchange rate illustrates how air quality depends on ventilation. It also shows the importance of sources. The stronger the source, the more ventilation is required to maintain the same concentration. The point at which the curve changes from a vertical to a horizontal slope is known as the "knee" of the curve. For most buildings the knee of the curve falls within the range of ventilation rates found in the buildings.

The average air exchange rate in a series of office buildings studied by the former National Bureau of Standards (now the National Institute of Standards and Technology - NIST) was about 0.8 air changes per hour (ach). (Persily, 1989) An open office environment with 140 square feet/person, 20 cubic feet of outside air per minute/person, and an effective ceiling height of 10 feet maintains about 0.85 air changes per hour.

The point at which changes in ventilation rates dramatically affect pollutant concentrations from indoor sources is likely to be between 0.5 and 1.0 ach. Most buildings operate within this range during much of the time they are occupied. Therefore, changes in the ventilation rate can have dramatic impacts on actual pollutant concentrations. This is illustrated in Figure 1.

Ventilation from mechanical systems depends on the outside air fraction at the air handler, the flow to the distribution point (local diffuser), and the location and number of distribution points in relation to the area and volume of the space and the "design" number of occupants. Table 2 shows that these relationships can produce a very wide range of values.

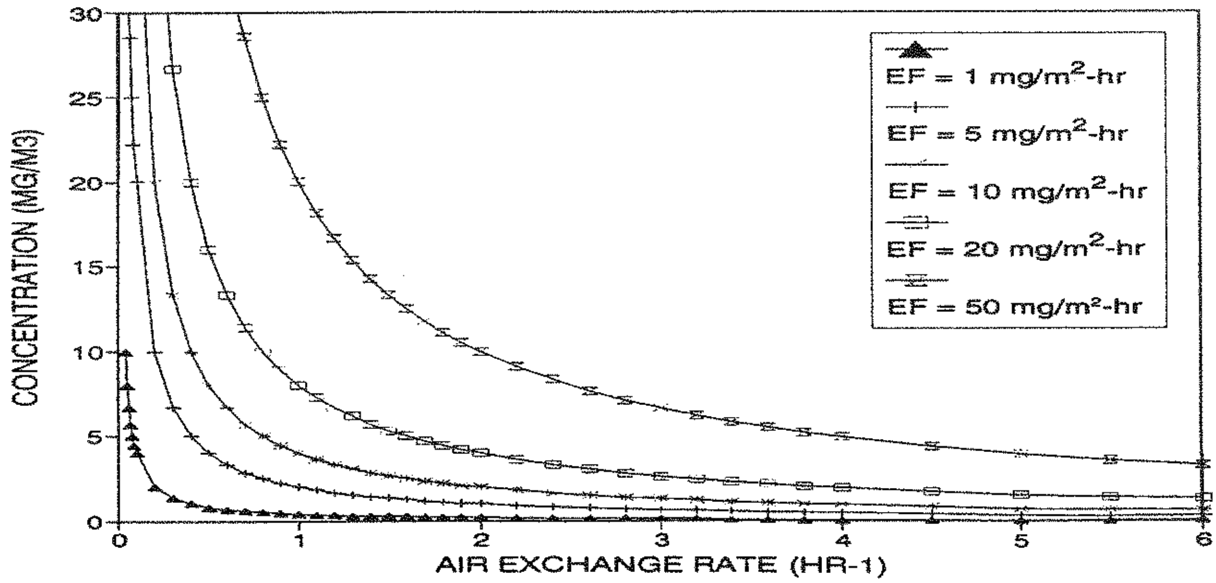

Figure 1 - Pollutant concentration as a function of ventilation at various source strengths.

OSA Fraction %	Distribution air flow rate 0.5 cfm/sf	0.5 cfm/sf	0.5 cfm/sf	1.0 cfm/sf	1.0 cfm/sf	1.0 cfm/sf
	Clear ceiling height					
	8 FT CLG	10 FT CLG	12 FT CLG	8 FT CLG	10 FT CLG	12 FT CLG
10	0.05	0.03	0.02	0.09	0.06	0.04
20	0.09	0.06	0.04	0.19	0.12	0.08
30	0.14	0.09	0.06	0.28	0.18	0.13
40	0.19	0.12	0.08	0.38	0.24	0.17
50	0.23	0.15	0.10	0.47	0.30	0.21
60	0.28	0.18	0.13	0.56	0.36	0.25
70	0.33	0.21	0.15	0.66	0.42	0.29
80	0.38	0.24	0.17	0.75	0.48	0.33
90	0.42	0.27	0.19	0.84	0.54	0.38
100	0.47	0.30	0.21	0.94	0.60	0.42

Table 2 - Outside air exchange rate for three ceiling heights and two air distribution rates according to OSA% at air handler.

Table 2 shows ventilation rates in air changes per hour for various outside and distribution air flow rates and ceiling heights. Typical outside air fractions range from around 10% up to 100% for buildings with air economizers. However, some buildings, most often very large ones, are limited to a maximum outside air fraction of around 10 to 20% of total flow. (See the Letter from Karl Guttmann on page 13.) Note that ASHRAE's ventilation standard calls for a minimum of 15 cfm/p in all occupied spaces with 20 cfm/p as the lowest value for most occupancy types.

Thermal Control vs. Air Quality

Historically, ventilation requirements were set to maintain air quality. In the 19th Century, before people began to bathe frequently and use personal deodorants, rates were specified to keep human body odor at acceptable levels. Traditionally, architects and engineers designed mechanical or natural building ventilation on the basis of established outside air requirements for assumed occupant loads and activities in the building program. Starting in the 1950s, thermal control objectives came to drive system design; ventilation requirements became minor components. The acceptance of VAV distribution systems, with its stronger emphasis on thermal control, resulted in outside air supply deficiencies.

However, VAV systems are not the only causes of these deficiencies. Fewer buildings use independent heating and ventilation systems. And, large-building thermal loads are dominated by cooling requirements because of the large ratio between the enclosed volume and the building envelope surface area. There is considerable internal heat gain from lights, occupants, and equipment. Most thermal loads are cooling loads except in small buildings and at the perimeters of larger buildings.

This size factor and building bulk are what have really driven the shift in ventilation design emphasis towards satisfying thermal requirements. This shift has led to the notion that "energy conservation causes indoor air pollution." At most, reduced air exchange to conserve energy exacerbates IAQ problems, but the causes are not the direct result of energy conservation (with some noteworthy exceptions discussed later). The problems are starting to be addressed now. ASHRAE has increased its recommended minimum ventilation air requirements and the new standards are being adopted into model codes and state building regulations.

Designing for Good IAQ

Architects and engineers can promote good IAQ at the design stage by taking into account expected loads and likely pollutant sources and by establishing effective source control strategies. In the following section, we discuss these topics as well as the energy costs of changing ventilation rates.

Determining Loads

Maintaining a healthy, safe, and productive environment requires that ventilation be sufficient to maintain air quality. As we have shown in Figure 1, the amount of ventilation required depends on the pollutant source strengths (from equipment, building materials, and consumer products), the types of activities within the building, and the occupant density. Since these factors can all vary independently, it is difficult to provide universally applicable ventilation rates. Using the ASHRAE standard's recommended minimum ventilation values assumes no "unusual sources" of indoor pollutants. The burden is on designers to determine the nature of any pollutant sources and whether they require more than the recommended minimums.

It's worth pointing out that the recommended minimums are not intended to provide a high quality environment. They are simply intended to avoid problems in most situations and to result in air quality that will be deemed "acceptable" to no less than 80% of a building's occupants. Most building owners would want air quality that would be acceptable to more than 80% of the occupants.

In designing buildings' structural systems, performance requirements are analyzed based on assumed and calculated design loads. The designer then selects structural systems and components that satisfy those requirements. Lighting design is also "load-based;" it depends on illumination requirements of the activities for which a space is planned. Acoustic control is also designed to support expected occupant activities.

Determining target levels of pollutants is, unfortunately, not an exact science. We know too little about the actual health and comfort effects of most pollutants to be able to set target or "safe" levels with confidence. This is especially true because the effects of most of the individual chemicals found indoors are poorly understood. In indoor air they are typically present in complex mixtures of hundreds of chemicals. it is possible that they act in a way that is independent, additive, synergistic, antagonistic, or even prophylactic.

Ventilation Rates and Energy Costs

ASHRAE promulgates the recommended minimum ventilation rates in its Standard 62-1989, "Ventilation for Acceptable Indoor Air Quality." Some critics claim this standard imposes a large burden due to the increased costs involved in the revision upwards from the 1981 ASHRAE recommended ventilation levels to the 1989 levels. In offices and some other environments where no smoking was permitted, minimum recommended ventilation rates were 5 cubic feet per minute per person (cfm/p) in the 1981 version. Where smoking was permitted the recommended minimum was 20 cfm/p. The 1989 version eliminated the distinction between smoking and nonsmoking environments and changed the minimum ventilation rate to 15 cfm/p.

Researchers at the University of California's Lawrence Berkeley Laboratory showed that the increased annual energy costs associated with increasing minimum ventilation from 5 to 20 cfm/p in offices is only about 5 percent of the total annual energy cost of operating a typical office building, even in the most severe climates. (Eto and Meyer, 1988)

Researchers at the Bonneville Power Administration have studied the increased costs in diverse climate zones of the Pacific Northwest and have determined that the increases are not larger than 15% except for three building types — schools, hotels, and large retail. In fact, only in these building types do the increased costs involved in meeting the revised standard exceed an additional 11% in operating energy. Because of the high occupant densities in schools, the per occupant ventilation rates result in larger but still not major increases in overall energy costs (Steele and Brown, 1990). And the ventilation rates for retail spaces are based on outside air supply per square foot regardless of occupant density. The results of their investigation are summarized in Table 3.

Source Control

Ultimately, we must control sources as best we can and use ventilation to limit pollutant concentrations to acceptable levels. The following discussion of indoor air pollution sources presents an overview of the subject and argues for the importance of pollutant source control.

Sources of Indoor Air Pollutants

There are many sources of pollutants in buildings and they vary considerably from building to building. For that reason, addressing these sources effectively must be part of the design process. To simply use general guidance for ventilation as a means of controlling pollutants is to choose the default solution; it does not represent the best effort of a good designer.

It is important to understand the relative contributions of various sources and to address the strongest ones. We must go after the ones with the most surface area, the most mass, and the emissions that we know or believe to be most irritating or toxic. Figures 2 and 3 show the amounts

Building Type	Seattle	Richland
Grocery	3.2	3.5
Hospital	0.9	1.4
Hotel	31.9	33.6
Small Office	10.3	10.5
Large Office	0.0	0.4
Restaurant	10.4	10.7
Small Retail	11.8	10.9
Large Retail	16.5	15.4
School	42.3	40.8
Warehouse	1.1	1.1

Note: Percent energy increases are averages between new and existing building configurations and are based on the difference between annual energy consumption at Standard 62-1989 of 20 cfm/person and the annual energy consumption at 5 cfm/person.

Table 3 - Average energy increase due to increasing outside air supply values from ASHRAE Standard 62-1981 to ASHRAE Standard 62-1989. (Percent of total energy)

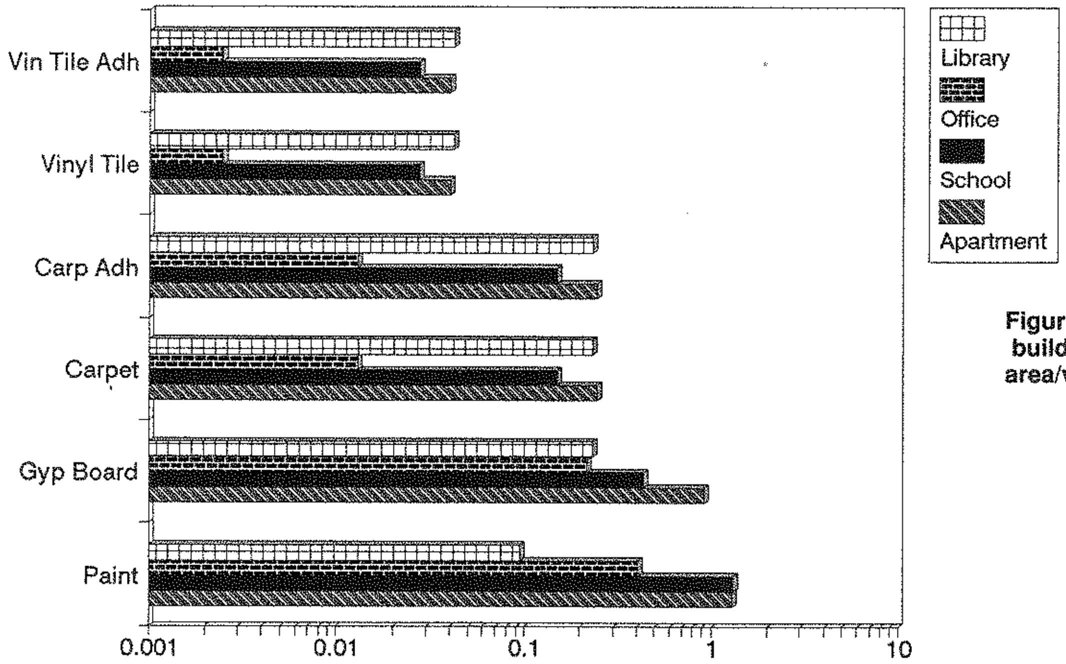

Figure 2 - Common building materials area/volume ratios. (m^2/m^3)

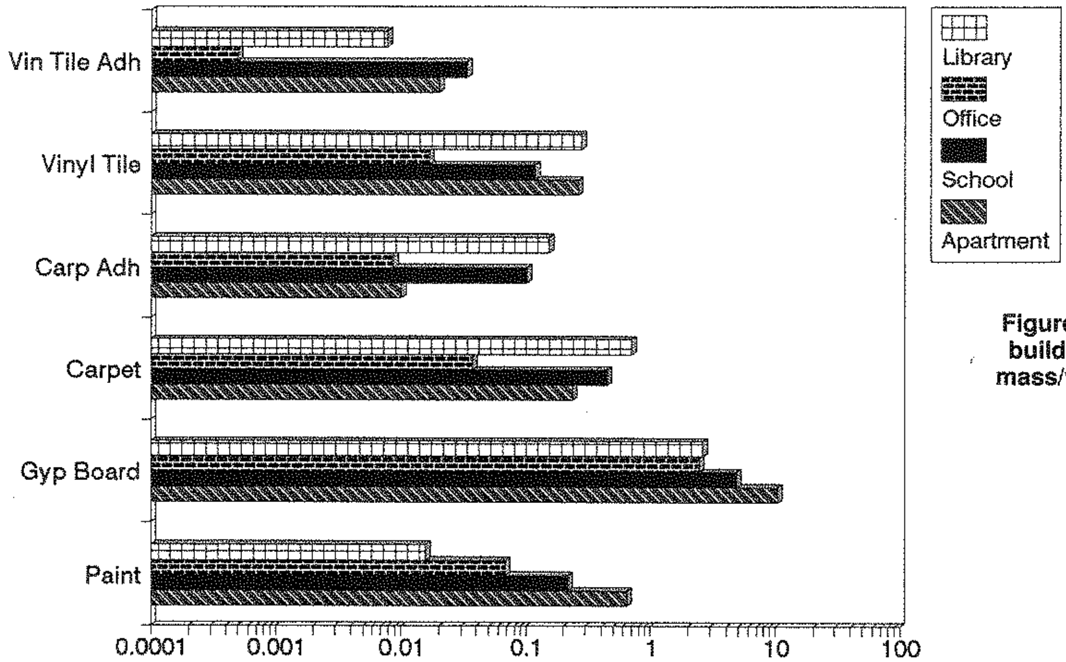

Figure 3 - Common building materials mass/volume ratios. (kg/m^3)

of dominant materials present in four different buildings. That type of analysis shows how different buildings are from each other and how widely the amounts of the major materials varies.

Figure 2 shows some of the sources and their relative surface areas compared with the building volume for a school, an office, an apartment house, and a public library. Figure 3 shows the mass of these materials relative to the building volume. Note that both figures show the amount present as a ratio to the volume on a logarithmic scale; the differences are really quite significant.

Emissions from new building materials are far greater than from aged materials. However, maintenance, refinishing, and replacement activities result in significant increases in pollutant emissions. Therefore, the durability of a material impacts IAQ significantly. It is important to note that "wet" products such as paints, adhesives, caulks, cleaners, waxes, and polishes emit very large fractions of their mass into the building air, and usually soon after application. However, even after these products are dry functionally, they continue to emit very slowly for a very long time.

Modern Building Materials In the past forty years, building materials have changed in ways that make them stronger sources of indoor air pollutants than "traditional" materials. For example, composite wood products have replaced solid wood materials, bringing binders, adhesives, and other chemical additives indoors. The most well-known and perhaps most widely-used examples are particleboard, plywood, and other composite wood products based on urea-formaldehyde resins. Fortunately, these resins are being replaced by more stable phenol-formaldehyde resins, and some manufacturers are developing and even marketing products that use no formaldehyde-based resins at all.

New, low-emitting adhesives are now available for installing flooring products. Paints that use far less organic solvent are also becoming more common. However, replacing a strong emitter with a non-durable, low-emitting product may result in more maintenance and replacement. This can mean more frequent, short-term emissions. Durability can therefore be a very important determinant of IAQ. Table 4 shows some of the major changes in building materials and furnishings.

Architects' and Designers' Roles

Architects and designers can substantially reduce indoor air pollution by proactively minimizing undesirable sources. There are studies that have evaluated the human health and comfort effects of measured mixtures, either in the laboratory or in real buildings, and have established target levels.

They can limit chemicals with known toxic effects to levels that will not cause adverse reactions. For example, the California Air Resources Board recommends that formaldehyde levels not exceed 50 parts per billion (ppb). Since it's known that most particleboard, plywood, hardboard, fiberglass insulation batts and boards, some textiles, and many other building products emit formaldehyde, architects and designers must try to limit their quantities, select lower-emitting products, or choose substitute materials. They can calculate emissions from these products based on test data. Knowing ventilation rates, they can estimate formaldehyde indoor air concentrations and change specifications if necessary.

Old (traditional) material or product	Modern material or product	Emissions from modern materials and products
Masonry or wood flooring	Resilient floor covering, carpet	Plasticizers, solvents, waxes
Plaster walls and ceilings	Painted gypsum board, ceiling tiles, fabric-covered panels	Solvents, drying agents, asbestos, plasticizers, textile finishes, insulation binders
Full-height plaster walls	Office workstation panels	Textile finishes, adhesives, solvents, insulation binders

Table 4 - Representative changes in modern building materials.

This approach, although it seems rather unscientific and not very specific, is, in fact, similar to the way we design illumination and acoustic and thermal control. This brings us back to our title topic. We don't say that energy efficiency causes poor lighting or visibility problems in buildings – we determine what lighting levels are necessary to perform the tasks for which the building is designed and built, then we attempt to achieve those levels in an energy-efficient manner. We must recognize the need to apply the same approach to IAQ.

Conclusions

In the end, the most effective strategy for good, energy-efficient IAQ is to control sources as much as feasible and then use ventilation as required to limit pollutant concentrations to reasonable levels. We reduce energy required for ventilation systems by minimizing the sources of indoor air pollutants in our designs. Sources can be controlled by eliminating polluting products, substituting less polluting products, encapsulating pollutant sources or by isolating and directly venting emissions. By requiring manufacturers to test emissions from their products and provide designers with reported results, we can choose the least polluting sources and the products with the lowest overall emissions. We can choose products that do not emit odorous or irritating compounds and avoid products with significant emissions of carcinogens, teratogens, and other unacceptable properties. To do less is to abdicate our responsibilities to our clients and to the building users.

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EPA Classifies ETS as a Human Carcinogen

EPA Administrator William Reilly has approved the long-debated risk assessment of ETS. The report concluded that ETS is a human (EPA Group A) carcinogen; this means that employers, businesses, and building operators will risk increased liability if they expose anyone involuntarily to tobacco smoke. While there have been major strides made toward separating smokers and non-smokers in many businesses and in many jurisdictions' public buildings, the newly-approved carcinogen status will stimulate a new round of anti-smoking actions. These are likely to include numerous petitions and lawsuits to protect non-smokers, restrictive local and state ordinances, a federal smoking ban on international airline flights, and modifications of existing buildings to reduce ETS exposure.

EPA apparently plans to go international by informing other governments about its action. "EPA will work closely with the Department of Health and Human Services and other organizations to ensure that officials around the world are made aware of the findings of this important study," Reilly said at a January 7 press conference announcing the report's release.

According to Reilly, "Twenty percent of all lung cancers caused by factors other than smoking are attributable to exposure to environmental tobacco smoke. That is a risk of about 1-in-1,000. Exposure to second-hand smoke varies, but higher exposure causes higher risks. For example, people whose spouses smoke in the home face an additional risk of about 2-in-1000."

Reilly went on to say that these risks are considered high when they are compared to other risks EPA generally regulates that are below 1-in-1,000 to as little as 1-in-1 million. "In other words," Reilly said, "the risks associated with environmental tobacco smoke are at least an order of magnitude greater than they are for virtually any chemical or risk that EPA regulates."

While EPA lacks the authority to regulate ETS, Reilly said the agency will work with the Occupational Safety and Health Administration which, he said, can regulate smoking in the workplace. He said he expects the report to be "...as important and influential, both in the United States and throughout the world, as any EPA has ever done."

Health Effects on Children

The EPA's ETS announcement and the press coverage that surrounded it emphasized the adverse health effects on children as much as the lung-cancer deaths in adults. Between nine- and twelve-million American children less than five years of age are exposed to parental smoking. Some of the respiratory effects identified by the report are irritation (cough, sputum, or wheeze); acute lower respiratory tract disease (pneumonia, bronchitis, and bronchiolitis); acute middle ear infections and indications of chronic middle ear infections (predominately middle ear effusion); reduced lung function; increased incidence of asthma and exacerbation of symptoms in asthmatics; and, acute upper respiratory tract infections (cold and sore throats).

Among the specific effects cited in the report are the following:

- ETS exposure causes additional episodes and increased severity of symptoms in asthmatic children. According to the report, between 200,000 and 1 million asthmatic children experience a worsening of their condition due to ETS exposure. And, ETS exposure increases the risk of new asthma cases in children who have not previously shown symptoms. The report calculates that a fairly high level of exposure is required to induce new cases of asthma in children; for children of mothers who smoke at least 10 cigarettes a day, between 8,000 and 26,000 new cases of asthma will occur annually.
- Exposure to ETS causes an increased risk of lower respiratory tract infections (e.g., bronchitis, pneumonia, bronchiolitis) in infants and young children. Exposure to ETS from parental (especially maternal) smoking leads to between 150,000 and 300,000 cases annually in children under 18-months old, according to the report. The report says that between 7,500 and 15,000 hospitalizations occur annually as a result of these infections. The elevated risk continues, but at a lower magnitude, for children until age 3, but the report made no estimates of the incidence beyond 18 months.
- ETS exposure increases the prevalence of fluid in the middle ear (pervasive middle ear effusion —

PMEE) that is very painful in young children. "Fluid in the middle ear is the single most frequent cause of hospitalization of young children for an operation, and it imposes a heavy financial burden on the health-care system," according to Reilly.

- The report also identifies ETS exposure as a possible risk factor in the occurrence of sudden infant death syndrome (SIDS). Other studies published too late for inclusion in this report have found more evidence of an increased risk of SIDS among children of women who smoked during pregnancy, after birth, or both.

Health Effects on Adults

The report places the number of excess lung cancer deaths among non-smokers exposed to ETS at 3,000 per year in the US. While the estimated excess lung cancer deaths for non-smokers from ETS pale in comparison to the 143,000 deaths in smokers, this still represents a much larger risk than any of the many chemicals EPA regulates at costs of millions and even billions of dollars annually.

Passive smoke also causes "subtle but significant effects on the respiratory health of nonsmoking adults, including coughing, phlegm production, chest discomfort, and reduced lung function," according to the report.

The report does not estimate the excess deaths due to heart disease among non-smokers exposed to ETS. It cites "[r]ecent analyses of more than a dozen epidemiology and toxicology studies...[that] suggest that ETS exposure may be a risk factor for cardiovascular disease." While the report did not address the impact of ETS exposure on the incidence of cardiovascular (CV) disease, it seems likely that the number of ETS-related premature deaths from CV are far greater than from lung cancer. However, the report clearly states its view that if "ETS is a risk factor for these diseases [non-respiratory cancer and heart disease]...the total public health impact from ETS will be greater than that discussed ...[in the report]."

Impact on the Tobacco Industry

Tobacco industry stocks fell significantly the day before the January 7 press conference at which EPA's Reilly announced the report. The *Wall Street Journal* focused several articles on the action and its implications. However, the tobacco industry is not expected to roll over. Industry spokespersons have already criticized the report saying that the evidence does not support its conclusions. It remains to be seen how the tobacco industry will fight the report, but it does not require a crystal ball to predict strong resistance when local and state smoking bans are considered by legislative bodies.

Implications

The effects of this action are legion. Local governments, manufacturers, business owners, researchers, and consultants will all be affected. To avoid running the risk of lawsuits, employers will have to consider a total ban on smoking to avoid exposure of non-smokers in the workplace. Government agencies at the federal, state, and local level will have little choice but to ban smoking.

- We visited one non-profit business the day after the announcement where the chief executive officer said: "I have no choice; I have to ban it. What else can I do?"
- The Baltimore Orioles baseball club has announced that the entire ballpark will be smoke free starting next year. For readers unfamiliar with the park, it is an open (un-roofed) stadium. This action reflects not only the view of employers but also that of any business with concerns about customer preference as well as its own potential legal liability.

Certainly the ban will have a stimulating effect on the indoor air research and consulting community as well as manufacturers of air cleaners and filters. While smoking bans will reduce the demand for some of the devices, operators of smoking-restricted buildings will want to increase the effectiveness of their equipment.

Many businesses will not choose to totally ban smoking. Instead, they will try to segregate smokers and non-smokers more effectively. Our view has long been that cigarette smoke should not be re-circulated by building ventilation; it should always exhaust directly to the outdoors. Needless to say, there are many consultants funded by tobacco industry sources that openly disagree.

We recently received a call from an environmental health and safety officer for a major corporation seeking advice. She said that there were extensive complaints about IAQ in one of the company's facilities, but that she ruled out a restriction on cigarette smoking or the installation of air cleaning equipment. The corporation owns a company that manufactures tobacco products.

The following is a discussion of likely action in various indoor environments.

Offices

Office workers are most likely to seek protection from second-hand smoke. Failing to receive it, they will probably look for help from their unions or the courts. Mixed smoking and non-smoking office areas served by the same ventilation system will vanish except, perhaps, in rare instances such as the one noted above. Even in extreme cases, local and state ordinances will probably require smoke-free environments for those who request them.

In smoking-permitted buildings with air recirculation, both particle and gas removal are required to achieve acceptable air quality free of ETS constituents. And, ventilation systems must be able to capture ETS before it drifts away from the source. Several devices are now available that were intended to respond to recent smoking restriction ordinances. These include fans and filters built into office furniture to provide air cleaning and improved circulation.

ETS particles are very small and may be removed only by high-efficiency particle arrestance (HEPA) filters or electrostatic precipitators (ESP). Both require additional energy to operate, although HEPA filters require more energy than ESPs due to the very large increase in resistance to airflow. ESPs must be cleaned frequently, between once a week and once a month, to be effective. HEPA filters are expensive to replace as well as to operate.

A real danger is that operators will not maintain and replace these devices as required to sustain their designed performance. The decentralized air cleaners and filters are even less likely to be properly maintained than centralized ones. The president of a firm that manufactures one of the widely promoted devices of this type, one that incorporates a HEPA filter, told the ***IAB*** that filters in their devices are usually not replaced at the recommended one-year interval due to the cost; instead, they may get replaced only when there is a recognized IAQ problem. A contractor who specialized in installation and maintenance of electrostatic precipitators told us he abandoned that enterprise because of the very great difficulty in convincing customers to obtain the proper maintenance.

In light of the problems cited above, we recommend completely segregating smokers within a building and ventilating with a dedicated air handler with no recirculation. Just to make our position clear, however, we do not believe employers or building operators are well-advised to permit smoking in office environments under any conditions, given the EPA report's findings.

Restaurants and Bars

Two environments where some smoking is likely to continue are bars and restaurants. Many restaurants already are smoke-free, and many more have separate smoking and "non-smoking" sections. Cartoonist Berry has characterized the so-called non-smoking sections as "secondhand smoking" sections. This characterization is often correct because of the typical layout of restaurants and their ventilation systems. Restaurants usually place the bar near the entrance so that customers waiting to be seated can have a drink while they wait. Keep in mind that many restaurants with liquor service earn far more from liquor sales than from food sales.

Ventilation in restaurants often involves providing supply air into the restaurant and bar and drawing that air into the kitchen where the exhaust fan over the cooking equipment requires as much or more make-up air as the restaurant and bar require together. Therefore, air is drawn from all parts of the restaurant into the kitchen where it is exhausted by the fan. In some cases, very little supply air is actually provided mechanically to the restaurant because of the reliance on air entering through the front door. This reliance may be inappropriate, but it is not uncommon. In any case, with the bar and smoking sections near the front entrance, the non-smoking section is often nearer to the kitchen; smoke-laden air passes through the non-smoking section to the kitchen. This is very typical of small, "storefront" restaurants commonly found in urban locations.

Total Bans Imperative

There is little doubt that smoking will be completely banned in public assembly spaces and other public access environments such as theaters, auditoria, supermarkets, public transportation vehicles and waiting areas. Questions arise around smoking opportunities for workers in these environments. We expect that if these workers are accommodated, it will be with separately ventilated spaces.

International Airline Flights

Because of the long duration of most international airline flights, it is quite likely that smoking will be banned there as well. Such a move has already been considered, and the EPA report forces the issue, at least for flights to and from the US.

Conclusions

Before the EPA scientific advisory panel met to review the report in December, 1990, there were accusations from both anti-smoking and pro-tobacco interests that the composition of the panel favored the other side. There was reportedly pressure to remove certain members from the panel. We conclude only that these perceptions reflect the tremendous importance of the report.

It is remarkable to us that under an overwhelmingly pro-business Republican administration, a report with such devastating consequences would not only be prepared, but would be approved and promulgated with such fanfare. Perhaps the reality is sadly buried in the tale we heard from a friend. When interviewed to head a tobacco industry-funded project, he offered the observation that cigarette smoking was virtually dead in the United States. His interviewers replied: "We know it. But that's not where the market is." Anyone who has traveled in Europe or Asia knows the enormous popularity cigarette smoking enjoys there. It remains to be seen whether EPA's plans to promulgate the report abroad will have a major impact.

To Obtain or Review a Copy:

Copies of the 560-page final report "Respiratory Health Effects of Passive Smoking: Lung Cancer and Other Disorders" (EPA/600/6-90/006F) are available by writing the Center for Environmental Research Information (CERI), U. S. EPA, 26 W. Martin Luther King Drive, Cincinnati, Ohio 45268. 513-569-7562 or fax 513-569-7566. The report is also available through the EPA Indoor Air Quality Information Clearinghouse (Call IAQ INFO at 800-438-4318). Inspection copies will be available at EPA Headquarters and EPA Regional Office Libraries and the Federal Depository Libraries.

For more information:

Office on Smoking and Health, Centers for Disease Control, Center for Chronic Disease Prevention and Health Promotion, Mail Stop K-50, 4770 Buford Highway, Atlanta, GA 30341.

National Cancer Institute, Building 31, Room 10A24, Bethesda, MD 20892. 800-4-CANCER.

The National Heart, Lung, and Blood Institute, Information Center, 4733 Bethesda Avenue, Suite 530, Bethesda, MD 20814.

National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, Ohio 45226-1998. 800-35-NIOSH.

Toxic Air Pollutants

California Study Underscores the Importance of Indoor Air

How many times have you heard that indoor air pollutant concentrations exceeded outdoor concentrations? And almost as often, that personal exposures were higher than indoor area samples would indicate? Another study confirms that measured personal exposures to air pollutants are often higher than indoor air samples, and that concentrations in indoor samples are higher than outdoor samples for all of the common solvents studied.

A study from California confirms the findings of previous studies done elsewhere. Lance Wallace and his colleagues at EPA studied exposures in California and New Jersey during various seasons. (See ***IAB***, Vol. 2, No. 7.) Now, a study performed by the same contractor, Research Triangle Institute, has found the same thing for a selective set of potentially hazardous chemicals found in indoor air. In a study conducted for the California Air Resources Board (CARB), researchers found these chemicals generally occurred at indoor/outdoor concentration ratios greater than one. But for all the common solvent-based "toxic air pollutants" (TAPs), the personal air samples showed the highest concentrations.

Of all the chemicals studied, researchers reported the highest indoor/outdoor ratios were found for styrene and para-dichlorobenzene (ρ-DCB). This, they say, suggests stronger indoor sources for the chemicals. Four chemicals were found in all samples; these were 1,1,1-trichloroethane, benzene, carbon tetrachloride, and the xylenes. Chemicals that were present in all indoor and/or personal samples included perchloroethylene, styrene, ρ-DCB, methylene chloride, and acrolein. Table 5 lists air concentrations of the most abundant TAPs studied.

		Air Concentration (μg/m³)							
		Indoor		Personal		Outdoor		Automobile	
Compound	Type[a]	median	90th percentile	median	90th percentile	median	90th percentile	median	90th percentile
1,1,1-Trichloroethane	VVOC,VOC	3.0	11	4.2	36	1.3	1.9	NT[b]	NT
Benzene	VVOC,VOC	2.2	8.3	3.1	8.9	1.1	1.9	NT	NT
Carbon Tetrachloride	VVOC,VOC	0.49	0.99	0.45	0.83	0.49	0.66	NT	NT
Perchloroethylene	VVOC,VOC	0.28	2.3	0.36	3.4	NQ[c]	0.59	NT	NT
Styrene	VVOC,VOC	0.95	3.9	1.2	3.3	NQ	0.70	NT	NT
p-Dichlorobenzene	VVOC,VOC	1.1	36	1.5	88	NQ	0.94	NT	NT
o-Xylene	VVOC,VOC	1.9	6.5	3.0	9.4	0.77	1.5	NT	NT
m,p-Xylene	VVOC,VOC	3.8	13	5.9	1.8	1.5	2.9	NT	NT
Methylene Chloride	VVOC	15	160	NT	NT	NQ	110	NT	NT
Acrolein	VVOC	4.1	21	NT	NT	NQ	8.6	NT	NT
Di-2-ethylhexylphthalate	SOC	0.059	0.64[d]	0.086	0.32	NQ	0.14	0.19	0.64

Table 5 - Air concentrations for the most abundant TAPs.
[a] Where VOC and VVOC data are available, VOC results are given. [b] Monitoring not performed. [c] Not quantifiable. [d] Maximum value reported.

The finding of the study is not new, but its focus on potentially hazardous substances underscores the growing consensus that indoor air presents a greater health risk than many more heavily regulated environments and activities. Although the study was limited to a single season and locale and to residential environments, the findings gain credibility because of their consistency with other studies, especially those conducted elsewhere in California by the contractor.

Implications

CARB identifies "toxic air contaminants" through a process that includes exposure assessment as part of a risk assessment process. CARB considers both indoor and outdoor exposures in the process. A list of candidate substances is drawn up, preliminary data is collected, and public comment is invited. Upon review of the information, substances are selected for more detailed consideration including risk assessment. Based on the results of this process, CARB classifies some substances as toxic air pollutants.

The impact of such classification is substantial. Under a recently adopted law, sources of regulated criteria ambient air pollutants must notify neighbors that they are exposed to these substances if the risk is calculated to exceed one in a million for cancer or an established threshold for non-cancer health effects. The notification process includes sending a letter to each residence that may be affected with information on the estimated risk. This, of course, is likely to raise concerns about the commercial or industrial process that is the source of the pollutant(s).

However, at least for the ubiquitous chemicals found at the highest concentrations, the greatest exposure occurs indoors and results from indoor sources. California has started to base its regulatory activities on risk-related criteria. The U. S. EPA has indicated its goal to shift its program emphasis to one based on the relative risks of various pollutants. If it does (as we believe it should), then indoor air pollution will receive substantially more attention than it now receives at the Agency.

Reference:

L. Sheldon, A. Clayton, B. Jones, J. Keever, R. Perritt, D. Smith, D. Whitaker, and R. Whitmore, "Indoor Pollutant Concentrations and Exposures, Final Report." Air Resources Board, California Environmental Protection Agency, January 1991.

For more information:

Research Division, California Air Resources Board, 1800 15th Street, Sacramento, CA 95814.

Linda Sheldon, Research Triangle Institute, Post Office Box 12194, Research Triangle Park, NC 27709-2194.

Negative Ion Generators

Washington Researchers Report No IAQ Effect

Do negative ion generators improve IAQ? According to preliminary results from Sweden described in Volume 2, Number 4 of the ***IAB***, negative ion generators with positive-charged collection plates showed clear positive effects on building occupant complaint rates. The negative ion generators were used along with a positively charged panel maintained at a nominal 8,000 volts in the experiment reported by David Wyon of the National Swedish Institute for Building Research.

Why then, did William Daniell and his colleagues at the University of Washington, Seattle, not find such positive effects? They conducted a double-blind, crossover design study to observe "the effects of functional and nonfunctional [placebo] negative ion generator devices on symptom prevalence in two Seattle area office buildings." One building had a long-standing reputation of IAQ problems.

The researchers reported "no detectable direct or residual effects of negative ion generator use on air ion levels, airborne particulates...or symptom reporting." Thus, we conclude that the negative ion generators were not effective in altering the important indicator parameters in the physical environment and, therefore, that the evaluation of their impact was not meaningful. If a negative ion generator is to be effective, it is likely that it will be from a change in the electrical fields and the concentrations of airborne particles. Absent such changes, we would not expect to observe any difference in occupant symptom prevalence rates.

The study, reported in the *Journal of Occupational Medicine*, did not employ the positively charged collection plates used in Wyon's study. Wyon demonstrated the effectiveness of his negative ion and positive charge collection plates and hypothesized a role for the reduced density of airborne respirable particles as important to the reduced symptom reports.

Daniell and his colleagues did find "job dissatisfaction was an apparent contributor to symptom reporting, with a magnitude comparable to presumed effects of air quality." We find this a confusing finding. Did it affect the symptom reporting rate, or did it contribute to the symptoms themselves? Does this finding suggest that symptom reporting is independent of actual air quality?

The measurement of air quality parameters was not sensitive enough to detect changes other than in the particulate concentrations due to the use only of a photoionization detector (PID) for organic chemical measurements. Measured parameters including carbon dioxide levels, particulate matter, and air ions were not significantly different in the two buildings in either of the two cases.

IAB Comments

Other research using negative ion generators alone appear inconclusive or negative as to their effect on symptom prevalence. It appears to us that the use of the negative ion generator alone is far less likely dramatically to affect the physical environment than its use in conjunction with the positive collection plate. If airborne particles are suspected as contributors to elevated symptom prevalence rates, then evaluation of the effectiveness of the negative ion - positive collection system appears warranted.

The researchers appear to have introduced an intervention that actually did not significantly change any measured parameter. Is this research of any value? If so, what? If not, doesn't it reinforce the beliefs of those who dismiss IAQ problems and occupant reports of symptoms as unimportant?

Reference:

William Daniell, Janice Camp, and Sanford Horstman, (1991) "Trial of Negative Ion Generator Device in Remediating Problems Related to Indoor Air Quality." Journal of Occupational Medicine, Volume 33, No. 6: pp 681-687.

CFCs and IAQ

Phase-Out Brings Possible IAQ Problems

As 1996 approaches, building operators and others who rely on refrigeration equipment face an important deadline. Nearly all production of chlorofluorocarbons (CFCs) will cease in order to comply with international treaties. Cooling is critical to maintaining thermal comfort; most commercial space in the U.S. would be uninhabitable a major portion of the time without refrigeration.

The GreenBusiness Letter (January, 1993) estimates that commercial buildings in the US now depend on about 80,000 centrifugal chillers to cool them. The newsletter also estimates that the air-conditioning industry has the capacity to replace or retrofit only about 6,000 chillers a year. The owners of equipment currently in place will either have to stockpile CFCs before the production phase-out, or they will have to replace their equipment.

Besides the commercial building use of chillers, they are also used in supermarkets. Automobile and truck air conditioners face similar challenges. The options are to take older equipment out of service and capture and store their refrigerants to replenish equipment left in service, or to replace equipment with devices that use refrigerants that will be produced after December 31, 1995, the deadline for ending CFC production.

According to *The GreenBusiness Letter*, the problem is not a lack of awareness, it's that most operators have not planned for the changeover. The typical useful life of a chiller is about 20 years, and devices older than that could be replaced with more efficient equipment that will pay for itself in energy savings in less than three years. A new machine may use only 60% as much energy as its 20-year old predecessor.

Medium-age machines, between 10- and 20-years old, can be less economical to replace because they still have some useful life remaining. Here too, however, efficiency gains may offset costs depending on utility rates in the area, financing costs, and other factors.

Newer machines under 10-years old represent about 40% of all machines in use. They are candidates for conversion. If the retrofit is done at the time of a scheduled major overhaul, normally every 5 to 10 years, savings as great as $15,000 per chiller can be achieved compared to retrofitting between regular service work.

Retrofits cost about half the price of a new machine, and they can use interim refrigerants such as HCFC-123, although less efficiently. HFC-132a is an alternative, although it is currently three to four times more costly than the CFCs it replaces. It is expected that the cost difference will become minimal as HFC-134a supplies increase and CFC costs increase due to taxes and diminishing supplies.

No matter how building operators address the problem, the most important thing now is to begin to plan for the post-1996 era. By inventory and plan preparation now, money and indoor environmental quality can be preserved economically and with the least damage to the outdoor environment. Failure to do so is likely to be costly both in financial terms and in terms of indoor environmental quality.

The Building Owners and Managers Association (BOMA) has established a CFC Task Force of 75 members who will respond to EPA's proposed CFC rules due out in April. The rules regard certifying companies and, possibly, technicians that service chillers.

BOMA notes that, depending on who you talk to, there is a 5- to 15-year supply of vacant office space in North America right now. The better quality space is doing well and is drawing tenants from lower quality space. But older stock and problem properties are being mothballed, according to BOMA. This suggests that many building owners may postpone action on CFC issues. This is likely to come back to haunt them when the market improves and they try to bring their properties back.

References:

"The Big Chill-Out: How to Survive the CFC Phase-Out Without Being Left Out in the Cold." *The GreenBusiness Letter*, January 1993. *The GreenBusiness Letter* is published 12 times a year. Annual subscriptions are $97 US, $102 Canada, $107 overseas. Single copies are $10. It is published by the Tilden Press Inc., 1526 Connecticut Avenue, NW, Washington, DC 20036. 800-955-GREEN.

Stephen P. Hokanson, "Looking Ahead in the New Year and Beyond." *Skylines*, January 1993. *Skylines* is the monthly magazine of the Building Owners and Managers Association, International. 1201 New York Avenue, NW, Washington, D.C. 20005, 202-408-2662.

For more information:

The GreenBusiness Letter lists the following contacts and resources for information and assistance in addressing the CFC issue:

Carrier Corp., Carrier Pkwy. P.O. Box 4808, Syracuse, NY 13221; 315-432-6000. Carrier has 92 branch offices in the US and 12 in Canada. Call 800-CARRIER to find a local Carrier Building Sciences office.

SnyderGeneral Corp., 3219 McKinney Ave., Dallas, TX 75204; 214-754-0500, fax 214-754-0949. This company makes the McQuay line of commercial air conditioners.

Trane Co., 3600 Pommel Creek Rd., La Crosse, WI 54601, 608-787-2000, fax 608-781-2252. Trane has a computer analysis program that will compute the life cycle costs for a specific system. Called TRACE, for Trane AC Economics, the program can factor in local utility costs and the load of the chiller to compare systems, and will calculate a company's cash flow, rate of return, and payback period.

York International, 631 S. Richland, York, PA 17405, 717-771-7890, fax 717-771-6476. York will help you locate a local district office or contact Roy Hubbord, manager of chiller conversion and retrofit services, at 717-771-6339.

American Society of Heating Refrigeration and Air-Conditioning Engineers, 1791 Tullie Circle NE, Atlanta, GA 30329, 404-636-8400, fax 404-321-0-5478.

Air Conditioning and Refrigeration Institute, 4301 N. Fairfax Dr., Ste. 425, Arlington, VA 22203, 703-524-8800, fax 703-528-3816. This group publishes the *Directory of Certified Refrigerant Recovery/Recycling Equipment*. Write or fax a letter on company letterhead to obtain a copy.

Letters

Guttman on Economizers

Dear Hal,

I have just received the ***IAB*** Vol. 2, Number 5 and read it, as always, with considerable interest. The article on Airborne Tuberculosis was particularly interesting, because many of our hospitals now find that they will have to provide isolation rooms for TB patients, yet there are at this time no standards available. The increase in TB patients, coupled with emergence of the new drug resisting strain, is of great concern to the medical profession, and our friends at OSHPD (Office of Statewide Health Planning and Development) in Sacramento are in the process of formulating new regulations relating to this problem.

However, on page 3 of the ***BULLETIN*** there is a box headed "Outdoor Air Amounts and Economizers." Hal, you did not do your homework. The information in this box is very misleading.

There are different versions of the traditional "economizer cycle." As the name implies, the purpose of this control feature is to save energy. The version which is easiest to understand and which, in my opinion, works best, uses two fans, a supply fan and a return/exhaust fan. In a simple constant volume reheat system, such as we use in hospitals, the supply fan always supplies a fixed amount of cooled and/or heated air to the conditioned spaces; the return/exhaust fan always returns a fixed amount from the conditioned spaces, but the amount returned to the supply fan, mixed with outside air, is varied according to the following rules:

1. The outside air temperature is below the (fixed) supply air temperature required to satisfy the zone requiring the most cooling:

In this case, return air and outside air are mixed to produce this temperature. The colder it gets, the less outside air is used, until the mixture reaches some pre-set minimum outside air percentage. In most cases, this minimum percentage is in the order of 10%, and except for very cold climates, such as the north east USA, Canada, Alaska, etc., it is never reached.

If the total air circulation rate for the system is 1.0 cfm/sq. ft., [0.472 L/s] as the box implies, the economizer cycle controls will modulate between 1 cfm/sq.ft. of outside air, when the outside air temperature is equal to the design supply air temperature and the economizer cycle is at 100% outside air, and a minimum which in California is usually between 30 and 50%, or .3 to .5 cfm/sq. ft. [.14 to .24 L/s].

2. The outside air temperature is between the (fixed) supply air temperature required to satisfy the zone requiring the most cooling, and the return air temperature.

At this time, the economizer controls position the dampers such that all return air is exhausted, and the supply fan uses 100% fresh air, as it is cheaper to cool the outside air than the return air. Under those conditions, if the supply air quantity is 1 cfm/sq.ft., all of it, or 1 cfm/sq.ft., is outside air. For a typical job, the supply air temperature may be 55°F [12.8°C] and the return air temperature 75°F, [23.9°C] and during the occupied hours the outside temperature falls into that range, you in fact get 1 cfm/sq.ft. of outside air.

3. The outside air temperature is greater than the return air temperature.

When the controls sense that condition, the dampers are abruptly positioned such that only the pre-set minimum of outside air is included in the mix, to save energy. That outside air minimum percentage is the culprit in many buildings experiencing sick building syndrome. It is typically in the order of 10%, or 0.1 cfm/sq.ft. [.05 L/s].

In other words, your worker occupying 140 sq.ft. [13 m^3] of office space receives anywhere from 14 cfm/p to 140 cfm/p [6.6 to 66.1 L/s]; most of the time it will be less than 140. If you know the statistical distribution of outside air temperatures, you can compute the number of hours the worker will receive a given cfm/p.

If you now use a VAV system instead of a constant volume reheat system, the ventilation rate as cfm/p will be significantly lower most of the time, and what is worse, will vary from room to room.

Hope this helps.

Regards,

Karl Guttmann

Guttmann & MacRitchie, San Francisco

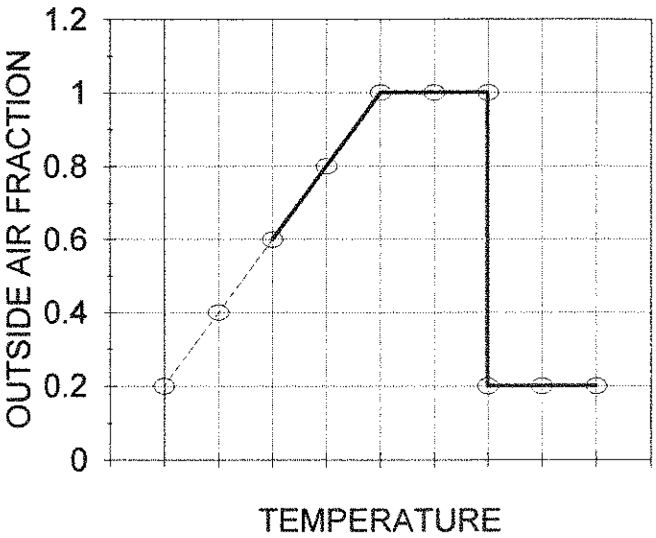

Figure 4 - Temperature dependence of outside air supply shown as a fraction of 100% outside air in HVAC systems with air economizers.

IAB Editor Replies:

Once again, we thank Karl Guttmann for his careful reading of the ***IAB***. We are happy to publish his letter in order to clarify the referenced article. We did not intend to imply that the use of an economizer cycle meant there would always be 100% outside air.

Guttmann discussed these issues in his paper, "Proposed Method of Indoor Air Pollution Control by Dilution with Outside Air," presented at ASHRAE's IAQ '87 (pp. 223-233 in *Practical Control of Indoor Air Problems; Proceedings of the ASHRAE Conference IAQ 87*. In fact, we nearly always use one of his diagrams (Figure 3 in the paper) when giving a talk or seminar on IAQ. Our re-drawing of his diagram (Figure 4 above) illustrates some of his comments.

Refer also to Figure 4 on page 4 of the last issue (Vol. 2, No. 7) of the ***IAB*** for a plot of air exchange rates based on various outside air supply fractions, distribution air volumes, and ceiling heights. Table 2 in this issue also shows the relationship between different outside air exchange rates and other variables.

OSHA Requires Formaldehyde Labeling

OSHA has revised its formaldehyde emissions rule effective December 28, 1992. The rule now requires labeling of all materials capable of releasing formaldehyde at levels of 0.1 ppm or higher. The regulation impacts a wide variety of products: from building materials, to textiles, to paper, to apparel. Specifically, the new rule will not only affect the traditional focus of OSHA regulation, the industrial environment, but it will also apply to the office environment.

The revised rule specifies that all products capable of releasing formaldehyde at levels of 0.1 ppm to 0.5 ppm must identify that the product contains formaldehyde. For materials that emit formaldehyde at levels greater than 0.5 ppm, the product must be labeled "Potential Cancer Hazard." The rule allows reliance on "objective" or third party determinations under "reasonably foreseeable conditions of use."

IAB Comments

We have difficulty with the units — emissions do not occur at parts per million. Emissions occur in units of mass per unit of material, expressed as either mass, area, or number. For example, typically, a thin material's emissions are reported in mg/m^2hr. A photocopying device would be reported in mg/unit output where output is reported as a number of copies.

Formaldehyde emissions are reported by the composite wood products industry (plywood, particleboard) in ppm, and they have influenced the OSHA rule as they did the Department of Housing and Urban Development (HUD) rule on formaldehyde emissions from particleboard for mobile homes. To convert from parts per million to mg/m^2hr, one must know the ventilation rate, the amount of material, and the volume of the test chamber.

Reference:

U.S. Code of Federal Regulations; 29 CFR Part 1910, Final Rule.

EPA Charters Risk Assessment and Management Commission

On December 24, EPA filed a charter with Congress to constitute the Risk Assessment and Management Commission authorized by Section 303 of the Clean Air Act Amendments of 1990. The act requires the commission to investigate risk assessment and management techniques used by EPA and other federal regulators to prevent cancer and other chronic health effects caused by exposure to hazardous substances. The hazards include air, water, and soil contaminants, pesticides, and waste.

In announcing the charter filing, its press office indicates that "EPA expects the Commission to direct a comprehensive investigation of federal decision-making, including scientific, economic and policy issues which arise in risk management decisions on cancer and other health problems."

The Commission is to prepare and publish a draft report for public comment by May 1994 and submit a final report to Congress by November 1994. The broad review of the risk assessments used under various federal laws may lead to proposals for legislation or administrative changes.

Calendar

Domestic Events

February 2-3, 1993. **IAQ Short Course for Building and Facility Managers**, Philadelphia, Pennsylvania. Presented by Mid-Atlantic Environmental Hygiene Resource Center, Sponsored by EPA Region 3 and US Public Health Service Division of Federal Occupational Health. Contact: Dr. Susan T. Smith, University City, 3624 Science Center, Philadelphia, PA 19104, 215-387-2255.

February 7-10, 1993. **Dynamics of a Changing Industry**, 4th Annual Meeting and Exposition, National Air Duct Cleaners Association, Loews Anatole Hotel, Dallas, Texas. Contact NADCA, Headquarters, 1518 K Street, NW, Suite 503, Washington, DC 20005, 202-737-2926, fax 202-638-4833.

February 11-12, 1993. **Indoor Air Quality for Facility Managers**; IFMA Professional Development Course, Tempe, Arizona. Sponsored by International Facility Management Association (IFMA). Contact: Susan Biggs, IFMA, 1 East Greenway Plaza, 11th Floor, Houston, TX 77046-0194. 800-359-4362, fax 713-623-6124. *This two-day overview of IAQ focuses on knowledge and skills needed by facility managers to prevent and solve IAQ problems. Instructor is **IAB** Editor Hal Levin. Enrollment is limited.*

March 18-19, 1993. **Workshop: Diagnosing and Mitigating Indoor Air Quality Problems**, Alexis Park Resort, Las Vegas, Nevada. Sponsored by Association of Energy Engineers (AEE). Contact: AEE, 4025 Pleasantdale Road, Suite 420, Atlanta, GA 30340, 404-447-5083, fax 404-446-3969. *Fee: AEE Member $695, Non-member $795.*

March 29-31, 1992. **Indoor Air Pollution, Sixth Annual Conference**, Adam's Mark Hotel, Tulsa, Oklahoma. Sponsored by University of Tulsa. Contact: Division of Continuing Education, 600 South College Avenue, Tulsa, OK, 74104-3189, fax 918-631-2154.

April 21-23, 1993. **Indoor Environment '93, Indoor Pollution Conference and Exhibition**. Hyatt Regency On the Inner Harbor, Baltimore, Maryland. Sponsored by IAQ Publications, Inc. Contact Conference Director Lisa Markham, IAQ Publications, 4520 East-West Highway, Suite 610, Bethesda, MD 20814. 301-913-0115, Fax 301-913-0119.

May 3-7, 1993. **Air & Waste Management Association Annual Symposium**, "Measurement of Toxic and Related Air Pollutants," Omni Hotel and Convention Center, Raleigh, North Carolina. Contact Martha Swiss, A&WMA, P. O. Box 2861, Pittsburgh, PA 15230, 412-232-3444, fax 412-232-3450.

May 15-21, 1993. **American Industrial Hygiene Conference and Exposition**, New Orleans Convention Center, New Orleans, Louisiana. Contact: AIHA, 2700 Prosperity Avenue, Suite 250, Fairfax, VA 22031, 703-849-8888, fax 703-207-3561.

June 13-18, 1993. **New Summits for Environmental Solutions**, 86th Annual Meeting and Exhibition of the Air & Waste Management Association. Colorado Convention Center, Denver, Colorado. Contact: Marci Mazzei, A&WMA, PO Box 2861, Pittsburgh, PA 15230-9940, 412-232-3444, fax 412-232-3450. *Nearly 200 technical sessions including three major topics: waste, air (including indoor air), and environmental management. Three-day exhibition is "most comprehensive event of its kind held in North America in 1993." Advanced registration $375/$460 for members/others respectively.*

June 26-30, 1993. **ASHRAE Annual Meeting**, Radisson Hotel, Denver, Colorado. Palmer House, Chicago, Illinois. Contact ASHRAE Meetings Department, 1791 Tullie Circle NE, Atlanta, GA 30329, 404-636-8400.

October 10-13, 1993. **Understanding the Workplace of Tomorrow**, 14th Annual Conference and Exposition on Facility Management, International Facility Managers Association (IFMA). Denver Convention Center, Denver, Colorado. Contact IFMA Headquarters, 1 East Greenway Plaza, 11th Floor, Houston, TX 77046-0194. 800-359-4362.

November 7-10, 1993. **IAQ '93: Operating and Maintaining Buildings for Health, Comfort and Productivity**, Philadelphia, Pennsylvania. Sponsored by ASHRAE. Contact: ASHRAE, see listing for Winter Meeting, January 23-27, 1993.

International Events

March 4-6, 1993. **Second Spanish and Interamerican Air Conditioning and Refrigeration Congress—CIAR '93**, Madrid, Spain. Contact CIAR '93, Parque Ferial Juan Carlos I, 238067, Madrid, Spain, 722-50 00, fax 722 57 90.

July 4-8, 1993. **Sixth International Conference on Indoor Air Quality and Climate**, Indoor Air '93, Helsinki, Finland. For more information, a copy of the conference announcement, or the call for papers, contact the confeence secretary at: Indoor Air '93, P.O. Box 87, SF-02151 Espoo, Finland, fax +358-0-451-3611. *Make plans now to attend this most important of international indoor air conferences. Devaluation of Finnish currency will help make this a more affordable conference to attend.*

October 27-28, 1993. **Volatile Organic Compounds**, Royal College of Physicians, London, England. Sponsored by Indoor Air International (IAI). Contact: Conference Secretariat, International VOC Conference, Unit 179, 2 Old Brompton Road, London SW7 3DQ, UK, +44 767 318 474, Fax +44 767 313 929.

November 1-3, 1993. **Clima 2000**, Queen Elizabeth Conference Centre, London, England. Contact: Anne Gibbins, CIBSE Headquarters, 222 Baltham High Road, London, SW 12 9BS, fax 44-1-6755449.

March 15 - 18, 1994. **Cold Climate HVAC '94 - International Conference on HVAC in Cold Climates**. City of Rovaniemi, Finland. Sponsored by FINVAC, Federation of Societies of Heating, Air Conditioning and Sanitary Engineers in Finland. Contact: FINVAC/Cold Climate HVAC '94, Mr. Ilpo Nousiainen, Sitratori 5, SF-00420 Helsinki, Finland, +358 0 563 3600, Fax +358 0 566 5093. *Abstracts are due March 1993; papers are due October 1993. The official conference language is English.*

April 17-19, 1994. **International Symposium on Volatile Organic Compounds in the Environment, Montreal**, Quebec, Canada. Sponsored by ASTM Committee E-47 on Biological Effects and Environmental Fate. Contact: symposium chair Dr. Wuncheng Wang, U.S. Geological Survey, WRD, P. O Box 1230, Iowa City, IA 52244. Tel 319-337-4191, Fax 319-354-0510. *Prospective authors are requested to submit a title, a 250-300 word abstract, and an ASTM paper submittal form by April 16, 1993 to Dorothy Savini, Symposia Operations, ASTM, 1916 Race Street, Philadelphia, PA 19103.*

Indoor Air BULLETIN

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Indoor Air BULLETIN sincerely invites letters or any comments you may have on either the topics presented within or on other indoor environmental issues of interest.