The Green Schools Handbook

How to Protect Children in the Classroom and Create Toxic-Free Environments

Published by:
EcoLogic Systems
7977 Capwell Dr.
Oakland, CA 94621
1-800-223-0690

INTRODUCTION 3

INDOOR AIR QUALITY STATISTICS FOR SCHOOLS 6

DIAGNOSING INDOOR AIR QUALITY PROBLEMS 8

THE IMPORTANCE OF PROPER VENTILATION 10

REDUCING CHEMICAL EMISSIONS FROM BUILDING MATERIALS AND EQUIPMENT 13

THE CAUSES AND CONTROL OF BIOCONTAMINANTS (MOLD AND FUNGUS) 19

HEALTH PROBLEMS CAUSED BY PARTICULATES 29

THE HEALTH EFFECTS OF OZONE 31

COMMON IAQ PROBLEMS AND SOLUTIONS FOR PORTABLE CLASSROOMS 32

IDENTIFYING AND MANAGING ASBESTOS-CONTAINING BUILDING MATERIALS 35

IDENTIFYING AND MANAGING LEAD IN DRINKING WATER AND PAINT 37

THE PROBLEMS WITH PESTICIDES AND NON-TOXIC ALTERNATIVES 41

SELECTING LOW-EMISSION NON-TOXIC BUILDING MATERIALS 43

PROBLEMS WITH CLEANING PRODUCTS AND THE NON-TOXIC ALTERNATIVES 49

THE IMPORTANCE OF TESTING FOR CANCER CAUSING RADON 51

HOW TO SOLVE COMMON IAQ PROBLEMS 53

THE BENEFITS OF USING ENVIRONMENTAL AND FACILITY MANAGEMENT SOFTWARE 61

HEALTHY SCHOOLS SOFTWARE 61

INDOOR AIR QUALITY PUBLICATIONS 62

Introduction

The Challenge We Face

Most environmental health experts agree that schools across the United States have serious environmental problems they are ill-equipped or financially unable to deal with. Here's what the California of Department of Health Services says about environmental quality in California's schools:

"Children have little or no control over their environment while at school. In California, no agency or group has central authority as a watchdog for children in their school environment. There are no right-to-know provisions in the law for parents or students pertaining to hazardous conditions which may exist in schools. While there are laws that regulate health and safety of schools as workplaces for teachers and staff, these do not directly apply to the students in the same buildings. Nonetheless, worker standards are not appropriate to children, as they are generally more susceptible to environmental hazards than adults."

"Poor school indoor environmental quality (IEQ) can cause both short-term (reversible) and long-term (chronic) effects in students and staff. Overcrowded, poorly ventilated classrooms contribute substantially to the spread of infections diseases, such as colds and influenza. Poorly maintained carpets, dirty air ducts, and water damaged materials are prime breeding grounds for a plethora of substances that can trigger asthma attacks, sensitize allergy-prone children, and cause sinus and respiratory infections."

"Responses of local school officials to IEQ problems tend to be unstructured and ad hoc. They are generally struggling within budgetary shortfalls to maintain educational programs, and IEQ complaints are often not considered to be serious or important. School administrators may not have on-site expertise to address IEQ problems and maintenance staffs are often ill equipped to manage these additional duties.

There are relatively few school districts that have the resources to provide appropriate training for their staff in technical skills necessary for them to properly identify, evaluate, monitor or remediate IEQ concerns."

About Green Schools

This publication was prepared by the Green Schools, a non-profit organization dedicated to helping schools create safe, clean and toxic free environments for children. The goal of this publication is to educate school administrators on the types of problems that may be present in their schools and providing them with the information they need to address them.

Green Schools works with companies known as Business Partners. Our Business Partners are local and regional firms who provide:

- Indoor air quality testing and consulting
- Asbestos and lead-based paint surveys and management programs
- Hazardous materials abatement and removal services
- Health and safety and IAQ training services
- Analytical services
- HVAC system inspections, design and installation
- Non-toxic classroom supplies, low-emission building materials and cleaning products

A listing of our business partners is found on our web site.

Our Web Site – www.greenschools.org

Our web site was designed to provide schools and concerned adults with:

- The latest information available on environmental hazards in schools and how to eliminate them;
- Resources such as publications and software that help schools manage environmental hazards and their facilities more effectively;
- The names of qualified health and safety professionals and contractors that can identify and correct environmental hazards; and
- A bulletin board that post actual events and studies so that schools and the media will know what is going on in our schools and be able to learn from the mistakes and successes of other Districts.

Guiding Principals

Healthy, safe and well-maintained school facilities give an important message to students about the values of the community in which they live, and how they are valued by the community. It is important to remind ourselves “that which we honor best will grow best”. Green School members believe that:

- Every child has a right to a safe and healthy learning environment that is clean and in good repair

- Schools should serve as role models for environmentally and socially responsible behavior

- Every child, parent, and school employee has a “right-to-know” about environmental health issues and hazards in their school environment

- School officials and appropriate public agencies should be held accountable for environmentally safe and healthy school facilities

In order to create healthier schools

We need parents to ask hard questions of their school boards regarding what the school is doing to (1) ensure buildings are properly cleaned and maintained; (2) ensure each classroom is receiving adequate ventilation to remove toxins from the air, and (3) ensure hazardous materials are properly managed.

We need legislators to enact sensible legislation to ensure that schools are properly constructed and maintained in a manner that will create healthier indoor environments.

We need regulatory agencies to rigorously enforce health and safety regulations enacted to protect students, teachers and maintenance personnel from exposure to environmental hazards.

Call to Action

To develop effective environmental quality programs, schools should start with these four basic steps:

Step 1: Become educated on the various environmental hazards found in schools. Take time to study this handbook to learn about the health effects of environmental hazards and what can be done to eliminate them.

Step 2: Implement programs and management plans that will help your district identify and correct current problems and maintain a healthy environment on an ongoing basis. Many of these resources are free and can be found at the end of this book.

Step 3: Provide training to maintenance and custodial personnel on:

Integrated pest management practices to reduce or eliminate the use of pesticides
Mechanical system maintenance to improve air quality and prevent the spread of disease
How to properly clean buildings to reduce the buildup of dust, molds and allergens

How to manage and safely work around hazardous materials such as asbestos, lead-based paint, and chemical inventories
How to diagnose and correct IAQ problems and prevent new ones from occurring

Step 4: Develop an ongoing management system to assist schools in tracking and managing hazardous material inventories and facility maintenance activities on an ongoing basis. Our Healthy Schools Software can help schools manage their IEQ programs on an ongoing basis. See the chapter titled “The Benefits of Using Environmental and Facilities Management Software”.

Indoor Air Quality Statistics for Schools

Environmental health and government organizations agree that Indoor Air Quality (IAQ) is one of the top environmental risks to the public health. The EPA estimates that indoor levels of pollutants may be 2 to 5 times and sometimes as much as 100 times higher than outside air. In addition, people spend up to 90% of their time indoors.

Asthmatics suffer greatly form poor indoor air, which can trigger attacks. As many as 10% of the children in the United States now suffer from asthma. Considering the maintenance, cleaning and IAQ problems found in schools across the country, they could represent the cause of a significant number of the skyrocketing asthma cases in this country.

IAQ in schools is a Serious Problem

The California Department of Education says IAQ complaints are the most common complaints they receive.

Studies clearly indicate there are serious IAQ problems in schools. A study of the nations schools indicate that 19% have reported IAQ problems and 36% have inadequate HVAC systems, the major cause of IAQ problems.

A Survey of New York City Schools indicated:

39% of students with medical conditions such as asthma or allergies said school conditions made their health problems worse

14% of occupants reported sensitivity to air or fumes in school

33% of schools were reported as having poor ventilation

24% of schools had inadequate heat

45% did not have clean bathrooms

24% of schools were reported as having cracks in walls and roof leaks

27% reported peeling paint in classrooms

A study of California Schools determined the state ranks 50th in the nation in facility construction and maintenance. In addition:

41% of school buildings have inadequate HVAC systems

30% of classrooms had air exchange rates less than half of the ASHRAE standard

22% reported IAQ problems

40% have problems with leaky roofs

5% of schools had radon levels above the EPA action level

According to a study of California schools conducted by the California Department of Health Services, only 10% of schools had developed lead-based paint management programs, even though almost all schools constructed prior to 1970 contained lead-based paint (LBP). The study also found that:

- For pre-1940 schools 95% had LBP and 64% had deteriorated LBP
- For schools constructed between 1940 and 1959, 91% had LBP and 42% had deteriorated LBP
- For schools constructed between 1960 and 1978, 70% had LBP and 14% had deteriorated LBP

Problems with Portable Classrooms

In California, one third of school children attend school in the states 85,000 portable classrooms. Tests by school districts and IAQ specialists indicate these manufactured buildings emit hundreds of chemicals and VOC's, which are known to cause cancer, birth defects, brain and nerve damage, asthma and other illnesses. Portables are also prone to mold due to their poor construction and inadequate insulation. They commonly have inadequate ventilation systems, which do not flush out toxins or supply an adequate amount of fresh air. Inadequate ventilation also causes in high levels of carbon dioxide, which causes drowsiness and effects learning.

Other studies conclude that:

- Overcrowded, poorly ventilated classrooms contribute to infectious diseases, such as colds and influenza;

- Poorly maintained carpets, dirty air ducts, and water damaged materials are prime breeding grounds for a plethora of substances that can trigger asthma attacks, sensitize allergy-prone individuals, and cause sinus and respiratory infections;.

- Chronic irritation by airborne chemical and biological contaminants can cause irreversible lung damage and respiratory illness; and

- Exposure to asbestos, volatile organic compounds (VOC) and lead-based paint can cause cancer and damage to the central nervous system.

Protecting children from poor IAQ is extremely important because:

- Children are still developing physically and are greatly affected by pollutants;

- Children do not have developed immune systems to protect them from disease; and

- Poor IAQ can lead to drowsiness, headaches, and lack of concentration, all of which affect learning.

The Good News

The good news is that most IAQ problems are preventable and can be solved through education, training, and purchasing the proper art and janitorial supplies, building materials and equipment. Many even have low and no-cost solutions. The majority of IAQ problems can be solved by:

- Maintaining buildings and mechanical systems in good condition to prevent mold growth, pest intrusion and the buildup of dust and allergens.
- Providing an adequate amount of outdoor air on a continuous basis of 15 CFM per occupant.
- Controlling space relative humidity so that it ranges from 30-60% to prevent mold growth.
- Using air filtration filters that have an efficiency necessary to prohibit most mold spores and fungi from entering the HVAC system.
- Developing integrated pest management programs to reduce the use of toxic pesticides.
- Managing hazardous building materials such as asbestos and lead-based paint by tracking their locations, removing damaged materials and training maintenance personnel.
- Purchasing and installing low VOC emission cleaners, furnishings, and building materials.

Diagnosing Indoor Air Quality Problems

Diagnosing symptoms that relate to indoor air quality (IAQ) can be tricky. Building occupants may experience IAQ problems as discomfort, irritation, or illness. Symptoms of IAQ problems typically are similar to those caused by colds, allergies, fatigue, or the flu. Clues that can serve as indicators of indoor air problems include:

- Symptoms that are widespread within an area of the building or within the entire building;
- Symptoms that disappear when the occupants leave the building;
- The sudden onset of symptoms after some change in the building, such as painting or pesticide application;
- Persons with allergies or asthma who have reactions indoors but not outdoors; and
- A doctors diagnosis that a building occupant has IAQ-related illness.

In many cases some individuals will be affected by IAQ problems while others sharing the same space are not affected. Building occupants who may be particularly susceptible to the effects of indoor air contaminants, include:

- Allergic or asthmatic individuals;
- People with respiratory disease;
- People whose immune systems are suppressed due to chemotherapy, radiation therapy, disease, or other causes.

Because of varying sensitivity among different individuals, one occupant may react to a particular IAQ problem while surrounding occupants have no ill effects. Symptoms that are limited to only one or a few persons can also occur when only their area is exposed to the airborne pollutant. The effects of poor IAQ are often nonspecific symptoms rather than clearly defined illnesses. Symptoms commonly attributed to IAQ problems include:

- Headache, fatigue, and shortness of breath;
- Sinus congestion, coughing, and sneezing;
- Eye, nose, throat, and skin irritation; and
- Dizziness and nausea.

Hiring IAQ Professionals

Because of the complexity of IAQ problems and building dynamics, as well as potential for serious human health effects, schools who suspect IAQ problems should seek the help of a competent, qualified IAQ specialist to investigate, diagnose, and mitigate IAQ problems.

Different problems call for different measures. In the absence of some strong indication of what the problem might be an initial investigation should consist of a review and inspection of building systems, measurements to determine ventilation rates and effectiveness, and air monitoring for such things as carbon dioxide, carbon monoxide, formaldehyde and particulate matter.

Sometimes, consultants advise unwarranted sampling, especially for microbiological contamination. This sort of testing should be done, experts say, only if preliminary findings, such as visible mold growth, suggest microbial contamination, or if building occupants suffer from a clearly defined but unexplained illness.

One thing to watch out for is a consultant who jumps in and tries to collect samples for everything, without first thoroughly analyzing the problem under investigation. Collecting and analyzing air samples should be performed in the second phase of an investigation and only to validate specific hypotheses about problems that can't otherwise be solved.

While it's hard to come up with an average figure, chiefly because each building is different and problems vary so widely, an initial investigation can run between $3,000 and $ 7,000. Clients have to pay for experience and it's experience that often leads to finding and correcting the problem sooner. If the people who perform the investigation don't have the necessary experience to interpret subtle clues as to what's going on in the building, and the inspection fails to uncover an obvious problem, then every aspect of the building and it's systems can become suspect.

Diagnostic Checklist

It is vital that the individual and the health care professional comprise a cooperative diagnostic team in analyzing symptom occurrences and other patterns that may provide clues to a complaint's link with indoor air pollution. A diary or log of symptoms correlated with time and place may prove helpful. If an association between symptoms and events or conditions in the home or classroom is not volunteered by the individual, answers to the following questions may be useful, together with the medical history.

- When did the symptom begin?
- Does the symptom exist all the time or does it come and go?
- If so, are you usually in a particular place at those times?
- Does the problem abate or cease, when you leave there? Does it reoccur when you return?
- Has the school been renovated or refurbished, or have you recently started working with new or different materials or equipment?
- Describe your classroom or work area?
- Have you recently changed your place of residence?
- Have you made any recent changes or renovations to your home?
- Have you or anyone else in your family recently started a new hobby or other activity?
- Have you recently acquired a new pet?
- Does anyone else in your home or school have a similar problem?

Additional Information

The EPA has developed the Indoor Air Quality Tools for Schools Action Kit. The kit is designed to help schools diagnose problems and create healthy school environments. Information on how to order the kit is found at the end of this handbook.

The Importance of Proper Ventilation

The heating, ventilating, and air-conditioning (HVAC) system acts as the lungs of the building and plays an essential role in determining indoor air quality. HVAC systems can generate, remove, introduce, dilute, or distribute contaminants inside a building, depending on the system design, condition, and usage, as well as other conditions in the building and it's surrounding.

The HVAC system brings outdoor air into the building and removes air from the building and improves IAQ by filtering contaminants from the air and diluting the concentrations of those remaining in the air. A system's capacity to remove and dilute contaminants depends on it's design features and how well it is maintained. HVAC systems can also harbor a variety of biological contaminants that grow within the system and can be distributed by it.

By drawing contaminated outdoor air into a building, the HVAC system can introduce pollutants into a building. The condition of the outside air, the location of outdoor air intakes, and the ability of the system to remove contaminants before distribution will determine the degree to which an HVAC system acts as an inducer or remover of contaminants.

In moving air throughout a building, the HVAC system also distributes contaminants from areas of higher concentration, such as smoking lounges or photocopying rooms, to those of lower concentration.

Types of HVAC Systems

An HVAC system typically consists of one or more air handling units (AHU) that contain fans to move the air, intakes for outdoor air, filters to clean the air, coils for heating and cooling the air, and dampers for regulating the air flow. The systems also include a distribution system consisting of ductwork connected to supply registers and a pathway for air leaving the occupied space to return to the AHU; and controls to regulate the operation of the system.

- Decentralized HVAC systems, which consist of individual ventilator units dispersed around the perimeter of a building, each of which has a fan-coil for heating and cooling and penetration through the wall with a damper to allow intake of outside air. These systems are low in cost and have a high degree of individual control, but are difficult to maintain.

- Centralized HVAC systems, which consist of single air handling systems for entire buildings. With central AHU it is important that all rooms served by the central unit have similar thermal and ventilation requirements. If these requirements differ significantly, some rooms may be too hot, too cold, or underventilated, while others are comfortable and adequately ventilated.

- Heat pump HVAC systems, which rely on water-source heat pumps located in ceiling plenum spaces and distributed air throughout the building to regulate heat in each zone.

Most AHU distribute a mixture of outdoor air and recircultaed indoor air. HVAC designs may also include units that introduce 100% outdoor air or that simply recirculate indoor air within the building. Uncontrolled quantities of outdoor air enter buildings by leakage through windows, doors, and gasps in the building envelope. Thermal comfort and ventilation needs are met by supplying "conditioned" air, which is a mixture of outdoor and recirculated air that has been filtered, heated or cooled, and sometimes humidified or dehumidified.

Ventilation to Meet Occupant Needs

Buildings need ventilation, which is the process of supplying outdoor air to the occupied areas.

As outdoor air is drawn into a building, indoor air is exhausted by fans or allowed to escape through openings, thus removing indoor air pollutants. Often, this exhaust air is taken from areas that produce high levels of pollutants, such as restrooms, kitchens, photocopying areas, toxic material storage closets, and fume hoods.

Operable Windows

Modern school buildings generally use mechanical ventilation systems to introduce outdoor air during occupied periods, but many older schools use only natural ventilation (openeable windows) and exhaust fans to remove odors and contaminants. In naturally ventilated buildings, unacceptable indoor air quality is particularly likely when occupants keep the windows closed because of extreme hot or cold outdoor temperatures. Even when windows and doors are open, under-ventilation is likely when air movement forces are weak, such as when there is little wind, or in multistory buildings, or when there is little temperature difference between inside and outside air, which reduces the stack effect. In these types of buildings, installation of ventilation systems designed to bring in outside air on a continuous basis is recommended.

The amount of outdoor air that is considered by ventilation specialists to be adequate for "proper ventilation" has varied substantially over time. Because updating building codes often takes several years, the building code, if any, that was in force when and HVAC system was designed may have required a lower amount of ventilation than what is currently considered adequate. ASHRAE ventilation standards are used as the basis for most building ventilation codes. ASHRAE Standard 62-1989, *Ventilation for Acceptable indoor Air Quality* is as follows:.

Selected Outdoor Air Ventilation Recommendations (Minimum)

Application	**Minimum Outdoor Air Ventilation Rate (CFM) Per Person**
Classroom	15
Music Rooms	15
Libraries	15
Auditoriums	15
Spectator sport areas	15
Office spaces	20
Conference rooms	20
Smoking lounges	20
Cafeterias	20
Kitchens (cooking areas)	15

Ventilation Modifications

The most important thing for the school's representatives to remember is to oversee the work and ask questions that will help assure that the work is properly performed. Specialized measurements of air flows or pre-and post-mitigation contaminant concentrations may be needed to know whether the corrective action is functioning properly. Performance specifications can be used as part of the contract package to establish critical goals for system design and operation.

Performance specifications can be used to force contractors to demonstrate that they have met those goals. At the same time, performance specifications should avoid dictating specific design features such as duct sizes and locations, thus leaving HVAC system designers free to apply their professional expertise. The specifications should require:

- The amount of outdoor air ventilation meets ASHRAE Standard 62-1989 minimum recommendations or shall be the maximum possible with the current air handling equipment.

- The proper operation of control sequences and outdoor air damper operation shall be verified by school personnel or the schools agent after ventilation system modifications and repairs have been made.

- School facility operators are provided with training and two copies of a manual that documents the ventilation systems control strategy, operating parameters and maintenance requirements.

Reducing Chemical Emissions from Building Materials and Equipment

Buildings contain a variety of materials that can act as very potent sources of chemical contaminants, including furnishings, cleaning products, wall and ceiling construction materials, paints, floor coverings, and machinery. The chemical compounds emitted or " off-gassed" from these indoor sources are known as volatile organic compounds (VOCs). VOCs are chemical compounds that contain one or more carbon atoms ("organic") and tend to evaporate at room temperatures and normal atmospheric pressure ("volatile"). In sufficient quanties, VOCs can cause eye, nose, and throat irritation; dizziness; and headaches. Some VOCs are suspected carcinogens.

Information is scarce on health effects resulting from exposure to the characteristically low levels of VOCs in most buildings. Many environmental health specialists are, however, concerned that continuous exposure to low levels of a large number of VOCs — common to many indoor settings has the potential to cause short-term and possibly long-term health problems. IAQ specialists refer to the combination of all the VOCs in an indoor space as total VOCs (or TVOCs). Preliminary research suggests that the large number of VOCs present in many school buildings can have additive effects.

Testing for VOCs

New direct reading equipment is available that measures VOCs in buildings and reports levels in the parts per billion range. Air sampling can also be performed. However, the direct reading instrument has the benefit of being able to identify the source of high VOC readings.

Health Impacts of VOCs

VOCs cause a large array of irritant reactions in people exposed to even low concentrations emitted by floor and wall coverings, furnishings, copying machines, and other VOC sources in school buildings. The irritation of VOCs can have a serious effect on health and comfort of the occupants of buildings. Many health officials are also concerned about more serious long-term effects because of the potential carcinogenicity of some of these compounds. Because indoor sources, such as furnishings or floor coverings, are significant contributors to indoor VOC concentrations, researchers have also implicated these sources as contributors to multiple chemical sensitivity (MCS) and sick building syndrome (SBS) in a number of cases.

Formaldehyde

Research and testing have shown that by far the dominant VOC in the emissions of most indoor sources is formaldehyde. Environmental health experts from around the world regard formaldehyde as a serious contaminant in indoor air, with the potential to cause irritant effects, neurological effects, and even cancer.

The most commonly reported and best documented health impacts of formaldehyde are its irritant effects. Formaldehyde, which is a gas at room temperature, is highly soluble in water. Even at low concentrations, formaldehyde can be irritating to all moist body surfaces, such as the mucous membranes of the eyes and upper respiratory tract. The irritant effects of formaldehyde, which can occur within minutes of exposures, include:

- Tearing, burning, and stinging of the eyes;
- Tingling sensations in the nose and sneezing; and

- Soreness and dryness in the throat.

Sensitive individuals can experience nausea and vomiting, histamine allergic reactions, or asthmatic attacks after exposure to concentrations of formaldehyde as low as 300 parts per billion (ppb).

Investigators usually find that the indoor concentrations of VOCs are 2-20 times greater than outdoor concentrations.

Though there is little rigorous research on the effect of VOC emissions other than formaldehyde, general research on VOCs has shown that many of these compounds can cause acute and chronic health effects of varying severity. Many are also known or suspected human carcinogens.

Health researchers have linked a number of VOCs commonly found in indoor sources with a variety of health problems:

- Benzene (found in paints, stains and varnishes on furnishings) cause respiratory tract irritation and is a carcinogen;
- Xylenes (found in varnishes and solvents for resins and enamels) is a narcotic and irritant that can affect the heart, liver, kidney, and nervous system;
- Toluene (found in chipboard) is a narcotic and may cause anemia;
- Trichloroethylene (found in furniture varnishes) may affect the central nervous system and is probably carcinogenic;
- Methylene chloride (found in acoustical office partitions) is a narcotic that can affect the central nervous system and is probably carcinogen;
- 2-Butanone (methylethylketone) (found in fiberboard and particleboard) is an irritant and central nervous system depressant; and
- Tetachloroethylene (or perchleorethylene) (found in dry-cleaned draperies) is an irritant to the skin and eyes, can induce central nervous system depression, and may be carcinogenic.

According to many environmental health experts, most of the more serious health effects are linked to exposure to levels of VOCs higher than those expected in most indoor environments. In certain situations, however, the levels of VOC emissions from indoor sources could be sufficiently elevated to cause mild to serious health effects in building occupants. These situations might include:

- Installation of a large volume of new furniture or wall partitions;
- Dry-cleaning of a large volume of draperies or upholstered furniture;
- Large –scale cleaning activities;
- Painting or installation of wall or floor coverings;
- Temporary temperature fluctuations; and
- Temporary or long-term insufficiencies in ventilation systems.

Multiple Chemical Sensitivity (MCS)

The reaction of any individual to VOC emissions from indoor sources will depend greatly on his or her sensitivity to the particular VOCs involved. Pre-existing medical conditions, such as asthma, allergies, and heart problems, can make reactions to some contaminants more severe.

A particularly perplexing condition that can cause extremely severe and debilitating reactions to even low concentrations of indoor contaminants in a minority of individuals has become known as multiple chemical sensitivity. While the cause of MCS is under great dispute, most health experts agree that the condition involves the sensitization of an individual to a large number of chemicals after acute or traumatic exposure to one particular chemical.

VOCs and Sick Building Syndrome

Sick building syndrome is an ill-defined condition that arises from being in a building with suspect indoor air quality. SBS can include a variety of symptoms such as:

- Irritation of mucous membranes;
- Headaches;
- Dizziness;
- Nausea;
- Diarrhea;
- Rashes;
- Abdominal and chest pain;
- Fatigue;
- Sensation of head pressure;
- Difficulties breathing;
- Itching, smarting, irritated eyes
- Sore, dry, or hoarse throat;
- Redness of the skin around the face caused by capillary congestion (erythema); and
- Itching, stinging, tightness, and a feeling of warmth in the face without the appearance of a rash.

Experience to the variety of VOCs present in indoor environments, even if each specific VOC is present at relatively low levels, can cause symptoms ranging from mild irritation to more severe reactions.

Cancer Risk from VOC Exposure

The potential for VOC exposure to cause cancer is the greatest concern to public health officials. Health officials from countries looked at epidemiological studies and animal studies to estimate the potential risks of contracting cancer from exposure to VOC's. The US EPA, for example, has classified a number of VOC's as known or suspected carcinogens, these include:

- Benzene
- Methylene chloride
- Chloroform
- 1,2 – Dichloroethane
- Trichloroethylene
- Tetrachloroethylene
- Formaldehyde
- Benz(a)-pyrene
- Dibenzo(a,h)-anthracene

Emissions from Indoor Sources

Source Type	Specific Source	VOC Emissions
Pressed-wood products	Particleboard Medium-density fiberboard (MDF) Hardwood plywood Chipboard Hardboard (e.g., pegboard)	Formaldehyde, α-pinene, xylenes, butanol, butyl acetate, hexanal, acetone
Wood Coatings	Acid-cured coatings	Formaldehyde, acetone, toluene, butanol
	Wood stain	nonane, decane, undecane, dimethyloctane, dimethylnonane, trimethylnonane, trimethylbenzene
	Polyurethane	nonane, decane, undecane, butanone, ethylbenzene, dimethylbenzene
	Latex paint	2-propanol, butanone, ethylbenzene, propylbenzene, 1, 1-oxybisbutane, butyl propionate, toluene
	Furniture polish	Trimethylpentane, dimethylhexane, trimethylhaxane, trimethylheptane, ethylbenzane, limonene
Fabrics	Upholstered furniture coverings	Formaldehyde, chloroform, methyl chloroform, tetrachloroethylene (or perchloroethylene), trichloroethylene
	Dry-cleaned fabrics	Tetrachloroethylene (perchloroethylene)
Polyurethane foam	Cushions, upholstered furniture	Toluene di-isocyanante (TDI)
Office Equipment	Dry-process photocopying machines	Hydrocarbons, respirable suspended particulates, ozone
	Wet-process photocopying machines	Aliphatic hydrocarbons, xylene, 2, 2, 4-trimethyl octane, branched alkanes (C_{10}-C_{11}), nitropyrene, phthalates, isocyanates, ozone
	Computers, printers, fax machines	1, 2, -dichloroethane, benzane, chloroform, styrene, tetrachloroethylene, trichloroethylene
Wall/Ceiling construction materials	Gypsum board	Xylenes, butylacetate, isododecane, decane, 3-carene, formaldehyde, *n*-hexane, 2-methyl pentane (isohexane), α-pinene, undecane
	Jointing compounds	Formaldehyde, *n*-butanol, *I*-butanol, toluene, ethylbenzene, styrene, xylenes, nonane, 1, 2, 4-trimethylbenzene, undecane
	Ceiling tiles/panels	Formaldehyde
	Latex caulk	Methylethylketone, butyl propionate, 2-butoxyethanol, butanol, benzene, toluene
	Non-latex caulking compounds	Formaldehyde, acetic acid, 2-butanone, toluene, ethylbenzene, 1, 3, 5-trimethylbenzene, *n*-propylbenzene
	Water-based adhesives	Benzene, toluene, methylene chloride, 2-propanone (acetone), hexane, xylenes, ethyl acetate, 2-butanone, butyl acetate

Office Equipment

Office equipment contributes a number of contaminants to indoor air, placing an additional burden on the already poor IAQ in many school buildings. The extent of these emissions depends on the type of equipment and processes involved, as well as the usage rate. The kinds of equipment that may present emissions problems include:

- Dry-process photocopying machines, which emit hydrocarbons, respirable suspended particulate, and ozone;
- Wet-process photocopying machines, which emit aliphatic hydrocarbons, VOC's, and ozone;
- Laser printers and other computer printers, which emit hydrocarbons and ozone; and
- Computer terminals, fax machines, and other electrical equipment, which emit ozone and VOC's.

A small amount of solvent is released into the air each time a copy is made. At low ventilation rates, there is generally not enough time overnight to exhaust the emissions accumulated in rooms containing this type of equipment during the previous workday. By the end of the work week, Total Volatile Organic Compounds (TVOC) concentrations can be considerably elevated.

With average usage, the concentrations of TVOCs in most copying areas are well below the 1,800 mg/cm^3 concentration suggested by some equipment manufacturers as the "recommended exposure limit." However, measured TVOC levels in these areas are often significantly above 25 mg/m^3, the level at which many people begin to experience mild discomfort and respiratory irritation.

In some cases, the VOCs directly emitted by photocopiers can make up the largest proportion of the TVOCs in indoor air. This is particularly true of libraries or other buildings that have large copying centers.

Reducing Equipment Emissions

Since removing all office equipment or reducing the need for this equipment is not usually a viable alternative, facility managers should implement measures to reduce occupant exposure to the ozone and VOC emissions from photocopiers, laser printers, computer terminals, and fax machines. These preventive measures include:

- Selecting lower-emitting equipment in consultation with manufacturers and authorities on emissions;
- Minimizing the use of equipment when possible;
- Ensuring that operators of equipment are educated on the proper use and maintenance of all equipment; and
- Removing emissions at the source through ventilation and/or filtration

A stringent approach to minimizing equipment emissions might include the following measures:

- Require testing data on emissions rates from manufacturers or suppliers of office machinery;
- Require manufacturers to provide testing reports describing emissions factors for five major VOCs emitted and for any compounds known to be toxic or irritating at concentrations of 5 mg/m^3 or less, as well as chamber testing conditions, and on the storage and handling procedures used for the product;
- Require information on ozone emission rates for office equipment;
- Reject office machinery that increases VOC concentrations by more than 10 parts per billion (PPB) in occupied space.

In many cases, reducing emissions through product selection is an unattainable goal, because not enough lower-emitting machinery is on the market. When the actual emissions of a product cannot be effectively reduced, a viable alternative is to prevent the emissions from reaching building occupants by removing them at the source. The two most common ways to do this are through specialized ventilation and through air filtration at the source.

Most IAQ professionals recommend the following techniques for reducing occupant exposure to office equipment emissions in new and existing buildings:

- Consolidate and install equipment in isolated rooms with separate exhaust systems and supply air ducts with increased amounts of outdoor air;
- If it is impossible to isolate the equipment, locate the machines so that airflow patterns do not direct fumes toward workers;
- Locate machines that need to be near workers (such as computer terminals) near return air ducts to increase dilution of contaminants;
- Provide for equipment operators to have breaks; and
- Turn machines off when not in use for long periods of time.

Furnishings

Furnishings used in commercial settings, including upholstered sofas and chairs, desks and other work surfaces, open shelving, cabinets, and modular partitions– can be sources of a large number of VOCs, particularly formaldehyde.

Furniture manufactures often apply acid-cured or acid-catalyzed paints and coatings to pressed-wood surfaces. These coatings are potent sources of formaldehyde emissions because of their urea-formaldehyde resin bases. Formaldehyde emissions decline substantially over time– by 90%-96% for spray-applied coatings and 82%-96% for brush-applied coatings during the first 16 weeks after application.

Additional information on VOC's is found under Building Materials. Additional information on how to reduce VOC levels is found under IAQ Solutions.

The Causes and Control of Biocontaminants (Mold and Fungus)

In the last few decades, biocontaminants such as mold and fungus and their byproducts have increased in many indoor environments to the point of affecting human health. Biocontaminants contributing to IAQ problems include:

- Bacteria
- Bacterial endotoxins
- Fungi
- Fungal spores
- Fungal VOCs
- Mycotoxins
- Viruses
- Algae
- Parasites (free-living amoebae)
- Cat dander allergen
- Dust mite allergens
- Plant pollen
- Insect pest allergens

The growing significance of these biocontaminants in indoor environments over the last few decades can be attributed to the following:

- Building envelopes have become tighter;
- Less outdoor air is used in HVAC systems to reduce energy costs;
- Microorganisms shed indoors by humans are not readily diluted by mixing with outdoor air;
- Energy conservation measures have contributed to the build-up of moisture in indoor environments, which facilitates the growth of microorganisms; and
- Neglected maintenance programs have contributed to the buildup of dirt and debris (potential nutrients for microorganisms) in HVAC systems.

Microbiological growth in any environment requires a source of microorganisms or their reproductive structures, as well as water, and nutrients. In addition, they require the appropriate temperature for colonization and amplification (growth of colonies through reproduction). Indoor environments easily provide these requirements:

- *Sources of microorganisms include:* outdoor air, air handling systems, humidification systems, building materials and furnishings, occupants, pets, and house plants;
- *Water sources:* roof and plumbing leaks, migration, condensation, house plants, humidifiers, human occupants, and aquariums;
- *Nutrient sources include:* dust, dirt, food, water, house plants, detritus (dead plant tissue), building materials, and furnishing surfaces; and
- Indoor ambient and surface temperatures in the range most favorable to the growth of many microorganisms of 40 – 100 degrees Fahrenheit.

<u>The growth or amplification of microorganism colonies and the accumulation of other biocontaminants in indoor environments have been associated with human health effects, including allergic and irritant responses, infectious diseases, respiratory problems, and hypersensitivity reactions.</u>

<u>Recently, as environmental health specialists have learned more about the causes of biocontaminant-related illnesses and developed more effective sampling methods, they have begun documenting a host of cases of building-related illnesses (BRI) traceable to specific microbial agents. In contrast to former studies, such as one conducted by the US National Institute of Occupational Safety and Health (NIOSH), which documented biocontaminants as causal agents in only 5%</u>

of problem buildings, investigators have begun to identify microorganisms as the primary cause of symptoms in as many as 35% - 50% of cases classified as sick building syndrome (SBS).

With the increased recognition of biocontaminants as the source of many building-related complaints, indoor air specialists are placing greater emphasis on including biocontaminants in indoor air investigations and remediation programs.

Biocontaminants include whole organisms that can increase their numbers through reproduction, byproducts of organisms that are multiplying indoors, and byproducts of organisms that may not even be growing on site.

Microbial Contaminants

Microorganisms that can live and reproduce and potentially cause health problems in indoor environments include:

- Viruses
- Bacteria
- Blue-green algae
- Fungi
- Free-living amoebae

Microbial contaminants can cause four main types of illness in exposed building occupants:

- Infectious diseases;
- Allergic illnesses;
- Toxic effects; and
- SBS or irritation

A microbial infection involves the invasion of microbes into the cells of a host for replication. In the process of growing and replicating, the microbes derive nutrition from host cells, destroying the tissue.

The two main types of infections are:

- *Opportunistic infections;* which involve an organism of relatively low pathogenicity (ability to cause disease) infecting a host with lowered resistance; and
- *Pathogenic infections;* which involve an organism that can reasonably be expected to cause infection in individuals that are more likely to be infected.

In general, indoor air plays a minor role in the transmission of opportunistic infections. Even when the organisms are present in the indoor environment, lowered host resistance is the deciding factor in infection. But responsible facility managers should be aware that immune-compromised individuals (e.g., those who are HIV-positive; have AIDS, asthma, or sickle cell anemia; or are undergoing cancer chemotherapy) are more common in today's workplaces and educational institutions. Ten percent of school age children in the United States now suffer from asthma. Settings where potentially sensitive individuals reside or work might call for additional preventative measures.

Allergins

Allergies develop when a person encounters an allergy-producing substance – an allergen. Often the person is not initially sensitized to the substance, but becomes sensitized through one or more contacts. After sufficient exposure to a potential allergen, the body's reaction to subsequent exposure is to release histamines. This causes the symptoms characteristic of allergies, such as:

- Sneezing
- Itching of nose and eyes
- Nasal obstruction and congestion
- Fatigue
- Irritability
- Depression
- Dermatitis
- Asthma

Any organic molecule can cause allergic effects in susceptible individuals. Fungal spores and bacteria, along with a number of other biocontaminants – dust mites, cat dander, cockroach skin, plant pollen – are common allergens in indoor environments.

In some cases, the connection between an allergen and allergic symptoms is clear-cut – when the allergen is removed, the symptoms disappear. In other cases, however, the connection is more difficult to establish. It may take a longer exposure to build up an obvious sensitivity.

Infectious Diseases Transmitted via Indoor Air

Organism	Diseases
Obligate Organism (requires host for survival)	Pathogenic infections
Bacterial	Anthrax Brucellosis Streptococcal pneumonia Tuberculosis
Viral	Common Cold Chicken pox Influenza Measles Rubella
Fungal	Blastomycisos Coccidioidomycosis Histoplasmosis
Opportunistic Organism (normally in environment, causing infection under unusual conditions)	Opportunistic infections
Bacterial	Legionnaire's disease Pontiac fever Pseudomonas pneumonia
Viral	Herpes Shingles
Protozoal	Cryptosporidiosis Pneumocystis pneumonia
Fungal	Aspergillosis Cryptococcosis Mucormycosis Phycomycosis

Many types of bacteria and fungi produce toxic substances as byproducts of their metabolic processes. In bacteria, these substances are called *endotoxins*, and in fungi, they are called *mycotoxins*. These substances can produce a wide variety of inflammatory or toxic reactions in humans.

The source of most bacteria found in indoor air is humans themselves. Most bacteria in indoor air – particularly *Micrococcus, Flavobacterium,* and *Staphylococcus* – are shed from skin and breathing. Humans shed particles containing these bacteria at the rate of about 40,000 particles/minute while sitting at a desk. The rate of bacteria shedding increases with exercise to about 45 million particles/minute.

Only about 1% of bacteria in indoor air are viable – able to reproduce. But the number of viable bacteria in school environments is often in the range of 1,000 colony-forming units per cubic meter (cfu/m^3).

In some cases, bacteria from humans or from other sources begin to grow in building materials, humidifiers, or HVAC systems, where they can amplify and disseminate into the air. Gram-negative bacteria are associated with a number of diseases spread by HVAC and humidification systems.

Fungi

Fungi include the filamentous molds and single-cellular, asexually producing yeasts. Mildew is a form of mold that occurs in the form of a thin layer of black spots on a surface.

The following conditions are necessary for mold growth to occur on surfaces:

- Temperature of 40-100 degrees Fahrenheit;
- Mold spores;
- Nutrient base; and
- Moisture (or high relative humidity).

Mold Spores

Fungi reproduce by producing spores. There are two types of fungal spores: *dry spores*, such as those of *Aspergillus* or *Penicillium* that are easily disturbed and can become airborne; and *slimy spores,* such as those of *Stachybotrys atra* and *Fusarium* that are produced in a slimy mass that is seldom airborne, yet can be a contributor to SBS.

Mold spores of various types are usually present in indoor and outdoor air. Indoors, high airborne mold spore levels are usually associated with the presence of mold-infested building materials or furnishings that have become sources of spores as the organisms grow and reproduce within them.

Mold spores can germinate, in conditions of at least 70% relative humidity (RH), when they settle on an appropriate nutrient base. It apparently does not take much to support fungal growth. Most sever indoor biological problems result from the growth of the offending organism on surfaces within structures. Virtually *any* substrate that includes both a carbon source and water will support the growth of some microorganism. Researchers have shown that molds can grow on such unlikely substrates as glass, jet fuel, paint, rubber, textiles, and electrical equipment. Mineral wool (or fiberglass) duct-lining materials and the substances used to hold these building materials together can also act as nutrient sources for mold growth.

Water damage from leaks in pipe, roofs or catastrophic floods has been associated with fungal growth. In these cases the source of moisture is obvious. But even subtle changes in RH and temperature can cause a film of moisture to form on indoor surfaces, forming an ideal environment for mold spore germination and fungal amplification.

Walls and ceilings, with their capacity to acquire moisture from water vapor in the air, or through direct contact with leaks from pipes or from outside sources, and with enough organic matter to support some microorganisms, make excellent sinks for molds and mildew. Besides providing large surface areas, walls and ceilings also provide an excellent nutrient base for mold growth under the right conditions of relative humidity (RH) and moisture condensation.

Carpets can harbor fungal growth, especially if they contain large amounts of dust. Researchers have demonstrated that carpets, particularly those made of synthetic materials, act as both reservoirs and amplifiers for fungi, particularly after water damage.

Mycotoxins

Mycotoxins are chemicals manufactured by fungi as byproducts of their digestive processes. Some of them are extremely toxic to humans and animals. Such useful substances as penicillin and such harmful substances as aflatoxin – a carcinogen – are mycotoxins. An important aspect of mycotoxins is that when molds make them, they also make synergizers – substances that can enhance the potency of other toxins in the environment. Some of these compounds may not be toxic in themselves but become toxic when combined with other substances.

Fungal VOC Emissions

Common indoor fungi also emit VOCs, which are responsible for their odor. In fact, the average person often first notices an unwelcome abundance of fungal growth by smelling it. More than 500 VOCs have been identified coming from different fungi. One of the commonly produced VOCs, ethanol, is very volatile and acts as a potent synergizer, i.e., it enhances the toxic and irritant effects of other VOCs.

In addition to their own VOC emissions, fungi also appear to be able to enhance the emission of their substrates. Researchers speculate that enhancement of emissions may be the result of physical alteration of the substrate, metabolization of its compounds, or possibly independent fungal emission of the same chemical.

Health Effects from Exposure to Fungi

Indoor fungi can impact human health through their spores, mycotoxins, and VOC emissions. Fungi and their byproducts can cause a number of different types of illness in indoor environments, including:

- Infection or pathogenic disease
- Allergic reaction
- Hypersensitivity pneumonitis
- Cancer
- Immune disorders
- Toxic reactions
- Inflammation/irritation
- Sick building syndrome

A few fungi are able to invade living cells and cause infectious diseases. With the exception of histoplasmosis and cryptococcosis, diseases associated with fungal spores present in bird droppings, most infectious fungal diseases occur in immune-compromised individuals, such as those with sever burns, AIDS, or those hospitalized for cancer treatment.

Among the types of illness attributed to fungi is aspergillosis, an invasive lung disease. Another invasive fungal disease is caused by *Fusarium* species.

Most fungi produce proteins or glycoproteins that are highly antigenic. In susceptible individuals, these fungal antigens can cause hypersensitivity diseases or allergies. Exposure to the propagules of filamentous fungi and yeasts invariably produces allergy. It becomes a question of exposure in terms of time and quantity of exposure. About 10% - 15% of the population is allergic to the common molds *Cladosporium* and *Alternaria* as ordinarily determined by skin tests done by allergy specialists.

It is often difficult for investigators to correctly diagnose building- or HVAC system-related allergies because tests for allergens are usually not available. Test allergen preparations are available commercially only for about 30 species of fungi.

Researchers have found that preparations of the same species from different sources produce different results in patients. For most mold contamination problems in buildings, the appropriate allergen preparation is unavailable. Therefore building occupants suffering allergic responses cannot be properly diagnosed unless they happen to be exposed to a mold for which a commercial preparation is available. Furthermore, allergy is not a universal outcome of mold exposure in buildings. In fact, researchers have not yet conclusively demonstrated a relationship between fungi present in indoor air and allergy.

A number of studies have shown that mold growth in damp schools and housing is associated with childhood respiratory illnesses – wheezing and asthma. Sensitization to dust mites and mold allergens plays a causal role in this association.

Inhaling large concentrations of dusts containing organic matter including fungal spores (and actinomycetes) can cause hypersensitivity pneumonitis. Temporary inflammation and sometimes permanent damage of the gas-exchange tissue of the lungs occurs. Very large airborne concentrations are believed to be necessary, perhaps as much as 100,000,000 cfu/m^3, although chronic exposure to lower levels could also cause symptoms.

Other studies have shown that fungal spores retained in air conditioning filters are capable of germinating, growing, and releasing spores into the air of conditioned rooms. Allergenic extracts of these fungi cause allergic symptoms in 90% of patients suffering from SBS responses in persons confined indoors for extended periods of time. This conclusion is based on the fact that naturally ventilated buildings, while having significantly higher fungal and bacterial counts, elicited the fewest occupant complaints.

Other Indoor Allergens

Several other biological contaminants affect IAQ, include:

- Dust mites, and their body parts and excreta;
- Cat dander;
- Insect pest body parts (e.g., cockroaches); and
- Plant pollen.

These contaminants, while not implicated in infectious diseases as many bacteria and fungi are, can cause a wide range of allergic reactions. They can cause allergic bronchial asthma, wheezing, rhino-conjunctivitis (inflammation of eye and nose membranes), and in some cases, atopic eczema in sensitized individuals.

Cockroaches

Cockroaches are the most common pest in schools. They live and reproduce in school buildings, depending on conditions such as food and moisture sources. Control of these organisms consists of controlling the growth of populations through extermination or environmental controls.

Dust Mites

Dust mites feed on shed skin cells or scales, sloughed off by humans during regular daily activities, that have been moistened, defatted, and decomposed. Dust mites thus tend to congregate in places where this nutrient material collects – in and around beds and bedding materials; in upholstered furnishings; and in carpeting around places of high activity. Skin flakes, on which the mites feed, are a common constituent of dust found in school buildings. Because of their large size, dust mite particles don't usually remain airborne and may cause reactions in some individuals only when the dust in the room is disturbed.

About 53% of allergic individuals are sensitive to household dust and more than 37% are allergic to dust mite allergens. Dust mite allergens include:

- Enzymes from the mite's digestive tract that are expelled with fecal matter;
- Mite saliva; and
- Soluble proteins from mite body parts.

Common allergic reactions to dust mite allergens include:

- Rhinitis (nasal inflammation)
- Asthma; and
- Atopic dermatitis.

The most important limiting factor determining the prevalence of dust mites is ambient relative humidity. Dust mites require at least 60% RH for survival.

Biocontaminant Control

Finding the root cause of biocontamination sheds some light on the best preventive strategies to take. The most common causes of microbiological contamination have been found to be:

- *Inadequate preventive maintenance.* The most frequent cause of biocontamination is inadequate or completely absent preventive maintenance. In many contaminated buildings the internal components of air handling units, fan coil units, and induction units are seldom cleaned. Drain pans contain stagnant contaminated water. Wet cooling coils and moist downstream surfaces are covered with dirt and debris.
- *Disregard of maintenance in design of mechanical system.* Frequently, maintenance is difficult or impossible

because of inaccessibility or poor design of the systems; e.g., air handling units are designed without access doors to the heat exchanger, air handling units and heat pumps are located in inaccessible places over ceiling tiles, or air handling units are located in rooms or plenums so confining that access is impossible. In many cases, fan coil and induction units are difficult to disassemble for cleaning.

- *Stagnant water in drain pans.* In many buildings, drain pans contain stagnant water. Drain pans should be constructed to allow for drainage of condensed water. Many IAQ specialists recommend periodic cleaning and disinfection of drain pans.
- *Porous insulation.* In some buildings, microbiological amplification occurs in porous insulation located adjacent to or downstream from the heat exchanger. In these locations dirt and debris collect in the wet or damp ventilation systems. Often investigators will detect bacterial and fungal growth in insulation material, particularly when the system is in an air conditioning mode.
- *Excessive humidity in occupied spaces.* In about one-third of contaminated buildings, fungal amplification can be attributed to elevated humidity levels. In most cases excessive humidity occurs during the summer months when latent heat is not removed due to a restrictive energy management program or when control sensors in the HVAC system are inadequate. Relative humidity should be kept below 70% to prevent fungal amplification in furnishings, and even lower – at 50% - to minimize condensation on cold surfaces during summer months.
- *Floods in occupied spaces and HVAC systems.* Buildings sometimes experience moisture incursion in ceiling tiles, walls, or carpeting that lead to fungal amplification.
- *Outdoor air intake located near bioaerosol reservoir or amplifier.* Occasionally, the HVAC outdoor air intake is located within 25 feet (7.6 meters) of a cooling tower. In other cases, the intakes are located close to restroom stacks, sanitary vents, or dead vegetation, which could serve as microbiological sources.

Mold/Mildew Control

The mitigation techniques employed to control mold and mildew infestations in wall and ceiling materials and other surfaces depend on the severity of the problem. Facility managers can control relatively minor mold infestations by controlling the relative humidity of the building and reducing surface temperature variations that foster water condensation on some surfaces. More sever infestations require a more active approach to remove the mold-infested materials.

<u>Mold spores are present in nearly all indoor environments. Mold infestations occur when these spores germinate and proliferate on appropriate substrates. Controlling the moisture content of indoor surfaces and materials is the best way to prevent mold proliferation and to control minor mold growth before it becomes a major infestation.</u>

Condensation on wall and ceiling surfaces occurs when the relative humidity (RH) of the air is high and/or surfaces are cooler than the surrounding air. Ways to reduce the increase if RH near these cooler surfaces include:

- Reducing the general moisture content of the room air;
- Increasing air movement;
- Increasing the general space temperature; or
- Increasing the temperature at building surfaces.

In some situations, air moisture content is the dominant factor in mold growth; in other situations surface temperatures are causing the problems. Selecting an effective control strategy requires determining which of these factors is dominant.

In heating climates, where indoor moisture levels are low, poor insulation is a common cause of mold and mildew buildup. Increasing ventilation will not control the fungal growth problem in these cases. Mitigation strategies should be aimed at increasing ventilation will not control the fungal growth problem in these cases. Mitigation strategies should be aimed at increasing surface temperatures and thus reducing the RH next to these surfaces. The best strategies in these cases are:

- Insulating and closing cracks in exterior walls to prevent outside air infiltration and to reduce wind-washing (air entering and passing through exterior walls without entering the building);
- Raising the thermostat setting; and/or
- Increasing air circulation to distribute warmed supply air better to interior surfaces.

In situations in which exterior wall insulation is sufficient, but mold and mildew buildup occurs because of high moisture levels in the indoor air, other strategies are called for:

- Venting indoor moisture sources to the outdoors;
- Dilution of moisture-laden air with lower-moisture outdoor air (only useful during heating periods, when outdoor air tends to be lower in humidity than indoor air); and/or
- Dehumidification.

If the immediate cause of the high RH levels next to surfaces is not obvious, the following procedure can be used to determine whether room surface temperature is too low or air moisture content is too high. The amount of moisture in the room can be estimated by measuring both temperature and RH at the same location and at the same time. Suppose there are two cases. In the first case, assume that the RH is 30% and the temperature is 70°F in the middle of the room. The low RH at that temperature indicates that the air moisture content (or absolute humidity) is low. The high surface RH is probably due to room surfaces that are too cold. Temperature is the dominating factor, and control strategies should involve increasing the temperature at cold room surfaces. In the second case, assume that the RH is 50% and the temperature is 70°F in the middle of the room. The higher RH at that temperature indicates a large amount of moisture in the air. The high surface RH is probably due to air that is too moist. Humidity is the dominating factor, and control strategies should involve decreasing the moisture content of the indoor air.

Some researchers have cautioned that while decreasing RH is recommended as an overall control and prevention strategy, airborne spore levels can temporarily increase. Over the short term, increasing relative humidity reduces viable spore levels; spore release occurs when humidity levels are decreased.

Mold/Mildew Control in Air-Conditioned Spaces

Air-conditioned spaces may present particular challenges for reducing condensation and consequent mold problems. The following measures are recommended for air-conditioned spaces:

- Preventing hot, humid exterior air from contacting cold interior finishes;
- Elevating the temperature of interior surfaces at cold spots by relocating ducts and diffusers;
- Ensuring that vapor barriers, facing sealants, and insulation materials are properly selected, installed, and maintained; and/or
- Avoiding overcooling by increasing room temperature.

Mitigation of Severe Mold Infestations

Once mold has infested walls or ceilings, whether from flooding or moisture intrusion due to faulty construction, stringent measures are necessary. Simply reducing the relative humidity of the building or sections of the building will not be sufficient to mitigate the mold problem.

Mold growth can begin soon after water intrusion, so it is important to begin remedial steps as soon as possible. The following steps will prevent the dissemination of mold spores into portions of a building not otherwise affected by water intrusion:

- Put water-damaged areas under negative pressurization;
- Erect floor-to-slab barriers;
- Prevent dissemination of spores through elevator shafts by constructing containment barriers around elevators in foyer areas;
- Create negative pressure in the elevator shafts by installing exhaust fans on the shaft roofs; and
- Collect fungal samples by spore traps for direct microscopic evaluation to verify that spore traps for direct microscopic evaluation to verify that spores from water-damaged areas are being excluded from occupied areas.

The areas infested can be treated by HEPA-vacuuming all walls and ceilings and treating all heavily mildew-stained areas with a wet disinfectant of the substituted phenolic type. In using disinfectants, it is essential that the chemical have 20-30 minutes of wet contact time to achieve the desired level of disinfection. All disinfected surfaces should remain visibly wet for at least 20 minutes. If indicated by the manufacturer, this should be followed by a wet rinse, after which all excess water should be wiped up.

When large areas of a building have become water-damaged it is important to implement stringent measures to avoid serious biocontamination. Damage caused by water is often discounted and treated lightly until microbial growth and odor (often called ‘moldy or musty’) from microbial fermentation become a problem.

A protocol for handling water intrusion emergencies includes the following steps:

- Maintain a proper inventory of flooded areas so that every water-damaged area is treated and cleaned;
- Remove and dispose of all water-damaged ceiling tiles. Replace them with new ceiling tiles within 24 hours;
- Remove and replace all walls and insulation materials between walls damaged by water. Since capillary action can cause water to saturate walls several inches above the water level, it is best to remove all wall materials up to 12 inches (30.5 cm) above the water line; and
- Introduce 100% fresh air to remove all odors.

Health Problems Caused by Particulates

Indoor air contaminants that occur as suspensions of minute particles of liquids or solids are collectively called "particulates." Airborne indoor particulates come from a variety of sources – biological organisms, the burning of tobacco or other substances, and materials made from minerals such as asbestos.

Particulates may occur as visible smoke or dust, or in forms not visible to the naked eye. Airborne particulates are present in nearly every environment, though the quantities and types differ considerably in different settings and under different situations.

Particulates become problematic air contaminants when they are in the "respirable" range. Respirable suspended particulates (RSPs) are less than 10 microns (10 μ) in diameter. (A micron is one-millionth of a meter; there are 25,400 microns to an inch). <u>RSPs are implicated as causes of and contributors to a wide variety of human health effects because of their respirability and consequent penetration into the lungs.</u>

Indoor particulates can be categorized as follows:

- *Biological particulates:* pollens, spores, molds, miscellaneous food byproducts (finely ground grains, coffee, and cornstarch), bacteria, viruses, hair, dead skin cells, and insect parts and byproducts (e.g, feces) (discussed under Biocontaminants);
- *Radioactive particulates:* radon-decay products from nuclear degradation, attaching to other larger particles (discussed under Radon);
- *Mineral particulates:* carbon, clays, elemental particles (e.g, lead), and man-made mineral fibers, asbestos (discussed under Asbestos);
- *Combustion particulates:* tobacco smoke and particles generated by cooking, heating appliances, and industrial processes.

Schools buildings can contain a wide variety of these different types of particulates. For example, samples of dust collected from a number of buildings included:

- Skin flakes
- Cellulose and synthetic fibers
- Fiberglass
- Pollen and plant materials
- Wood fragments
- Bird feathers

The physiological effects of these particulates on exposed individuals depend on two major factors – their *size* and their *chemical makeup.*

Health Effects of Particulate Inhalation

Inhalation of different types of particulates can lead to a variety of health effects, including respiratory irritation, allergies, infections, and cancer, depending on the nature of the particulates. In general, inhaled particles affect the human body in the following ways:

- Chemical or mechanical irritation of tissues;
- Impairment of respiratory mechanics;
- Aggravation of existing respiratory or cardiovascular disease;
- Reduction in particle clearance and other body defense mechanisms;
- Impact on the immune system;
- Morphologic changes in lung tissue; and
- Carcinogenesis (cancer)

<u>Indoor air investigations often link elevated particulate levels with increased incidence of various symptoms known collectively as sick building syndrome (SBS). Studies have shown that particulates are associated with increased</u>

prevalence of SBS symptoms such as mucous irritation, concentration difficulty, and odor annoyance.

Several studies have linked elevated levels of particulate matter with acute and chronic respiratory diseases, such as chronic obstructive pulmonary disease, bronchitis, and asthma. Exposure to particulate matter can cause respiratory illness or exacerbate existing conditions.

The EPA defines the following populations as being at risk for health impacts from particulate matter exposure:

- Preadolescent children (less than 13 years old);
- Elderly people (65 years an older); and
- People with preexisting respiratory conditions (chronic obstructive pulmonary disease, emphysema, and asthma).

Removing Particulates from the Environment

Most vacuum cleaners do not have filtering systems capable of removing respirable particulates from the environment. Schools should use vacuums equipped with high efficiency particulate filters (HEPA) to remove particulates. Wet wiping as opposed to dusting will also help reduce particulate levels in classrooms.

The Health Effects of Ozone

Ozone is a gas naturally created in outdoor photooxidation reactions with sunlight, and artificially created as a by-product of human activities both outdoors and indoors.
In school buildings, the major indoor source of ozone is office machinery – particularly electrical equipment, computer terminals, laser printers, and photocopiers. These emissions can be substantial, according to some researchers. In urban areas, these indoor sources can add to the already elevated ozone levels from the intake of outdoor air contaminated with ozone from the photooxidation of vehicle exhaust.

In most school rooms, computer equipment, laser printers, and photocopying machines do not add significantly to indoor ozone levels. But high densities of this equipment and/or deficiencies in ventilation systems can lead to elevated ozone levels that may cause adverse health effects.

In recent years, many schools have replaced wet-process photocopiers with dry-process machines to reduce the emissions and servicing problems associated with toner and dispersant liquids. However, emissions testing on dry-process photocopiers has shown that this kind of equipment can also be a significant indoor source of ozone.

With extended usage, ozone production can peak at 131µg per copy, with an average of 40µg per copy.

In copying rooms or centers with several machines or where a large number of copies are produced each day, the concentration of ozone in copying rooms or vicinity of copying machines are about 68 ppb. In a small, poorly ventilated copying room the ozone concentration can reach a steady state of 200 ppb, twice the level at which health officials have reported adverse health effects.

Most public health and environmental officials consider concentrations up to 80 parts per billion (ppb) (157 µg/m^3) to be "normal and acceptable," but become concerned about possible health impacts at concentrations over 100 ppb (196 µg/m^3). Most experts consider concentrations over 500 ppb (980 µg/m^3) to be "extremely high."

Health Impacts of Ozone

As a strong oxidant, ozone can have a variety of physiological effects on pulmonary (lung) function – including decreases in physiological lung functions, and decreases in air exchange rates and airway permeability. Ozone can also act as an irritant. The health impacts from exposure to elevated ozone levels include:

Eye irritation;
Shortness of breath (dyspnea);
Coughing;
Asthma;
Excessive mucous production and mucous membrane irritation; and
Chest pain upon inspiration.

Certain individuals may be more susceptible to the irritant and pulmonary effects of ozone than others. Some health officials have, for example, warned that asthmatics may be particularly susceptible to the effects of elevated ozone, though research studies have not found any difference in lung function in healthy and asthmatic subjects upon exposure to ozone levels as high as 400 ppb.

Some health officials have expressed concern over ozone as a potential carcinogen. As with most suspected carcinogens, there is little conclusive evidence to substantiate this. Some studies indicate that ozone may increase the rate of lung tumor development in animals. Other researchers have provided some evidence that ozone may enhance cancer development or may act as a cocarcinogen.

Common IAQ Problems and Solutions for Portable Classrooms

Tests by school districts and indoor air quality specialists, plus extensive documentation of air toxins in mobile homes and similar structures, indicate that manufactured buildings emit hundreds of chemicals. A number of these chemicals are known to cause cancer, birth defects, brain and nerve damage, asthma and other illnesses. Of greatest concern are volatile organic compounds (VOC) such as formaldehyde, benzene and toluene, which are emitted from the particle board, plywood, fiberglass, carpets, glues and other materials used in portable construction.

The chemicals found in portable classrooms are very similar to those found in conventional buildings. But the combination of tighter construction, fewer widows and inadequate ventilation in the majority of potables can lead to a greater buildup of toxic compounds.

Formaldehyde

There is widespread evidence that mobile homes and similar portable construction have higher concentrations of formaldehyde than conventional construction. According to the California Air Resources Board, research finds mean concentrations of 24 parts per billion (ppb) in office and public buildings, 50 ppb for conventional homes and 72 ppb for mobile homes. The California Department of Health Services recommends that short-term indoor air concentrations not exceed 50 ppb.

Since 1986, when formaldehyde manufacturers and users voluntarily accepted emissions guidelines, considerable progress has been made to reduce formaldehyde in indoor air. However, it is likely that cash-strapped districts continue to use tens of thousands of portable classrooms built before the stricter emission standards were implemented. According to research, the emission of formaldehyde processed wood products only decreased to some extent, but still remains on a rather high level. A California study of 500 mobile homes found that the formaldehyde concentrations in older homes were only 20 to 30 percent lower than newer homes. This suggests that even older portable classrooms may continue to emit dangerous levels of formaldehyde despite more than a decade of off-gassing.

Benzene

Another toxic chemical found in portable construction is benzene as a component of glues and paints. Even at levels as low as 1 ppb benzene increases a child's risk of cancer. Exposure to seven hours a day carries an increased risk of cancer two to three times higher than the cancer level deemed acceptalbe under the Clean Air Act.

Carbon Dioxide

Portable classrooms can also be a source of harmful levels of carbon dioxide. Poor ventilation and airtight construction in manufactured buildings can trap carbon dioxide exhaled by the occupants and result in concentrations that can have significant physiological effects including fatigue, drowsiness, lack of concentration and breathing difficulty. Studies in Mane found average carbon dioxide levels in portable classrooms of more than twice the concentration that is generally regarded as acceptable.

Recommendations for HVAC Systems

When specifying a relocatable classroom it is important to ensure that the HVAC system can meet the ASHRAE standard of 15 cubic feet per minute per occupant. Order the "outdoor air kit" so a fresh supply of outdoor will be provided on a continuous basis during occupancy.

Installation of an outdoor intake must be specified as part of the exhaust system. Lack of the exhaust system with the outdoor air intake will result in room pressurization, reduced outdoor airflow rates, and lower efficiency of removal of pollutants from the room.

Outdoor air must be supplied continuously when a classroom is occupied. Demand-controlled HVAC systems often used in relocatable classrooms typically operate only when the temperature of a space is different from the thermostats set point. It is important to ensure that the HVAC thermostats are set in the "on" position when occupied so that the fan operates continuously.

It is important to check the noise level of the HVAC system. If a noisy HVAC system is turned off because it interferes with classroom activities, recommended ventilation requirements will not be met.

Particle filters are needed for protection of HVAC components and reduction of airborne dust, pollens, and microorganisms from recirculated and outdoor air streams. Where system design can accommodate them, filters with over 65% efficiency for 1 to 3 micron particles will improve IAQ with respect to particulates.

Renovating Classrooms

When school facilities are renovated for classroom use, it is imperative that new designs provide for adequate outdoor air in the renovated spaces. A common problem occurs when a large room is retrofitted with interior walls to create several, smaller rooms, and the required number of air supply outlets or return inlets is not installed. This results in inadequate ventilation in parts of all of the renovated rooms. Ensure that new designs are evaluated for ventilation adequacies.

Wall and Ceiling Materials

Formaldehyde-free particleboard is available from several manufacturers.

Flooring Materials

In most school classroom settings, hard floor surfaces, such as commercial sheet flooring are preferable to carpet because they are easier to keep clean and are not as prone to water damage or mold growth. When carpets are specified, require the classroom manufacturer to install carpets that have been certified under the Carpet and Rug Institute's Indoor Air Quality Labeling Program.

Other Important Issues

- Site classrooms away from locations where vehicles idle, water accumulates after rains and electric magnetic fields are high.
- Ensure that at lease one supply air outlet and return air inlet are located in each enclosed area.
- Ensure that building air intakes are located away from any exhaust outlet or other contaminant.
- Specify operable windows to provide user-controlled ventilation when needed.
- Locate HVAC and air handler units as far away as possible from teaching areas.
- Have insulation installed only on the outside surfaces, not inside the air ducts.
- Ensure HVAC ducts and plenums have easy access for inspection and cleaning.
- Specify building materials used in construction and room furnishings that are certified as "low emitting" for volatile organic compounds.
- Before use, have a certified professional inspect the HVAC system to ensure it meets these recommendations.
- Flush out the building for 3 to 5 days and test the air for VOCs and formaldehyde prior to occupancy.

Maintenance

Designate specific personnel to perform specific tasks:

- Provide training on operation and maintenance of new HVAC equipment to appropriate staff
- Be certain that O&M documentation is kept readily accessible to staff servicing the system
- Instruct teachers and staff on proper use and setting of thermostat and ventilation controls
- Provide each classroom with hardcopy plastic covered instruction sheets

Establish a regular and timely plan for inspecting:

- Roofs, ceilings, walls, floors and carpeting for evidence of water leakage or infiltration, and for mold and mildew growth or odor and replace water-damaged materials
- Inspect air supply outlets and return air inlets to ensure they are open, operable and unobstructed
- Check airflow rates at the outlets and inlets periodically
- Inspect air plenums for mold growth, excess dirt, etc
- Establish a periodic air filter replacement schedule
- Clean condensate pans monthly and do not allow freestanding water to accumulate
- When carpets are cleaned, ensure they dry as thoroughly as soon as possible
- Maintain documentation of completed tasks

Identifying and Managing Asbestos-Containing Building Materials

Asbestos is a mineral found in certain types of rock formations. When mined and processed, it takes the form of small fibers which are invisible to the naked eye. These individual fibers are generally mixed with a material which binds them together for use in a wide variety of products. The fibers are so small and light, they can remain in the air for many hours.

Asbestos became a popular product throughout industry because of its unusual combinations of qualities—it is strong, it will not burn, it resists corrosion, and it insulates well. The peak years of asbestos use in schools began during World War II and continued until the 1970's, when several major kinds of asbestos materials were banned due to growing concern about related health effects. Use of asbestos materials in manufacturing and processing has continued to decline throughout the 1980's.

EPA estimates that there are asbestos-containing materials in most of the nation's approximately 107,000 primary and secondary schools. Asbestos is most commonly used in schools as building materials, including:

- Spray-applied fireproofing
- Acoustic ceiling material
- Ceiling tiles
- Floor tile and sheet flooring
- Thermal systems insulation (duct, pipe and boiler insulation)
- Plaster and exterior stucco
- Sheet rock mudding and texturizing compounds
- Roofing materials and adhesives

Asbestos fibers can cause serious health problems, especially in occupational settings by disrupting the normal functioning of the lungs. Exposure to asbestos has been linked to several diseases, including asbestosis, lung cancer, and mesothelioma (cancer of the chest and abdominal linings). These diseases do not develop immediately after inhalation of asbestos fibers, it may be 20 years or more before symptoms become apparent.

Although studies have concluded that high levels of exposure to asbestos in the workplace has caused malignant and non-malignant diseases, uncertainty continues to surround the probability of malignancies occurring at low levels of exposure. <u>In school settings, the major concern is the inadvertent disturbance of asbestos-containing construction materials during renovation and maintenance activities. For this reason, OSHA requires that outside contractors and maintenance and custodial personnel receive notifications regarding the locations of asbestos in the school buildings in which they work, as well as, training in the risks associated with asbestos.</u>

Due to lack of reliable exposure data extracted from epidemiological studies and the absence of an exposure threshold, the fact that school children and custodial workers are exposed to any amount of asbestos fibers continues to constitute a concern.

The presence of asbestos-containing material in a setting does not necessarily pose a health threat; however, materials can become extremely hazardous when they are inadvertently disturbed by renovation and maintenance activities or become damaged due to deterioration over time.

Asbestos Hazard Emergency Response Act (AHERA)

Asbestos that is well managed and maintained in good condition appears to pose relatively little risk to students and school employees. Accordingly, the Asbestos Hazard Emergency Response Act (AHERA) was enacted by congress in 1989 to require schools to identify and manage asbestos in their buildings and remove materials that are damaged and releasing fibers.

Sometimes everyday school or maintenance activities can damage asbestos material and cause fiber release, particularly if the material is friable. It is also very important that the custodial and maintenance staff receive proper training on how to clean up small disturbances, and proper work practices and personal protection during any activities where asbestos might be disturbed. In addition, any renovation work at the school must be closely monitored to ensure that asbestos is not disturbed or that any disturbances are minimized and controlled. A thorough initial inspection and regular surveillance is an important step in preventing accidental exposure to high levels of asbestos fibers.

Under AHERA, each public school district or private school must do the following:

- Designate and train a person to oversee asbestos-related activities in the district (designated person).
- Inspect every school building for both friable and non-friable asbestos-containing building materials.
- Prepare a plan for managing asbestos and controlling exposure in each school and update the plan every 3 years
- Use only accredited persons to conduct inspections and develop the asbestos management plan.
- Provide custodial staff and short-term workers with information about the location of any asbestos-containing materials. Post warning labels on materials and warning signs in routine maintenance areas.
- Provide custodial and maintenance staff with two hours of awareness training for employees whose duties may cause them to disturb asbestos.
- On an annual basis, notify parents, teachers, and other school employees about the asbestos inspection and the availability of the asbestos management plan for review.
- Utilize properly accredited individuals to design and conduct asbestos abatement actions that are necessary and appropriate to protect health and the environment. These actions or methods must be documented in the management plan.
- Keep records of all asbestos-related activities in the plan and make them available for public review.

Identifying and Managing Lead in Drinking Water and Paint

Lead is a toxic metal harmful to health even in small amounts. Lead is especially dangerous for children under the age of 7 and pregnant women. Lead exposure may result in:

- Learning disabilities;
- Attention Deficit Disorder;
- Decreased intelligence;
- Speech and language problems;
- Behavior problems;
- Slow physical growth;
- Hearing problems; and
- Damage to the kidneys.

Lead can also interfere with the body's ability to make red blood cells, thus reducing the amount of oxygen in the blood and affecting many different body functions.

Many lead-poisoned children show no symptoms at all. The only sure way to know if a child has lead poisoning is to get a blood test. When symptoms do occur, they are often the same as those of common illnesses like a cold or the flu. Other early signs and symptoms of lead poisoning in children can include:

- Persistent tiredness or hyperactivity;
- Irritability;
- Loss of appetite;
- Weight loss;
- Reduced attention span;
- Difficulty sleeping; and
- Constipation.

Lead enters the human body through inhalation, such as breathing particles of lead-contaminated dust by drinking contaminated water, or ingesting lead-contaminated dust. It is important to note that lead, unlike other metals, may be stored in the bone, to be released later into the bloodstream. For this reason, even low exposure to lead can have cumulative negative effects.

There are no safe levels for lead exposure, especially for children. While adults excrete most of the lead they inhale or ingest, children process the metal differently. Their developing bodies absorb more of the lead they consume and the physical and behavioral effects of lead occur at lower exposure levels. In addition, children at play often come into frequent contact with such potential sources of lead contamination as dirt and dust. Because children habitually put their hands to their mouths, a lot of this lead may be ingested.

The U.S. Centers for Disease Control and Prevention found that approximately 900,000 U.S. children between 1 and 5 years old have abnormally high levels of lead in their blood.

Children can be exposed to lead if they:

- Swallow lead dust that is on their hands or other surfaces;
- Swallow lead paint chips;
- Chew on surfaces with lead paint;
- Drink water that contains lead;
- Play in soil that is contaminated with lead; or
- Breathe lead dust created when lead paint is disturbed.

Lead in Paint

Most paints manufactured prior to 1950 contained lead. As a result, most schools built prior to 1950 will have significant amounts of lead paint. From 1950 to 1978 manufacturers removed lead from paint over health concerns so the amount of lead paint in buildings constructed during this time frame was reduced. In 1978, the consumer products safety commission banned the use of lead in all residential paints.

Considering the serious health effects of exposure to lead, schools test for lead and, if present, manage the paint as recommended by the EPA and required by OSHA.

According to a study of California schools conducted by the California Department of Health Services, only 10% of schools had developed lead-based paint management programs, even though almost all schools constructed prior to 1970 contained lead-based paint (LBP). The study also found that:

- For pre-1940 schools 95% had LBP and 64% had deteriorated LBP
- For schools constructed between 1940 and 1959, 91% had LBP and 42% had deteriorated LBP
- For schools constructed between 1960 and 1978, 70% had LBP and 14% had deteriorated LBP

Identifying LBP

The first step in developing a LBP management program is to identify the locations of LBP in each school. This can be accomplished by collecting paint chip samples and sending them to a laboratory or hiring a consultant to test paints in a very cost effective manner using an X-Ray Fluorescence (XRF) Analyzer. The XRF is capable of recording lead measurements in the field in a about 30 seconds per sample.

During the survey the condition of paint containing lead and its potential for disturbance from impact or friction (windows and doors) should be assessed and damaged paint and paint with the potential for being damaged and releasing dust and chips should be abated (removed, enclosed or encapsulated) by trained in-house personnel or a certified LBP abatement contractor.

LBP Management Programs

For the ongoing management of LBP, it is important for schools to develop management programs. Components of a program include a written procedures manual, a training program for workers in safe work practices and the use of personal protection, procedures for assessing and abating hazards, and the purchase of tools and equipment to safely abate LBP.

Lead in Drinking Water

Lead in drinking water, although rarely the sole cause of lead poisoning, can significantly increase total exposure to lead, particularly for infants who drink liquids made with water, such as formula. EPA estimates that lead in drinking water can account for 20% or more of total exposure in young children. Some of this exposure occurs in schools and day-care centers.

Levels of lead in drinking water are measured in parts per billion (ppb). <u>EPA recommends that schools take action if samples from any water fountain, water cooler, or other drinking water outlet show lead levels over 20 ppb. Such fountains, coolers, or other outlets should be removed from service until lead levels are reduced to below 20 ppb.</u>

Unlike most drinking water pollutants, lead does not usually occur naturally in source water such as rivers and streams. What lead is present can be removed from the water at the supplier's treatment plant. However, between the water source and the point of consumption there are a series of pipes and connections, and outlets that can be sources of lead.

Another potential source of lead contamination is the solder used to join sections of copper pipe. Until recently, this solder contained up to 50 percent lead. This solder is one of the major causes of lead contamination in drinking water today. Brass or plastic fixtures or other parts of the plumbing system may also be a significant source of lead.

You cannot see, taste, or smell lead dissolved in water. The only way to know if lead is a problem is to test the water. Schools are most likely to have a lead problem if:

- The school or water system has lead pipes;
- The school has water coolers with lead-lined storage tanks or lead parts; or
- The school has copper pipes with lead solder that is less than 5 years old (or has areas of recent construction or plumbing repair in which lead solder or materials were used), or has soft or acidic water, or has areas where water sits in the pipes for extended periods of time (such as areas of low or infrequent use or after vacations or weekends).

The Lead Contamination Control Act of 1988

The Lead Contamination Control Act of 1988 (LCCA), another major amendment to The Safe Drinking Water Act, focuses on lead in the drinking water of schools and day-care centers. This law's programs and provisions affect primary and secondary schools, kindergartens, and day care centers, water-cooler manufacturers and distributors, and federal, State and local agencies.

As directed by the law, EPA has published a guidance document to help schools and day care centers test for and remedy lead contamination in drinking water. Entitled Lead in School Drinking Water, the manual explains why lead is a problem, how to identify possible sources of leas, how to conduct a step-by-step sampling program, and what kind of options are available to remedy any problems.

The LCCA requires that EPA publish and make available to the States lists with the name and model number of water coolers that have lead-lined tanks and those that contain lead parts.

Water coolers identified by EPA as having lead-lined tanks are considered to be "immediately hazardous consumer products" under the law**.** The Consumer Product Safety Commission must issue an order requiring manufacturers and imports of coolers with lead-lined tanks to repair, replace or recall the coolers. The law also attaches penalties for the manufacture or sale of any water cooler that is not lead-free. The law requires that each State establish a program to assist schools to test for and remedy lead contamination in school drinking water.

Schools are urged (though not required under the LCCA) to test drinking water for lead contamination. Those schools that do test are required under law to make the test results available in the administrative offices for review by teachers, staff, parents, and others. They must also notify parent, teacher, and employee organizations of the availability of the test results.

What Schools Should Do

EPA encourages schools to develop a three step program to identify and remedy lead contamination within the school:

Step 1. **Develop a profile of the buildings**. This profile combines a review of construction and repair records with physical inspection of the exposed plumbing within the buildings (both original plumbing and any recent repair or construction). The survey will help determine if the schools is likely to have a lead problem and will help control costs by identifying those areas, outlets, and water coolers with the highest risks of lead contamination.

Step 2. **Establish a Testing Program.** Using EPA's list of water coolers which are not lead free and the plumbing profile, EPA urges that water taps, in addition to those connected to water coolers, be sampled for lead where such taps may be contaminated by lead and supply drinking water for cooking. The drinking waster samples drawn from theses outlets should be analyzed by a competent laboratory. To help establish the source of the contamination, follow-up samples are drawn from those outlets with test results showing elevated lead levels.

EPA recommends that schools remove from service any outlet with lead level above 20 ppb until lead levels can be brought down.

Step 3. Take Corrective Action. Schools have numerous options for remedying lead contamination. Each school and district is unique, and each must make its own decisions based upon such factors as cost, availability of water, and manpower requirements. The school should seek advice on the best remedy for a school's particular problem from the State. The school's water supply may also be able to supply technical advice regarding a solution for a school's particular situation.

Removing standing water from the pipes by flushing is the simplest option and can be highly effective, especially if the contamination is limited to a few outlets. Flushing should be practiced early in the morning before school begins.

Reverse-osmosis devices and distillation units, and filters may be installed at the tap. The National Sanitation Foundation tests and evaluates these devices and should be contacted before the
School purchases any units. Contact NSF, 3475 Plymouth Road, P.O. Box 1468, Ann Arbor, MI 48106.

Replacing outlets, lead pipes, and lead solder can be the most practical solution for some schools where contamination is limited.

An alternative grounding system for electrical wires grounded to water pipes may be installed only by a qualified electrician if allowed by local and State building codes.

Bottled water may be purchased if other treatment fails or is impractical. Check to make sure that the bottler tests quality of the water to ensure it meets drinking water standards.

Interim Control Measures

Remove sediments from accessible screens at the end of faucets as a part of regular maintenance program. Drain reservoirs of water coolers where the presence of sediments are suspected or seen. Sediments containing lead may have produce high lead levels in water.

Use only cold water for the preparation of food and beverages in school cafeterias and cooking. Do not use water that has been in contact with the school's plumbing for more than 6 hours, such as overnight, after weekends, or after vacations. Make sure the system is flushed before school begins.

The Problems With Pesticides and Non-Toxic Alternatives

Wherever there are people, there are other living things that interfere with people or their property. These organisms may be considered pests, and may be managed or controlled by various means. Preventive measures that modify the site to exclude or reduce hiding and nesting places and food available to pest will provide the most effective long-term results. If the pest populations get out of hand they may threaten the health of people or damage property. Then other means of control will probably be necessary. Usually this means relying on the use of pesticides to achieve control.

Health Effects

According to the National Academy of Sciences, children need to be protected from exposure to pesticides because of their physiology and behavior. Children take in more pesticides relative to body weight than adults and have developing organ systems that are more vulnerable and less able to detoxify the chemicals. Children also have behaviors that expose them to higher levels of toxins than adults. They play on the floor indoors and the ground outside and hand to mouth activity is frequent.

Low levels of pesticide exposure can adversely effect a child's neurological, respiratory, immune and endocrine system. Some of the most commonly used insecticides in schools are nervous system poisons. These pesticides poison children by reducing the body's production of the enzyme cholinesterase, necessary for the transmission of nerve impulses and trigger a range of symptoms including:

- Nausea;
- Dizziness;
- Headaches;
- Aching joints;
- Disorientation; and
- Inability to concentrate.

The substances that make the pesticides fatal to rats, mice, insects, and other pests are also toxic to humans. Some of the more common pesticides used in indoor spaces are:

- Chlorpyrifos (Dursban)
- Chlordane
- Heptachlor
- Diazinon
- Propoxur
- *o*—Phenylphenol
- Lindane
- Dichlorvos
- Bendiocarb
- Aldrin
- Dieldrin

Exposure to these chemicals can have serious health effects ranging from irritation of mucous membranes to systemic toxic effects, depending on the exposure concentration. These chemicals generally comprise only about 0.5%-5% of the volume of ingredients in the pesticide solutions, and are known as the "active" ingredients in that they are what actually kill the pests.

The "inert" ingredients of pesticide solutions, such as xylene, *n*-decane, 1, 1, 1-trichloroethane, mesitylene, methyl ethyl benzene, cumene, and kerosene, are included to dissolve the active ingredients and provide qualities that allow for better dispersion of the pesticide on application. But these "inert" ingredients are by no means without health effects. Many of these compounds are VOCs that can have irritating and other more serious health effects. Their volatility makes them likely to remain in the air after application, usually for at least 24 hours. Active ventilation with fresh air for at least several hours after application can expedite the removal of these VOCs from indoor air.

The active pesticidal compounds are usually semi-volatile organic compounds (SVOCs), which do not evaporate as easily as VOCs, but nonetheless can remain in the environment, either airborne or adhering to solid surfaces and dust, for long periods of time after application. Children, who are more likely than adults to put their hands in their mouths, are more likely to ingest these chemicals. Since these compounds can remain in the environment for months and even years after application, according to many studies, it is important to minimize their use wherever possible.

Integrated Pest Management – The Pesticide Alternative

The good news is that there are ways to control pests without the use of toxic pesticides. Integrated Pest Management (IPM) is the coordinated use of pest and environmental information with available non-toxic pest control methods to prevent unacceptable levels of pest damage by the most economical means, and with the least possible hazard to people, property and the environment. The goal IPM approach is to manage pests and the environment so as to balance costs, benefits, public health and environmental quality. IPM systems utilize a high quantity and quality of technical information on the pest and its interaction with the environment. Because IPM programs apply a holistic approach to pest management decision-making, they take advantage of all appropriate pest management alternatives to pesticides.

Selecting Low-Emission Non-Toxic Building Materials

Pressed –Wood Products

The irritating emissions from presses-wood products come mainly from the resins, adhesive, and glues that hold together the pieces of wood. Manufactures of pressed wood use formaldehyde resins because of their excellent bonding properties, but they are potent emitters of VOCs.

By far most significant VOC contaminant is formaldehyde, though pressed-wood furnishings also emit a large number of other VOCs that may have adverse health effects. While the pressed-wood industry has taken a number of measures in the last decade to reduce the amount of formaldehyde resins used in the manufacture of particleboard, plywood, and MDF; public health and IAQ professionals are still concerned about their emissions.

Researchers investigating the complaints of odors and irritation quickly traced the source to the formaldehyde used in the production of particleboard. The particleboard then on the market contained approximately 1%-6% free formaldehyde by weight. While manufactures of pressed wood reduced the amount of formaldehyde in subsequent years, a significant amount of formaldehyde remains in nearly all pressed-wood products on the market today.

The less expensive urea-formaldehyde resins are used exclusively for interior-grade products because of their susceptibility to moisture damage. Manufactures use these resins in the production of particleboard and MDF, which make up the bulk of furnishings. Urea-formaldehyde resins have 10-20 times the off-gassing potential of phenol-formaldehyde resins. Due to the high resin content of MDF, it presents the highest potential for formaldehyde emissions.

Health officials and indoor air professionals have expressed great concern about levels of formaldehyde emissions from pressed-wood furnishings, as these can contribute significantly to indoor concentrations of this irritant and potential carcinogen. These products can occupy large amounts of space within an school building or portable classroom. Work surfaces often cover 65%-70% of a classroom. Shelving, which typically adds an additional 10%-20% coverage, is of particular concern because it is exposed to the air on both the upper and lower sides. These surfaces are also usually in close proximity to students.

Emissions from indoor sources can increase indoor concentrations of formaldehyde to levels that greatly exceed the maximum indoor concentration of 0.1 mg/m3 recommended by the World Health Organization.

While there have been a number of reports of excessively high indoor levels of formaldehyde in portable classrooms composed almost entirely of pressed-wood building materials, indoor concentrations in permanent (non portable) school buildings are typically much lower.

Vinyl and Linoleum

Vinyl has been implicated as a significant source of VOCs.

Linoleum is made from “natural” ingredients: linseed oil, wood flour, cork flour, and jute. During manufacturing, the linseed oil is slowly oxidized and mixed with natural pine resin to form jelly-like slabs. Linoleum does, however, emit VOCs.

Carpets

The US Consumer Product Safety Commission has characterized health effects associated with new carpets as including:

- Rashes, hives, itching, and swelling;

- Eye, nose, and throat irritation;
- Headache; and
- Fatigue

The two VOCs that are emitted in greatest concentrations from carpets are associated with certain symptoms, which can thus presumably occur after exposure to carpet emissions. 4-Phenylcyclohexene appears to produce a variety of symptoms, including headaches, dizziness, memory loss, fatigue, and irritation of the eyes and respiratory tract. Some data suggests that this compound may also be associated with the development of multiple chemical sensitivity (MCS). Formaldehyde, which is present in carpet emissions, as well as in a host of other indoor sources, is an irritant of the mucous membranes in the eyes and respiratory tract. Formaldehyde also produces neurophysiological symptoms, such as short-term memory loss, increased anxiety, and sensitivity of dark-adapted eyes to light.

The prevalent group of VOCs that carpets emit include aliphatic and oxygenated aliphatic hydrocarbons, and aromatic hydrocarbons. Laboratory testing has revealed as many as 32 VOCs are emitted from carpet.

Medical researchers have linked 4-PC to odor problems associated with new carpets. The chemical has also been linked to complaints about headache, runny eyes, irritation of mucous membranes, dizziness, neurological symptoms, and fatigue after carpet installation. Some researchers also theorize that 4-PC may be responsible for inducing MCS, a poorly defined illness characterized by hypersensitivity to a range of environmental agents. Metabolites of 4-PC may be carcinogenic. While 4-PC emissions from some carpets may be high initially, they tend to diminish quickly and they are very dependent on carpet type.

The adhesives used to install floor coverings can be a significant source of VOCs in indoor air, particularly since they are often used to cover large surface areas.

Researchers suspect that health problems associated with carpets are probably attributable to the SB latex backing. Some studies seem to indicate the problem emissions may be connected to a breakdown in the SB latex backing.

It is important to note that ventilation alone may not alleviate the problems of carpet emissions and that it is difficult to predict which carpets will cause problems. In many cases it is almost impossible to trace the manufacturer of the carpet or the batch from which one particular sample came.

Kawasaki Syndrome

Kawasaki syndrome or disease is the popular name for mucocutaneous lymph node syndrome, a little-understood illness that has been linked to carpets, specifically to carpet cleaning. Named after the Japanese pediatrician who first reported the disease in 1967, Kawasaki syndrome is extremely difficult to diagnose because it mimics the symptoms of measles and scarlet fever. It generally strikes toddlers, although some cases in children as old as 12 years have been reported. The symptoms of the disease include:

- Sudden high fever that spikes and subsides daily for up to 20-odd days;
- Swollen eyelids and red eyes (conjunctivitis);
- Swollen and reddened lips, tongue, and throat;
- Swollen and reddened palms and soles (which may later peel);
- A measles-like rash;
- Swollen glands (lymph nodes) in the neck (in half of reported cases); and
- Extreme irritability

While none of these symptoms is life threatening, the unseen effect of the disease is. The disease causes the production of large numbers of lymphocytes (a class of white blood cells that are part of the immune system), which inexplicably attack the walls of the coronary arteries carrying blood to the heart. Weeks after having the fever and rash, a child may develop an aneurysm, an area of the blood vessel wall that has weakened and dilated. One in five children develop aneurysms as a result of Kawasaki syndrome. In about 10% of these cases, the aneurysm is large enough to cause blood colts that can subsequently lead to heart attacks. About 3,000 cases of Kawasaki syndrome are diagnosed in the US each year, though others may remain undiagnosed.

The cause of the disease is unknown, though researchers suspect that the cleaning releases an agent – perhaps a retrovirus like the one responsible for Acquired Immune Deficiency Syndrome (AIDS)- that triggers the immune response characteristic of the disease.

Ceiling and Wall Materials

For the most part, VOC emissions from wall and ceiling sources tend to be highest immediately after application or installation. After this, the emission rate depends on the nature of the material, how long it has been in place, and the environmental conditions of the indoor environment.

Ceiling tiles and panels, many of which are made with fibers held in a formaldehyde-based resin, can be a significant source of formaldehyde, as well as other VOCs.

Builders use adhesives for a number of applications in the construction and decoration of walls and ceilings. The chemical composition and consequent VOC emissions of these adhesives vary considerably. Water-based adhesives have significantly higher VOC emissions than solvent-based adhesives. The VOCs emitted from adhesives are similar to those emitted from a variety of other "wet" products used in building renovations. High levels of a wide variety of VOCs can emanate from paints, lacquers, varnishes, enamels, glues, adhesives, and thinners.

Formaldehyde makes up the bulk of the VOC emissions for most types of wood paneling, including hardwood plywood paneling, medium-density fiberboard, hardwood paneling, and UFFI simulated wall paneling.

Environmental factors can increase airborne concentrations of formaldehyde from wood paneling. Increasing temperatures and relative humidities increase formaldehyde emissions from these products.

Emissions testing of wall coverings has shown that:

- Vinyl wall coverings have negligible emissions of vinyl chloride;
- Paper products emit far more formaldehyde than vinyl wall coverings;
- Formaldehyde emissions from wallpaper remain above recommended exposure limits for one to three days after installation;
- For all wall coverings, formaldehyde emissions drop to 50 $\mu g/m^3$ or below within a few days.

Paints

Wet coatings, such as paints and varnishes applied to walls and ceilings as protectants, sealants, or decorative finishes are often potent sources of VOCs. VOC emissions are particularly pronounced during and immediately after application, though emissions can continue over longer periods of time at a reduced rate.

Water, oil, and solvent-based paints are potent sources of aromatic hydrocarbons, alcohols, and aliphatic hydrocarbons. Solvents used in the mixing, removal, and application of paints are also potent sources of VOCs, such as methylene chloride in paint stripper.

Painting exposes workers and building occupants to elevated levels of ethylbenzene, *o*-xylene, *m*-xylene, *p*-xylene, decane, and undecane. Studies have shown that airborne VOC concentrations of several hundred to several thousand milligrams per cubic meter are common after application of petroleum-based interior paints and that levels of aromatic compounds (toluene, xylenes, ethylbenzene, and styrene), as well as aliphatic compounds (decane and undecane) may be elevated by a factor of 100 immediately following painting or renovation.

Paints and varnishes continue to emit VOCs even after drying. Six months after application, waterborne paints still emit film-forming agents.

Emissions vary according to the type of paint used. Latex and oil- or solvent-based paints contain different ingredients. Water-based latex paints release much lower quantities of VOCs than oil-based paints and varnishes.

The most potent and common wall/ceiling source of VOCs is paint, particularly during and immediately after application. Painting activities in a building can cause acute exposure to a number of VOCs in the individuals involved in the painting and in the building occupants. One researcher found elevated levels of several VOCs – benzene, tetrachloroethylene, styrene, ethylbenzene, *o*-, *m*-, and *p*-xylenes – in the breath of persons exposed to paint. The potential for such exposure exists in many buildings where major renovations in one part of the building or even minor painting operations in occupied areas are conducted while people are in the building.

Waterborne paints are associated with:

- Irritation of the mucous membranes;
- Irritation of the skin by monomers;
- Sensitization of the skin by monomers;
- Possible cancer hazards;
- Possible birth defects;
- Irritation from odors.

While paint continues to emit VOCs even after drying, in most cases the health impacts are significantly reduced within a few weeks after painting operations are completed. For this reason, it is recommended that areas that have been painted are ventilated continously with fresh outside air for 3 to 5 days prior to occupancy.

Selecting Safe Products, Furnishings and Building Materials

Selection of lower-emitting or "IAQ-safe" products, furnishings and building materials is not always clear-cut. Those in charge specifying and purchasing products and materials should base their decisions regarding product selection on known and tested product safety. However, even when information on emissions and chemical content is available, it may be difficult to make educated choices. Since currently no testing standards exist for emissions from products, the accuracy of emissions information reported by manufacturers is often questionable.

Health experts do not have a good understanding of the potential health effects of low levels of contaminants, so categorization of products as IAQ-safe or unsafe is often arbitrary. With additional research on product emissions and health effects, environmental health officials may establish more practical standards and guidelines for product selection. Until then, consider the following factors in selecting products:

- How much surface area will be exposed to circulating indoor air?
- How much of the product will be used in the building?
- What is the chemical composition of the product based on information available from the manufacturer?
- How chemically stable are these compounds in the warm, dry conditions typically found in the school building?
- What is currently known about the toxicity or irritation potential of the major chemical constituents of the product?

A stringent program for reducing emissions might include the following measures:

- Require manufacturers or suppliers of materials and products including coatings (paints, varnishes, waxes) and furniture or furnishings with substantial amounts of

pressed wood or fabrics to provide testing data on emissions rates;
- Require manufacturers or suppliers to provide Material Safety Data Sheets (MSDSs) for chemicals used to manufacture each product;
- Require manufacturers or suppliers to provide an emissions rate testing report that documents:
- Model indoor concentrations and employee inhalation exposures for building designs and applications being considered (as a function of tim)e;
- Reject, or evaluate conditioning of, materials or products likely to increase organic vapor concentrations by 0.5 mg/m^3 or more;
- Evaluate the likely benefits of product conditioning before installation;
- Evaluate ventilation strategies for a building; and
- Conduct quality assurance checks on selected data supplied by manufacturers or suppliers.

Preconditioning of Furnishings by Manufacturers

Newly manufactured furnishings generally off-gas a major portion of their total lifetime emissions within the first few hours, days, or weeks after removal from their packaging. Therefore, if manufacturers are willing to cooperate, they can greatly reduce the emissions potential of their products by allowing the materials to off-gas prior to installation. This requires unpacking and exposing materials (e.g., unrolled carpet) in a well-ventilated space before bringing it into the building.

Sealant Applications

Sealants and other coatings may be used to encapsulate high-emitting materials, thus preventing subsequent emissions. Sealants can be applied by the manufacturer prior to shipping furnishings, or on site, after installation.

The most common use of furnishing sealants is on pressed-wood products, such as shelving, countertops, desktops, and cabinets. These coatings can act to reduce emissions wither by:

- Preventing the release of formaldehyde;
- Preventing the transport of moisture into the material; or
- Reacting with the formaldehyde to form non-emitting or inert compounds.

There are two main kinds of coatings; (1) thin layers of laminates or veneers glued onto the surface with adhesives, and (2) liquid coatings that form a hard surface after curing and drying. Manufacturers often apply laminates or veneers at the end of the manufacturing process, mainly for decorative purposes. They can also act as an effective barrier to emissions if applied to all surfaces. The adhesives themselves can, however, emit irritating VOC vapors while still wet and for a time during the curing process. Wet-applied sealants include: acid-curing lacquers, polyacrylamide, paint with formaldehyde-reactive chemicals, polyurethane, lacquer or varnish, latex paints, and other paints.
For maximum effectiveness, sealants must cover all surfaces and edges completely.

Many of the sealants and coatings that effectively encapsulate furnishing surfaces and thus minimize the emissions of pressed wood and other materials can themselves be a significant source of VOC emissions. The major VOC emissions from sealant products generally occur only during application, curing, and drying, however.

Mitigating Emissions from Wet Material Applications

Manufacturers and suppliers of wet materials, such as paints, varnishes, sealants, and caulks recommend temporarily “increasing ventilation” during application of these products. Increasing natural or forced ventilation during painting does not, however, always maintain airborne solvent concentrations in the renovation area, it is particularly important to isolate the ventilation to this area to prevent these contaminants from reaching other sections of the building. The return registers in the renovation areas should be blocked off so that contaminants are not recirculated from the demolition/construction area into adjoining occupied areas. Temporary local exhaust may also be installed to remove odors and contaminants. Ventilation in other areas of the building may need to be temporarily increased.

Control Measures for Sink Effects

The following control measures can shorten the time during which sink effects (VOCs are sorbed and re-released by surfaces) will contribute to elevate indoor VOC levels:

- Use maximum outside air ventilation during and following the installation of finishes and furnishings to reduce airborne VOC concentrations.
- Use temporary exhaust – through doors, stair towers, operable windows, and emergency exits – during the installation process rather than using the HVAC return system.
- Operate ventilation systems 24 hours per day, 7 days per week during episodes of elevated VOC emissions.
- Protect installed materials with sealed plastic vapor barriers to the extent possible during the use of VOC-containing finishing products and the installation of VOC-emitting furnishings.
- Protect fiber-lined HVAC ducts and return-air plenums from air flows to prevent contamination of system components. Exposed upper surfaces of ceiling panels and spray-on insulation enclosing concealed spaces used as return plenums can absorb large quantities of VOCs from air flowing past them.
- Operate newly occupied buildings at the lowest acceptable temperatures to avoid acceleration of VOC emissions.

Problems with Cleaning Products and the Non-toxic Alternatives

Emissions from Maintenance Activities

Regular building maintenance is important to prevent IAQ problems, but activities undertaken to “clean” a building may themselves create IAQ problems by releasing VOCs into the air. Most cleaning materials, air fresheners, and pesticides emit a wide variety of VOCs and other contaminants. Cleaning activities are problematic both for building occupants and for maintenance or janitorial workers who are engaging in these activities.

Worker Exposure

Workers using cleaning products or pesticides may suffer from exposure through the skin and through inhalation of concentrated doses of chemical agents. Ways to reduce worker exposure to these chemicals include eliminating the use of concentrated solutions or employing dispensers that eliminate the handling of concentrated solutions.

Maintenance workers can also be affected by the use of aerosol cleaning products. Products applied as aerosol sprays can be particularly harmful since the fine particles emitted are easily breathed deeply into the lungs, where they are quickly absorbed by the bloodstream. Inhaled aerosol sprays can cause headache, nausea, dizziness, eye and throat irritation, shortness of breath, skin rash, lung inflammation, and liver damage.

Occupant Exposure

While the greatest danger of acute exposure occurs in workers applying the cleaning products, building occupants, especially children, can also be affected. The emissions from cleaning products can linger long after they have been applied, affecting occupants in] other parts of the building served by the same ventilation system.

One particular problem with cleaning products and pesticides is that they are often applied when the building is unoccupied, at night or on weekends, in order to avoid exposure to them by building occupants. But the HVAC system is often shut down during these periods of non-occupancy to conserve energy. The ventilation shutdown prevents the contaminants from being cleared out of the building, exposing building occupants.

Cleaning Products and Air Fresheners

The chemicals in cleaning compounds that make these products capable of removing dirt, grease, and grime, as well as disinfecting, are often toxic to humans. While their toxicity is increased at higher concentrations, and thus is more of a concern for workers handling the cleaning compounds, exposure to lower concentrations in indoor air can also cause irritation and more serious health effects.

Despite their name, air fresheners rarely do anything to freshen the air or break down any offensive odor. Usually air fresheners function in one of the following ways:

Interfering with the ability to smell by deadening nerve endings;
Coating the nasal passage with an oil film; or
Disguising one odor with a stronger one.

The ingredients in air fresheners themselves can add harmful concentrations of VOCs to indoor air.

Non-Toxic Cleaners

Non-toxic cleaners are available from a number of suppliers. Many of the cleaners work as well or better than toxic cleaners. If you are having trouble locating non-toxic cleaners we recommend performing Internet search on "non-toxic cleaners" and finding the brand that works best for you.

The Importance of Testing for Cancer Causing Radon

The US Surgeon General has warned that radon is the second leading cause of lung cancer deaths, after smoking. Some evidence indicates that children are at greater risk than adults are for certain types of lung cancer from radiation, but there is currently no conclusive data on whether children are at greater risk from radon than adults.

Radon risk estimates are based on scientific studies of thousands of workers exposed to radon in underground mines. Scientists are far more certain of radon risk estimates because these estimates are based on studies of humans. The National Academy of Sciences, the World Health Organization, the Surgeon General, and other national and international authorities agree that radon is a serious health problem. The EPA has issued Interim Reports to provide guidance on how to test and fix schools for radon. **Information regarding this report is found under Publications.**

Radon is naturally occurring radioactive gas. It comes from the breakdown, or radioactive decay, of uranium. Uranium is found in soils and rocks all across the US. When uranium decays, it eventually breaks down into radon, which can move through the soil and into buildings through cracks and openings in the foundation. Radon breaks down into decay products that may become trapped in your lungs when you breathe. These decay products are radioactive and release small bursts of radiation when they break down. This radiation can damage lung tissue and lead to lung cancer over time.

Radon concentrations in outdoor air average about 0.4 pico curies per liter (pCi/L). Inside buildings, radon and its decay products can build up to higher concentrations.

Health Risks

Radon is known to cause cancer in humans. The radiation given off by the decay products inside human lungs can damage the cell lining of your lungs and lead to lung cancer over the course of a lifetime.

The risk of radon increases with the level and length of time to which an individual is exposed. Smoking combined with radon is an especially serious health risk.

The longer the exposure, or the higher the level of radon, the greater the risk. That is why it is so important that schools in areas where radon may be present be tested.

The excess deaths caused by rado are as follows:

Annual Radon Level	**If a community of people were exposed to this level:**
100 pCi/L	About 35% of the people may die
410 pCi/L	About 17% of the people may die
20pCi/L	About 9% of the people may die
10pCiL	About 5% of the people may die
4pCi/L	About 2% of the people may die

Testing for Radon

Radon is colorless, odorless, and tasteless. The only way to know whether or not there is a high level of radon in a building is to test the building using specialized instruments.

The US EPA recommends that managers of schools and other buildings take action to reduce the level of radon when levels are 4 pCi/L or greater after initial testing, this measurement should be confirmed with a follow-up test. If the initial and follow-up test indicate that the radon level is at or above 4pCi/L, action should be taken to reduce the radon level below 4 pCi/L.

EPA recommends that schools consult the RMP list when choosing a testing company. To obtain a copy of the RMP list contact your State Radiation office.

In a study of schools in 16 States, nineteen percent of the 3,000 rooms tested had levels above EPA's action level of 4 pCi/L. The highest level found, 136 pCi/L, is the equivalent of having over 10,000 chest x-rays a year. EPA has issued an Interim Report on how to measure schools for radon. This report is available from your State Radiation Office.

What to Do If Elevated Levels are Detected

EPA is also conducting a School Evaluation Program for diagnosing and fixing radon problems in schools. Preliminary work in schools shows that techniques proven successful in fixing homes also works in schools. However the unique construction and operation characteristics of school buildings present special considerations.

How to Solve Common IAQ Problems

Responsibilities for Healthful Indoor Environments

Maintaining a healthy indoor environment involves a combination of education about IAQ, proper maintenance and operating procedures, the elimination of containment sources, and sufficient ventilation and filtration. An integrated prevention program requires cooperation among several factions with different responsibilities:

- *Individual workers/building occupants*:
  Maintain and properly use products and equipment.

- *Facility managers*
  Clean and maintain buildings and ventilation systems to control contaminant sources;
  Test and balance ventilation systems to ensure adequate ventilation is provided to each area of the building;
  Use zone ventilation or local exhaust at sources of pollution; and
  Properly use and install furnishings and equipment.

- *Architects, and contractors:*
  Adopt protection of IAQ as design criterion;
  Design ventilation systems to comply with ASHRAE standards;
  Provide for separation of occupants and indoor pollution sources; and
  Eliminate or contain potential sources of pollutants.

- *Manufacturers:*
  Test, certify, and label potential air pollution sources;Conduct research on potential health and comfort effects resulting from normal use or possible misuse of products; and
  Substitute less harmful products and materials

- *Government Agencies:*Ensure healthfulness of buildings supported through public funding; Ensure compliance with building ventilation codes and acceptable IAQ;
  Sponsor research to assess indoor pollutant concentrations, health and comfort effects, and control and policy options;
  Establish guidelines, codes, and performance standards to protect the public;
  Provide information and assistance to local and state governments; and
  Advise the public on safety of products, materials, and practices.

Schools need to take a proactive approach to IAQ by inspecting their schools and mechanical systems and implementing programs to address the common causes of poor IAQ. In many cases, a number of IAQ problems within a building will need to be investigated and addressed through a combination of general measures to improve maintenance practices and the systems of a building, along with more specific measures aimed at reducing and eliminating contaminant sources.

The best approach to take in a specific IAQ situation will depend on a number of factors:

- The extent of indoor air contaminants (the kinds and concentrations of pollutants involved);
- The sensitivity and concerns of building occupants;
- The economic and technical resources available;
- The extent to which mitigation will disrupt school operations;
- Relevant regulations; and
- Concerns about health effects, liability, litigation and public relations.

Basic Control Strategies

Controlling the quality of the air that building occupants breathe involves a combination of improved ventilation to flush out the building, contaminant source control, and improvements in operation and maintenance and cleaning procedures.

Ventilation Control

Improvements in ventilation generally involve two basic strategies: diluting contaminants with outdoor air; or isolating and removing contaminants by controlling relative air pressure in different zones. Both strategies can be applied to reduce occupant exposure to contaminants from a variety of indoor sources.

Controlling the intake, distributions, and exhaust of building air can be essential in maintaining acceptable IAQ. These controls include:

- *Design and layout changes* – modifications to building design and layout to increase ventilation or reduce air flow restrictions;
- *Air filtration and purification* – use and maintenance of filters and air cleaners to remove pollutants from both outdoor air and recirculated air; and
- *Maintenance and adjustment of HVAC equipment* – assuring that ventilation rates are sufficient to remove contaminants and provide adequate ventilation to all locations.

Source Control

Methods of source control include the following:

- *Elimination* – the complete removal of biological contaminants (and their breeding grounds and conditions), toxic substances, and emissions sources;
- *Substitution* – using products known to produce lower emissions of hazardous substances;
- *Isolation* – containment, encapsulation, shielding, sealing, relocating, or altering time of use of emissions sources;
- *Conditioning* – decontamination of products or furnishings after installation, as in the case of bake-outs, or manufacturers' preconditioning of products prior to installation;
- *Housekeeping* – maintenance to reduce the buildup of dust, molds, chemical spills, etc.;
- *Maintenance practices* – specifications for proper work procedures to reduce or control contaminate releases, as in the application of pesticides; and
- *Replacement* – replacing materials that have become breeding grounds for biological contaminants, such as wet carpeting, ceiling tiles and sheet rock.

Contaminant Dilution

The contaminant dilution strategy usually involves:

- Increasing the total quantity of supply air, which should contain outdoor air;
- Increasing the proportion of outdoor air to total air; and/or
- Improving the distribution of the air

Increasing the supply and improving the distribution of outdoor air not only decrease the levels of contaminants originally emitted by indoor sources but also decrease the concentration of contaminants from other sources that could be absorbed and later released from absorptive surfaces, such as furnishings and carpeting.

Concentrations of VOCs and their adsorption onto furnishings can become particularly pronounced when facility managers turn HVAC systems off at night or over weekends. When the system comes on again following a turn-off period, concentrations of contaminants in HVAC supply air can increase significantly. The rate of re-release after adsorption onto furnishings can also be temporarily increased. Some experts advise facility managers to arrange for the HVAC systems to “flush out” buildings after weekend turn-off prior to the return of employees and students on Monday morning.

To effectively dilute and exhaust contaminants, it is essential that the HVAC system continuously take in a supply of outdoor air and not merely recirculate air within a building. Recirculating air could lead to increased concentrations of airborne contaminants from indoor sources because, as some researchers have demonstrated, the emissions rates of VOCs from some surfaces, such as formaldehyde and benzaldehyde from particleboard, can actually increase as the rate of airflow across the surface increases. Higher ventilation rates are then necessary to effectively dilute airborne concentrations of the emitted compounds.

Isolation and Removal of Contaminants

Generally recommended methods of controlling air pressure to isolate and remove contaminants include:

- Installing effective local exhaust near sources;
- Locating occupants near supply diffusers, and sources near exhaust registers;
- Maintaining pressure differentials and eliminating pollutant pathways; and/or
- Separating pressure zones, when possible.

Selecting Safe Products, Furnishings and Building Materials

Selection of lower-emitting or “IAQ-safe” products, furnishings and building materials is not always clear-cut. Those in charge specifying and purchasing products and materials should base their decisions regarding product selection on known and tested product safety. However, even when information on emissions and chemical content is available, it may be difficult to make educated choices. Since currently no testing standards exist for emissions from products, the accuracy of emissions information reported by manufacturers is often questionable.

Health experts do not have a good understanding of the potential health effects of low levels of contaminants, so categorization of products as IAQ-safe or unsafe is often arbitrary. With additional research on product emissions and health effects, environmental health officials may establish more practical standards and guidelines for product selection.

Sealant Applications

Sealants and other coatings may be used to encapsulate high-emitting materials, thus preventing subsequent emissions. Sealants can be applied by the manufacturer prior to shipping furnishings, or on site, after installation.

The most common use of furnishing sealants is on pressed-wood products, such as shelving, countertops, desktops, and cabinets. These coatings can act to reduce emissions wither by:

- Preventing the release of formaldehyde;
- Preventing the transport of moisture into the material; or
- Reacting with the formaldehyde to form non-emitting or inert compounds.

There are two main kinds of coatings (1) thin layers of laminates or veneers glued onto the surface with adhesives, and (2) liquid coatings that for a hard surface after curing and drying. Manufacturers often apply laminates or veneers at the end of the manufacturing process, mainly for decorative purposes. They can also act as an effective barrier to emissions if applied to all surfaces. The adhesives themselves can, however, emit irritating VOC vapors while still wet and for a time during the curing process. Wet-applied sealants include: acid-curing lacquers, polyacrylamide, paint with formaldehyde-reactive chemicals, polyurethane, lacquer or varnish, latex paints, and other paints. For maximum effectiveness, sealants must cover all surfaces and edges completely.

Many of the sealants and coatings that effectively encapsulate furnishing surfaces and thus minimize the emissions of pressed wood and other materials can themselves be a significant source of VOC emissions. However, the major VOC emissions from sealant products generally occur only during application, curing, and drying, however.

Reducing Emissions During Renovations

Manufacturers and suppliers of wet materials, such as paints, varnishes, sealants, and caulks – recommend temporarily "increasing ventilation" during application of these products. Increasing natural or forced ventilation during painting does not, however, always keep airborne solvent concentrations in the renovation area.

It is particularly important to isolate the ventilation to this area to prevent these contaminants from reaching other sections of the building. The return registers in the renovation areas should be blocked off so that contaminants are not recirculated from the demolition/construction area into adjoining occupied areas. Temporary local exhaust may also be installed to remove odors and contaminants. Ventilation in other areas of the building may need to be temporarily increased.

Reducing VOC Emmissions

The following control measures can shorten the time during which sink effects, (VOCs are absorbed and re-released by surfaces) will contribute to elevate indoor VOC levels:

- Use maximum outside air ventilation during and following the installation of finishes and furnishings to reduce airborne VOC concentrations.
- Use temporary exhaust – through doors, stair towers, operable windows, and emergency exits – during the installation process rather than using the HVAC return system.
- Operate ventilation systems 24 hours per day, 7 days per week during episodes of elevated VOC emissions.
- Protect installed materials with sealed plastic vapor barriers to the extent possible during the use of VOC-containing finishing products and the installation of VOC-emitting furnishings.
- Protect fiber-lined HVAC ducts and return-air plenums from air flows to prevent contamination of system components. Exposed upper surfaces of ceiling panels and spray-on insulation enclosing concealed spaces used as return plenums can absorb large quantities of VOCs from air flowing past them.
- Operate newly occupied buildings at the lowest acceptable temperatures to avoid acceleration of VOC emissions.

Reducing Equipment VOC and Ozone Emissions

Since removing all office equipment or reducing the need for this equipment is not usually a viable alternative, facility managers should implement measures to reduce occupant exposure to the ozone and VOC emissions from photocopiers, laser printers, computer terminals, and fax machines. These preventive measures include:

- Selecting lower-emitting equipment in consultation with manufacturers and authorities on emissions;
- Minimizing the use of equipment when possible;
- Ensuring that operators of equipment are educated on the proper use and maintenance of all equipment; and
- Removing emissions at the source through ventilation and/or filtration

In many cases, reducing emissions through product selection is an unattainable goal, because not enough lower-emitting machinery is on the market. When the actual emissions of a product cannot be effectively reduced, a viable alternative is to prevent the emissions from reaching building occupants by removing them at the source. The two most common ways to do this are through specialized ventilation and through air filtration at the source.

Most IAQ professionals recommend the following techniques for reducing occupant exposure to office equipment emissions in new and existing buildings:

- Consolidate and install equipment in isolated rooms with separate exhaust systems and supply air ducts with increased amounts of outdoor air;
- If it is impossible to isolate the equipment, locate the machines so that airflow patterns do not direct fumes toward workers;
- Locate machines that need to be near workers (such as computer terminals) near return air ducts to increase dilution of contaminants;
- Provide for equipment operators to have breaks; and
- Turn machines off when not in use for long periods of time.

Asbestos Management

The source control options available for reducing asbestos fiber exposure from asbestos-containing materials (ACM) include:

- Preventive building operation and maintenance practices;
- Repair of friable (easily crumbled) ACM;
- Enclosure of friable ACM;
- Encapsulation of friable ACM; and
- Removal of friable ACM

Preventive building operation and maintenance practices for reducing asbestos fiber exposure involves in-place asbestos management or control. In cases in which the asbestos-containing materials are in good condition with low potential for future disturbance, these practices may be used on a long-term basis.

In evaluating the potential for disturbance and whether an in-place management approach is appropriate, school facility managers have to assess the following factors:

- Proximity to direct airstream or plenum;
- Accessibility to building occupants or maintenance personnel;
- Degree of activity in the immediate area that may cause disturbance; and
- Changes in building use.

The best in-place management approach is for school districts to implement the following practices in accordance with the EPA's Asbestos Hazard Emergency Response Act (AHERA) regulation:

- Train maintenance personnel on the locations of friable ACM in their schools;
- Avoid activities that may damage or disturb ACM, such as drilling holes, hanging or attaching materials to walls and ceilings, causing physical abrasion, and removing ceiling tiles below ACM;
- Instruct custodial staff to avoid resuspending fibers during dry sweeping and dusting, by dusting with damp cloths and using wet mops on floors;
- Wet down any noticeable asbestos debris and remove it with a dust pan, and place it into plastic bags;
- Follow any debris cleanup with vacuuming with a HEPA-filtered vacuum cleaner;
- Dispose of all cloths, mopheads, and other asbestos-containing wastes in double-ply plastic bags.

Lead-based Paint (LBP) Management

For the ongoing management of LBP, it is important for schools to develop management programs. Components of a program include a written procedures manual, a training program for workers in safe work practices and the use of personal protection, procedures for assessing and abating hazards, and the purchase of tools and equipment to safely abate LBP.

Biocontaminant Control

Finding the root cause of biocontamination sheds some light on the best preventive strategies to take. The most common causes of microbiological contamination have been found to be:

- *Inadequate building and mechanical system maintenance.* The most frequent cause of biocontamination is inadequate or completely absent building and preventive maintenance. In many contaminated buildings the roof leaks, there is the presence of standing water, and humitidy and temperature levels are not controlled within acceptable ranges. In addition, internal components of air handling units, fan coil units, and induction units are seldom cleaned. Drain pans contain stagnant contaminated water. Wet cooling coils and moist downstream surfaces are covered with dirt and debris.
- *Stagnant water in drain pans.* In many buildings, drain pans contain stagnant water. Drain pans should be constructed to allow for drainage of condensed water. Many IAQ specialists recommend periodic cleaning and disinfection of drain pans.
- *Porous insulation.* In some buildings, microbiological amplification occurs in porous insulation located adjacent to or downstream from the heat exchanger. In these locations dirt and debris collect in the wet or damp ventilation systems. Often investigators will detect bacterial and fungal growth in insulation material, particularly when the system is in air conditioning mode.
- *Excessive humidity in occupied spaces.* In about one-third of contaminated buildings, fungal amplification can be attributed to elevated humidity levels. In most cases excessive humidity occurs during the summer months when latent heat is not removed due to a restrictive energy management program or when control sensors in the HVAC system are inadequate. Relative humidity should be kept below 70% to prevent fungal amplification in furnishings, and even lower – at 50% - to minimize condensation on cold surfaces during summer months.
- *Outdoor air intake located near bioaerosol reservoir or amplifier.* Occasionally, the HVAC outdoor air intake is located within 25 feet (7.6 meters) of a cooling tower. In other cases, the intakes are located close to restroom stacks, sanitary vents, or dead vegetation, which could serve as microbiological sources.

Mold/Mildew Control

The mitigation techniques employed to control mold and mildew infestations in wall and ceiling materials and other surfaces depend on the severity of the problem. Facility managers can control relatively minor mold infestations by controlling the relative humidity of the building and reducing surface temperature variations that foster water condensation on some surfaces. More sever infestations require a more active approach to remove the mold-infested materials.

Mold spores are present in nearly all indoor environments. Mold infestations occur when these spores germinate and proliferate on appropriate substrates. Controlling the moisture content of indoor surfaces and materials is the best way to prevent mold proliferation and to control minor mold growth before it becomes a major infestation.

Condensation on wall and ceiling surfaces occurs when the relative humidity (RH) of the air is high and/or surfaces are cooler than the surrounding air. Ways to reduce the increase if RH near these cooler surfaces include:

- Reducing the general moisture content of the room air;
- Increasing air movement;
- Increasing the general space temperature; or
- Increasing the temperature at building surfaces.

In some situations, air moisture content is the dominant factor in mold growth; in other situations surface temperatures are causing the problems. Selecting an effective control strategy requires determining which of these factors is dominant.

In heating climates, where indoor moisture levels are low, poor insulation is a common cause of mold and mildew buildup. Increasing ventilation will not control the fungal growth problem in these cases. Mitigation strategies should be aimed at increasing ventilation will not control the fungal growth problem in these cases. Mitigation strategies should be aimed at increasing surface temperatures and thus reducing the RH next to these surfaces. The best strategies in these cases are:

- Insulating and closing cracks in exterior walls to prevent outside air infiltration and to reduce wind-washing (air entering and passing through exterior walls without entering the building);
- Raising the thermostat setting; and/or
- Increasing air circulation to distribute warmed supply air better to interior surfaces.

In situations in which exterior wall insulation is sufficient, both mold and mildew buildup occurs because of high moisture levels in the indoor air, other strategies are called for including:

- Venting indoor moisture sources to the outdoors;
- Dilution of moisture-laden air with lower-moisture outdoor air (only useful during heating periods, when outdoor air tends to be lower in humidity than indoor air); and/or
- Dehumidification.

Determining the Cause of High Humidity

If the immediate cause of the high RH levels next to surfaces is not obvious, the following procedure can be used to determine whether room surface temperature is too low or air moisture content is too high. The amount of moisture in the room can be estimated by measuring both temperature and RH at the same location and at the same rime. Suppose there are two cases. In the first case, assume that the RH is 30% and the temperature is 70°F in the middle of the room. The low RH at that temperature indicates that the air moisture content (or absolute humidity) is low. The high surface RH is probably due to room surfaces that are too cold.

Temperature is the dominating factor, and control strategies should involve increasing the temperature at cold room surfaces. In the second case, assume that the RH is 50% and the temperature is 70°F in the middle of the room. The higher RH at that temperature indicates a large amount of moisture in the air. The high surface RH is probably due to air that is too moist. Humidity is the dominating factor, and control strategies should involve decreasing the moisture content of the indoor air.

Some researchers have cautioned that while decreasing RH is recommended as an overall control and prevention strategy, airborne spore levels can temporarily increase. Over the short term, increasing relative humidity reduces viable spore levels; spore release occurs when humidity levels are decreased.

Mold/Mildew Control in Air-Conditioned Spaces

Air-conditioned spaces may present particular challenges for reducing condensation and consequent mold problems. The following measures are recommended for air-conditioned spaces:

- Preventing hot, humid exterior air from contacting cold interior finishes;
- Elevating the temperature of interior surfaces at cold spots by relocating ducts and diffusers;
- Ensuring that vapor barriers, facing sealants, and insulation materials are properly selected, installed, and maintained; and/or

- Avoiding overcooling by increasing room temperature.

Mitigation of Severe Mold Infestations

Once mold has infested walls or ceilings, whether from flooding or moisture intrusion due to faulty construction, stringent measures are necessary. Simply reducing the relative humidity of the building or sections of the building will not be sufficient to mitigate the mold problem.

Mold growth can begin soon after water intrusion, so it is important to begin remedial steps as soon as possible. The following steps will prevent the dissemination of mold spores into portions of a building not otherwise affected by water intrusion:

- Put water-damaged areas under negative pressurization;
- Erect floor-to-slab barriers;
- Prevent dissemination of spores through elevator shafts by constructing containment barriers around elevators in foyer areas;
- Create negative pressure in the elevator shafts by installing exhaust fans on the shaft roofs; and
- Collect fungal samples by spore traps for direct microscopic evaluation to verify that spore traps for direct microscopic evaluation to verify that spores from water-damaged areas are being excluded from occupied areas.

The areas infested can be treated by HEPA-vacuuming all walls and ceilings and treating all heavily mildew-stained areas with a wet disinfectant of the substituted phenolic type. In using disinfectants, it is essential that the chemical have 20-30 minutes of wet contact time to achieve the desired level of disinfection. All disinfected surfaces should remain visibly wet for at least 20 minutes. If indicated by the manufacturer, this should be followed by a wet rinse, after which all excess water should be wiped up.

When large areas of a building have become water-damaged it is important to implement stringent measures to avoid serious biocontamination. Damage caused by water is often discounted and treated lightly until microbial growth and odor (often called 'moldy or musty') from microbial fermentation become a problem.

A protocol for handling water intrusion emergencies includes the following steps:

- Maintain a proper inventory of flooded areas so that every water-damaged area is treated and cleaned;
- Remove and dispose of all water-damaged ceiling tiles. Replace them with new ceiling tiles within 24 hours;
- Remove and replace all walls and insulation materials between walls damaged by water. Since capillary action can cause water to saturate walls several inches above the water level, it is best to remove all wall materials up to 12 inches (30.5 cm) above the water line; and
- Introduce 100% fresh air to remove all odors.

The Benefits of Using Environmental and Facility Management Software

Creating and maintaining healthy school environments is an ongoing challenge that is not easily accomplished using standard paper-based tracking and recordkeeping systems. School districts with multiple school sites can use specially designed software to track and manage hazardous materials in their buildings such as asbestos, lead-based paint, chemical inventories and IAQ records and testing results.

Since proper building and mechanical system maintenance is also an important part of maintaining a healthy indoor environment, schools should use software to track and manage their facility maintenance activities on an ongoing basis.

Healthy Schools Software

Green Schools has worked with EcoLogic Systems, a leading developer of environmental management software to create Healthy Schools Software, a web-based environmental and facilities management system.

Healthy Schools Software:

- Provides quick and easy access to Environmental Management Program documents, emergency response procedures and the districts various health and safety program managers so everyone who needs it including, facility managers, teachers and maintenance personnel all have access to this critical information

- Stores the locations of hazardous materials such as asbestos, lead-based paint, chemical inventories, throughout the district on a room by room basis so the materials can be managed more effectively and will not be inadvertently disturbed by maintenance or renovation activities

- Stores basic indoor air quality readings, sample results and ventilation readings to identify problems and help ensure the quality of the indoor environment

- Tracks and provides reminders for ongoing building maintenance activities and hazardous materials inspections to ensure buildings, mechanical systems and hazardous materials are inspected and maintained on an ongoing basis

To learn more about the healthy schools software you can visit their web site at www.healthybldgs.com**.**

Indoor Air Quality Publications

Indoor Air Quality

Indoor Air Quality and Facilities Management Software
EcoLogic Systems
7977 Capwell Drive, Suite 150
Oakland, CA 94621
(800) 232-0609
www.ecologicsystems.com

Indoor Air Quality Tools for Schools
U.S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460
(202) 233-9030

A complete kit that includes manuals, forms and video's that help schools establish IAQ management programs and solve common IAQ problems. Also available on line at www.EPA.gov/IAQ

Managing Asthma: A Guide for Schools
(Pub. 91-2650)
NHLBI
P.O. Box 30105
Bethesda, MD 20824

The Healthy Schools Handbook ($24.95)
NEA Professional Library District Center
P.O. Box 2035
Annapolis Junction, MD 20701-2035

Ventilation

ASHRAE materials are available from:
Publication Sales Department
1791 Tullie Circle, NE
Atlanta, GA 30329
(404) 636-8400

Titles Include:

- Ventilation for Acceptable Indoor Air Quality (ASHRAE Standard 62-1989)
- Method of Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter (ASHRE Standard 52-76)
- Practices for Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems (ASHRAE Standard 111-1988)

Selecting HVAC Systems for Schools
Maryland Department of Education
200 West Baltimore Street
Baltimore, MD 21201
(410) 333-2508

Asbestos

Asbestos Management Software
EcoLogic Systems
7977 Capwell Drive, Suite 150
Oakland, CA 94621
(800) 232-0609
www.ecologicsystems.com

Asbestos Issues and Regulations, A Guide for Building Owners ($20.00)
ACC Environmental Consultants
7977 Capwell Drive, Suite 100
Oakland, CA 94621
(510) 638-8400

Asbestos Management Program Manual ($75.00)
ACC Environmental Consultants
7977 Capwell Drive, Suite 100
Oakland, CA 94621
(510) 638-8400

Lead

Lead Paint and Drinking Water Management Software
EcoLogic Systems
7977 Capwell Drive, Suite 150
Oakland, CA 94621
(800) 232-0609
www.ecologicsystems.com

Lead-based Paint Issues and Regulations, A Guide for Building Owners ($20.00)
ACC Environmental Consultants
7977 Capwell Drive, Suite 100
Oakland, CA 94621
(510) 638-8400

Lead-based Paint Management Program Manual ($75.00)
ACC Environmental Consultants
7977 Capwell Drive, Suite 100
Oakland, CA 94621
(510) 638-8400

Lead-Safe Schools Guide
Labor Occupational Health Program
Center for Occupational and Environmental Health
University of California
2223 Fulton Street
Berkeley, CA 94702
(510) 642-5507

Lead in School Drinking Water ($3.25)
Superintendent of Documents
U.S. Printing Office
Washington, D.C. 20402.
GPO stock number 055-000-00281-9

EPA Training Video, Lead in School Drinking Water. This recently developed one-hour video demonstrates how to carry out a successful sampling program. Contact your regional EPA office to find out how you can get a copy of the video.

Radon

Radon Measurement In Schools- Revised Edition
EPA 402/R-92-014.

Reducing Radon in Schools: A Team Approach
402/R-94-008

Integrated Pest Management

IPM for Schools: A How-to Manual ($40.00)
BIRC
P.O. Box 7414
Berkeley, CA 94707
(510) 524-2567

Chemical Safety

Science Safety Handbook ($17.50)
CDE Press
Sales Office
P.O. Box 271
Sacramento CA 95812
(916) 445-1260

Non-Toxic School Supplies

Center for Safety in the Arts
5 Beekman Street
New York, NY 10038, USA
Tel: +1 212 227 6220
The center maintains a list of art materials and products that are deemed safe for children in grades K-6. The list is provided by the center for a nominal charge.