HEPA FILTRATION AND ITS EFFECTS ON INDOOR AIR QUALITY AND PRODUCTIVITY IN THE WORK PLACE

A Capstone Seminar Paper for
HSA 596, Seminar in Health Service Administration
Presented to Dr. Robert Guerrin
Department of Health Services Administration
Sage Graduate School

In Partial Fulfillment
of the Requirements for the Degree of
Masters in Science in
Health Services Administration
with a Health Education Concentration

By
Lorin D. Beller
May 1992

RESEARCH PROBLEM

Sick Building Syndrome is caused by poor indoor air quality. Indoor air quality has diminished since the 70's when we began insulating and becoming more concerned with preserving energy. Now that homes and offices are tighter and more well insulated we have developed indoor air problems. These problems cause employees to have a wide variety of symptoms such as: runny nose, headaches, allergies, asthma, low energy, etc. Poor indoor air is caused by less fresh air able to come in and "clean" the more polluted air. Some of the common indoor pollutants are: formaldehyde, asbestos, carbon monoxide, dust, etc. These pollutants build up in the air and people exposed to it will then breath the pollutants into their nose and respiratory system causing various symptoms.

When employees have adverse symptoms during the work day they are most likely going to be less productive. Therefore it will take more time to get the same task accomplished than if the employee was feeling well. This leads to a loss in productive time and money for the business. Sometimes the financial loss can be extravagant. Sometimes employees think that they are catching the flu so they stay home for a day or two. Other times they think that the symptoms are "normal" so they lose time at work between breaks, taking medication, moving at a slower pace, etc.

The question is "What can a company do to correct the problem without losing energy and spending huge amounts of money to develop a new ventilation system for a particular building." Indoor air problems have become not only an economic issue but also an administrative and health issue. If employees are not

working at their most productive rate, administrators need to know the reason why and try to correct it. Poor indoor air is an issue that is just beginning to be recognized and many administrators do not know what can be done. When the employees health is at risk then loss of money is at risk. The question is what can an administrator do at the work place to clean up the air in the most cost effective and efficient way possible? Most administrators feel that they are not educated, or understand the problem, well enough to address this issue. Therefore there is a need for administrators to be more educated and aware of the problem of indoor air and its effects on staff.

High Efficiency Particulate Air (HEPA) filtration will clean up the air in the workplace in turn allowing the employees relief of various symptoms that may be caused by the indoor air. HEPA filters combined with a trimedia (carbon and silica) filter will remove particulate matter from the air as well as gases and odors. Particulate matter, gases and odors are usually the main types of contaminants in the air that cause poor indoor air.

The problem: Sick Building Syndrome (SBS) or poor indoor air. When people have scratchy throats, runny nose, or itchy eyes, during work they are more likely to be less productive. Could High Efficiency Particulate Air (HEPA) filtration systems alleviate SBS problems bringing the productivity level back to where it should be? This will be the question that is to be analyized.

LITERATURE REVIEW

Sick Building Syndrome and Indoor Air Quality

Indoor air quality, according to the American Lung Association, is up to twenty times worse than outdoor air quality. The American Lung Association says that SBS results from sealing our buildings tighter and tighter to keep cold air out in the winter and cool air in, in the summer. The buildings are so tight that there is no circulation or movement of "fresh" air into the building. Therefore when someone in that building gets sick, it often times spreads to others in the building. When people are not feeling well at the workplace the productivity level diminishes. Wellness in the workplace has been more of an issue in the past decade than at any other time in history. Could the indoor environment be effecting our wellness?

Sick Building Syndrome is defined by the Environmental Protection Agency (EPA) as "when a significant number of building occupants experience symptoms that do not fit the pattern of any particular illness and are difficult to trace to any specific source." This is the definition that will be used throughout the study.

Pollutants that cause SBS

Indoor air pollutants come from many regular, normal things in the office and home. According to the New York State Department of Health there are many different pollutants.

Formaldehyde

Formaldehyde is an organic chemical and the actual chemical formula for it is HCHO. There are serious, long term health effects from being exposed to formaldehyde for long periods of time. Formaldehyde is difficult to remove from the air because it is used to manufacture so many common home and office products.

Formaldehyde, is found in foam insulation, plywood, particle board, carpeting, drapes, cabinets, wallboard, and sometimes clothing, it is an unpleasant smelling gas. Formaldehyde, according to National Safety Associates and Florida Polymers is ubiquitous. Often it causes eye and throat irritation, breathing problems, and headaches. The source of formaldehyde is manmade products, as mentioned above. There have been studies by the Electric Power Research Institute (EPRI) that show that one way to reduce the formaldehyde from being emitted from these products is to apply various paints, lacquers, varnishes, and vinyl papers to the particle board or other products that ware made with formaldehyde. This will reduce the emission of formaldehyde. The covering may emit some other pollutant though.

Passive Cigarette Smoke

Passive cigarette smoke is another pollutant. Formaldehyde is released into the air when someone is smoking, usually the gases are a mixture of carbon monoxide and formaldehyde. The United States EPA says that second hand smoke is the most widespread and harmful indoor air pollutant. Environmental tobacco smoke (ETS) also contributes ammonia into the air. If we were to calculate the num-

ber of cigarettes smoked we would find that about 467,000 tons of tobacco is burned indoors each year, according to the American Lung Association.

Hedges (1991c) explains that a fully burned cigarette releases 4,000 chemicals into the air, most of which are volatile organic compounds (VOC's, to be discussed later) and/or particulate matter. Hedges' solution to the problem is breathing zone filtration which, also will be discussed later.

Sterling (1984), on the other hand, says that his research shows that there is "little evidence that tobacco smoke is responsible for building illness, and there is good evidence of health risks from problems of carbon monoxide and nitrogen oxides from gas ranges in the home." On the other hand, National Safety Associates with the research from Florida Polymers explains that environmental tobacco smoke (ETS) is made up of both a particulate portion and a gas portion. The particulate portion is ash coated with tar and nicotine. The particles range from .10 to 1.2 microns. The burning method creates different particle size with varying tars and nicotine content. One thousand different gases and vapors make up the gas portion of the ETS. Every tobacco leaf burns differently. The burning yields different gas mixtures as: carbon monoxide, carbon dioxide, hydrogen sulfide, ammonia, hydrocarbons, formaldehyde, and oxides of nitrogen.

Bacterial Contaminants

Molds are another form of indoor air pollution. Molds grow in dark damp warm areas such as basements, bathrooms or anywhere where there is moisture or water. Molds are tiny disease causing microorganisms. Microorganisms are often the cause of asthma and other health problems. Dust mites and fungal spores

are common irritants. Both are more prevalent when humidity is high. Anderson and Korsgaard (1984) say that "higher ventilation and reduced indoor generated water vapor can act as preventive measures." Molds often effect allergies. Healthy Buildings International (HBI) (1989a) say that out of all their studies of sick buildings, one third have one or more major pollutants that are fungi. Fungi are a form of bacterial contamination. Bacteria is what caused the tragic Legionnaires disease. There is more risk of bacteria contamination when an air conditioning unit is in the office because the system more effectively disperses the microbiological contaminants. Some of these contaminants cause allergic reactions and others cause infections. Other forms of biological pollutants are viruses, bacteria, and protozoans.

Miller and Daglish, (1970), explain that molds can effect allergies in a variety of ways. Should one breath, eat, or touch a specific mold, that person could have their allergies triggered. To treat a mold allergy there are three different methods: avoidance, medication, or desensitization.

Asbestos

Asbestos is a mineral. Asbestos is used in the manufacturing of many building materials some of which are: insulation, walls, flooring, roofing, pipes, tiles, cement, etc. In Arkansas, according to Indoor Pollution News (1989b), a government building had an asbestos ceiling fall in. Asbestos lingers in the air for weeks after it is stirred up. The government referred to a NOVA program that stated that "even short term exposure to asbestos can cause cancer later . . . Once asbestos is in the lungs it stays there and causes cancer." Therefore the danger of asbestos is real and needs to be taken seriously, asbestos in the air definitely leads to a sick building that should be evacuated so it can be cleaned up. Asbestos is a solid mineral of vary-

ing particle size, according National Safety Associates and Florida Polymers. The source of asbestos is usually insulation. Asbestos is suspected to be a carcinogen.

Radon

More and more people are concerned about radon. Radon is naturally occurring, usually from decay of natural substances in the soil or rock beneath the home or office. The EPA (1987a) first began looking at radon as the main problem of indoor air quality. The EPA also noted the high incidence of lung cancer among the underground miners exposed to elevated levels of radon gas in the 1970's. Hedges (1991b) says that radon is responsible for 20,000 lung cancer cases per year among non-smokers in the U.S. The reason radon is such a concern is that it attaches itself to particles in the air and then the particles and radon enter the lungs. National Safety Associates and Florida Polymers says that radon is a radioactive gas that has been around forever. It is in all indoor environments just at different levels. It has a half life of 2 1/2 days. The only solution to rid the problem is ventilation, unless it is attached to a particle. Radon is suspected to be a carcinogen. The source of radon is the earth and earth derivatives. Breathing zone filtration also will remove this type of contaminated particle from the air according to Hedges (1991c).

Ozone

A Canadian Union (1985) found that fluorescent lamps emit ultraviolet light. These lamps provide energy for photochemical reactions among pollutants. This could be the cause for photochemical smog. What makes fluorescent lamps dangerous, is that often times the ventilation systems circulate air around and over the lights, this exposes a large volume of air to ultraviolet light. Ozone also comes from copy machines, electrostatic air cleaners (ironically) and smog.

Carbon Monoxide

Indoor Air Quality (IAQ) can be polluted from spillage of even the most pleasant aromas. 23% of emergency room complaints of flues and cold symptoms were really cases of carbon monoxide poisoning, in Canada. Most of the time carbon monoxide in the indoor air was a result of gases spilling from furnaces and fireplaces that people thought was a pleasant smell and never corrolated the smell getting to sick. If doctors asked their patients if their fireplace or furnace was "spilling or leaking," they would report "no." If the doctor asked, "does their home have that pleasant smell of woods aroma coming from the fireplace or furnace," they would report "yes." This is spillage, according to the Indoor Pollution News. (1990c) This type of problem comes from improper venting of wood burning or gas or oil stoves or furnaces. The term for such a problem is "combustion spillage," according to Indoor Pollution News (1990c). This is the cause of several hundred to thousands of deaths each year in the United States and Canada.

Volatile Organic Compounds (VOC's)

"California researchers link indoor VOC's with tap water. Volatile organic compounds (VOC's) can be transferred through contaminated tap water into indoor air, and the resultant human exposure to VOC's may be equal to, or greater than exposure by ingestion," according to Indoor Air Review (1991). Research has shown that 61% of the contaminants transfer from the water to the air during a regular shower. VOC's are from the chemical in the water mixing with the organic compounds that are in the water; the mixture of the two, forms the VOC. VOC's are

also formed from other chemicals that are liquids but quickly evaporate into the air.

Dust and Particulate Matter

Typical dust around the home and office often can build up at fast rates. The dust particles consist of a variety of things such as: just plain dirt, dust mites, dust mite feces, etc. Often particles get into air then other more harmful contaminants attach themselves to the particle creating an even more harmful particle.

An example of just one form of dust or particulate matter is paper particles. Paper is different depending on the manufacturer, the weather conditions also affect the particles (humidity level), and people all have a varying sensitivity level to the particles. Horstman and Scott (1981) found that the formaldehyde from the paper caused many membrane irritants (eye, nose, throat). The evidence showed that just handling the paper resulted in the release of the chemical into the air. Kleinmann and Horstman (1982) found the same relationship but also noted that there were other factors that took place such as poor ventilation, high temperature, low humidity, etc.

Other Pollutants

We live with many allergens in our indoor air. Reed and Swanson (1984) "...emphasize that almost any organic dust or volatile chemical which reacts with proteins can cause allergic respiratory disease, such as allergic rhinitis, asthma, and hyper-sensitivity pneumonitis." Long term exposure to these allergens can cause permanent damage to occur.

Finally the New York State Department of Health says that household

chemicals such as: paint, glue, beauty sprays, lawn and garden products, polishes, etc. are causing problems with the indoor air. These gases and odors get into the air in the home or office and if ventilation is not good, this creates poor indoor air quality. When particulate matter is combined with gases indoor air quality is further reduced. The most typical causes of Sick Building Syndrome are: the presence of indoor pollution, poorly designed buildings, and poorly maintained or operated ventilation systems and finally, poorly designed buildings for a particular use. Copy machines, fax machines, photography equipment and print machines, are other sources of pollution in offices.

If the ventilation system is not functioning properly, fresh air will not be brought in. Another problem is contaminated outside air, if that is being brought in by the functioning vent many problems can arise. Converted office buildings that were not originally planned for such a use, may be the cause of poor ventilation in the building.

OSHA (1989) adds to their list of indoor air pollutants: acetic acid for x-ray development, nitrogen oxides from gas furnaces and appliances, and welding, and diesel engine exhausts. The Environmental Protection Agency (EPA) (1988b) also is concerned about indoor air quality and has done extensive research on the problems causing it. The EPA adds a few more sources to their list of indoor air pollutants: humidifiers, moth repellents, dry cleaned goods, dust mites, personal care products, air fresheners, stored fuels, car exhaust, wood stoves, unvented gas stoves, unvented clothes dryers, and pesticides.

According to Healthy Buildings International (HBI) (1990), the major

contaminants found over an eleven year period of studying SBS has been: fungi 35% of the time, 28% of the time the problem is airborne dust, 19% low relative humidity, 11% bacteria, 8% is HCHO, 7% fibrous gas, 6% exhaust fumes, 4% VOC's, 3% is tobacco, 2% is high relative humidity, and 1% of the time the problem is ozone. (See Fig. #1, below)

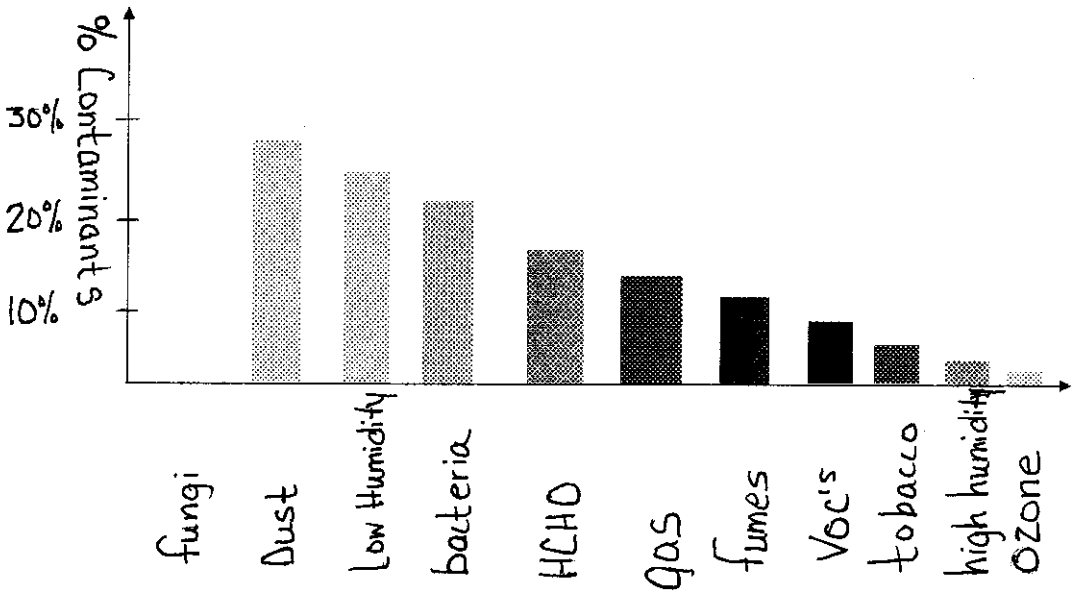


Fig. 1: CONTAMINANTS FOUND IN A "SICK BUILDING"

Turiel, Hollowell, Miksch, Rudy, Young, and Coye (1983) studied two buildings that had complaints of different health problems (eye irritants, itching, nose and throat irritation, eye inflammation/infection, skin dryness, tightness of the chest, and shortness of breath). "Results showed that carbon dioxide levels and odor perceptibility increased with reduced ventilation rate, although this was not the case for other pollutants. Most pollutants were at very low concentrations, below current health standards," Turiel, et al, (1983). Turiel et. al. (1983) conclude that "a synergistic effect of air pollution may account for the differences in sickness between build-

ings studied." Hedges (1991b) says that SBS is the "consequence of exposure to multiple risk factors, only some of which are environmental." The activities of the workers in the work environment directly effects the IAQ.

The World Health Organization has done a very detailed report on four air pollutants: chlorine, formaldehyde, nitrogen dioxide and sulphur dioxide. They see these pollutants as having short and long term effects depending on the exposure to them. Chlorine could come from the fumes from tap water. According to Cushing and Samet (1991) nitrogen dioxide comes from unvented gas appliances, kerosene space heaters, and tobacco smoke.

What are the Health Effects of SBS?

Because we spend as much as 90% of our time indoors we are exposing ourselves to poor air for long periods of each day. The longer the exposure to dangerous pollutants the more likely of adverse effects on peoples health. The EPA says that some groups of people are more susceptible than others i.e.- young, elderly, chronically ill, and especially those suffering from respiratory and cardiovascular disease. Indoor air quality can affect your health in two ways either immediately or later in life. The immediate symptoms are usually: irritation to the eyes, nose and throat, headaches, dizziness, and fatigue. The long term effects are usually diseases such as: asthma, hypersensitivity, pneumonitis, and humidifier fever. There are even other effects that show up years after exposure such as: emphysema and other respiratory diseases, heart disease and cancer. According to National Safety Associates and Florida Polymers, there is a direct relationship between particle size in the air and health. Particles that are 1.0 micron and larger are effectively removed by nose hairs and moist nasal passage walls. The production of mucous in the nose

and sinuses help to dislodge collected particles. Moist, warm nasal passages promote growth of microorganisms. The nose and sinuses react to the build up of particles through the sneeze mechanism. Therefore the sneeze is a positive cleaning action that happens in the body. Particles that are 1.0 micron and smaller have a better chance of getting lodged in the lungs during respiration. If many solids become accumulated in the lungs it will block the transport of oxygen in the lungs. Particles (and some solids) are dissolved by the liquids in the body and sometimes produce chemical allergic type reactions. Lungs bring the gases to the blood stream while breathing, otherwise known as the transport process. The gases are absorbed and dissolved by the blood stream. The reaction of the gases in the body is dependent upon the individual persons threshold level to that particular gas, according to research done by National Safety Associates and Florida Polymers.

There has been many illnesses related to poor ventilation in the office place such as: Legionnaire's disease, asthma, hypersensitivity, pneumonitis, and humidifier fever. According to the EPA (1988b) some symptoms of someone working or living in a building with SBS are: dry or burning mucus membranes in the nose, eyes, and throat, sneezing, stuffy or runny nose, fatigue or lethargy, headache, dizziness, nausea, irritability, and forgetfulness.

The Energy Crisis and Our Changing World

Thompson (1990) explains that what prompted our building design and construction to be more efficient was the energy crisis of the 1970's, consequently making the buildings air tight. Typical infiltration sites in a home are: vents, plumbing, door frames, exhaust vents, ducts, chimneys, dropped ceilings, whole house fans, windows, fireplace, and outlets. Newer building occupants are 45 percent more like-

ly to get a respiratory infection than occupants housed in older more breathable buildings.

Cities are building more and more parking garages. Often times they are around restaurants, office space, health clubs, etc. This type of setting will add combustion byproducts, including carbon monoxide to the indoor air, according to the Canadian Union (1985). Parking garages could effect indoor air quite severely.

Nancy Feigenbaum from The Orlando Sentinel, explains that "SBS is a problem with a low profile" because no agency tracks the quality of air, only if a problem is reported. In Florida, nearly half of all offices are affected by poor air quality. Some of the most unhealthy buildings are mobile homes and portable buildings, most often used by offices and schools. The reason for this is that "the glue laden materials plaster the walls floors and ceilings" (Feigenbaum, 1990). According to the Indoor Pollution News (1990e), allergens may contribute to pupils ills, and poor performance in schools. Some of the potentially allergic agents in the classrooms found were clay, felt tip markers, poor ventilation and wallpaper paste.

According to Saltzman and Silberner (1989), "people who live in modern buildings come down with respiratory infections 45 percent more often than people in older structures." The article goes on to say that the "National Institute for Occupational Safety and Health (NIOSH) and the Environmental Protection Agency, as well as university researchers, confirm that buildings can make people sick." One of the problems is that researchers are unable to draw the line and say "this amount of this chemical is going to cause people to get sick." Researchers and doctors are both having a difficult time pin pointing problems as they relate to indoor air quality.

Detection of the indoor air problems has been from the actual sick person doing their own detective work, such as noticing the patterns of the illness, the consistent date of doctors bills, etc.

At the University of Florida, College of Veterinary Medicine, it took years for employees to connect their symptoms to the workplace. Because stress has been the "catch all" for many problems this is what many IAQ problems are often attributed to. Therefore nothing may be being done about harmful contaminants.

"Famous" Indoor Air Problems

The most severe indoor air problem has been the well known Legionnaires' Disease that was traced to bacteria growing in the hotel's air conditioner. This was in 1976, 29 Legion conventioneers in Philadelphia died. This is not a contaminant that just affected people 15 years ago, it is still a problem today in buildings. In Richmond, California in September 1991, a social security building was shut down because an outbreak of Legionnaire's disease. One person died and eight more had the disease; the contaminated ventilation system was the cause. Some investigators are saying that it could have been from the earthquake in 1989. The quake could have shifted the building enough to shift the tiles in the cooling system this would have let contaminants in so that bacteria could grow. Others say that the building has always caused them to be sick ever since it opened in 1975. The employees complain that the windows cannot be opened. The employees feel that their "work is killing them," (Goodavage, 1991).

Even before the Legionnaires Disease, Turner, from Healthy Buildings International, explains that in Pontiac, Michigan 144 people complained of headaches,

fever, muscular pains, etc. The health department employed most of the victims. The unidentified contaminant was from the air conditioning, it was referred to as "Pontiac Fever." Years later it was identified as *Legionella pheumophila.*

Various forms of SBS

The EPA (1988b) also termed another type of SBS category. That is "building related illness" (BRI). A BRI according to the EPA, is "when an occupant's exposure to indoor contaminants results in a clinically defined illness, disease or infirmity, the building is said to manifest building related illness, which is characterized by: complaints of symptoms such as cough, chest tightness, fever, chills, and muscle aches that can be associated with illness." Hedges (1991b) says that "SBS differs from BRI because objective clinical signs of illness usually are absent, symptoms are less specific, chronic, and have a high prevalence among workers e.g., up to 80% of workers may report one or more symptoms."

IAQ problems can be just temporary too. For example, the EPA had one building in Washington that exhibited signs of SBS for only a few days. This was because there was painting going on, on the roof and the air intakes were open. Half of the EPA employees had to go home. This is an example of how a building can be sick for a little while, Indoor Pollution News, (1989q).

According to Hedges (1991b) the World Health Organization distinguishes two types of SBS. The first is "temporary SBS" this is when the symptoms last only a few months and tapers off. The other is "permanent SBS," this is when the symptoms last forever and something needs to be done to the building to alleviate the problem. Relief from SBS symptoms usually only happens when the person

leaves the building.

What can one do to eliminate SBS?

The EPA (1989b) is so concerned about the problems associated with indoor air quality (IAQ) that in August of 1989, the EPA submitted a report to Congress that discusses the problems and potential problems related to IAQ saying that we need a federal response to the problem. At this time there are no federal regulations, just regulations set by ASHRAE. "To undertake the projects set forth by EPA it would require a combined effort of the federal and state governments as well as the private sector. The EPA (1988a) says that "ventilation rates specified in local building codes are often not enforced and in many jurisdictions the rates are designed to conserve energy rather than promote indoor air quality." The EPA (1988a) also stresses "that energy costs should be balanced with indoor air quality considerations and employee health and productivity costs." In 1987 the EPA submitted articles to the Federal Government explaining how the implementation plan would work to improve IAQ. Since the EPA has focused its efforts on the development of information about exposures to indoor air pollutants and their health effects, they have developed a method of diagnosis. EPA has also identified common ventilation and building design practices and sources of specific contaminants and the appropriate control measures.

When there is a possible IAQ problem the first action taken usually is a diagnostic check list to help target the possible cause or area affected. This helps target where further testing should take place. Hedges (1991b) reports that "there is

growing evidence that SBS symptoms are associated with particles." Specifically the number of particles, does not affect SBS, the composition of the particles does.

Feigenbaum (1990) explains that to correct the problem, either more clean air needs to be brought in or the pollutants need to be removed. There are rules and regulations around the quality of air (set by ASHRAE) in a workplace according to the number of people in the building. At the current time, Feigenbaum (1990) explains that most municipalities require buildings to take in 5 cubic feet of air per person in each minute. If this is not happening there is risk of SBS if there is no other means of removing pollutants. The loss of manpower from SBS can be 100 times more expensive than the cost of properly maintaining a building.

When a SBS report is submitted, OSHA has a set of investigation guidelines they must follow. First the technician needs to go through a number of air contaminants and their health effects as compared to what the symptoms are within the workplace. An interview takes place with the employer and all employees. This is a standard procedure where each person gets asked the same question as the next. The basic script is written out for the investigator. Then a site inspection takes place, this is when the person walks around the facility and collects screening samples. The walk around inspection consists of a check list and is used to look for inadequate ventilation. Actual samples are collected and tests are carried out to measure contaminants. Based on the previous findings, the next piece to the inspection is the environmental evaluation. Upon completion of the previous steps, implementation of remedial action is taken depending on the findings.

OSHA explains some causal factors for indoor air problems which, are

much the same as the Department of Health as well as EPA. OSHA explains that often times if the symptom that the employees are having disappears when the employee leaves the workplace, it is most likely related to the indoor air at the work place. OSHA has found that 52% of the indoor air quality problems are from inadequate ventilation, 16% from contaminants from inside the building, 10% from contaminants from outside the building, 5% from microbial contamination, 4% from building fabric and 13% from unknown sources. (See Fig. 2) The recommended ventilation rates that OSHA follows are from the American Society of Heating Refrigeration, and Air Conditioning Engineers (ASHRAE). Originally rates were established in 1973, then updated in 1975 to 5 cubic feet per minute (cfm) of outdoor air per person in the building. There are other regulations set for general office space and reception areas as well as smoking places. ASHRAE is constantly updating and checking ventilation for acceptable indoor air quality. Ventilation rates are updated and checked periodically, (ASHRAE, 1981).

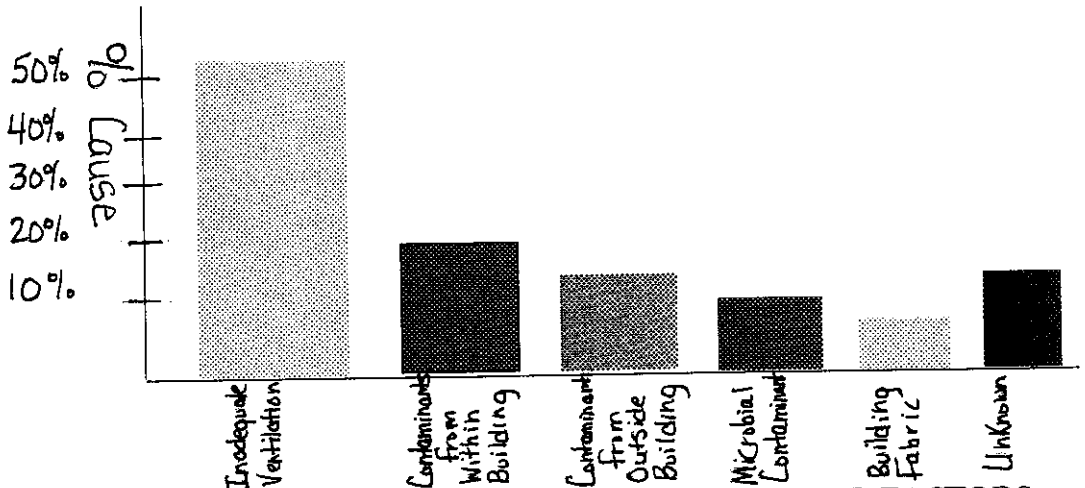


Fig. 2: OSHA'S CAUSES FOR SBS, CAUSAL FACTORS

There has been a number of guidelines set so the fresh air coming into a building is standard or minimum: (recommended standards by the Ventilation for Acceptable Indoor Air Quality)

1) voluntary standard of ventilation:	15 cfm/person
2) bars and cocktail lounges:	30 cfm/person
3) commercial dry cleaning:	30 cfm/person
4) typical office setting/industrial facility:	20 cfm/person
5) workplace smoking lounge:	60 cfm/person

Spengler and Sexton (1983) explain that though air pollutants may be low the amount of time we are potentially exposed to the contaminants is high. We spend about 16 hours per day in our home and the other 8 either at the workplace or in transit in buses, automobiles, subways, etc. For years, industrialized countries have known about the more obvious indoor pollution problems. To clean up various indoor air problems, Spengler and Sexton (1983) offer five different suggestions.

The first option to use to help an IAQ problem is ventilation. Ventilation would take care of radon and radon progeny, combustion byproducts, tobacco smoke, and biological agents (particles). An example of this control measure is exhaust of gas stove emissions. Finnegan and Pickering (1984) studies the difference among office workers in naturally ventilated buildings and buildings with air conditioning. Naturally ventilated buildings had fewer health complaints. Hedges (1984) found the same thing when studying IAQ in the United Kingdom.

The second option is to remove the source of the problem and\or substitute it. This process actually removes the source that is causing the contaminant and would be used to remove organic substances, asbestiform minerals, and tobacco

smoke. Removal of asbestos is an example of this control measure for indoor air pollution.

The third option for IAQ clean up is some sort of modification to the process or the design. This process would reduce emission rates through changes in design or process, this also could mean use of barriers or sealants. It would remove radon and radon progeny, organic substances, asbestiform minerals, and combustion by-products. This control measure could include designing homes or offices without basements to avoid radon leaks.

The forth method for IAQ clean up is air cleaning. This process is purification of air by gas adsorbers, air filters, and electrostatic precipitators. Cleaning would remove particulate matter, combustion byproducts, and biological agents (particles). HEPA filtration would be an example of this control measure.

Finally, to clean up and improve the indoor air quality there could be a behavioral adjustment. This includes behavior change, consumer education, product labeling, building design, warning devices, and legal liability. This would remove organic substances, combustion byproducts, and tobacco smoke. Creating a smoke free workplace is an example of this control measure.

When discussing consumer education this is very similar to health promotion and disease prevention. According to Holtz (1987), prevention is a "holistic process composed of 3 levels aimed at enhancing health promoting behaviors and reducing or eliminating health compromising behaviors." Most of Holtz's (1987) work is in substance abuse prevention but as seen by the definition when discussing

indoor air quality prevention and education is theoretically the same prevention steps needed to change behavior and raise awareness. The three areas that need to be addressed are: biological, psychological, and social. For indoor air quality we would also add physical changes to the environment.

Spengler and Sexton (1983) point out that there are many shoulders that indoor air quality responsibilities fall on. Individuals, building owners or mangers, architects, developers and contractors, manufacturers, and government. Each segment of the population all have different roles that each can play in trying to control the indoor air quality problems. Individuals can help to keep the indoor air clean by using appliances properly and maintain them as suggested by the manufacturer. Individuals also can be aware of ventilation both at home and in the office (Sexton and Spengler, 1983).

Building owners and managers need to not only use and maintain appliances correctly but also abide by codes. It is also important that managers are using the cleaners, paints, herbicides, and insulation in properly vented areas both for themselves and the people that are occupying the buildings. Sexton and Spengler, (1983) explain that we all have basic responsibilities but, as people have professional roles, their responsibilities to indoor air may become more and more important. Another problem that arises is that managers feel that they are poorly equipped to handle any indoor air problem. They do not know what to do and how to respond to such complaints, according to Indoor Air Pollution (1990a).

With a different responsibility and view of this problem, architects, developers, and contractors need to be aware of indoor air when designing a build-

ing so that it is easier for the individual and the business manager to keep indoor air clean. The designers need to be sure that their designs comply with existing set standards (see standards and guidelines on page 20). Designers also can eliminate potential sources of pollution as well as provide a separation for the pollution and the occupant (Sexton and Spengler, 1983).

Manufacturers have a very important role, they need to be sure that all potentially harmful products are labeled as such and tell the user how to use the product in the safest way possible. Manufacturers are also responsible for testing and researching new products on the market. Sexton and Spengler, (1983) also suggest that it is the manufacturer's job to substitute less harmful products for those already on the market.

Government plays a major role in indoor air quality too. Their responsibilities are (according to Sexton and Spengler, 1983) to "ensure healthfulness of indoor environments built, maintained, supervised, or financed through public funding." Government also needs to ensure compliance of the set standards. Therefore there are frequent government audits and site visits. The government also should be involved and sponsor research regarding indoor air quality. The authors feel that it is the government's job to make the codes, set the guidelines, etc. to protect the public. The government also should provide the people with information regarding indoor air quality and be a resource for individuals and agencies. Finally, the authors feel that the government should advise the public about indoor air quality around such issues as products, construction, equipment, and performance of systems. Sexton and Spengler (1983) feel that it is many peoples' responsibility to be sure that indoor air quality is appropriate for all in the environment.

The government has been responsible for the 1963 Clean Indoor Air Act. The purpose was to stop smoking in public places. City after city and state after state has adopted this act but Simon Turner, in an article that he wrote, says that the Act only takes care of one component of the problem: cigarette smoke. Turner points out that the government needs to address the "true cause of the indoor air pollution: inadequate ventilation, inefficient filtration, lack of hygiene and ignorance of the proper operation and maintenance of a building's ventilation are the true culprits of poor air quality. The accumulation of all pollutants is a symptom of these faults and not the cause of the problem."

The EPA (1988c) also notes the importance of understanding that it is "normal for some percentage of building occupants to experience one or more of such symptoms that were mentioned. These symptoms can be related to other things than SBS such as: illness contracted outside the building, acute sensitivity (allergies), job related stress or dissatisfaction or other psychological factors."

Occupational Health and Safety in Washington recently issued a compliance program regarding indoor air quality. The new program will ensure that new regulations are being implemented by all personnel from regional levels down to area directors of government agencies. The program gives personnel background information on indoor air problems, it gives the enforcement procedures, and review and evaluation procedures. Therefore it is important to note that the government is now enforcing more specific guidelines for indoor air quality. OSHA needs to follow specific guidelines when carrying out an indoor air investigation, as previously mentioned.

There are many ways to "clean up" SBS. The Indoor Pollution News (1990d) says that some of the most popular ways are: cleaning and sanitizing the building's duct work, sanitizing coils, condensate pans, and other parts of the heating, ventilation, and air conditioning system, installing high efficiency polyester HVAC filter, balancing the HVAC system and introducing more outdoor air. Air filtration is accomplished by air passing through a filter, usually of woven fabric, a paper material, or fibrous mat, according to the Electric Power Research Institute (1984). This particular explanation of a filter will not remove gases, only particles. Gases attached to particulate matter are removed. Usually, filters are characterized by there airflow resistance, and their capacity. EPRI explains that high efficiency filters usually remove particles that are smaller than .3 microns and that furnace filters are not as efficient. The filters on all air units need to be replaced to keep them efficient. There are many different types of air cleaning devices.

EPRI, addresses many of the different filtration types. The first is the electrostatic precipitators. This particular unit can be effective in removing submicron particles but not effective in removing gas contaminants. One advantage of these units is that small particles can be removed without requiring fan power to impart a large pressure drop to the air stream. Another advantage is that the collection surface can be washed either in the dishwasher or with soap and water. This unit works by the air flow going through the unit, charging the particles opposite of what the inside charge is, therefore, the collector collects the particles on the electric field. Some of these units produce a small amount of ozone but a charcoal unit can be put in to absorb the ozone. On June 27, 1990 the Star Tribune reported that the American Lung Association in Minnesota said that people are doing more harm

than good when using ozone-type air cleaning systems. Such machines can irritate the lung tissue in people that already have asthma or respiratory problems. There is no evidence what the long term effects are. The manufacturer of the ozone air cleaners said that the machines cannot be turned up to a dangerous level. He explained that ozone is made up of three oxygen atoms in a molecule. Oxygen has two atoms in the molecule. The ozone molecule, because of its molecular make-up, reacts readily with other chemicals. Ozone can then break down smoke and odors but also irritate lung tissue. This issue is of great controversy. National Safety Associates and Florida Polymers say that ozone is an unstable, highly reactive gas. It is toxic to humans and has an acidic, sharp odor. Its sources are electrical discharges through air and UV light.

Air ionizers produce many negative ions. The principle is similar to the electrostatic unit but with air ionizers, the charged ions attach to something in the room that is of a different charge. With this unit the particles are not really removed from the air they are stuck to something so they are not free for us to breathe. The particles are attached to walls, drapes, carpets, etc., when they are rubbed or bumped into, they are floating in the air again. Because of this, the use of air ionizers has been controversial.

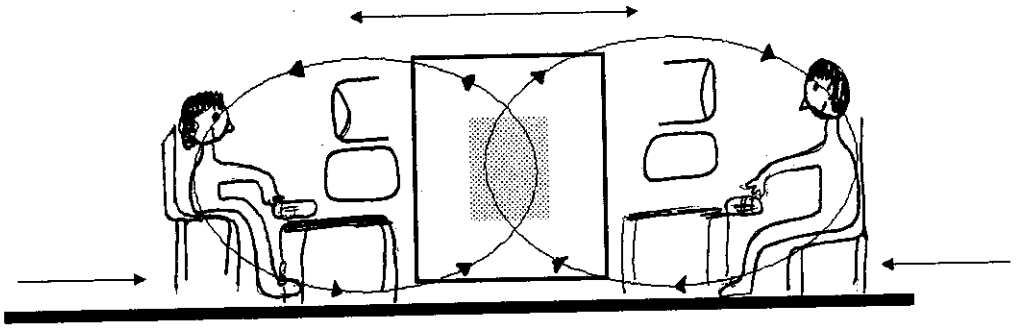
Absorption takes pollutants out by a process that can be described by "scrubbing" or "air washing" because particles passing through a liquid that is soluble or chemically reactive to the liquid. This is impractical for indoor use. Absorption is what the body does with particles and gases. Adsorption on the other hand is when a porous solid traps pollutants in the numerous pores on the surface. Exactly how adsorption works is really not yet understood. Activated carbon/charcoal is the most

efficient adsorbent known to man. The adsorbent becomes saturated and will need to be regenerated after a certain period. National Safety Associates (NSA) uses EC-1270tm, as their adsorbents to remove odors, gases and molecular pollutants from the air. This bed of material works like a "treated sponge," according to the NSA research department. The bed includes granular activated carbon (GAC), a neutralizing molecular adsorbent and a processed silica compound. All three work on different types of gaseous pollutants. The combination treats a wide range of pollutants in the home and office setting.

"Breathing Zone Filtration"

Hedges (1991c) has termed "breathing zone filtration" (BZF), as "localized air filtration in each worker's breathing zone that supplies each worker with continually cleaned air." To provide BZF, Hedges (1991c) uses a High Efficiency Particulate Arrester (H.E.P.A.) filter. This unit removes particulate matter from the air down to .5 microns and is 99.97% effective at that level of removal. There is also an activated carbon filter to remove volatile organic contaminants (VOC's). The unit Hedges (1991) uses is separate from the main air ducts and heating system. It is easy to move, install and upkeep. The unit can be installed anywhere in most any situation. A H.E.P.A. filter, depending on the motor size, moves air through the filter 7.5 to 13 times per hour. Because of the effectiveness of this unit, the particulate matter in the air will be greatly reduced. From Hedges' (1991c) research, he found that Danish researchers also found that the amount of particles in the air was directly related to the SBS symptoms in the office. In Hedges' (1991c) study of the reduction of particulate matter he found that before the implementation of the HEPA units there were counts of 242,250 particles per cubic foot and after the placement of the HEPA units the particle count was down to 112,000 per cubic foot. Because the

HEPA takes out particles down to .5 microns it removes many microbiological contaminants that cause cross infection, colds, flue, etc. Therefore, the units should help reduce this type of sickness and increase productivity. The HEPA also will remove dust mites, dust mite carcasses and their feces all of which many people are allergic to. (See Fig. 3)



-Polymer prefilter removes larger particulates
-Carbon polymer filter removes VOC's
-HEPA filter removes smaller particulates

FIG.3: HEDGES (1991), BREATHING-ZONE FILTRATION (BZF) SYSTEM

The size of airborne solids is usually measured in microns. To understand and grasp a reference for microns, measurements of various substances were conducted by The Family Handyman, (1991). The results were as follows:

POLLUTANTS

DUST

1.biological Pollutants

a. dust mites = 100 to 300 microns

b. pollens = 10 to 100 microns

c. plant spores = 10 to 50 microns

2. insecticide dust = .175 to 10 microns

3. lead in dust and fumes = .001 to 6 microns

4. asbestos Fibers = .1 to 1 microns

FUMES

5. tobacco smoke = .01 to 1 microns
6. combustion particles = .01 to .1 microns
7. organic solvents = .00016 to .01 microns

GAS MOLECULES

8. radon = .001 microns
9. formaldehyde = .001 microns
10. carbon monoxide and carbon dioxide = .001 microns

COMMON OBJECTS FOR COMPARISON

beach sand = 100 to 1,500 microns
hair (diameter) = 15 to 120 microns
red blood cell = 10 microns
bacteria = .15 to 50 microns
viruses = .001 to .1 microns

National Safety Associates and R. Kent Arblaster of Florida Polymers list average particle size for some other common items.

Particles	Size Range
skin cells	1-10 microns
yeast cells	5-17 microns
fog	3-12 microns
mist	12-110 microns
hair	7-250 microns
pollen	8-80 microns
dust	over 5 microns
bacteria	0.1 - 10 microns
viruses	less than 0.2 microns
mold spores	3-15 microns

Particles that are larger than 10 micron often fall out of the air quickly and are put back into the air when they are disturbed.

Who is SBS affecting?

Sick Buildings are becoming more numerous all the time. Indoor Pollution News, (1989a), reports that a school in Arizona, had to close because the adults and students complained of headaches, stomach aches, and irritated eyes. The district did many things to the school to try to correct the problem. The plumbing vent system was tested, they installed an automatic environmental monitoring system, and an automatic barometric relief vent, etc. The health department did a study to see if the school was safe for reoccupancy using real people. They found no significant difference in health factors and no significant factors in environmental quality. The problems were most prevalent during the winter months and the study was implemented in the summer therefore the county health department will continue to keep monitoring the school throughout the school year. These are very typical problems with sick building syndrome.

Axcel (1990) found that 15 to 20 percent of all children are affected by at least one major allergy and 5 to 10 percent of all children will develop asthma before they become adolescents. Evidence concluded that allergic reactions directly affect learning and cause psychological and social difficulties. Asthma accounts for 20 percent of all lost school days among students.

There are hundreds of articles published that discuss sick buildings and complaints from people regarding the air. According to Indoor Pollution News, (1989o) Albany High School in Albany, NY complained about the quality of the air.

No one can say exactly what it is from or if there is really a problem. In Arizona, a university is seeking the cause of their complaints. Another elementary school in Arizona had to be evacuated because of many health related problems. Some thought that the school was on a toxic dump but that turned out to be not the case. Kentucky, also had problems with a government building and now there is a lawsuit pending because officials told employees that it was safe to return and they do not feel that it was. A hospital in Arizona was identified as having fumes both outside and inside the institution. This was a problem created by the incinerator. The time of use of the incinerator has been altered because that was the source of the problem, according to Indoor Pollution News, (1989j). The EPA has gotten in on the problem by allocating a special office that handles workers suffering from SBS ills. The EPA recommends several different things to do to reduce the SBS problems. Some suggestions are: not to use carpets, drapes, and wall coverings, furnish areas with metal or wood, be sure photocopying equipment is in a room vented to the outdoors, and provide fresh air at a rate of 20 cubic feet per person per minute.

Another SBS complaint from a San Diego office building came from heat load. Fumes took over a Boston high school because of the renovation that was taking place. The school brought in special engineers to review the situation and suggest ways of cleaning up the environment before students and teachers returned, Indoor Pollution News, (1989f).

SBS is even affecting IRS employees. In Washington, D.C. the employees complain of the air problems and water problems. There has been no response, the employees are scared of a possible problem from the PCB room and any leaks that may ever occur. The employees on that floor, suffer from many health problems, no

serious illnesses have occurred at this point but they wonder what the cause is. Frustrated employees want something to be done to correct the problem and no one is listening, Indoor Pollution News, (1989e).

After reports of illness, the HVAC system is being replaced at the Austin City Hall, in Texas. It is going to be replaced later in the year. It was the cause of many health problems and sick time was being used at an increased rate, Indoor Pollution News, (1989d).

Psychological Influence of SBS?

In the 1970's environmental psychology became an issue that is now still being studied it is explained as: "that perpetual experience as a response to complex, multidimensional stimuli usually encountered under naturalistic conditions outside the laboratory" as per Baird and Berglund (1989). The authors, Baird and Berglund (1989) theorize that "what starts out looking like a clear cut environmental problem may cycle around a few times and eventually conclude with a set of findings of great importance to psychophysics and vice versa." Psychophysics defined by Webster (1966) is "a branch of psychology that studies the effect of physical process upon the mental process of an organism." The authors address sick building syndrome and psychophysics. Psychophysics became involved in the issue, the authors say, because most of the sick building syndrome symptoms are sensory in nature as discussed previously. The authors conducted studies because a building was "sick" from a chemical such as formaldehyde, then studies measured people's perceptions of the problem. There were many shortcomings to this study because of the odor threshold levels. The authors took the study further to find that the judgement of different chemical intensities has nothing to do with the actual intensity of the chemical.

Time had a great deal to do with the perceived intensity. Peoples' perception of the air changes when their health perceptions change. Reduction to pure psychophysics, is not implied by the authors. The point is, that the problem that one may start with may not be the problem that one ends with, this information is substantiated by Occupational Health and Safety. The author is quick to point out that physical and psychological complaints can be a result of indoor air quality. IAQ problems always affect worker morale, efficiency and attendance, according to Burton (1991). Psychological factors are also important to mention, Burton (1991) explains that noise, glaring lights, stressful work loads, deadlines and other factors contribute to the intensity of IAQ problems. NIOSH has found that in about 10 percent of the problem IAQ cases studied nothing was the matter with the air. People attributed problems to gender specific complaints, labor/management problems, socially powerful people affected, boring, repetitive, excessive work, rigid management structure, the feeling of "lack of control," and poor work environment. So it is important to see that poor psychological environments also can lead to "sick" people.

Hedges (1991b) points out that in most SBS studies, symptom data is gathered using a self administered questionnaire. This means that the data can be influenced by numerous variables such as: psychological factors, the person's perceptions of their problem, the intensity of the problem at that time, the perception of their symptoms with the workplace, their perception of the workplace, etc. Although this could contribute to a problem it is also the best measure we have of gauging the quality of the workplace. Each person's perception varies from person to person and this could explain why some report SBS symptoms and others do not. Hedges (1991b) measures SBS by testing the pollutants in the air and it has been found that this is not always accurate. The workers are the most accurate measure-

ment for the quality of the environment. Unfortunately there has not been much work done on the development of a quality survey, or evaluation, or questionnaire. Hedges (1991b) has designed a strategy for diagnosing IAQ problems using a survey and strategic evaluation.

The evaluation is as follows:

Phase One:

1. research and literature review
2. walk through the building
3. building history and review of user issues
4. questionnaire development and survey design/pilot test

Phase Two: Part one

1. questionnaire administration
2. computer aided facilities diagnosis
3. indoor air quality survey
4. remedial action

Phase Two, Part Two:

1. Floor plans review
2. facilities performance database
3. facilities diagnostic checklist
4. remedial action

Finally: Resurvey building and/or resolution of complaints

Communicate it with tenants or occupants

If there is still a problem then one would begin with phase two again.

SBS Symptoms and the Common Cold?

Often-times management gets frustrated because it seems that the employees' complaints are just like the common cold and to find out if it is the building, there is much time and money spent. Bureau of Business Practices (1991), lists some ways of helping to make the distinction between sick building syndrome and common colds and flu.

1) 30% of employees will be complaining of symptoms
2) discomfort typically increases as the day progresses
3) most will notice a dramatic improvement after leaving the building

There have been many Legislative hearings that have taken place over the years. Often-times government, managers, and building owners may blame symptoms on the individual and not really believe that the problems could be coming from the indoor air. The testimonies for various hearings have people explaining their symptoms and saying that they felt that it was just them but then they realized there were often-times many people sick with such symptoms. The testimonies really prove that SBS is real and that the symptoms could not be just one person or one group of people. SBS is a wide-spread problem affecting people world wide.

It is important to be careful when blaming people for being sick. In the health education field, this is a very important issue. Who should be blamed for being sick? Is it the person that is not taking care of him or herself? Is it the manager of the apartment complex or the office? In the case of SBS who should be blamed if people are sick? This question will be answered by many authors throughout the paper.

Union Involvement

There has been many disputes between government, unions and managers over sick buildings. Many unions are now getting in on the problem. People lobbied the legislature of New York in 1991 to adopt new IAQ regulations. This is to ensure safety and health for their employees. The office managers that lease to the State Government may soon have to abide by IAQ regulations, to protect the workers in those buildings. This will hold the landlord responsible for

IAQ.

The indoor air quality is an emerging union/management battleground according to HBI. SBS and IAQ must be taken seriously because it could be a detriment to the employee/management relationship. It is important that the issue get addressed and there is a reasonable solution to the problem.

A World Wide Problem?

Hedges (1991a) found that when researching air quality in the UK; they too have indoor air quality problems. He also found that when comparing two office buildings, SBS was more prevalent in buildings with air conditioning and there were no significant differences between buildings in environmental measurement. In another study in the UK, Hedges (1991) found a "significant positive correlation between relative humidity and SBS symptoms." Research has shown a correlation between the level of job stress and workers negative perceptions of environmental conditions as the two significantly correlated with SBS symptoms.

Scandinavian researchers found that the amount of volatile organic chemicals (VOC's) in the workplace related to SBS. "VOC's come from any organic molecule that can become a vapor at normal room temperature." Some types of VOC's that we use are paints, carpet and cleaning fluids, formaldehyde, etc. Normal air venting systems are not designed to take such contaminants out of the air but plants (spider plants) as well as BZF can remove VOC's , according to Hedges (1991b).

In Scandinavia the work environment was studied in relation to personal

characteristics such as: job related factors and psychological factors in relation to sick building syndrome. Research proved that women had a substantially higher symptom prevalence then the men. The lifestyle factors such as smoking, alcohol and coffee consumption, exercise, etc. were only weakly associated with the symptoms. People wearing contacts had a higher frequency of work related mucosal irritation than the others. People that handled the carbonless paper regularly had the general SBS symptoms, other similar findings were photocopying and video display terminals. Peder, Valbjurn, and Pedersen (1989) concluded that the building factor was strongly associated with sick symptoms but the other individual factors also had some effect and must be accounted for. Another group of Scandinavian authors also studied the sick building syndrome and personal factors. Norback, Ingegerd, and Widstrom (1990) "...concluded that the sick building syndrome is of multifactorial origin and related to both indoor hydrocarbon exposure and individual factors." The authors in their discussion, stated that there is a wide range of possible biases in a study such as this one because of the subject's belief that the symptoms are coming from the office. Therefore originally there is some bias and psychological factors that must be addressed. Also in this study there was a selection bias and the participation response rate was low. Sick building syndrome depends on both personal factors as well as environmental factors such as the actual quality of the indoor air.

Factors Influencing SBS

Sterling, McIntyre, Collett, and Sterling (1985) found that women complained of illness more than men. They also found that the air conditioned buildings had lower humidity by 12%. therefore had more SBS problems than other buildings. Other factors remained the same such as: carbon dioxide and temperature.

Hedge (1984) also found that there was a significant difference between sex. Women reported more complaints than men. Hedges, in a letter to the editor of the HBI (1991a) issue explains why there are gender differences, the effects of VDT (visual display terminal) use and job stress, and how they all account for specific issues related to SBS. First, Hedges says that there is a linear relationship between VDT use and SBS symptoms because there is an electrostatic charge on the VDT and this may attract office dust in the worker's breathing zone. Specifically eye irritation and contact lens wearers are affected because VDT use will slow down eye blinking. Second, Hedges explains that women report more problems than men with SBS symptoms because they generally have more exposed body surface area or particulate deposition. Women also wear clothing that contains more synthetic fibers which create an electrostatic charge to attract particulate matter. Women wear cosmetics and cleaning fluids that make for a stickier skin therefore particulate matter will be attracted to it. Women have less hairy skin, fewer eyebrows, and less hair in the nostrils which all act as filters for the particles and fibers in the air. Finally women show an increased sensitivity to mineral fiber exposure. Lastly, Hedges says that SBS symptoms increase job stress. This is making the body have an increased sensitivity to contaminants and reduces the body's ability to repair physical insult. It also increases the body's ability to produce sweat which then allows for more fibers to stick to the body.

The Measurement of Productivity in the Workplace . . .

Hedge (1987) refers to a letter written in Occupational Health and Safety. Hedges (1987) says that "stress, indoor air pollution and VDT related complaints are the most pressing health and safety issues among office workers in the USA."

Thompson (1990) says poor IAQ is the cause for 150 million lost workdays annually and has a cost of $15 billion for direct medical care. A building is considered "sick" if 20 percent of the occupants are experiencing symptoms. This problem is becoming so prevalent that banks are even ensuring that buildings are not "sick" before they will lend money to the purchaser. The motivation behind making buildings "well" again is either to improve productivity and reduce operating costs and/or the threat of litigation. These are good reasons for businesses to focus on cleaning up their building.

Garibaldi and Dixon, (1985) estimated that "respiratory tract infections annually account for approximately 150 million lost work days and $15 billion of direct medical care costs in the U.S. alone." Turner explains that "air quality costs workers a great amount of money not only in absenteeism and lost productivity but also increased liability of a building operator to litigation from affected employees working in so called sick buildings."

Baron and Sterling (1984) studied indoor air pollution and its effects on productivity. Although the authors mention that accurate measurement of productivity is very difficult to obtain, the study concluded that since the 1970's, when more buildings were sealed resulting in less air flow and ventilation, there has been an adverse affect of efficiency and well-being of people that work in the offices.

Hawkins and Morris (1984) did a study that surveyed health complaints. They studied air ionization using an ionization system. The reason for the significance of this study is the design of the study and the use of the air unit. Hawkins studied 79 workers for 12 weeks. The first four weeks were the control weeks. The

second four weeks was the placebo period. Negative ions were used the last four weeks with the ionization air systems. No significant effects from the negative ions were found but there were fewer complaints of lethargy. Krueger and Sobel (1979) studied negative ions with lower animals and plants and found that it did have an effect on health but there were no studies on humans.

Healthy Buildings International takes a prevention approach to the situation of sick building syndrome. The company feels that with the "health of so many employees at stake, increased absenteeism, and the potential loss of hundreds of thousands of dollars, employers are finding it cost effective to ensure that indoor air quality and employee health is kept at a premium." The company says that if employers take "steps to prevent indoor air pollution from affecting the health of their tenants it will result in reduced absenteeism rates and improved productivity." To proactively monitor indoor air several steps need to be taken, according to Healthy Buildings International. The first step is to have an inspection. An inspection means that a survey, studying ventilation rates, studying filtration design, and visual inspection of the facility needs to be done. The second step is a sampling for different matter in the air i.e., carbon dioxide, airborne particles, organics and inorganics, bacteria and fungi, and humidity level. The last step in a proactive monitoring is that the there needs to be on going monitoring on a regular basis i.e., every six months.

The Canadian Union carried out many surveys with employees asking them particular questions regarding their health during the work day as well as with the work environment.

Some of the questions in the survey are:

Please indicate any of the following you presently suffer from:

migraine _____

Asthma _____

Eczema _____

Hayfever _____

Other allergies _____

Chronic Back Pain _____

What is your smoking status?

non-smoker **former smoker** **current smoker**

During the past month how often have you experienced each of the following environmental conditions while working in this building? (list of conditions)

There are several surveys that have been used to measure indoor air quality. One in particular that is used by NYCOSH. This survey references some ideas that a loss of productivity is taking place. Some of the questions are:

Have you had to leave work early or miss work because of ill symptoms?

_____ **yes** **How many times in the past month?** ___

How long were you out from work? ____

_____ **no**

Do you seem to be getting more colds or flu than you normally might?

In the survey that was used for this particular study, some of the productivity questions that were used were:

Overall, during the past month how much has your work been disrupted by this condition? (list of conditions)

not at all disrupted **somewhat disrupted** **very disrupted**

Overall, during the past month how much has your work been disrupted by this symptom? (list of symptoms)

not at all **somewhat** **very**

Some polled federal workers in Denver, exposed that the government is losing a great amount of money due to poor indoor air quality. "The price that is being paid is in reduced efficiency and lost time due to illness; it is enormous," claimed Indoor Pollution News (1989c).

Hedges (1990) discusses the Breathing Zone Filtration effects on productivity and how it is used to compliment other clean air techniques. Breathing Zone Filtration (BZF) is simply using a HEPA filter that blows clean air over the employee's desk (see Page 27). The employee is then constantly breathing clean air. Hedges (1990) explains how he studied this method but also had the HVAC system cleaned in the building and had the appropriate amount of ventilation in place throughout the building. Sometimes he explains that the two mentioned techniques do not affect the IAQ because first the ventilation could be already polluted (outside air, this could happen if the air is coming from a parking lot or some other contaminated area) and other problems could arise from a contaminated HVAC system. Hedges (1990) carried out the whole study in one building and the findings were significant. He used a survey both pre and post the installation of the BZF filter. The ill symptoms were significantly less where the HEPA filters were installed. If Hedges (1990) used two separate buildings, the results may have shown more of a difference between floors. The "clean" floors affected the "unclean" floors and vice versa. Hedges (1990) studied many different SBS symptoms such as: lethargy, sore throat, congested nose, headache, irritability, unwell feeling, difficulty breathing, itching eyes, irritated nose, dry cough, dry eyes, and irritated skin. He also studied many environmental conditions such as: air too dry, air smells stale, insufficient air movement, insufficient fresh air, unsatisfactory ventilation, too warm, unpleasant

odors, air smells smokey, too cold, air too dusty, unsatisfactory temperature, drafts, and air too humid. Breathing Zone Filtration relieved most of these symptoms therefore the productivity also increased, according to Hedges (1990).

Cleaning up indoor air in the office: a health promotion effort? Is cleaning up the air up to the employees or the employers or the office manager or the owner of the building? When the indoor air is or may be affecting the productivity of the employees there is many different approaches to take. Lets look at this issue from a health education or promotion effort on the part of the employer. Jeffery, Forster, and Schmid (1989) say that their weight loss and smoking cessation program was successful because 33% of the employees that participated lost weight and of employees who participated, 28% reduced their cigarette smoking. Cigarette smoking effects other office employees unless there is a specified area for smoking and then that area must be "vented" or the air must be cleaned in some way. Another study measured the difference between cardiovascular fitness and absenteeism (one measurement of productivity). If the indoor air is better in the work place are people more apt to work out cardiovascularly later in the day? This is a question that has not yet been studied but as the problems of IAQ continue to get worse and worse it will be addressed. The authors Tucker, Aldana, and Friedman (1990) found that there was a strong relationship between cardiovascular fitness and absenteeism. In other words if someone was cardiovascularly fit they probably were also missing work less often than those who were not cardiovascularly fit.

General Mills, Inc. participated in a lifestyle risk factor program and studied absenteeism (one measure of productivity). The authors Wood, Olmstead, and Craig (1989) found that the one year program made a significant difference in

the healthy lifestyles of the participants and they were absent less from work. The question is, would relief from the poor IAQ help workers to be better able to take care of themselves, (physically, emotionally, etc)? This question will not be answered in this study but it does easily correlate with the current question and might be the next reasonable question to try to answer.

HBI addresses the issue of whom is responsible for taking care of the problem of SBS. HBI says that the landlord would be the most likely one to be responsible because, if a particular building does have a problem the landlord is going to have trouble keeping tenants in the office space. What company would choose to be housed in a building that may lead to having unproductive workers?

The already completed studies regarding health behavior and productivity could help us understand the best possible way to measure productivity in the work place. Barker and Glass (1990) said that the reason that there is a significant economic reason to implement wellness programs is that it helps to contain health care costs. The healthier the employees are, the less they will be absent, and when illness does occur they will recover faster. The authors said that the employees are also less likely to have accidents if they are not sick on the job therefore reducing disability claims. One very important factor is, that if an employee likes the atmosphere that he/she is working in and "feels good" then there is most likely going to be less turnover, reducing significant costs to the employer.

Sloan and Allergrante (1985) compare man to machine in the workplace, "Both man and machine are essential to the functioning of any company; both are costly; both operate optimally under certain conditions only. Health promotion

programs in the work place may be the human counterpart to machinery-maintenance policies. Such programs, however, often encounter corporate resistance, a major reason is, that many people believe human beings are resilient. Unlike machines, people can rebound from illness or injury; functioning is merely temporarily restricted. In most cases, people eventually recover. What isn't considered is the cost of an employee's absence and reduced productivity while he or she is recovering. Furthermore, what is the cost when an employee does not recuperate? Illness and injury produce direct and indirect costs to organizations. Direct costs include the absent employee's salary, medical expenses, rehabilitation costs, and in the case of death, survivor benefits. The indirect costs are even more numerous. They include the distress and disorganization caused by other employees during the period of absence; the costs of temporary replacement or overtime pay to cover the missing employee's work; the costs of training a temporary replacement and retraining the employee when he or she returns; the costs of recruiting, selecting and hiring a permanent replacement if the employee goes on permanent disability or dies; and any accompanying administrative costs. For one employee, the total cost is significant, for several employees it can be enormous."

According to Conrad (1987) the definition of "work-site health promotion," he says that it is "a combination of educational, organizational and environmental activities designed to support behavior conducive to the health of employees and their families." According to this definition we can say that improving the quality of the air for employees is a health promotion activity both directly and indirectly.

The evaluation of the effectiveness of health enhancement programs is just as important as the program itself. Evaluation of health enhancement programs

has been studied very infrequently. Eddy, Gold, and Zimmerli (1989) discuss some important guidelines to stick by when evaluating a program to see if it is effective. The authors say that first one must know the basic reasons for evaluation. This gives the person guidelines to use when targeting whether it was appropriate, how to change it next time and providing structure for the evaluation. Second, the person doing the evaluating needs to understand the corporate structure. The person must understand the attitudes of the people in various positions. One must understand what the corporate executives believe the goal of the new program is. (Are they looking to save money? Are they looking for the employees to "feel" better?)

The third area of research and evaluation, is viewing the evaluation in context; In other words it needs to be looked at as a "whole." The authors say that the evaluation should occur at a variety of levels. First an evaluation should be implemented to understand the basics of the new program. For example, is it reaching the targeted population? Is the program implemented properly? Does it have legal and fiscal accountability? There needs to be program feedback, this is a form of evaluation. The needs of the participants need to be considered, what they liked or disliked, or what they may recommend for next time. Finally an evaluation of the program effectiveness is very important. Has the new program met its goals? Was it cost effective?

The authors proceed to say that the design and methodology of the study or program needs to be followed. Finally the authors say that it is important to know the possible pitfalls of evaluation in the workplace. According to Eddy et al. (1989) "some of these pitfalls include: inadequate data collection and analysis procedures, absence of baseline data and of a true control group, the impact of the Hawthorne ef-

fect and the influence of multiple or intervening variables."

Schwartz (1989) discusses career wellness and the National Wellness Institute, Inc's six dimensions of wellness. The six dimensions are: physical, spiritual, emotional, environmental and social, intellectual, and occupational. Schwartz (1989) discusses how each area plays an intricate part to lead to higher employee productivity, higher worker health, satisfaction, development, and advancement. In turn this creates a positive image of the company.

Sperry (1984) discusses the various "ingredients" of wellness programs, he mentions that indoor air quality is one major concern. He explains that The National Research Council, 1981, said that in the typical office there are 20 major air pollutants, some of which are: asbestos, fiberglass, ozone, formaldehyde, and cigarette smoke. He goes on to say that the contaminants have "several delirious health effects on employees." Specifically he mentions the Centers for Disease Control (CDC) that did an investigation of a Florida agency because more than 40 employees had SBS symptoms. The culprit was ion depletion. This is another problem with air inside closed areas. Sperry (1984) notes that the "challenge of a wellness program is to effect a greater degree of wholeness in the person and in society."

According to Healthy Buildings International (HBI), The Netherlands Ministry of Housing and Construction, a study of offices studied in Holland reports that 24 percent of the employees studied called in sick because of work related complaints for an average of two and a half days per year. Bergs, (the author of the study) says that " . . .it is estimated that this results in over one million work days lost by office staff in the Netherlands per year, costing in excess of the equivalent of 500

million U.S. dollars per year." HBI says that in the U.S. The American Journal of Medicine "...estimates that respiratory tract infections accounted for 75 million physician visits per year and approximately 150 million lost workdays annually in the USA alone. They equated the lost income from work absenteeism due to these infections in the USA to $59 billion annually."

HBI (1991b) refers to a study done by Honeywell, Inc. it was found that one fifth of office workers surveyed have difficulty doing their work because of their indoor environment. These complaints are not just in the U.S., they are also in the United Kingdom (39% frequency of complaints to management about unsatisfactory temperature in offices), Singapore (12%), Germany (22%), France (27%), and Australia (51%). HBI does a simple cost analysis to help us understand energy efficiency and health. Consider that a "...building operator has an annual budget of $50,000 to heat, ventilate and air condition a 100,000 square foot building. Under pressure to save money, he trims the operating budget between five and twenty percent saving his company between $3,500 to $10,000 over the year. The same 100,000 square foot building will house on the average 667 employees (see Fig. 4). If each employee is paid a conservative salary of $25,000 a year, and the annual payroll for the building will be about $16.7 million a year. In other words, each one percent of absenteeism cost the company over $160,000 each year. With typical absenteeism rates ranging from three to seven percent, this employer would be faced with an annual absenteeism cost of $480,000 to $1,200,000- a large portion of this is due to so - called "savings" of less than $10,000 in energy costs- certainly poor business judgement."

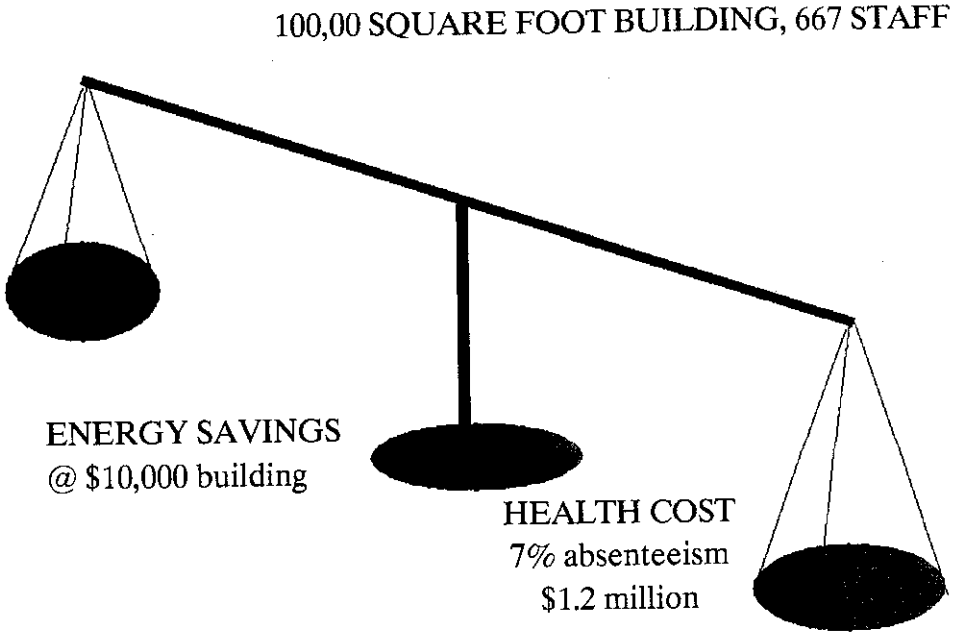


FIG: 4: HBI: COMPARATIVE COST OF ENERGY VERSES HEALTH

What is HEPA filtration?

According to Hudson (1982) a typical HEPA filtration unit consists of five stages. He reviewed the system in R Home Care (1982). The first stage of a HEPA filtration system is the pre filter that takes out large particles such as dust, pollen, dirt, soot, etc. The second stage is the one that has activated carbon in it. It takes out a wide variety of contaminants such as bathroom, cooking, and cigarette odors. The third stage consists of a filter that is made of small granules which, is the gas filter. Many gases are removed such as: formaldehyde, organic solvents, oxides, and smog gas. The fourth stage is an ultraviolet lamp. (This stage is not always found in all HEPA units.) This takes care of all airborne pathogens like mold, spores, and microorganisms. Finally the HEPA filter is the last stage. According to Hudson (1982) it removes 99.9% of airborne contaminants as small as .3 microns. Overall

the unit takes out many contaminants that may reduce the chance of getting sick or passing illness between workers therefore the HEPA should improve the health of the workers thereby improving the productivity of the workplace.

Hudson (1982) explains the history of the HEPA filter, "HEPA filters were developed in the 1940's by the Atomic Energy Commission during World War II to remove radioactive dust from plant exhausts." The actual HEPA filter, according to NSA and Florida Polymers is made up of paper and glass fibers, (often referred to as Boro Silicate fibers) that are compressed during manufacturing to achieve the desired filtering efficiency. One manufacturer says that the first non-governmental use for the HEPA filter system was in hospitals to help prevent infection during operations and burn treatment centers to curb airborne infectious diseases (such as legionnaires disease). HEPA filters are used in the bomb shelter for the President of the United States, atomic submarines, nuclear power plants, and shuttle spacecraft. They have also been used to remove dust from the air in photographic printing plants. HEPA filters also increase in effectiveness over time. The fibers that make up the HEPA filter slowly close as it collects particles and then the fibers are even more effective. This is true for particles both over .3 microns and under .3 microns.

King (1973) feels that electronic air cleaners are not effective and also can be misleading for consumers. Compared to the HEPA filter, electronic air cleaners are not as effective. Efficiency decreases with larger particles being screened where the HEPA becomes more effective. Electronic cleaners produce ozone and need to be cleaned often. Often particles pass through the unit and are not captured. The HEPA filtration units are 99.97% effective by particle count at a

size of 0.3 microns, which King (1973) says is "1/75,000 of an inch or 1/300 the diameter of a human hair." There is no maintenance with HEPA filters for at least two years. King (1973) says that there are three criteria used to determine the effectiveness of air cleaners. The first is the time required to clean a specific area. The second is the ultimate level of cleanliness reached. The third is the durability of filtration efficiency with continued use.

Reisman, Mauriello, Davis, Georgitis, and DeMasi (1990) conducted a study that tested the effectiveness of HEPA filtration on patients with allergies. This was an eight week study that was conducted in the homes of the patients. There was a four week period that the unit was on with the filters in place and another four week period with the unit on and the filters were not in place. The patients were not told which pattern of filtration they received during the study, therefore it was a double blind study. "The overall impression of the study was that the HEPA filter can reduce allergic respiratory symptoms," according to Reisman, et al. (1990).

Future issues regarding IAQ

The Senate Democratic Task Force on Indoor Air quality was released in September of 1990. The Task Force is considering recommending the following indoor policies. The department of Health should be designated as the lead agency to coordinate IAQ problems. The Department of Health should be the agency to evaluate problems. New York State should develop ventilation standards for new building construction. Two issues need to be addressed, they are IAQ and energy conservation. Educational campaigns need to be conducted by the federal and state governments as well as with private industry.

On September 12, 1991 the CBS Albany News aired a news segment regarding Allergists prescribing air cleaners for patients suffering from allergies, asthma, and hay fever. One Doctor in particular from California has done extensive research on the topic and found that out of 1400 allergy sufferers tested 80% found relief from air cleaners. There were other positive influences as well:

85% slept more comfortably
28% had more energy
28% were more active
23% fewer days of school were missed by the children tested

The broadcaster explained that for many people, flowers are a tremendous problem, but with the help of air cleaners relief from the flowers could "only be a sneeze away."

King, (1973) says that our health depends on the air we breathe. In 1969, 150,000 air cleaners were sold and the number of cleaners sold each year since has been bigger and bigger. It is estimated that indoor air clean up will be a billion dollar industry in the next decade.

The Discovery Channel on television had a segment regarding indoor air quality. The EPA has found that 50% of illnesses are either from or enhanced by indoor air. What they recommended was air filtration systems for the home and office. Air filtration is the way to clean up the air in our homes and offices.

RESEARCH DESIGN AND METHODOLOGY

Two groups will be selected. The groups will be work sites that employ quite a few people that work in one large main open space. The groups will be office workers who for the most part have desk jobs. The two groups will be on different floors or even different buildings. The study will take place during late winter early spring. The groups will have to agree to let the study take place therefore the selection will not really be random.

First, both groups will fill out an environmental survey (see appendix A). The survey has been used by Cornell University Researchers for a similar study. It will be the same survey for each group the only difference will be the color paper that the two are printed on in order to tell the difference between the experimental group and the control group. Some of the specific survey questions that will be used to measure productivity are: "Overall, during the past month how much has your work been disrupted by this symptom?", "Estimate any productive work time lost each day in the past month because of this condition?" There are many other questions in the survey that will help to draw conclusions but are not as directed to productivity as the ones mentioned. The survey will also allow the employee to identify the uncomfortable work environment conditions. Then he/she will identify what symptoms they also may be experiencing. The survey will also help us to identify if the worker enjoys his/her job as well as what type of job it is. The employees that are a part of the study will not know that the study is about productivity.

After the surveys are completed, the experimental group will have NSA HEPA filtration units (Model 7100A) installed in the workplace. There will be

enough units to appropriately take care of the particular size of the experimental groups work space, one unit for every 3000 cubic feet. The filtration units will be implemented after work hours so as to not disrupt employees during their work time. The units will be plugged in and remain on for a one month period of time. At the end of the period, both groups will take the same survey again. The units will be removed after employee work hours.

Some of the threats to the validity of the study is that the experimental groups will see the filtration systems and know that something is being done to the air. They employees will not know what is being done to the air, whether something is being taken out or put in.

Another difficulty is that when comparing sick days from this year to last year there may be different employees working now than there was then. This would result in a history problem.

Other problems that will influence the outcome is that the control group will not be getting the units at all. In the original design of the study, the control group was going to get the filtration system without the filters in place. This would only just move the air around not removing anything from it. Because of the cost factor this may not be possible. This could have been a blind study if done this way.

The independent variable is productivity and the dependent variable is the HEPA filtration/clean air. The internal validity may be influenced because of the survey. The subjects may become more aware of the indoor air and the environment as well as their control of their productivity based on there health. Because of

local media coverage of local buildings with poor indoor air quality there may be more knowledge and awareness of its effect on productivity than the "normal" person, therefore there may be a selection bias. The experiment does run for a period of one month and does ask for some information going back as far as one year this could mean that some experimental mortality could occur from people leaving a job. If the study were to take place in one building on different floors then there is the possiblity of diffusion or imitation of treatment.

The design of this study could vary in a number of ways in order to make it more effective.

1. Experimental group pretest stimulus posttest
   control group pretest posttest

(time)

2. Experimental group stimulus postest
   control group posttest

The reason the second design may be more effective is because it would eliminate the experimental and control group from "learning" from the pretest. Although there are a number of different alternative designs, the design that will be used is a combination of design one and two.

(actual design)

Experimental group:

pretest stimulus posttest

Control groups: ——————→

(time)

pretest posttest

posttest

The two different designs could address some possible external validity issues. There are approximately 200 subjects total. There were two different buildings used and the control group came from both buildings as well as the experimental group.

The statistical treatment of the data will be a variety of tests: means test, t-tests, and crosstabs test. The relationships that will be looked at with a t-test are: the experimental and control groups and their difference in productive work time as well as symptoms experienced, pretest and posttest and the difference between these two groups in productive work time and the symptoms experienced. Disrupted work time or productivity is looked at using two different questions in the survey. One is looking at the employees opinion of how their work time is disrupted from envionmental condtions in the building. The other form of productivity is from the employees measuring how much time is lost from work because of actual symptoms they are experiencing which are often from poor indoor air. Another way of breaking the data down even further is by looking at the employees that had some sort of respiratory problem which often is effected by poor indoor air.

A crosstab will be used to compare the employees perception of their happiness at work as compared to their perception of their work environment. This is an important isssue because of the psychological effects that indoor air air will have on employees, as Hedges (1991) mentions in his work which was discussed in the literature review.

Means tests will be used to compare job categories with various symptoms. Means will also be used to measure the comparison of the employees perception of their environment to see how it relates to productivity time.

Sick days will also be looked at for the experimental group only. This will compare the number of sick hours used during 1992 during the study and 1991 during the same time period. Sick time will be used to get another indicator of productivity time. The sick time during the month of the study will be compared to last year at the same time. This will be information that the administration or manager will have to have access to in order to measure any change. Sick time should represent time that employees take because of illness but it may represent time other than that, therefore making it slightly an inaccurate reading.

Therefore the hypothesis that is being tested is that: "HEPA filtration use in the workplace increases productivity." Specific survey questions will provide data that will allow us to either agree or disagree with the hypothesis. The survey is subjective. Therefore we will be able to draw conclusions of productivity level based on what the employee thinks his/her productivity level is. Relationship between poor indoor air conditions and health symptoms will be carefully analyzed

PRESENTATION AND ANALYSIS OF DATA

The findings of this study show that indoor air affects productivity in the workplace. This hypothesis is supported by a number of findings. By comparing the post tests of the experimental as well as the control group it was found that the control group has more environmental conditions that disrupted their work time such as insufficient ventilation, too little air movement, unpleasant odor in the air, "stale" air, and dusty air. This comparison was significant at the .01 level. The control group also had more disrupted time due to "health" symptoms such as: dry eyes, sore throat, dry skin, hoarseness, congested nose, excessive mental fatigue, nervousness, irritability, headache, wheezing , chest tightness, nausea, dizziness, and lethargy. The control group also had more of the health symptoms (listed above) than the evironmental group in the post test.

	disruption from symptoms	disruption from conditions	number of symptoms experienced
Control Group (post test)	25.76	8.37	30.76
Experimental Group (post test)	22.69	7.40	27.66

Table 1: Control and Experimental Groups with Mean of the three Productivity Variables (environmental conditions, disruption from symptoms, number of symptoms)

When analyzing the experimental group only it was found that the pretest group had more of a loss of productivity time from both environmental conditions, and health symptoms disruptions, as well as more health symptoms. Although in all three comparisons the mean was higher in the pretest group but none of the comparisons were significantly higher.

	disruption from symptoms	disruption from conditions	number of symptoms experienced
pretest (experimental)	25.02	8.50	30.98
post test (experimental)	22.69	7.40	27.66

Table 2: Pretest and Post test of the Experimental Group, the Mean in each of the Three Productivity Comparisons, (disruption from environmental conditions, disruptions from the symptoms, and number of symptoms.)

Indoor air quality may effect people with respiratory problems more than people without respiratory problems. This data was gathered from one question on the survey where the subject had to indicate whether he/she experienced certain symptoms. Therefore the data was broken down so as to compare people with respiratory problems (asthma, hayfever, allergies) just within the experimental group to see if they actually were losing more productivity time than those without respiratory problems. The data showed that in all three of productivity measurements that the groups with respiratory problems had a higher mean. In other words,

They showed more loss of productive time and had more symptoms. This was significant in the case with disrupted time from environmental conditions and the number of symptoms that they had compared to the healthier group.

	disruption from symptoms	disruption from conditions	number of symptoms experienced
Respiratory problems (pretest experimental)	27.61	8.90	36.17
No Respiratory problems (pre test experimental)	23.08	8.20	27.08

Table 3: Comparison of People with Respiratory Condtions and People without in the Three Productivity Measurements (disruption from environmental conditons, disruptions from health symptoms, and number of symptoms)

Perception of ones environment directly correlates with how happy they are at work. This was seen in the data with the people that strongly agreed with the statement that "I am happy at my job," these people were satisfied with their enviroment. For those that were uncertain about this statement, it was found that they were less satisfied with their work environment. Those that were in strong disagreement with the statement "I am happy with my job" were even more dissatisfied with their work environment (see Fig. 5).

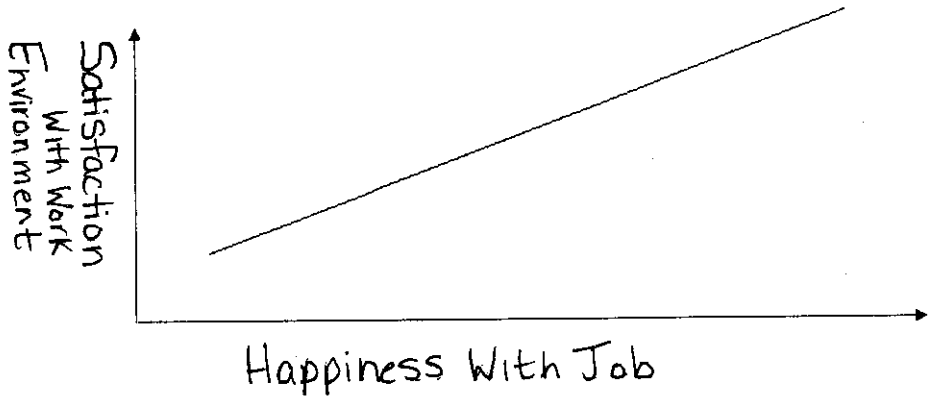


Figure 5: The Happier People are with Their Job Correlates Directly With Their Satisfaction with their Work Environment, (generalization from the data)

The relationship of happiness at work and perception of work environment was significant at the .01 level with the data collected in this study.

If employees did not like their environment there was a significant realtionship to their decrease in productivity time. In other words, the more that employees disliked their environment the higher their loss of productivity time.

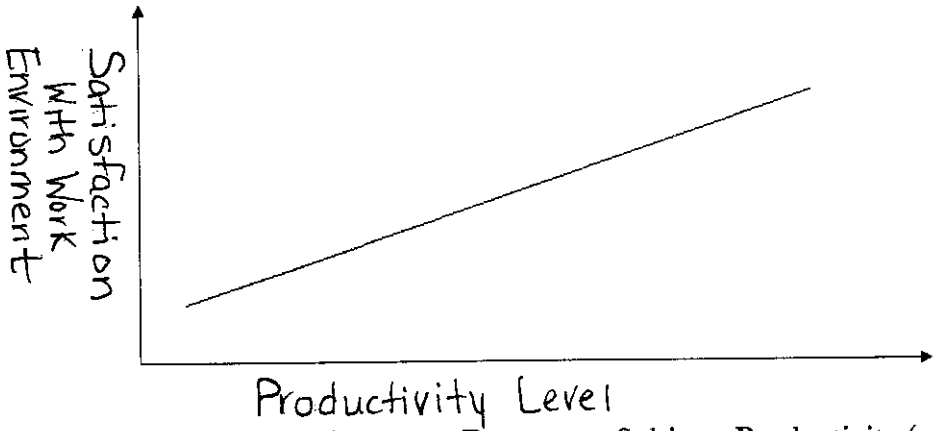


Figure 6: As Satisfaction of Environment Decreases, Subjects Productivity (according to environmental condtions) Level Decreased

This relationship was significant at the .01 level. The same exact relation-

ship was found with the loss of productivity time due to a number of symptoms experienced. This was also significant at the .01 level.

The data, although not always significant shows that the better the indoor air environment the better productivity at the wokplace. This will support our hypthesis that indoor air quality effects productivity in the workplace. Some of the deductions from that data is that it seems that ones perception of the indoor air is actually a stronger correlation than actually the quality of air according to the symptoms experienced.

Other siginficant data that was gathered was the number of sick hours that were lost last year as compared to this year in the experimental groups. In both buildings the number of sick hours used this year reduced during the time that the air units were in the workplace (see Table 4). The only problem with this data is that there could be a problem with history because there are different employees that work there now as compared to last year at this time. Also long term sick leave could be included in this time as well as personal time depending on company policy.

	Sick Hours Used 1991	Sick Hours Used 1992
Building 1	206.25	68.75
Building 2	176.75	72.75

Table 4: Sick Hours used Two Different Groups with Different Locations Both Experimental Groups in the Study

When the employees were exposed to the HEPA air units for a period of one month they were out sick less, they were more productive, and they had less sick symptoms during the 4 week period of time as compared to the control group.

Some non findings were that there was no comparison as to the type of job people had compared to their productivity level on the job. Therefore we could not say that specific jobs are more at risk of indoor air problems. This was suggested by Hedges (1991) because of particulate matter that often times is found around paper products or where paper products are used. Therefore secretaries may have more symptoms than professionals who do not handle so much paper.

Hedges (1991) also explained that females were more likely to have symptoms relating to indoor air than men are because of their oily skin, make up, more hair, etc. In this particular study we were not able to look at differences between females and males because 90 percent of our subjects were female. This was the case just because these particular companies had more females working in the particular areas that were used.

The two buildings that were used were both companies in similar industries in the Capital District. The data showed that there was a difference between the buildings. In other words, the pretests compared between the two buildings were significantly different. Some explanation as to why this is is that the room selected in the two locations were very different. In one building there were many employees in one area with dividers through out the area. This may not let the air circulate as well creating more productivity problems. When looking at the post

test of this building it did not have as positive results as the other. This was probably because with the dividers, the room needed more units in order to have the air filters work effectively between dividers.

There were no contradictions of data just data that was not significant. There are many factors that could have attributed to the non-significant data. The units were in place for approximately one month. The companies had to leave them on for one month continuously. When arriving to retrieve the units one of them was shut off. The staff could have turned them off at night making them not as efficient, especially if they were not always turned back on the next day.

The pretest surveys also raised awareness of ones symptoms and conditions in the office. This could have made the employees feel or be more aware of symptoms after the pretest and before the post test, making both the control group and the experimental group respond with more symptoms during the post test making the units seem less effective. This is why the design of the study was the way that it was with two different control groups one that did not receive a pretest and one that did.

Survey response was not truly a problem because there were approximately 100 subjects but there were suposed to be about 200. One building was very orderly and every employee returned their survey. The other building did not administer the survey with such organization and authority. This group had less than a 50% return rate. If all of the surveys were returned rather than just the subjects who "wanted" to turn them in this may have made the data look slightly different.

How the buildings were selected was a difficult task. These two particular buildings agreed to have the study run in them. Both contact people felt that their buildings were healthy as opposed to sick (SBS). Other building managers and directors felt that the study would stir up too much concern about their indoor air and wanted nothing to do with the study. Of the buildings that were chosen, one was an older building (the one with less symptoms reported) and the other was built within the last 5 years, this had many more complaints of symptoms. As the research suggested the newer buildings have more indoor air problems because of the tightness of the buildings. In both buildings the employees were not able to open windows.

Smoking effects indoor air quality as seen in the reaserch. The new building did not allow for any smoking within the building or even on worksite property! Subjects reported that because of this strict rule many of them have quit smoking others still smoke on their lunch hour and at home. In the other building, there is smoking allowed in special smoking offices and in the smoking lunch room. Of the subjects exposed to the smoke they were exposed to smoke for less than 2 hours at work. The subjects smoking status was not looked at because there were not many smokers at all.

Productivity was measured subjectively because the subjects had to estimate how much work was disrupted by particular conditions or symptoms. This could have led to some error because everyone interpretes "none, somewhat, and very" differently. It was based on the subjects own opinion of how much time was really lost due to this condtion. The sick time was a more concrete measurement but still one may take a sick day not just because they are sick therefore this may not al-

ways be accurate.

Other observations from the implementation of the study was that after the filters were removed from the offices after the four weeks of use the front prefilters were covered with white dust particles. Because the particles were not analyzed we are not sure exactly what the particles were but they could have been a number of things that typically float in the air such as dust and dirt, asbestos, paper particles, etc. The reason this fact is important is because Hedges (1991) explains in his research that the particulate matter in the air is one of the main contributing factors to Sick Building Syndrome. Both of the sets of filters used in the study in each building had tremendous amount of particulate matter filtered from the air in the workspace. The gases would not even be visible in the filters, some of gases that could have been removed if present in the air were: 1) formaldehyde that could come from the new carpets, dividers, drapes, etc., 2) cigarette smoke where there was some in one of the buildings used, 3) radon, carbon monoxide, and ozone could have been removed only if they were attached to a particle of some sort, 4) volate organic compounds which often times come from tap water could be removed because it is an organic compound and would be removed by the carbon filter.

When the units were being removed at the end of the work day many informal personal testimonials were given from employees when the filters were being removed many people commented on the effectiveness of the units. Some of the comments were: an employee no longer sneezes during work time when she used to sneeze all day long, a decrease in allergies, less headaches, less dust in the air, etc.

Most of the people surveyed spent at least 8 hours a day in the building

that they work in. Some of the health effects that they reported as experiencing were all of the ones mentioned in the survey: dry eyes, irritated eyes, tired eyes, sore throat, dry skin, hoarseness, stuffy nose, runny nose, excessive mental fatigue, nervousness, headache, wheezing, nausea, dizziness, skin irritation, skin rashes, diarrhea, and lethargy. Not all of these symptoms could be from indoor air some of them could be intensified from poor indoor air quality. This study does not answer the question of what the long term effects from poor indoor air do to a person or what it does to work productivity or expenses in the workplace. This would need to be addressed over a much longer period of time such as ten or twenty years. There are short term health effects from poor indoor air therefore it would seem as though there would also be long term effects too.

With the energy crisis in the 1970's it is clear that we are building offices and homes differently that we did years ago. The proof is in comparing the two buidings that were used, the newer building had more symptoms experienced as well as more of loss of productivity time. In both buildings the windows were not meant to be opened, in order to conserve energy. In one of the buildings, they had a large printing operation in the basement which very clearly emitted fumes into the main staircases which lead to the main floors. This would be emitting chemicals from the printing department into the building. Another "informal" report from one of the building managers was that they have two parts to their building: a new wing and old, the old was what was used for purposes of the study but the manager explained that she receives many more indoor air complaints from people working in the new part of the building verses the other older wing. When refering to the HBI (1991) study, it seems as though we may be saving money from energy bills but the loss in productivity time that could be saved from having improved air could be substantial. Lets

for the purposes of this study compare last year sick time used as compared to this year (see Table 4), the cost savings is quite dramatic. In the case of buiding 1, the difference in sick time from last year to this year is 137.5 hours or a 67% savings. If we were to estimate that the company pays their employees $15.00 per hour, the company then would be paying a sick employee $2062.50 to stay home and be sick verses be in the office working in healthier conditions. This is a loss in productivity time. These numbers are only estimates from **ONE** of many departments in this particular company. The second company saved 41% of the company sick time as compared to last year or in dollar figures (if figured at $15.00 per hour just like the other company) $1560.00. These figures are just for a one month period of time. If we were to estimate what a company could save over a year period of time the figures drastically increase for example building one would save over $24,000 per year, just with one department. Company number two would save over $18,000 per year, just with one department. The cost of implementing one of the units that were used in the study is actually quite inexpensive if it is compared to the savings. Just to get the cost savings in the areas that were tested for the study it would cost building one $2445.00 to get the units in place to accomplish what was accomplished during the study. Building two because it was bigger, would need to spend $2934.00 to save over $18,000 for the first year. This is an approximate net savings of $22,000 in building one and an approximate net savings of $15,000 for building two. It seems that if employees are heathier, the insurance rates for the company would also decrease therefore there would be indirect savings as well. If the employees are able to be more productive during work hours the companies would also get more out of the employees during that time. The employees would not be taking time to blow their noses, take asprin and allergy medicine, would not be so lethargic, etc., leading to

healthier happier employees. In this design to improve indoor air the company would still be conserving energy costs. The only extra cost would be the electricity to run each air filtration unit which is literally pennies per day, the manufacturer explains.

Another aspect to the filtration units which could help the employees "feel" better about their environment, it was seen in the data that the perception that the employee had of the environment was just as if not more important than the actual environment, this too would improve productivity as seen in the study.

Hedges (1991) discuses breathing zone filtration and he used very similar units as the ones used for this study. It is important to note though that in this study, BZF was not used only because there were approximately one unit for every ten workers. This cleaned the air near the employee and eventually all the air in the room but BZF cleans the air around the employee all day long just from the position of the units. Financially we were not able to have enough units to supply every employee with their own unit but the general idea of how HEPA filtration works was used within the room that the employees were in.

Often people confuse sick building syndrome symptoms with the common cold symptoms but we were able to distinguish the two by one particular question on the survey which asked the employee if their symptoms improved when they left work, many said yes the symptom did improve but not enough to make the data significant. This finding could be because even homes are built different than they were 20 years ago. Generally though when the symptoms improve during the time that the person is away from the area where he/she is experiencing symptoms then it

is more likely to be SBS verses the common cold.

If HEPA filtration is one answer to improving the air in buildings why then was the data not stronger? There are a number of possible conclusions when trying to understand indoor air clean up. One reason may be that the air was very dirty and the filters just began the process. The filters got very dirty and maybe were not as efficient after they took much dirt and debris out of the air. The indoor air clean up begins and then as it cleans it over time the filters will then "maintain" the clean air but at first it may be taking a lot of particulate matter out of the air until it is at a level that would be "normal." Also there were many questions about the units that the employees had such as "Are they going to make us sick," "What did you put in it?" People knew that it was an experiement and thought that something was done to "tamper" with the units. Therefore in some cases the psychological effects that the units had could have been more negative than postitive.

SUMMARY AND CONCLUSIONS

Poor indoor air is a result of the tightening of our buildings in the seventies in order to conserve energy. We continue to construct buildings this way. Many of the new offices have windows that do not open. Fresh air comes from the air vent system. It is estimated that the indoor air problem is going to continue to get worse before it gets better. Companies are going to have to do something in order to ensure employees that their air is safe.

Employees do not want to experience conditions that often emerge from poor indoor air: too little air movement, odors, "stale" air, and dusty air, all of which lead to possible unhealthy symptoms. Symptoms that are experienced from poor indoor air are: headaches, runny noses, nausea, lethargy, etc. If employees do experience such symptoms they will be less productive and spend more and more time out of the office than in.

The research that was conducted had a control group and an experiemental group. Both groups were taken from two different buildings in the Capital District. A survey that asked questions about the employees perception of their work place environment and their health status and health symptoms was administered to the experimental group and some of the control group. HEPA filters were then placed in the experimental groups workspace. There was one filter for every 3000 cubic feet of space. At the end of one month all of the subjects took the same survey again. Productivity time was measured, number of symptoms experienced, and the

perception of the employees of their environment, as well as sick time.

HEPA filtration is one alternative to sick building syndrome. HEPA filtration could drastically reduce money spent on loss in productivity time. Millions of dollars is lost each year from companies that have poor indoor air problems. Some probably do not even recognize that they can do anything about it. Poor indoor air is relatively a new problem because of the way we are constructing our newer offices and homes.

HEPA filtration will remove partiuclate matter from the air as well as gases and odors. They are relatively inexpensive compared to the cost saving a company can have even immediatley! The psychogoical harm that comes from employees feeling that their work place has poor indoor air could be even more damaging. Employees perform better when they feel that the enironment that they are working in is clean and safe.

The conclusion is that employers will eventually need to do something about the air that their employees are breathing so as to get the most productive work from them and keep them healthier. HEPA filtration is an alternative. Breathing Zone Fitration (employing HEPA filtration) would probably be an even more effective alternative.

REFERENCES

Air Cleaners and Allergy Suffers. 9/12/91, 6:00pm CBS Local News.

American Lung Association, (1986). Indoor Air Quality.

The American Society of Heating, Refrigeration, and Air Conditioning Engineers, Inc. (ASHRAE) (1981). Ventilation for Acceptable Indoor Air Quality. A1 - B8.

Anderson, I.B., and Korsgaard, J., Asthma and the indoor environment: assessment of the health implications of high indoor air humidity. Indoor Air, Vol. 1, P. 79 - 86.

Assembly of the State of New York, Assembly Standing Committee on Health, Assembly Standing Committee on Labor, Assembly Committee on Environmental Conservation. Joint Public Hearing on Indoor Air Quality (1990).

Assembly of the State of New York, Assembly Standing Committee on Health, Assembly Standing Committee on Labor, Assembly Committee on Environmental Conservation. Public Hearing on Indoor Air Quality, (1991).

Baird, J. C. and Berglund, B. (1989). Thesis for Environmental Psychophysics. Journal of Environmental Psychology, 9, 345 - 356.

Barker, J. W. and Glass Jr., J. C. (1990). Perceived Wellness Needs of University Employees 38, 187 - 189.

Baron . L.I. and Sterling, E.E.. (1984). Does Indoor Air Pollution Affect Office Productivity. Proceedings of Third International Symposium on Building Ecomonics, 5, Session E E3, 21-28.

Bureau of Business Practices, 1991. The Healthy Way to Eliminate Sick Building Syndrome. Safety Management, 339, 1 - 4.

Burton, J. (1991). Physical, Psychological Complaints can be result of Indoor Air Quality. Occupational Health and Safety, March, 53.

Canadian Union of Public Employees Communications Workers of Canada, (1985). Indoor Air Pollution.

Conrad, P. (1987). Wellness in the Work Place: Potentials and Pitfalls of Work-site Health Promotion. The Milbank Quarterly, 65, 2, 255 - 273.

CBS Local News, 9/12/91, 6:00 PM Broadcast. Dr. Robert Hamburger, Allergist, University at San Diego, California.

Cope, L. (1990). Warning Issues For Some Air Cleaners. Star Tribune, June 27, 1..

Cushing, A. C. and Samet, J. M. (1991). Indoor Pollutants: How Hazardous for Children? Contemporary Pediatrics, 2, 109 - 112.

Eddy, J. M., Gold, R. S., Zimmerli, W. H. (1989). Evaluation of Worksite Health Enhancement Programs. Health Values, 13, 1, 3 - 9.

Electric Power Research Institute (EPRI) (1984). Manual on Indoor Air Quality.

Environmental Protection Agency (EPA) (1988c). The Inside Story - A guide to Indoor Air Quality.

Environmental Protection Agency (EPA) (1990). Residential Air Cleaning Devices: a summary of available information. 1 - 22.

Environmental Protection Agency (EPA) (1987a). Indoor Air Facts. EPA and Indoor Air Quality. No. 1.

Environmental Protection Agency (EPA) (1987b). Indoor Air Facts. Indoor Air Quality Implementation Plan. No. 2.

Environmental Protection Agency (EPA) (1988a). Indoor Air Facts. Ventilation and Air Quality in Offices. No. 3.

Environmental Protection Agency (EPA) (1988b). Indoor Air Facts. Sick Buildings. No. 4.

Environmental Protection Agency (EPA) (1989a). Indoor Air Facts. Environmental Tobacco Smoke. No. 5.

Environmental Protection Agency (EPA) (1989b). Indoor Air Facts. Report to Congress on Indoor Air Quality. No. 6

Feigenbaum, N. (1990). Buildings with a Bug. The Orlando Sentinel, 7/30 - 8/5

Finnegan, M. J., Pickering, C. A. C., and Burge, P. S.. (1984). The Sick Building Syndrome: prevalence Studies. British Medical Journal, 289, 1573 - 1575.

Goodavage, M. (1991). USA Today, Workers fear Return to "Sick Building, 9/21, 3.

Hawkins, L.H., and Morris, L. (1984). Air Ions and the Sick Building Syndrome. In-

door Air, Vol. 3. P. 197 - 200.

Healthy Buildings International (1991a), Jan/Feb., 2 - 11.

Healthy Buildings International (1991b), July/Aug., 6 - 7.

Healthy Buildings International (1991c). Sick Building Syndrome Causes and Cures.

Healthy Buildings International (1989a). Biological Pollutants in the Indoor Environment. 1 - 11.

Healthy Buildings International (1989b). Proactive Monitoring: Controlling Indoor Air Quality.

Hedge, A. (1984). Ill Health Among Office Workers: An Examination of the Relationship between Office Design and Employee Well-being. Ergonomics and Health in Modern Offices, Section A, 46 - 51.

Hedge, A. (1987). Office Health Hazards: An Annotated Bibliography. Ergonomics, 30, 5, 733 - 772.

Hedge, A. (1991a). State Government Policy for Diagnosing and Managing Indoor Air Quality and Sick Building Syndrome Complaints in Buildings. Statement Presented to NYS Assembly, Assembly Standing Committee on Health, Assembly Standing Committee on Labor, and Assembly Standing Committee on Environmental Conservation.

Hedge, A. (1991b). Clearing the Air. August. 8 - 10.

Hedges, A., Martin, M. G., McCarthy, J. F. (1990). Breathing Zone Filtration Effects on Indoor air Quality and Sick Building Syndrome Complaints., 351 - 357.

Holtz, T. (1987). Theoretical Foundations of Prevention. Narcotic and Drug Research Inc.

Hudson, J. (1982). Air Purification: A Cure For New Home Sickness. R Home Care, Aug., 21 - 24.

Indoor Pollution News (1989a). In Arizona, Volunteers to Test School Before Reoccupancy, 9/7, 2 - 3.

Indoor Pollution News (1989b). Arkansas Federal Workers Moved to Alleviate Site..., 9/7, 2 - 3.

Indoor Pollution News (1989c). ...While in Denver, Poled Workers List Problems, 9/7, 2 - 3.

Indoor Pollution News (1989d). In Texas, HVAC system Replaced After Ills at Austin City Hall, 2, 3, 2.

Indoor Pollution News, (1989e). IRS Employees Take to Street to Demonstrate the SBS Ire, 2, 4, 5.

Indoor Pollution News, (1989f). In Boston, Oldest High School Plagued by Renovation's Fumes, 2, 6, 6.

Indoor Pollution News, (1989g). In Arizona, Troubled School is Evacuated; Culprit Unknown, 2, 7, 2.

Indoor Pollution News, (1989h). In Problem Building, Level of Complaints tied to Health load, 2, 8, 4.

Indoor Pollution News, (1989i). Washington, D.C. Navy Building Shut By False Cyanide Readings, 2, 9, 2.

Indoor Pollution News, (1989j). Arizona Hospital Incinerator Blamed for Foul Odors, Fumes. 2, 10, 8.

Indoor Pollution News, (1989k). In Arizona, Test AT School Is Negative For Toxic Waste, 2, 11, 3.

Indoor Pollution News, (1989l). In Kentucky, Workers Sue For Injuries, Are Forced Back into Building BY State, 2, 13, 1 - 7.

Indoor Pollution News, (1989m). In Arizona, ASU Officials Look For Source of Complaints..., 2, 21, 3.

Indoor Pollution News, (1989n). ...While Beleaguered Grade School Finally Free of Woes, 2, 21, 3.

Indoor Pollution News, (1989o). Albany School Puzzle Causes Rift with Principal, Teachers, 2, 20, 3.

Indoor Pollution News, (1989p). Pennsylvania Finance Building Repaired To Address IAQ Faults, 2, 19, 5.

Indoor Pollution News, (1989q). Another Episode of EPA: Fumes Send Half of Employees Home, 2, 18, 3.

Indoor Pollution News, (1989r). Arizona School Cleared By Testers for Reoccupancy, 2, 17, 3.

Indoor Pollution News, (1990a). Building Managers Say they Are Poorly Equipped, 3, 23, 6.

Indoor Pollution News, (1990b). EPA Sets Aside Special Offices For Workers Suffering SBS ills, 3, 20, 3 - 4.

Indoor Pollution News, (1990c). Spillage Among Most Common, Unhealthy of IAQ Problems, August, 3.

Indoor Pollution News (1990d). Carbon Filters make Excellent Protectors of IAQ, California Firm Says. Vol. 3, 11, 7.

Indoor Pollution News, (1990e). Classroom Allergens May Contribute to Pupils Ills, Poor Performance, 3, 15, 5.

Indoor Pollution News, (1991). NY Lawmakers Urged to Adopt Legislation Regulations IAQ problems, 4, 2, 3.

Jeffery, R. W., Forster, J. L., Schmid, T. L. (1989). Worksite Health Promotion: Feasibility Testing of Repeated Weight Control and Smoking Cession Classes. American Journal of Health Promotion, 3, 4, 11 - 16.

Johnson, D., (1991). Sizing Up The Top 10 Pollutants. The Family Handyman, February, 8 - 13.

Kleinmann, G.D., and Horstman, S. W. (1982). Health Complaints Attributed to the use of Carbonless Copy Paper. American Industrial Hygiene Association Journal, 43, 432 - 435.

Krueger, A. P., and Sobel, D.S. (1979). Air Ions and Health. Holistic Approaches to Ancient and Contemporary Medicine, 413 - 433.

King, J. G. (1973). Air For Living. Respiratory Care, 18, 2, 38 - 41.

Miller, K. and Daglish (Allergy Information Association), (1970). Mould (Fungus) Control.

National Safety Associates, 1989. #855100 Dual LPC (Laser Particle Counter) Filter Test System, Indoor Air Pollutants

New York State Health Department, New York Stae Energy Research and Development Authority, Indoor Air Quality and Your Home - A Guide to Common Indoor Pollutants, Their Sources and Control Measures.

New York State Assembly, Committee on Health, Committee on Labor, Committee

on Environmental Conservation. Public Hearing: Indoor Air Quality (1991).

Norback, D., Ingegerd, M., Widstrom, J. (1990). Indoor air Quality and personal Factors Related to the Sick Building Syndrome. Scandinavian Journal of Work, Environment, and Health, 16, 2, 121 - 126.

Occupational Health and Safety (1989). OSHA Technical Manual. Indoor Air Quality Investigation.

Our Environment, 11/17/91, Discovery Channel

Peder, S., Valbjurn, O., Pedersen, B. V. (1989). Influence of personal Characteristics, job-related factors and psychosocial factors on the Sick Building Syndrome. Scandinavian Journal of Work, Environment and Health, 15, 4, 286 - 295.

Reed, C.F., and Swanson, M.C., (1984). Indoor Allergens: Identifacation and Quantifacation. Indoor Air, Vol. 1., 99 - 107.

Reisman, R. E., Mauriello, P. M., Davis, G. B., Georgitis, J. W., and DeMasi, J. M. (1990). A Double-blind Study of the Effectiveness of a High-Efficiency Particulate Air (HEPA) Filter in the Treatment of Patients with Perennial Allergic Rhinitis and Asthma. Journal of Allergy and Clinical Immunology, 6, 1050 - 1057.

Saltzman A. and Silberner J. (1989). When Each Day is a Sick Day. US News and World Report, March 13, 65 - 67.

Schwartz, D. C. (1989). Career Wellness. Fitness in Business, Feb., 138 - 140.

Senate Democratic Task Force on Indoor Air Quality (1990). Indoor Air Quality Report - A preliminary Report.

Sloan, R. P. and Allergrante, J. P. (1985). Corporate Health is More Than a Robust Balance Sheet. Training and Development Journal, Dec., 57 - 59.

Spengler, J. D. and Sexton, K. (1983). Indoor Air Pollution: A Public Health Perspective. Science, 221, 4605, 9 - 17.

Sperry (1984). Health Promotion and Wellness Medicine in the Workplace: Programs, Promises, and Problems. Individual Psychology - Journal of Adlerian Theory, 40, 4,401 - 411.

Sterling, T.D. (1984). Economics and Politics in the Assessment of Causes of Building Illness: the NAS/NRC Report on Indoor Pollutants. International Journal of Health Services, 14 (1), 43 - 53.

Sterling, E.M. McIntyre, E.D., Collett, C.W., Sterling, T.D., and Meredith, J. (1985).

Sick Buildings: Case Studies of Tight Buildings Syndrome and Indoor Air Quality Investigation in Modern Office Buildings. Environmental Health Review, 29, (3), 11 - 19.

Thompson, A. (1990). Special Issue: The Environment - The Next Battleground: air in our workplaces. The Costco Connection, 4, 7, 1.

Tucker, L. A., Aldana, S. G., Friedman, G. M. (1990). Cardiovascular Fitness and Absenteeism in 8,301 Employed Adults. American Journal of Health Promotion, 5, 2, 140 - 145.

Turiel, I., Hollowell, C.D., Miksch, R.R., Rudy, J.V., Young, R.A. and Coye, M.J. (1983). The Effects of Reduced Ventilation on Indoor Air Quality in an Office Building. Atmospheric Environment, 17 (1), 51 - 64.

Turner, S. Indoor Pollution: Sources, Effects and Mitigation Strategies. Healthy Buildings International.

U. S. Department of Labor, (1990). Directorate of Compliance Programs: Indoor Air Quality.

Webster's Seventh New Collegiate Dictionary (1967). R.R. Donnelley and Sons Company, The Lakeside Press, Chicago, Ill.

Wood, E. A., Olmstead, G. W., Craig, J. L. (1989). An Evaluation of Lifestyle Risk Factors and Absenteeism after Two Years in a Worksite Health Promotion Program. American Journal of Health Promotion, 4, 2 128 - 133.

CORNELL OFFICE ENVIRONMENTAL QUALITY SURVEY

This survey is being conducted by researchers at Russell Sage Coll. to determine the environmental quality of your office building. This questionnaire asks about how you think your office environment and your work affect you. Please answer the questions as accurately and completely as you can, regardless of how satisfied or dissatisfied you are with conditions in the office.

You do not need to put your name on the questionnaire, and all of your answers will be treated in the STRICTEST CONFIDENCE.

Answer directions: place a ◯ around the appropriate number to indicate your answer to each question.

Answer like this: 1 2 (3) 4 5

If you make a mistake: erase your incorrect answer then put a ◯ around the correct response

OFFICE USE ONLY										
#	Bldg.		Floor		Area	D	T	Case		
4										

General Information I

1. How long have you worked in this building?

Years								
less than 1	1	2	3	4	5	6	7	8 or more

2. How many days a week do you work in this building?

Days a week						
1	2	3	4	5	6	7

3. How many hours a day do you work in this building?

Hours a day								
less than 1	1	2	3	4	5	6	7	8 or more

4. How old are you?

Years					
19 or less	20-29	30-39	40-49	50-59	60 or more
1	2	3	4	5	6

5. What is your sex?

Female	Male
1	2

6. Please indicate <u>any</u> of the following you presently suffer from:

Migraine	Asthma	Eczema	Hayfever	Other Allergies	Chronic Backpain
1	2	3	4	5	6

7. What is your smoking status:

Non Smoker	Former Smoker	Current Smoker
1	2	3

8. What types of correction lenses do you usually wear?

None	Reading glasses	Regular glasses	Other glasses	Contact lenses
1	2	3	4	5

Appendix A

All answers are <u>STRICTLY CONFIDENTIAL</u>

9. Please circle below the day of the week and the time of day you are completing this questionnaire:

• DAY OF THE WEEK

Monday	Tuesday	Wednesday	Thursday	Friday
1	2	3	4	5

• TIME OF DAY

AM	PM
1	2

Conditions	10. During the PAST MONTH how often have you experienced each of the following environmental conditions while working in this building?				11. Overall, during the PAST MONTH how much has your work been disrupted by this condition?			12. What TIME OF DAY is this condition usually experienced?				13. Are you CURRENTLY experiencing this condition?	
	Never	1 to 3 times a Month	1 to 3 times a Week	Almost every day	Not at all disrupted	Somewhat disrupted	Very disrupted	AM	PM	Both	No Pattern	YES	NO
a. temperature too warm	1	2	3	4	1	2	3	1	2	3	4	1	2
b. temperature too cold	1	2	3	4	1	2	3	1	2	3	4	1	2
c. satisfactory temperature	1	2	3	4	1	2	3	1	2	3	4	1	2
d. satisfactory lighting	1	2	3	4	1	2	3	1	2	3	4	1	2
e. lighting too dim	1	2	3	4	1	2	3	1	2	3	4	1	2
f. glare problems from lighting	1	2	3	4	1	2	3	1	2	3	4	1	2
g. insufficient ventilation	1	2	3	4	1	2	3	1	2	3	4	1	2
h. uncomfortable drafts	1	2	3	4	1	2	3	1	2	3	4	1	2
i. too little air movement	1	2	3	4	1	2	3	1	2	3	4	1	2
j. air too dry	1	2	3	4	1	2	3	1	2	3	4	1	2
k. air too humid	1	2	3	4	1	2	3	1	2	3	4	1	2
l. distracting ambient noise	1	2	3	4	1	2	3	1	2	3	4	1	2
m unpleasant odor in air	1	2	3	4	1	2	3	1	2	3	4	1	2
n. "stale" air	1	2	3	4	1	2	3	1	2	3	4	1	2
o. dusty air	1	2	3	4	1	2	3	1	2	3	4	1	2
p. static electricity shocks	1	2	3	4	1	2	3	1	2	3	4	1	2

All answers are STRICTLY CONFIDENTIAL

14. During the PAST MONTH how often have you experienced each of the following symptoms while working in this building?					15. Overall, during the PAST MONTH how much has your work been disrupted by this symptom?			16. What TIME OF DAY is this symptom usually experienced?				17. Are you CURRENTLY experiencing this symptom?		18. During the PAST MONTH what happened to this symptom at times you were away from work? (eg. evenings,weekends)		
Symptoms	Never	1 to 3 times a Month	1 to 3 times a Week	Almost every day	DISRUPTED Not at all	Somewhat	Very	AM	PM	All Day	No Pattern	YES	NO	Got worse	Stayed the same	Got better
a. Dry eyes	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3
b. Irritated, sore eyes	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3
c. Tired, strained eyes	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3
d. Sore, irritated throat	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3
e. Dry skin	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3
f. Hoarseness	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3
g. Stuffy, congested nose	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3
h. Runny nose	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3
i. Excessive mental fatigue	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3
j. Nervousness, irritability	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3
k. Headache across forehead	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3
l. Wheezing, chest tightness	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3
m Nausea	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3
n. Dizziness	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3
o. Skin irritation, rashes	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3
p. Diarrhea	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3
q. Unusual tiredness, lethargy	1	2	3	4	1	2	3	1	2	3	4	1	2	1	2	3

All answers are STRICTLY CONFIDENTIAL

19. This section contains questions concerning the characteristics of your job. Please say how much you agree or disagree with each of the following statements about your job.

Job Characteristics	Strongly agree	Mostly agree	Uncertain	Mostly disagree	Strongly disagree
a. My job is usually interesting	1	2	3	4	5
b. I'm happy in my job	1	2	3	4	5
c. I dislike my job	1	2	3	4	5
d. I am satisfied with my job	1	2	3	4	5
e. I'm enthusiastic about my job	1	2	3	4	5
f. My job is rather monotonous	1	2	3	4	5
g. My job is not very stressful	1	2	3	4	5
h. I usually have to work fast	1	2	3	4	5
i. I often feel stressed at work	1	2	3	4	5
j. My job demands a lot of concentration	1	2	3	4	5
k. I often feel overworked	1	2	3	4	5
l. The office environment is satisfactory for my job	1	2	3	4	5

20. How often do you use the following at work?

	Several times a day	About once a day	3-4 Times a week	Less often	Never
a. Photocopier	1	2	3	4	5
b. Self copying/Carbonless copy paper	1	2	3	4	5
c. Correction fluid (specify below)	1	2	3	4	5

21. What is your job category?

Managerial	Professional	Technical	Clerical	Secretarial	Other:
1	2	3	4	5	6 (please specify)

22. About how many hours a day do you work with a computer or word processor?

Hours per day								
Never use	Less than 1	1	2	3	4	5	6	7 or more

All answers are STRICTLY CONFIDENTIAL

General Information II.2

23. In an average working week (Monday - Friday), how many hours PER DAY are you exposed to other peoples' tobacco smoke?

	Never	Less than 1 hr	1-2hrs	3-4hrs	5-6hrs	7-8hrs	More than 8hrs
a. At home	1	2	3	4	5	6	7
b. At work	1	2	3	4	5	6	7
c. In Other Locations	1	2	3	4	5	6	7

24. In an average weekend , how many hours PER DAY are you exposed to other peoples' tobacco smoke?

	Never	Less than 1 hr	1-2hrs	3-4hrs	5-6hrs	7-8hrs	More than 8hrs
a. At home	1	2	3	4	5	6	7
b. In Other Locations	1	2	3	4	5	6	7

25. How bothersome are the following to you:

	Very Bothersome	Fairly Bothersome	Somewhat Bothersome	Not at all Bothersome
a. Seeing "No Smoking" Signs at work	1	2	3	4
b. Seeing tobacco smoke in the air in any place	1	2	3	4
c. Smelling tobacco smoke in the air in any place	1	2	3	4
d. The company's present smoking policy	1	2	3	4

26. How much time do you spend in the smoking area in these activities on an average day in total?

	Never	Less than 1/2 hr	1/2-1hr	1-2hrs	2-3hrs	More than 3 hrs
a. In meetings	1	2	3	4	5	6
b. Individual work	1	2	3	4	5	6
c. Other	1	2	3	4	5	6

IF YOU ARE A CURRENT OR FORMER SMOKER PLEASE COMPLETE THE APPROPRIATE SECTION

Former Smokers

27. How many years in total did you smoke?

Less than 1 yr	1-5yrs	6-10yrs	11-15yrs	16-20yrs	More than 20 yrs
1	2	3	4	5	6

28. About how much did you smoke EACH DAY:

	Cigarettes	Cigars	Pipe bowls
a. At WORK			
b. At HOME:			
c. At other places:			

29. How long ago did you stop smoking? ____ Years ____ Months

Current Smokers

30. How many years in total have you been smoking?

Less than 1 yr	1-5yrs	6-10yrs	11-15yrs	16-20yrs	More than 20 yrs
1	2	3	4	5	6

31. About how much do you smoke EACH DAY:

	Cigarettes	Cigars	Pipe bowls
a. At WORK			
b. At HOME:			
c. At other places:			

32. How accessible are the smoking areas to you?

Very accessible	Somewhat accessible	Not very accessible	Not at all accessible
1	2	3	4

33. How have your smoking habits been changed by the present smoking policy in your office?

	Smoke much more	Smoke slightly more	No change	Smoke slightly less	Smoke much less
At HOME	1	2	3	4	5
At WORK	1	2	3	4	5

Please write any comments on back of page

Thank you for completing this questionnaire *All answers are STRICTLY CONFIDENTIAL*