

A Comprehensive Series Concerning "Sick Building Syndrome" and "Building Related Illness" Pertaining to People in the Buildings Marketplace

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A GROWING EPIDEMIC

Part I: "Sick Building Syndrome": A comprehensive series about a growing concern to all people involved in the buildings marketplace. The purpose of this series is to explore the causes, sources, and solutions of pollutants that have been linked to many health and environmental problems.

The issue of indoor air quality is a serious problem that continues to become more prevalent everyday.

Indoor air quality is not only hazardous to our health, but also hazardous to the economic life of our businesses. Loss of building materials and furnishing, drops in productivity, increased health care costs, and even legal liability are all problems that we don't want to deal with.

These very same problems effect everyone involved in the buildings marketplace and they must be informed about concerns. People involved in this particular market must be ready to react to these problems when they happen in their own facilities -- and they will happen -- and they must react.

Indoor air pollution has spawned a broad array of "solutions" to the building and human problems lumped under the very misleading banner of "Sick Building Syndrome." These include real solutions from tearing out offensive materials and improving filtration/air circulation to just covering it up. This is why the American public spent over \$1 billion on air fresheners, deodorizers, and disinfectants in 1998 and the worldwide market for such products is exploding.

Indoor air pollution problems were magnified when the energy efficiency standards and materials used by architects and designers changed dramatically in the early 1970's. Circulation of air in an office building was reduced by 80%. With poor circulation, this literally left the door wide open to the many pollutants, bacteria, mold, and mildew that we struggle with everyday.

Working within these pollutant laden enclosed spaces, it is no wonder that many of the world's employees develop symptoms such as headaches, dizziness, burning eyes, and upper respiratory complaints just to name a few. Over time though, the severity steadily gets worse as exposure is prolonged. Reaction to indoor pollutants usually occur 1 to 2 hours after they arrive to work and last 3 to 4 hours after they get home from work.

Emotionally, however, people don't get over impairments that easy. When people are struck by an illness of any type or size, productivity starts to decrease, morale falls, and eventually your could find your company with a high turnover rate of employees. This is especially true if the cause of the illness is unknown.

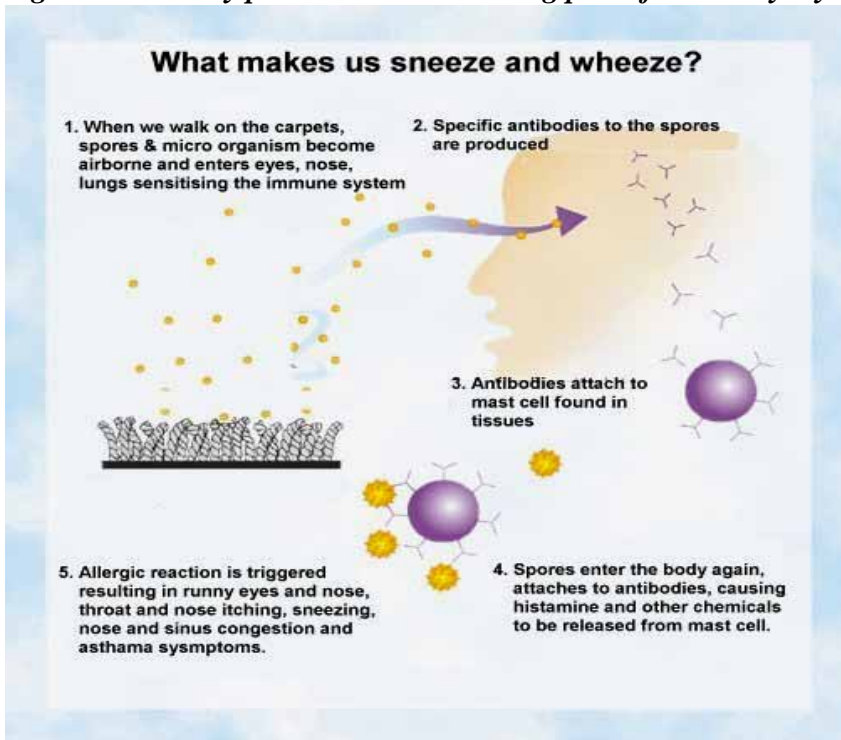
Buildings themselves suffer as well. Deterioration and structural degradation are common effects of the contamination inside a building. Of course your building is not going to crumble before your own eyes, but over time occupational

safety and values of buildings become issues that nobody wants to deal with legally or financially.

Anyone in the buildings marketplace must be concerned with "Sick Building Syndrome" and "Building Related Illness." The problems are real and are costly. The symptoms may seem clear, but the causes and sources of the biological, chemical, or particulate pollutants are complex. These pollutants and their sources must be understood if protection strategies are to be taken in learning more about these problems to avoid human and building problems.

Part II: "Sick Building Syndrome" (SBS) -- The Causes

The causes of "Sick Building Syndrome" and "Building Related Illness" are endless. From dust to gases to microorganisms, the number of pollutants is infinite. Fortunately, there are three basic categories that we categorize the many pollutants that are a big part of our everyday lives.



The problems of SBS are serious and cause an economic impact on all people involved in the buildings marketplace. The billions of dollars of direct and indirect damage caused by indoor pollutants affect every surface, manufacturing process, piece of operating equipment, and person in a building. Asbestos, radon, lead, formaldehyde, and Legionnaire's Disease are only a few of the press-event pollutants that are present in our homes, offices, hospitals, hotels, schools and other buildings. These pollutants at high levels cause obvious and immediate effects. At low levels, symptoms start out small and gradually get worse. Human health problems range from simple irritations to deadly diseases, like cancers.

Indoor pollutants can be thought of in a rather simple way. They consist of particulates, gases, and biologicals. The diversity of each of these is great. The reality of an occupied and useful building is that these pollutants will always be present at some level. Much like weeds, many pollutants are normal until their levels or locations make them undesirable.

Particulates consist of a great variety of materials that vary in size from sub-micron to grains of sand. This matter which is transferred through the air is often small enough to be inhaled deep into the lungs, yet large enough to remain lodged once they enter. The nose, throat, and lungs filter out particles that are 1.5 microns in size (a micron is one-millionth of a meter), while particles smaller than 0.1 micron are usually exhaled. Therefore, the particles with the greatest concern are 0.1 to 1.5 microns. Asbestos, paint chips containing lead, disease-causing dust, or a fungus that stimulates an allergic response can be a serious problem. Even insecticides or rodent control treatments can cause short-term (acute) or long-term (chronic) health problems to occupants of building facilities. These join the list of

second-hand smoke, industrial process source pollutants, and irritating dirt and dust from the outdoors and generated indoors by human activity, as serious health impacting indoor pollutants.

Gases are generally referred to as volatile organic compounds (VOC's) and include a wide variety of solvents, formaldehyde, and many other manmade and natural materials. They also include carbon dioxide, oxygen, nitrogen, ammonia, metallic oxides such as nitrous oxides and sulfur oxides.

Ozone from machinery and formaldehyde from building materials have been recognized as "major health impacting indoor pollutants" long before today's concerns about indoor pollution came about. Formaldehyde is the most common of all VOC's. Six billion pounds are produced in the United States each year and globally this is still a major component of adhesives and insulation materials. Health effects of formaldehyde and other VOC's mimic that of a cold. If the exposure is prolonged, the health effects generally get worse until the individual experiences such problems as chemical sensitivity, potential for an asthma attack, and other chronic health problems. Typically, indoor concentrations are 2 to 5 times higher indoors with some up to one hundred times higher.

Various insects, mites, ticks, protozoans, bacteria, and fungi are what make up the biological category. This group also includes particulates and gases as well. Biologicals interact so dramatically, directly, and destructively with buildings and their inhabitants that they have earned the right to be called the most potent of all pollutants. Even more significant, is the fact that the biologicals can be tied to all of the human responses that we associate with SBS. This is not true of the other pollutants. Non-biological pollutants, such as particulates or gases can stimulate specific human symptoms but not all of them. Besides the bacterial, fungal(mold, mildew, and yeast), and viral disease causing organisms, there are a number of these organisms that cause allergic response in sensitive individuals. Legionella bacteria, lung disease causing bacteria, E. coli, Salmonella species, and the typical skin bacteria such as Staphylococcus and Pseudomonas are all part of the biologicals found in buildings. Each of these organisms has specific life styles and habitats in buildings and are the reasons for the growing concern of occupants in today's buildings marketplace.

Particulates, gases, and biologicals represent the classes of pollutants that negatively affect people and materials in buildings. These groups are complex and are present in all areas throughout a building. The most potent of these pollutants are of course the biologicals. Knowing as much as we can about these classes, arms us with the knowledge necessary as we determine where these pollutants are and how they can be dealt with.

Part III: "Sick Building Syndrome" (SBS) -- Finding The Sources

The detectives stood by the side of the building shaking their heads and saying aloud -- "Where do we begin?" "What do we do?" "Where do they come from?"

Human and building problems associated with indoor air pollutants are worse than ever. Modification of materials used to build, furnish, and decorate buildings and the reduction of indoor air circulation brought on by the "energy crises" in the early 1970's, were all changes that had a great impact on indoor air pollution.

When human or even building-based symptoms occur, a search for the cause must be undertaken. This can be done a number of different ways: using your colleagues' experiences, your own experiences, the U.S. EPA manual, calling in some expert, or just plain old common sense. The easiest and cheapest way is of course, common sense. We will focus on using common sense for the discovery of pollutants in this article. Found everywhere, microbes are also particulates that produce gases. Thus making microbial contaminates the best example to look at.

By simply looking at your building, you will see areas where pollutants originate, come in, move around, and then exit. HVAC systems, windows, doors, venting systems, elevator shafts, and even people movement are pathways for pollutants. Areas where moisture is noticeable are also good indicators of possible pollutant sources. Condensation on pipes, windows, doors, water faucets, and even over-watered plants are great places for mold and mildew to grow. The biggest sources of microbial growth are fabric furnishings such as carpets, upholstery, and drapes where dirt and moisture get trapped.

Surrounding natural and human built structures greatly influence your indoor environment. Weather patterns, nearby

highways and parking garages must be counted as potential sources of your building problems. In addition, neighboring industrial factories that omit pollutants into the air must all be considered when searching for sources.

The quality of air at the point of entry must be understood and should not be taken lightly. Keeping air intakes free from dirt, standing water, and bird roosting is very important. Your air handling and conditioning system are the "lungs of your building." Therefore, by completely understanding how outside pollutants enter into your building, proper design and operation of filtration equipment can be made.

Once inside the HVAC system, the air is usually mixed with the recirculating building air and is heated or cooled. Mixture of this air at different temperatures creates moisture. This moisture encourages abnormal levels of microbial growth, odors, deterioration, and staining. These pollutants are then transported through the air ducts into the areas occupied by people.

This occupied space becomes a large mixing bowl of contaminated air for contact with the unknowing occupant. In an ideal system, this air would immediately be returned through vents to the outside. Unfortunately, indoor air circulation is still at a much slower rate than it used to be in the past. Therefore, before this polluted air can be recycled or vented, it is in constant direct contact with its building occupants. This reality makes it increasingly important that pollutant sources are identified, isolated, and removed.

In summary, the simple way to understand sources of pollutants is to take a broad view of the external and internal environments and check these areas for abnormalities. Also knowing the areas throughout your building where there have been "water events," should sharpen your senses to any potential sources of pollutants.

Part IV: "Sick Building Syndrome" (SBS) -- Microbial Pollutants

By far the worst known pollutants is the one that you cannot see, but they are everywhere.

Microbes are a part of our everyday lives. They are found on all environmental surfaces, in the air and in the water associated with normal or catastrophic events. Microbes can, given certain conditions, multiply from one organism to more than one billion in just 18 hours. Unfortunately, most people think that since they cannot even see these organisms, they offer no real threat to us humans. In reality these microscopic beasts, among other factors, are being implicated as primary and contributory factors leading to an array of health concerns in the work place.

The broad spectrum of microbes are particularly potent because they can cause a full breadth of discomfort, irritation, sensitization, toxic reaction, and disease. When employees start to develop symptoms associated with "Sick Building Syndrome" they point the finger at anything or anybody. From this stems many company problems; low morale, loss of productivity and unwanted employee turnover are just a few.

Do not be panicked by the somewhat frightening array of microbial pollutants. Microorganisms fall into three basic categories: Bacteria, Fungi, and Algae. Some of these organisms only flare up as problems under very unusual conditions. Most microorganisms are at levels in buildings that do not cause problems for normal healthy individuals. Their balance is generally controlled by your operating conditions and housekeeping practices. The problem for building administrators occurs when there is an upset of this balance. In addition, the fact that 30% of the general population has some form of respiratory handicap, asthma or allergies amplifies the imbalance. As does the growing population of "immunosuppressed" people such as AIDS, organ transplant, or cancer patients. These "at-risk" people are further added to, when you include the very young and the elderly.

Bacteria, in its growing stages, usually needs lots of water. This is why *Legionella spp.*, the causative agent for Legionnaire's Disease, is associated with showers, cooling towers, humidifiers or other water sources such as standing water near a fresh air intake. Elevated levels of endotoxins, the toxins produced by bacteria, have been measured in agriculture, the biotechnology industry, swimming pool areas, and in office buildings. The respiratory complications caused by these toxins are somewhat understood, but their real importance in "Sick Building Syndrome" events may be obscure and is yet to be determined.

Another group of microbes is Fungi. Most commonly known as bread mold or yeast, fungi are found in all areas of a

building but are most often a problem in areas that see a lot of moisture or have been significantly wet. The moisture allows these organisms to "bloom"(grow rapidly). During the rapid growth stages, these organisms give off odors, cause deterioration, and spread their irritating and allergy stimulating reproductive spores for unknowing people to encounter.

We see tremendous variation in fungal types and numbers depending on indoor surfaces, time of year, weather conditions, and even geographical area of your facility. Average temperatures, rain fall, land topography, the surrounding environment, coastal or river sited versus an inland plain, are all part of the factors that determine the types of fungal contaminants in a building. Fungi are a very common part of the outdoor air and so finding them in buildings is not a big surprise. If you smell them or if you see their characteristic stains, they are a problem and it's only a matter of time before your employees become affected.

The various fungi that occasionally receive "bad press" are generally those that are known to produce chemicals referred to as mycotoxins or aflatoxins. These chemicals are known to cause headaches, bleeding of the lungs, and cancer in agricultural workers, babies, or sick individuals that may be more susceptible than young, healthy people. Exposure routes, doses, pathogenicity and susceptibility of individuals are not fully understood but when these organisms are present they should be considered a serious concern and actions should be implemented. *Stachybotrys chartarum*, *Aspergillus flavus*, *Aspergillus versicolor*, and a few others are prominent in this group of fungi both because of their prevalence and their ability to be identified.

Algae, the most understudied of all microbial pollutants, are not commonly thought of as part of the microbial pollutant profile of the indoor environment. However, they can be significant. Algae found in indoor environments can cause staining and are known to have proteins that stimulate allergic response in sensitive individuals.

This review of indoor microorganisms hopefully provides an overview for those of you faced with the everyday and unusual problems caused by microorganisms in buildings. Part V will examine some of the mitigation and protection strategies useful for dealing with the human and building related consequences of indoor environmental pollutant problems.

Part V: "Sick Building Syndrome" (SBS) -- Mitigation and Prevention Strategies

The search for indoor pollutants takes us to every area in a building, to every process, and to every occupant. "We have found the enemy; now what do we do!"

Throughout this series we have identified some of the causes and sources of "Sick Building Syndrome" and "Building Related Illness." We have explored many of the infinite ways that various pollutants affect our lives. This sections will provide for you 16 strategies which will help guide you to effectively controlling the overwhelming array of pollutants that are a real factor in the health of your building facilities.

As stated in previous articles, pollutant control begins with their identification, potential sources, and their pathways to unsuspecting occupants. Following these three stages, mitigation and prevention strategies can be defined and implemented. Pollutants are everywhere and the distinction between tolerable and intolerable levels is very important. **Absolute** control is not a practical goal. Due to this fact, the ALARA principal (As Low As Reasonably Achievable) is a commonly used and accepted guideline.

As preceding articles have discussed, bacteria, fungi, mold, mildew, yeast, and other one-celled organisms are the most potent pollutants in the indoor environment. Although microbes represent biologicals as pollutants, they are in fact representative of all of the classes of pollutants. This allows us to use these potent pollutants as an example for typical pollutant control strategies.

Depending on the pollutant, mitigation and prevention can be very difficult, time consuming, and expensive. In earlier articles we have acknowledged the importance of the full range of pollutants on the integrity of the building materials, the operating systems, the furnishings, productivity, and the health of the occupants. Knowing your building and your occupants is part of the needed defensive strategy but only part of what needs to be done to avoid occupant and "press event" problems.

The following are a few of the 16 Defensive Strategies. These strategies provide some perspective on the countless "solutions" to the SBS/BRI problem.

Architectural design of a building is critical. Everything from the climate to the relationship with other buildings must be considered. This strategy has a direct affect on the sources and pathways that pollutants take. Another area is the materials used in construction are primary sites for microbial growth and contamination. Once these materials are contaminated, remediation can be costly and very time consuming. Also the slightest swing in temperature has dramatic effects on IEQ. Therefore, heating and cooling along with humidity control should be closely monitored and kept in balance.

Other strategies include having baseline audits of your building. This way when emergencies do occur you have something to reference to. This can be a simple audit of the building materials, operating systems, furnishings, and the processes used in the building. Or, it can include actual measurement of suspect particulates, VOC's, and microorganisms. Under certain circumstances it can also be valuable to have an audit of the occupants and staff. The forms and formats for such audits are too complex for this article, but they are available from some government authorities and some service companies.

The importance of having a pollutant control contingency plan for emergency situations and a basic knowledge of your building is essential. One extremely important safeguard, that is often overlooked, is that all buildings should have a clearly written policy designed to respond to building problems. Included in this policy should be a clear scheme of response to environmental issues. Occupant complaints of temperature, air flow, lighting, noise, humidity, and the like should not only have an organized reporting system, but key response people dedicating to handling these issues. Suspected medical problems should also have clear channels for reporting and response.

Understanding the strengths and weaknesses of each strategic component is absolutely essential and often takes outside expertise. Accurate records, good common sense, compliance with regulations and standards, and involving all of the people on a prevention and solutions team will clearly help with and minimize problems associated with indoor environmental quality.

The role of microbes is paramount and their control must be a major target for anyone trying to eliminate the real and potential indoor environmental problems in our buildings. Part VI will cover the unique problems associated with the mitigation and control of microbial pollutants.

Part VI: "Sick Building Syndrome" (SBS) -- Microbial Mitigation and Prevention Strategies

Control of the microbial pollutants in the air and on building surfaces both for today and tomorrow, is essential to the health of the building and its occupants. Unfortunately, there is not a simple, one-step solution.

This last section will focus on the mitigation and prevention strategies deemed necessary in order to effectively control the most potent of all pollutants--Microorganisms. Their diversity, persistence, and prevalence allow them to live, adapt, and reproduce under a wide variety of conditions on all interior surfaces within modern buildings.

As we have pointed out in these articles, microorganisms are the most important part of the many pollutants that cause problems in the indoor environment today. Unfortunately, controlling these pollutants with traditional thinking and methods is not an easy task.

The most effective procedure for controlling and preventing microbes in your indoor environment is (1) the identification of the pollutants, (2) the determination of the sources, (3) the removal, and (4) the prevention of the pollutants. This procedure may sound simple to carry out. Unfortunately, depending on the situation and the pollutant or pollutants, remediation can become very costly and time consuming.

The identification of the problems caused and the places where the microbes exist is where controlling of these pollutants begins. AEGIS Environments often finds that the strategies to counter these problems revolve around the control of environmental conditions such as moisture, nutrients, and/or the surfaces that these versatile organisms need for survival and reproduction. Regrettably this does not remedy all of the problems. Only controlling the

moisture or the relative humidity of the building is usually ineffective. This is due to the fact that it is inevitable that water events (e.g. flooding), broken windows, leaking pipes, human activity, or other unplanned events will occur. These unforeseen events provide the excess moisture microorganisms need to bloom to population levels that are unhealthy.

One often cited strategy that must be rejected for microbial control is the "solution to pollution is dilution." This strategy of increasing the intake of outdoor air may have merit for some pollutants, but not ones that reproduce. Re-engineering the environment through moisture control, temperature control, air intake and circulation rates, new materials of construction, or new operating parameters for the HVAC system is not a reasonable alternative by itself.

Other tools must be used and these include a simple list of techniques, all of which are filled with common sense, and include: source removal or total isolation, cleaning, disinfection, and surface modification with the ÆGIS Microbe Shield Technology.

Each of these methods is filled with different risks and costs in terms of money and time. As we have stated, the use of only one method to control your microbial problem is usually ineffective on its own. The proper use of **ALL** the techniques and technologies together is absolutely essential for successfully removing and minimizing of any re-growth of organisms. It is also critical that the techniques used are appropriate with the building being treated. For example, techniques used in the treatment of a cancer hospital may be different then the techniques used in an office building. Also, techniques that you might use for a small isolated problem may not be at all appropriate for a large, wide-spread problem.

The following is a real world experience where utilization of all the necessary mitigation and prevention steps were taken to fully remedy a microbial contamination problem.

In the hot and humid state of Texas, the Tom Green Elementary School had high levels of mold and mildew growth on the walls, ceilings, carpeting, library books, desks, and other furniture. Students and teachers were reporting a variety of building related illnesses and the community was becoming aware of the risks of having their children in the school. A variety of building site associated problems, construction details and techniques, air handler problems, and building housekeeping and maintenance practices all led to chronic moisture problems that allowed for rampant growth of the offending fungi.

Increased outdoor air did not solve the problem. Cleaning and disinfection of the walls only provided for three or four days of relief. Fungal growth was so bad that the musty odors were overwhelming and recently cleaned areas became visibly fuzzy in just days.

QIC, an HVAC and Indoor Air Quality company from Dallas, undertook the coordination of experts for determining the cause and effects of the human and building related problems. Occupant and administrator interviews were done and medical experts were brought in to deal with the human symptoms.

ÆGIS Environments was called in to define the nature of the microbiological problems and to deliver appropriate remedies. In a coordinated effort, drainage for the building was improved and the HVAC systems were altered. Also, the crawl space, the occupied space, and the above ceiling space were all cleaned of visible dirt and were "blown free" of dirt and microbial spores under negative pressure.

Then, all of the surfaces were treated with the durable and broad spectrum ÆGIS Antimicrobial. The durable aspects of the ÆGIS Microbe Shield treatment provided a barrier to re-growth as the building environment was stabilized. Over the last four years there have been no new building related illness cases and the environment has stayed fresh and absent of fungal stains. This has been accomplished in spite of the breakdown of the HVAC system, storm damage, broken water pipes, and the heavy use of the building.

No single technology could have solved this chronic problem short of tearing down the building and starting over. With good planning and good community communication this serious problem site became the model school for the school district at a fraction of the cost of starting over. This scenario of using the multiple mitigation and prevention tools to control existing and future indoor microbiological problems has played itself out in hotels, hospitals, office

buildings, and residences as well as schools.

Remember, the first and best defense is a good offense. The importance of having a microbial pollutant control and prevention component as part of your contingency plan and having a baseline of knowledge about the microbial habitats in your building is essential. The usefulness of a proven long-lasting, effective antimicrobial treatment which offers protection from the re-growth of microorganisms is also essential.