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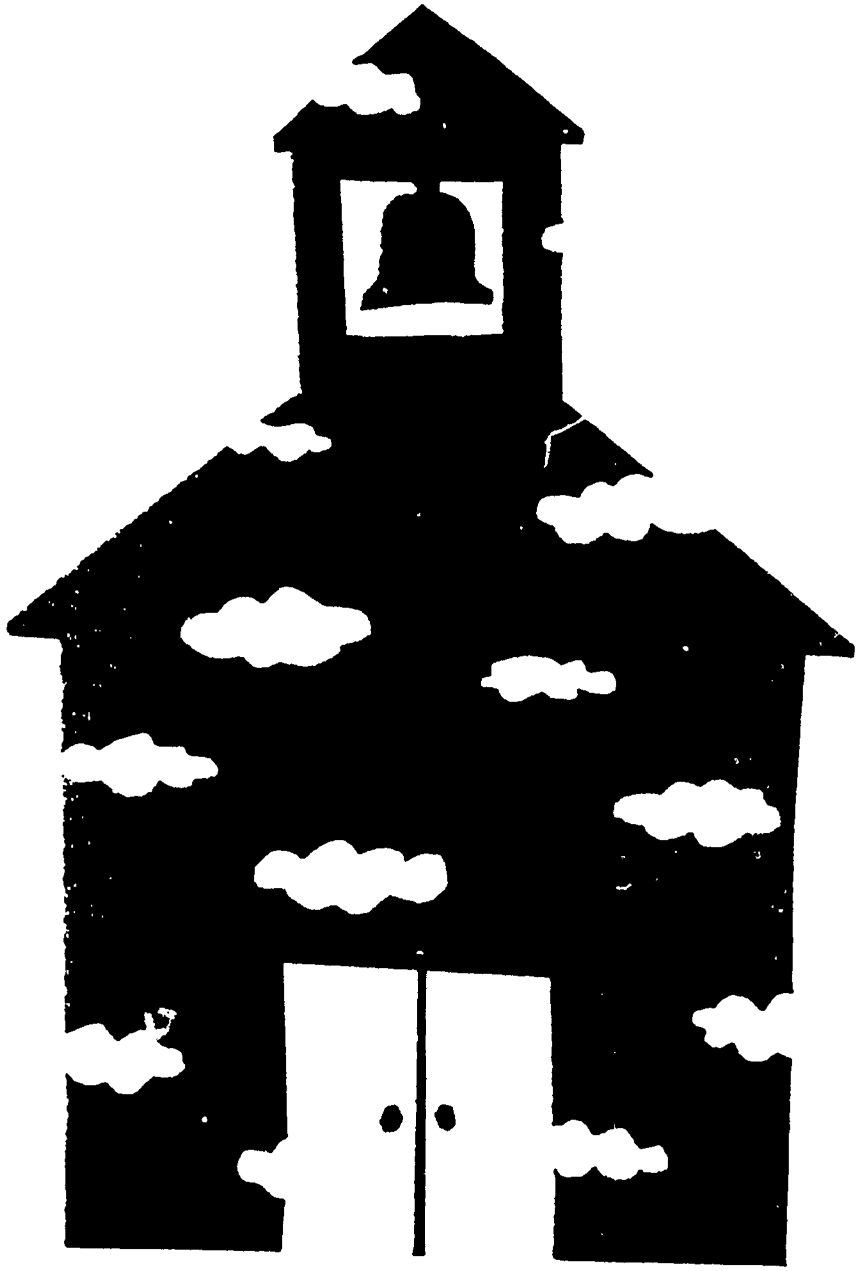
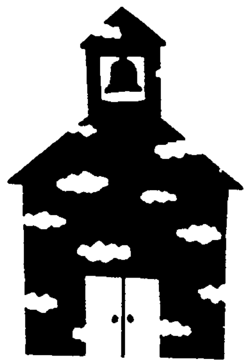
ABSTRACT

Less than adequate indoor air quality in schools can lead to a higher risk of health problems, an increase in student and teacher absenteeism, diminished learning, and even hazardous conditions. An indoor air quality program that addresses the planning, design, maintenance, and operation of public school buildings should be implemented at the earliest possible date in each local school system. This document provides guidelines to help local education staff responsible for construction planning, maintenance, and operation. Information is provided on the following: factors leading to the present concern about indoor air quality; the two types of air quality problems--the thermal environment and air contaminants; assessment of indoor air quality; establishment of a comprehensive facilities maintenance program; and building planning and design. Risks associated with specific activities are highlighted and control methods are described. Ten case studies illustrate typical examples of indoor air quality problems encountered in schools. The final section describes existing federal statutes and government activity. Two questionnaires (short form and extended form) pertain to the investigation of an indoor air quality problem. One figure and three tables are included. (LMI)



INDOOR AIR QUALITY
Maryland Public Schools



INDOOR AIR QUALITY MARYLAND PUBLIC SCHOOLS

NOVEMBER 1987

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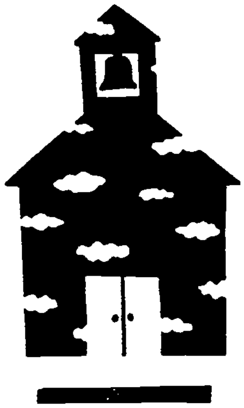

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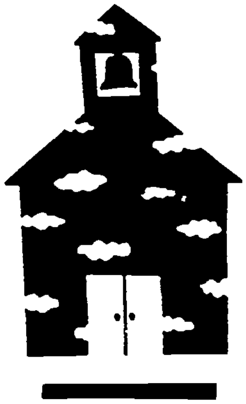


Foreword

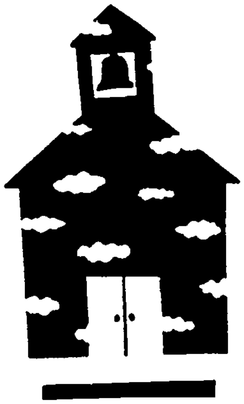
Indoor air quality has been identified as a new and complex public health concern. Many factors including energy conservation measures, new building materials, maintenance practices, and changes in building use have contributed to the potential problems with indoor air quality. Less than adequate indoor air quality can lead to a higher risk of health problems, an increase in student and teacher absenteeism, diminished learning, and, in extreme situations, a hazardous condition.

We are especially interested in understanding and managing indoor air quality in schools because younger people are at a greater health risk than the adult population. In addition, some children including special education students may have health characteristics which compound their level of risk.

An indoor air quality program that addresses the planning, design, maintenance, and operation of public school buildings should be implemented at the earliest possible date in each local school system. This document has been developed to assist local board of education staff responsible for the planning of school construction projects and for the maintenance and operation of existing schools. We hope architects, engineers, school staff and parents will also find it useful.

Our understanding of indoor air quality is in its earliest stages; the knowledge of this topic will undoubtedly grow and change at a rapid pace. We welcome any recommendations for updating or adding to the information found here.

David W. Hornbeck
State Superintendent of Schools



Historic Review

The type and frequency of indoor air quality problems present in educational buildings today are a relatively new phenomenon. Several factors have contributed to the present concern about indoor air quality.

Energy Conservation

The energy crisis of the early 1970s caused building owners to make great efforts to conserve energy. Buildings were planned and renovated to reduce outside air infiltration. Window and door openings were reduced and more tightly sealed. Outside air intake for the mechanical system was minimized. The operating times for heating, ventilation, and air conditioning equipment were decreased. The standards for the number of air changes per unit of time for a room were reduced. Buildings have become more compact in an effort to minimize perimeter wall surface and reduce heat loss and heat gain. Compact buildings have more spaces without exterior walls. As a result, facilities are more apt to retain potentially hazardous particles and gases from pollutant sources within the indoor environment for longer periods of time and in higher concentrations than ever before.

Product Technology

The number and type of particles and gases introduced into indoor air by new products have grown rapidly in the last few decades. New products are introduced each year for use during and after the construction of buildings. The effects on humans of the materials in these products often can not be forecast. Many years can pass before the dangers of a chemical are realized and brought into public awareness. Consider, for example, the past and present uses of formaldehyde, asbestos, tobacco and solvents released by glues. Product technology has given us materials that directly affect the quality of indoor air in ways that are of increasing concern to building planners and users.

Maintenance

Teacher salaries, instructional materials and building construction have understandably been given higher priority than maintenance of school facilities in budget decisions. As a result, longer periods of time between changing air filters, cleaning condensate pans, or cleaning and replacing mechanical equipment have become common practices in the past. The reevaluation of maintenance practices will undoubtedly come about as we begin to understand their relationships to indoor air quality. The realization that the health of students and staff may be affected by insufficient maintenance will elevate its importance in budget decisions.

Education and Training

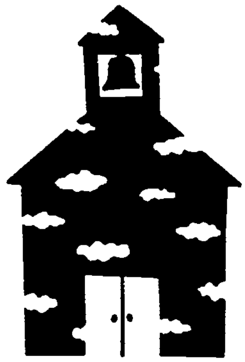
People who plan, design, maintain, and operate buildings have not received formal education or inservice training regarding indoor air quality. Practicing architects, engineers, educational facility planners, and maintenance operations personnel may not have received training in the link between their decisions and the quality of indoor air. This and other health-related subjects are noticeably absent from the curricula in architectural and engineering schools. Indoor air quality is discussed in terms of human comfort but not as an environmental health factor. While workshops have been available very recently they are too few and not specifically geared to those people involved in the planning and operation of school facilities. Inservice training programs and professional continuing education courses will have to be provided to fill this educational gap.

Change in Building Use

Changes in programs during the life of a building are common in the educational field. These changes can be stimulated by federal laws such as PL 94-142 (Equal Educational Opportunity for Handicapped Students) or state and local program implementation. Facility planners must frequently modify school buildings to accommodate the change. Building changes often take the form of spatial modifications, new equipment or alterations to electrical and lighting systems. Many times the mechanical system receives little or no corresponding change resulting in poor quality of indoor air due to over or under heating, cooling and ventilation.

Cost of Construction

Construction costs have spiraled up in the last decades. To reduce costs, building technology has been used to decrease the volume of a building, reduce the number of windows, create multi-use educational spaces, and simplify mechanical system designs. Cost decisions can and do have an impact on the quality of indoor air by creating buildings with few or no operable windows and mechanical systems that offer minimal ventilation under optimum conditions. In the future people will have to add indoor air quality into construction cost decisions.



Indoor Air Quality Problems

Indoor air problems can be discussed under two categories: (1) thermal environment and (2) air contaminants

The thermal environment involves several variables that cause relative degrees of human comfort or discomfort. These include air temperature, radiant temperature of surrounding surfaces, uniformity of air temperature, humidity, and air movement. Adverse thermal conditions can stress students or staff and, in turn, affect the quality of the learning situation.

Air contaminants consist of numerous particulates, fibers, mists, fumes, bioaerosols, and gases or vapors that can impair human performance as well as present a full range of implications from mild irritation of the upper respiratory system to a serious health threat.

Thermal Environment Conditions

Satisfaction with the thermal environment is based on a complex, subjective response to several interacting variables. The design, construction, and use of an occupied space, as well as the design, construction, and operation of its heating and air conditioning systems, will determine the degree of satisfaction with the thermal environment.

Not all individuals perceive the thermal environment with the same degree of acceptability. The perception of comfort relates to an individual's physical activity, body heat exchange with the surroundings, and physiological characteristics. The heat exchange between the individual and surroundings is influenced by:

- air temperature
- thermal radiation
- relative humidity
- air movement
- amount of clothing
- activity level
- direct contact with surfaces not at body temperature

While ideal thermal conditions are complicated to define for any one individual in a particular setting, The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) has produced a consensus standard (Thermal Environmental Conditions for Human Occupancy, ASHRAE 55-1981) based upon experience and research that specifies conditions likely to be thermally acceptable to at least 80 percent of the adult occupants of a space. These conditions, as they most commonly apply to educational facilities, are presented under the Planning and Design Considerations section of this document. A more complete explanation of the conditions, factors affecting comfort, and the methods for their determination and measurement can be found in the ASHRAE Standard. Figure 1 is taken from the ASHRAE standard and summarizes the comfort levels.

Studies comparing the basal metabolic rate of children from kindergarten to high school with those of adults in the same environment show that it is not rare to find the comfort levels for pupils and teachers separated by at least 5°F. Children are generally more comfortable in somewhat cooler temperatures due to their higher metabolic rate.

Indoor Air Contaminants

Indoor air contaminants can be divided into particles (solids or liquid droplets) and gases or vapors. Within these types are compounds known to be irritants that are known or suspected of causing damage to health. Contaminants which are irritants may impair human performance without being deleterious to health.

Standards for vapors and gases specify a quantity of pollutant per unit volume, e.g., parts per million of air (ppm).Standards for particles often specify the mass concentration of particles expressed as micrograms per cubic meter (ug/m^3). These include all particle sizes, or total suspended particulate concentration (TSP). Large particles are filtered by the nasal passages and cause no adverse physiological response unless they are allergenic or pathogenic. Smaller respirable suspended particles (RSP) are important because they can lodge in the lung. The size of respirable particles ranges up to 5.0 micrometers (um).

Particles of specific interest include:

1. Respirable particulates as a group.
2. Tobacco smoke (solid and liquid droplets) (tobacco smoke also contains many vapors and gases).
3. Asbestos fibers.
4. Allergens (pollen, fungi, mold spores, insect feces and parts), and
5. Pathogens (bacteria and viruses), almost always contained in or on other particulate matter.

Vapors and gases of particular interest include:

1. Carbon monoxide (CO), carbon dioxide (CO_2)
2. Radon (decay products become attached to solids).
3. Formaldehyde (HCHO)
4. Other volatile organic compounds (VOC), and
5. Oxides of nitrogen (NO and NO_2)

Some contaminants, such as sulfur dioxide, are brought in with outside air by mechanical ventilation or by uncontrolled infiltration. Many of the contaminants, for example nitrogen oxides and carbon monoxide, found in the air outdoors also have indoor sources. However, most indoor pollutants emanate from inside sources. People are sources of CO_2 and biomatter, as well as other contaminants characterized as "body odors." People's activities—smoking, cleaning, educational activities (such as gluing and refinishing furniture) and cooking—also cause pollution. Building materials and finishes can also "outgas" pollutants.

Furnishings, business machines, and appliances, particularly unvented or poorly vented heaters and ranges, can be contaminant sources. The soil surrounding a building can be a source of radon and insecticides that enter the indoors through cracks, drains, or by diffusion. Heating ventilation air-conditioning (HVAC) systems, drains, plumbing systems, and poor construction or maintenance practices can result in "environmental niches" where pathogenic or allergenic organisms can collect and multiply to be reintroduced into the air.

An additional complicating factor in the build-up of contaminants is the non-uniform mixing often present in buildings. Concentrations vary spatially as well as temporally. Pollutants can emanate from point sources, such as an unvented space heater, or from area sources, such as wall panels. These variations add further non-uniformity to the pollutant concentration.

Table 1 provides information about known contaminants.

Toxicological Considerations

This discussion provides the reader with some background concerning the interpretation of indoor air contaminant levels. The information presented here should be considered to initially evaluate air monitoring data. It is recommended that all monitoring data be reviewed in detail by professionals such as toxicologists and industrial hygienists.

Exposure Standards

THERE ARE NO REGULATORY STANDARDS FOR INDOOR AIR CONTAMINANT LEVELS ESTABLISHED FOR CHILDREN IN SCHOOLS. Human exposure guidelines for a number of air pollutants have, however, been established in regulations or recommended for other exposure settings by various governmental agencies and professional organizations. Differences observed when comparing the various guidelines usually stem from the underlying assumptions about the population each guideline is intended to protect. For example, air contaminant limits for the work place are comparatively high since they are intended to protect a relatively healthy, adult workforce, are not intended to protect the more sensitive individuals, and assume little or no exposure to the contaminant beyond the normal 40-hour work week.

The Occupational Safety and Health Administration (OSHA) regulates workplace exposure through the use of Permissible Exposure Limits (PELs). The National Institute for Occupational Safety and Health (NIOSH) performs health effects research and studies, then makes recommendations to OSHA for new legislation based on their work. The OSHA PELs and NIOSH recommendations are contained in DHHS (NIOSH) Publication No. 85-114, Pocket Guide to Chemical Hazards, available from the Superintendent of Documents, U S Government Printing Office, Washington, D.C. 20402.

The American Conference of Governmental Industrial Hygienists (ACGIH) annually publishes a list of Threshold Limit Values (TLVs) to be used as guidelines for the control of potential health hazards in the workplace The OSHA PELs are based on the 1968 list of TLVs. TLV booklets are available from the ACGIH, 6500 Glenway Ave., Bldg. D-7, Cincinnati, OH 45211-4438.

The American Industrial Hygiene Association (AIHA) has developed Workplace Environmental Exposure Limit (WEEL) Guides for a number of chemical substances for which there are no legal or authoritative limits in existence. The WEEL Guides are available from the AIHA, 475 Wolf Ledges Parkway, Akron, OH 44311-1087

The National Academy of Sciences (NAS) Committee on Toxicology develops recommended exposure limits for narrowly defined occupational groups (military personnel). On at least one occasion they have recommended an indoor air limit for military housing (the termiticide Chlordane). The NAS Committee on Toxicology may be contacted in Washington, D.C. at (202)334-2538.

The Environmental Protection Agency (EPA) has developed National Ambient Air Quality Standards (NAAQS) for six pollutants. These standards are designed to protect the more susceptible members of the general population (asthmatics, etc.) and, therefore, may be more applicable for evaluating the indoor environment where protection of similar populations is desired.

Many states are in various stages of development for 'air toxics' regulations or guidelines. Most of these states are applying safety factors to workplace exposure limits to develop ambient (outdoor) exposure limits.

The safety factors that the states are using are applied gene ically. That is, the same safety factor is applied to a large group of chemicals, generally with little or no regard to toxicity or mode of action within the human body. The rationale is that a conservative safety factor is chosen so that if the chemical exists in the air below the ambient limit (workplace standard/safety factor) it can be assumed to exert no toxic effect. If the air concentration is above the ambient limit, however, it is not assumed to be a hazard *per se* but a condition that warrants further investigation. Use of these "air toxics" limits in this manner is termed a "screening" approach. Maryland is currently using this approach informally and has proposed regulations which would incorporate this concept

The Hazardous Pollutant Evaluation Section of the State of Maryland's Air Management Administration (225-5270) may be consulted concerning the use and derivation of these 'screening levels as well as the status of the proposed regulations. The Division of Stationary Source Enforcement (225-5250) may be consulted concerning the EPA NAAQS.

The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) has recommended indoor air limits for five contaminants (ASHRAE Standard 62-1981). Thi ındard is currently being revised. Information regarding ASHRAE Standards is available form ASHRAE, 1791 Tullie Circle, N.E., Atlanta, GA 30329.

The Population at Risk

The population characteristics that must be taken into consideration when evaluating the potential health effects related to indoor air quality are age, sex, occupation, and health status The age of the school system population generally will range from approximately five to over 60 years of age, with special education services mandated from birth to age 21 Factors related to the younger age groups (elementary school age) include a higher respiration rate per unit body weight and less ability to comprehend and communicate adverse health responses (this latter concern may be applicable to a wider age range for special education students). The significance of the higher respiration rate per unit body weight has to do with the amount of toxic material per pound of body weight that will produce an adverse health effect. Therefore, if a child breathes in more material per unit of weight, the child will theoretically experience adverse effects before an adult.

The health status of the school population is important since many indoor air pollutants may aggravate preexisting disease. For example, individuals with lung disease (e.g., asthma, bronchitis, emphysema) will have their symptoms aggravated by respiratory irritants.

Nature of the Exposure

Exposures to indoor air pollutants and their ensuing health effects are generally classified as acute or chronic. Acute exposure to a chemical is usually measured in minutes or in some cases seconds, and acute health effects are those manifested almost immediately (e.g. irritation of mucous membranes, cough). Chronic exposure to a chemical refers to a repeated exposure over a long duration; usually measured in days, months, or years. Chronic health effects are those that develop and persist over time (e.g., cancers, liver and kidney effects). Since chronic effects develop over time, their appearance may or may not coincide with exposure to the causative agent(s).

Although some elevated chemical exposures can occur indoors due to spills and the misuse of chemicals, exposures in the indoor environment are generally characterized by the comparatively low concentrations of large numbers of pollutants and the subtle health effects that result. Typical concentrations found for individual pollutants in the indoor environment are 2-3 orders of magnitude, i.e., 100-1000 times, below those found in the industrial workplace.

The adverse health responses to pollutants in the indoor environment are often subtle (headache, malaise, etc.), i.e., the reactions are not always immediately obvious as being related to an air contamination problem. Conversely, industrial workplace exposures are more commonly related to clear toxic reactions (e.g., choking, severe irritation, tremors).

Modification of Workplace Exposure Limits

In the industrial workplace, exposure is monitored and single or small numbers of contaminants are identified. Protection for workers may be provided, where necessary, and alertness to the hazard is common. In schools, many different substances are found, varying greatly in time and space and in the occupants' reactions to them.

If workplace standards are to be used as an aid in assessing the indoor environment, the standards must be modified to account for the more susceptible members of the school population and for exposure to multiple pollutants. Workplace standards are frequently divided by a safety factor of 10 to account for more susceptible individuals. There is no consensus on how to handle multiple exposures. Some have recommended a simple additive approach, but the true interaction between pollutants may range from protection (one pollutant protects against the effects of another) to synergism (the combined effect is more than additive). The safety factor of 100 has been used by others to account for all the special considerations mentioned above including susceptible individuals.

Note to Investigators and Designers

It is hoped that this information will equip the reader with some insight into the complexity of evaluating indoor air exposures and health effects.

The facility planner should appreciate that he or she is designing a facility to be used by a population that includes a large number of individuals who, because of age or health status, are at increased risk of experiencing adverse health effects due to exposure to indoor air pollutants. Therefore, every effort should be made to anticipate possible sources of indoor air pollution and to take appropriate action. Likewise the investigator should understand the peculiarities of the school population and the complexities of attempting to link health effects to indoor air pollutant exposure. While air monitoring data should be reviewed by appropriate health professionals, the investigator can use the information in this section to help guide the investigation.

Control Methods

Control methods are important means of mitigating indoor contaminant problems. There are six basic methods for lowering concentrations of indoor contaminants.

1 **Ventilation** is a commonly used method for controlling indoor contaminants. Usually it is employed to both dilute the indoor air with quantities of outdoor air that are presumed to be less contaminated and to exhaust polluted air. In buildings with mechanical ventilating systems, outdoor air quantities are provided by design at rates specified in the applicable building codes. In other cases, local exhaust may be employed to remove contamination near its source, such as in restrooms, studios, and laboratories.

2 **Filtration and purification** of contaminants are employed where specific problems exist and practical devices are available. Particulate filtering is a highly advanced technology, but increased performance can involve significantly higher costs. Ordinary furnace filters are not effective in capturing pollen and other small particles. Higher performance filters are available at higher cost.

Vapor and gas removal equipment is also available, but the technology for general use in ordinary occupied spaces is expensive. Activated charcoal filters are used to adsorb high molecular weight gaseous molecules in varying efficiencies and holding capacities, usually at costs in relation to their performance. However, it is difficult to determine when the filters are loaded, and they can desorb lighter molecules previously adsorbed. Potassium permanganate impregnated into porous alumina pellets (and other chemicals) are available in order to oxidize or otherwise change particular gases and vapors into other, less hazardous or odorous forms.

3 **Removal or substitution** of materials that contribute to indoor air problems should be practiced. However, much work is necessary to identify these materials and to provide satisfactory substitutes. Such materials include paints and other finishes, manufactured wood products, plastics, cleaning and maintenance materials. Also included are a multitude of manufacturing processes that may be used to lessen the outgassing of some undesirable materials.

4 **Encapsulation** with coating materials, or otherwise interfering with the materials' ability to off-gas pollutants, is another control method.

5 **The Time of Use** of a contaminant is an important administrative strategy. Contaminants should be used when the least number of people will be exposed.

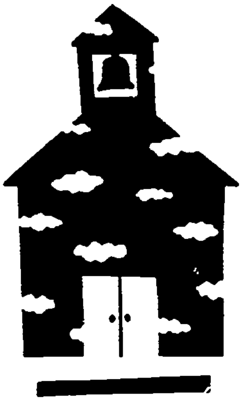
6. **Education** of the building occupants is an important activity. If people are provided information about the sources and effects of contaminants, they can act to mitigate their personal exposure. More building users will minimize their use of possible contaminants indoors when they are provided an understanding of their relationship to indoor air quality.

Description of Contaminants (Table 1)

	Description	Sources	Standards & Guidelines
ASBESTOS	Asbestos is composed of small natural mineral durable fibers.	Widely used in insulation and other building materials until recently. The use of asbestos-containing spray-on materials is banned in U.S. buildings today.	A safe level of asbestos fibers has not been established. A standard for the assessment of asbestos material and selection of an appropriate action will be detailed in the final federal regulations due out [illegible] the Asbestos Hazard Emergency Response Act [illegible] AHERA. AHERA also will provide a clearance [illegible] abatement projects [illegible] TEM.
TOBACCO SMOKE	Tobacco smoke consists of solid particles, liquid droplets, vapors and gases resulting from tobacco combustion. Particles of condensed combustion products are almost all in the respirable range and [illegible] specific materials have been identified in the particulates and associated gases.	Tobacco combustion.	No general standard has been agreed [illegible] ASHRAE standard [illegible] in quantities of [illegible] cubic feet per minute per person where smoking is permitted [illegible] the ASHRAE standard is being revised [illegible] is now contemplated.
FORMALDEHYDE	Formaldehyde is a colorless water soluble gas. Due to its wide use it is frequently considered separately from other volatile organic compounds (VOCs).	Materials containing formaldehyde are widely used in buildings, furnishings and consumer products. Urea formaldehyde resins are used in the manufacture of plywoods, particleboards and textiles. The walls of some buildings have been insulated with urea formaldehyde foam insulation (UFFI). Formaldehyde outgases from the above mentioned products. Tobacco smoke and other combustion products are secondary sources. Indications are that in time outgassing diminishes from materials.	[illegible] ASHRAE [illegible] standard [illegible] states [illegible] residences [illegible] emission rates [illegible]
OTHER VOLATILE ORGANIC COMPOUNDS (VOCs)	There are hundreds of other volatile organic compounds that are found in the indoor air sometimes in concentrations which are suspected of being harmful. Those listed below do not comprise a complete list. acetone—by products of human metabolism, cleaners, personal care products, tobacco smoke acrolein—tobacco smoke alcohols—by products of human metabolism, cleaners, personal care products, tobacco smoke ammonia—cleaners, tobacco smoke aromatic hydrocarbons—combustion processes, pesticides, paints, solvents, tobacco smoke benzene—combustion processes, gasoline, solvents, tobacco smoke chlorinated hydrocarbons—PCBs, wood preservatives, solvents organophosphates—pesticides phenols—equipment, furnishings, tobacco smoke toluene—adhesives, gasoline, paints, solvents, tobacco smoke		Gas chromatographs [illegible] meters are used [illegible] measure VOCs [illegible] suitable [illegible]
NITROGEN OXIDES	The two most prevalent oxides of nitrogen are nitrogen dioxide (NO_2) and nitric oxide (NO). Both are toxic gases with NO_2 being a highly reactive oxidant and corrosive. NO gradually reacts with the oxygen in the air to form NO_2.	The primary sources indoors are combustion processes such as unvented combustion appliances, vented appliances with defective installations, welding, and tobacco smoke.	No standards have been agreed [illegible] in indoor air. The U.S. National Ambient Air [illegible] Standards [illegible] limit as does ASHRAE.
CARBON MONOXIDE	CO is a colorless, odorless and tasteless gas. It results from incomplete oxidation of carbon in combustion.	Incomplete oxidation during combustion in gas ranges, unvented heaters, leaky wood and coal stoves and tobacco smoke may cause high concentrations of CO in indoor air. Worn or poorly adjusted and maintained combustion devices can be significant sources. Automobile, bus or truck exhaust entering buildings from attached garages, nearby roadways or parking areas can also be a source of CO.	No standards [illegible] indoor air. The U.S. National [illegible] standard [illegible]
CARBON DIOXIDE	CO_2 is an odorless, tasteless and colorless product of completed carbon combustion.	All combustion processes and the human metabolic processes are CO_2 sources. Concentrations of CO_2 from people and smoking are always present in all occupied buildings.	[illegible] ASHRAE standard [illegible] upper limit [illegible]
ALLERGENS AND PATHOGENS	Biological material, bacteria, viruses, fungi, mold spores, pollens and insect parts are ubiquitous in indoor environments. These particulates range from less than one to several microns in size. When airborne they are usually attached to dust particles of various sizes so that all sizes of airborne particulates may include them.	People and animals shed such materials. Rugs, bedding, carpeting and other places where dust collects can harbor them. Cooling towers have been known to be incubators of Legionella bacteria. Dirty air-conditioning equipment, humidifiers, condensate drains, and ductwork can incubate bacteria and molds. High humidity areas exacerbate their growth.	No standards exist for general [illegible] except that ASHRAE recommends a relative humidity between [illegible]
RADON	Radon is a radioactive gas, the first decay product of Radium-226. It decays into solid alpha emitters which can be inhaled directly or attach to dust particles which are inhaled. The unit of measure for radon is picocuries per liter (pCi/L).	Radium is ubiquitous in the earth's crust in widely varying concentrations. Well water can also have high concentrations of radon. Masonry building blocks can have radium concentrations. The earth around buildings, however, is the principal source of indoor radon. Radon penetrates cracks and drain openings in foundations, into basements and crawl spaces. Water containing radon will outgas into spaces when drawn for use indoors. Some building materials will outgas radon, some of which may enter buildings.	[illegible] EPA [illegible] ASHRAE [illegible]

x

Comfort & Health Effects	Measurement Methods	Control Measures
No acute health or comfort effects due to asbestos are known. Fibers deposited in the lung are the only known cause of mesotheliomas, a fatal cancer of the pleural or peritoneal linings of the body. Asbestosis and other lung conditions also have been associated with asbestos exposures.	Phase contrast microscopy is used as a screening method for sampling asbestos fibers in the air. Fibers other than asbestos are also counted. Electron microscopy is a method which can distinguish asbestos definitively, but it is much more expensive than PCM and takes longer to complete. The proposed AHERA regulations require schools to use the TEM protocol for clearance samples for projects. Its use is phased in through Oct [illegible]	Asbestos abatement in the U.S. is being handled as a special case separately from other air pollutants by U.S. agencies due to the perceived high public risk. The methods of abatement include repair, removal, enclosure and encapsulation.
The effects of tobacco smoke on smokers are well known. However, many people who do not smoke object to smoke in their environments because of eye, nose and throat irritation. The health effect on non-smokers has received increased attention. Acute health effects have been found in the lung function of children and spouses of smokers, and allergic reactions occur in a small fraction of the population.	Particulate concentration is measured by optical scattering or gravimetrically by particles collected on filters. Gas chromatographs are used to study gaseous components. Enough work has been done so that reasonable estimates of the source strength can be made by simply counting smokers and estimating that about [illegible] of adults smoke and consume about two cigarettes per hour.	Prohibition of smoking or [illegible] is becoming more common. [illegible] is partially effective but careful management of ventilation is required. If well applied and properly maintained, high efficiency air cleaners and gas filters are effective. Increased ventilation is partially effective since very large ventilation rates are necessary [illegible]
Formaldehyde has a pungent odor and is detected by many people at levels of about 0.1 ppm. Besides the annoyance it also causes acute eye burning and irritates mucous membranes and the respiratory tract. Formaldehyde has also caused nasal cancer in laboratory animals, but chronic effects have not been established for human beings. Some people exhibit a high sensitivity to very small concentrations.	Inexpensive passive samplers and detector tubes have been developed. The more accurate method of collecting formaldehyde is by impingers. Concentrations are then determined by colorimetric methods.	For problem UFFI cases, removal [illegible] the cost can be high. Even then residual materials may remain in the structure and [illegible] Increased temperature, humidity [illegible] accelerate outgassing. Therefore ventilation [illegible] an effective means of mitigation. [illegible] manufacturers are producing products with lower outgassing rates. Some surface treatments are being used to seal against outgassing, but long term effectiveness [illegible]
No standards have been set for VOCs in non industrial settings. NIOSH has recommended occupational standards for many compounds. ASHRAE standard 62-1981R (as currently proposed) includes a rationale suggesting that in the absence of better data the NIOSH limits be divided by 10 to account for the possible continuous rather than workplace time of exposure and to account for the elderly, young and infirm in the general population.	Several of these compounds have been identified individually as causing acute and chronic effects at high concentrations. Some have been directly linked to cancer in humans and others are suspected of causing cancer. The effects of combinations of the compounds at low concentrations have been suggested as causes of several sick building situations.	Where practical, uses of these sources should be restricted, and these materials should be stored in well ventilated areas apart from occupied zones.
Oxides of nitrogen have no sensory effect at low concentrations. Acute effects of lung dysfunction have been reported at higher concentrations. Oxides of nitrogen produce immediate short term effects on airway reactivity. Persons at special risk are those with chronic [illegible] emphysema, asthma and children under 2 [illegible] effects are not well established.	Small inexpensive passive NO_2 monitors suitable for field use are available. Nondispersive infrared techniques are used to measure nitrogen oxides in laboratory settings or for continuous monitoring.	Venting the NO_x source [illegible] practical measure for existing conditions. Manufacturers are developing devices which generate lower NO_x emissions.
Acute effects are due to the formation of carboxyhemoglobin in the blood, which inhibits oxygen intake. At moderate concentrations, cardiovascular disease, impaired vision and loss of brain function may result. At higher concentrations CO exposure is fatal.	Some relatively high cost infrared radiation absorption and electrochemical instruments do exist. Moderately priced real time measuring devices are also available. A passive monitor is currently under development.	It is most important to be sure combustion equipment is maintained and properly adjusted. Vehicular use should be carefully managed adjacent to buildings and in vocational programs. Additional ventilation can be used as a temporary measure when high levels of CO are expected for short periods of time.
At concentrations above [illegible] ppm, some loss of mental acuity has been noted.	Instruments exist which are reliable and inexpensive for most commercial applications.	Ventilation methods are used to control carbon dioxide.
[illegible] diseases, staphylococcus infections and influenza are known to be transmitted by air, as is Legionnaires' disease. Pollens and molds can cause allergic reactions for a significant portion of the population.	Air samples must be collected on appropriate microbial media and incubated for visual examinations of viable growths. Microscopic examinations of collected dust can be used to identify molds and pollen. No inexpensive field monitors exist which are suitable for large-scale use. Active sampling should be the method of choice (e.g. Anderson two-stage impactor or impinger).	General good housekeeping and maintenance of heating and air conditioning equipment are very important. Adequate ventilation and good air distribution also helps. Higher efficiency air filters remove large particles along with other particulates. Cooling tower treatment procedures exist to reduce levels of Legionella and other organisms.
No sensory perception or acute health effects are known. The chronic effect is lung cancer or other lung dysfunction due to the retention of radon decay products in the lung. These chronic effects are among the best known of all indoor pollutants as the result of studies on uranium miners. It is speculated that non-occupational radon exposure in the U.S. may cause between [illegible] and [illegible] additional cancer deaths per year.	Inexpensive charcoal canisters (less than $15) are available to screen radon concentrations over a four to seven day period. Relatively inexpensive alpha track detectors (less than $50) are available for survey use which integrate radon concentration over a one month to one year period. Air sampling instruments for real time measurements are more expensive. No inexpensive method exists to measure radon decay products concentrations.	Sealing of foundations to prevent entry has been demonstrated to be effective, although the long term reliability of sealing is unknown. Specific ventilation of basement areas and crawl spaces has also been shown to be effective. Increased ventilation with outdoor air will lower radon levels for a given building. However, radon levels do not correlate well with ventilation rates among different buildings, i.e. buildings with low ventilation rates will not necessarily have high indoor radon levels and vice versa.



Investigation of an Indoor Air Quality Problem

This section is designed to help school officials who respond to reports of indoor air quality problems It is aimed at acute symptoms, such as headache and mucous membrane irritation, most commonly caused by poor indoor air quality. Two forms are presented on the following pages, a short form and an extended form The short form will serve for investigations with an obvious source of the problem The extended form should be used when the cause of the problem is not immediately apparent to the investigator The purpose of these forms is to provide a mechanism for school system staff to quickly investigate and solve indoor air quality problems with their own resources whenever possible A prompt visit is key to identifying many sources and to maintaining good relations with the people experiencing the problem

The investigation is symptoms-driven, you begin when symptoms are reported and stop when symptoms are eliminated If symptoms appear to be serious, life-threatening, or likely to cause long-term health damage, it may be necessary to bring in an outside consultant immediately and move very rapidly through the investigation while taking immediate steps to protect faculty, staff, and students This may include building evacuation This investigation process does not replace a disaster plan such as would be required for a chemical spill near a school nor address long term hazards

The forms should be filled out at the site of the problem Primarily two individuals are involved the "reporter" who is the person who has recognized the problem and the "investigator" who is assigned to evaluate the problem When the form is completed, it should be filed at the central office and at the school

Once the school officials have designed a strategy to identify and/or solve the problem, they may obtain outside assistance, if needed Consultation may be available from the public as well as the private sector and could involve medical diagnosis, air pollutant monitoring, and/or HVAC system evaluation and redesign Previous work should prepare school officials to clearly define what tasks a consultant is to perform, the techniques to employ, the anticipated product, and how it will aid the solution Every building is different and needs for consultation must be considered on a case-by-case basis Finally, school officials need to be prepared to follow the consultant's recommendations

Investigation of an Indoor Air Quality Problem
(Short Form)

Date Time Notified: ______________ Who Reported: ______________

Position: ______________

Building Name ______________

Building Location ______________

Designated Investigator ______________ Position ______________

On-Site Evaluation Date: ______________ Time: ______________

People Present: ______________

Reporter Describe the problem including symptoms.

Investigator Is there an obvious source of the problem? If so, record the source and describe your assessment and plan of action (if a plan of action is not apparent, seek consultant services).

Signatures: Investigator ______________ Date: ______________

Principal. ______________ Date: ______________

If there is no obvious cause of the problem, proceed to the following extended form.

Investigation of an Indoor Air Quality Problem

(Extended Form)

Symptoms Questionnaire

Complete this questionnaire for each person affected (use additional pages as required)

Name of person. ______________________________

Specific building location(s) involved. ______________________________

Date: ______________________ Time: ______________________

Person administering questionnaire ______________________________
(May be self-administered)

Do you have a history of allergies? If yes, describe the type of problem, when it occurs, and any medication you take

Check any symptoms you have experienced since the beginning of the school year. Estimate and check number of days you have had this symptom

	0-24 Hrs	24 Hrs-1Wk	1-4 Wks	>4 Wks
☐ Headache	☐	☐	☐	☐
☐ Dry mouth	☐	☐	☐	☐
☐ Dizziness or Faintness	☐	☐	☐	☐
☐ Weakness	☐	☐	☐	☐
☐ Difficulty Concentrating	☐	☐	☐	☐
☐ Eye Irritation	☐	☐	☐	☐
☐ Hoarseness	☐	☐	☐	☐
☐ Fever	☐	☐	☐	☐
☐ Burning of the Nose	☐	☐	☐	☐
☐ Throat Irritation	☐	☐	☐	☐
☐ Nasal Congestion	☐	☐	☐	☐
☐ Coughing	☐	☐	☐	☐
☐ Skin Irritation	☐	☐	☐	☐
☐ Other (describe):	☐	☐	☐	☐

Have your symptoms occurred ☐ Continually ☐ Intermittently

Did you have any of these symptoms during the last summer or school year? If yes, name them. ______________________________

If you checked any symptoms, please describe in more detail:

Have you sought medical attention for these symptoms? Describe.

During which months are you likely to experience symptoms? (Circle all that apply).
J F M A M J J A S O N D

During which days of the week are you likely to experience symptoms? (Circle all that apply)
M T W Th F S S

During which part of the day are you likely to experience symptoms? (Circle all that apply)
a.m. p.m All-the-time Anytime

What are the weather conditions when you experience symptoms?
- ☐ Rainy, stormy
- ☐ Dry
- ☐ Calm, mild
- ☐ Windy
- ☐ Hot, humid
- ☐ Cold

How long have you worked/attended school in this building?

After you began work or started school in this building, how long was it before symptoms started? (Circle one)

Right away days weeks months years

Symptoms began before I was in this building

If you leave the building, do your symptoms improve? Yes ____ No ____
If yes, how rapidly: minutes hours overnight days

Do you smoke? Yes ____ No ____

Are you bothered by cigarette smoke? Yes ____ No ____

Have you detected any odors? Describe.

What do you think is the cause of your symptoms.

Potential Sources of Indoor Air Quality Problems

The investigator may complete this section to the extent necessary to identify a likely source of contamination.

There are many potential sources of indoor air pollution, many not immediately apparent. This questionnaire will assist in the recollection of events that may have contributed to exposure to specific pollutants. This should be a "brain-storming session" with the investigator collecting all possible information and not trying, yet, to judge its relevance to the present problem.

If appropriate, sketch the affected area including equipment, activities, lighting, intake and exhaust ducts, room dividers, and windows. Also include the adjacent rooms and spaces (e.g., science classroom). Attach your drawing.

Does this area or a nearby area have:
- ☐ Motor vehicles
- ☐ Arts and crafts
- ☐ Animals
- ☐ Garbage storage
- ☐ Science
- ☐ Cigarette smoking
- ☐ Duplicating machine
- ☐ Industrial arts
- ☐ Other ____________

Has there been any:
- ☐ New construction
- ☐ Pesticides used
- ☐ Painting
- ☐ Installation of carpets
- ☐ Cleaners used
- ☐ Other ____________

Is there any evidence of:
- ☐ Water damage or stains
- ☐ Mold growth
- ☐ Dirt around air ducts

Equipment, Materials, Supplies

List equipment, materials and supplies that have been introduced or modified, or whose emissions are not being removed

a) Equipment

Type, brand, model number	Date installed	Special comments
1		
2.		
3		
4		
5		

b) List materials used in this classroom or work area:

Material description or brand	Date of use	Special comments (any warnings on labels?)
1		
2		
3		
4		
5		
6		
7		

c) List furniture, accessories, and their protective coating used. Include rugs, drapes, curtains, or other decorative materials

Type	Material	Date introduced	Comments
1			
2			
3			
4			
5			
6			
7			

d) List any chemicals introduced such as paints, surface coatings, floor, rug or fabric cleaners, deodorants, insecticides, detergents, etc.

Type of material (include brand)	Use	Last date used	How often used	Comments
1				
2				
3				
4				
5				
6				
7				

Activities

a) List activities performed in this classroom or work area:

Activity	Usual schedule	Emissions from activity (heat, odors, fumes)
1		
2		
3		
4.		
5		
6		
7		

Episodic or Unusual Events

Building problems sometimes begin after an event such as pipes breaking, roof leaks, etc. Describe any such events

Event	When occurred	Comments
1		
2		
3		
4		
5		

Evaluation of Heating, Ventilation, and Air Conditioning (HVAC) Systems

As needed, the investigator or a person knowledgeable about proper operation and maintenance of heating, ventilation, and air conditioning systems should complete this section of the protocol. Often the HVAC system is the cause of an indoor air problem, delivering air that is the improper temperature or humidity or delivering too few air changes for human comfort. Also, improper maintenance can lead to mold growth, which may be the source of symptoms. It is important to have a way to identify these problems. In most cases, adjustments in the HVAC system will eliminate indoor air symptoms. When a point source is causing the problem, several solutions exist: the source can be eliminated, local ventilation can be installed, or alterations in the HVAC system may be necessary.

The following pages will allow you to systematically review the HVAC system and identify common types of problems Some school systems may be able to collect additional data due to appropriate staff and equipment.

In any investigation of a problem with the indoor environment, it is important to understand how the HVAC system in the building works and to document any recent changes that may have occurred in the HVAC system's design or operation

It will be very important to the investigation if, in addition to answering the general questions below, the investigator obtains prints or diagrams of the HVAC system for the affected area as well as a description of the building intake and exhaust systems and any other pertinent information

1 Is the building served by one HVAC system or is the building divided into sections served by different units? Describe

2 What type of heating is used for the building?
  a) On site boiler Yes _____ No _____ If yes, what type of fuel:
    Gas _____ #_____ Oil Other _____
    Approximate age of boiler _____
  b) Central steam: Yes _____ No _____
  c) Electric. Yes _____ No _____
  d) Other _____

3 Is accessory heating used in the affected area? Yes _____ No _____
  If yes, please describe _____

4 What type of cooling?
  ☐ None ☐ Central ☐ Area ☐ Individual Unit

5 Temperature
  What is the air temperature of the room(s) involved?

Room	Time	Wet-Bulb Temp	Dry-Bulb Temp
a)			
b)			
c)			
d)			

6 Ventilation:
  Can windows be opened? Yes _____ No _____
  Is there a central ventilation system? Yes _____ No _____
  Where is the fresh air intake with respect to any building exhausts? (e.g. boiler flue, kitchen exhaust)

7 Are the outdoor air dampers on air handling units fixed in the closed position or not providing outdoor air for another reason? Yes _____ No _____
  If yes, list each air handling unit and the space(s) served:

8 Are there other areas in the building that share the same conditioned air as the area where symptoms have occurred? Yes ____ No ____

If yes, there may be activities within these areas that could emit gases or aerosol of liquids or solids into the air circulated throughout the building. Based upon what you know about activities in the building, please list those which should be investigated

9 Are there any activities outside the building, such as garages, industrial plants, restaurants, and dry cleaners, whose emissions can under certain conditions be taken in by the building ventilation system? List them

10 Are condensate pans in air handling units draining? Yes ____ No ____

11 Were there any changes made in the heating, ventilation, and air conditioning system around the time of the incident? If so, describe them.

Investigator's Assessment:

Review previous data collected. Summarize the main features of this problem and what you think are the relevant sources or HVAC information. This should be only a few paragraphs and should demonstrate the logic of your hypothesis as to what is causing the problem

Do you have an explanation for these symptoms? (for assistance, review Frequently Encountered Problems on Pg 18)
Yes ____ No ____

If yes, what is the cause?

What is the recommended solution and time frame?

If no, what is the next step (this is a matter or judgment for the investigator)?
____ Monitor for 1-3 weeks to determine if the problem continues

____ Initiate further evaluation

Signatures: Investigator ____ Date ____
Principal ____ Date ____

Follow-Up: (complete A or B as appropriate) Follow-up should take place 1-3 months after the initial response or after the action plan is completed. Continuous communication should be maintained with the reporter(s)

A This problem has been solved:

Signatures: Investigator ______________________ Date: ____________
Principal ______________________ Date: ____________

B This problem has not yet been solved (describe the ongoing problem briefly):

____

____

Action planned and time frame (describe): ______________________

____

____

We have discussed the problem and recommend the above plan of action for its evaluation and solution

Signatures: Investigator: ______________________ Date ____________
Principal: ______________________ Date: ____________

Frequently Encountered Problems

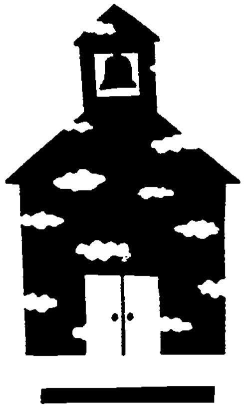
1 Ventilation
- Vents obstructed by furniture, partitions, etc
- Local exhaust improperly used/functioning
  - Shop areas
  - Arts and crafts
  - Science labs
  - Home economics
  - Photo lab
- Loose Fibrous glass insulation inside ductwork
- Maintenance or repair of HVAC system
  - Inadequate fresh air intake
  - Improper air flows (check settings of dampers)
  - Fans blowers wired incorrectly
  - Toxic solvents used to clean the system
  - Inadequate air distribution

2 Volatile organic compounds
- Paints
- Cleaning fluids
- Furniture stripping
- Heating oil
- Science lab
- Auto repair (degreasers, cleaners, gasoline)

3 "Fumes"
- Welding
- Auto, bus, truck exhaust

4 Thermal
- High or low temperature
- High or low humidity

5 Other
- Formaldehyde
  - Plywood and pressed wood products
  - Carpet and glue
  - Draperies, furniture, etc
- Carbon monoxide
  - Boilers and furnaces
  - Motor vehicle exhaust
- Particulates
  - Tobacco smoke
  - Diesel exhaust
- Carbon dioxide
- Arts and crafts
- Molds
  - In standing water



Building Maintenance and Operations

Once a building has been constructed, responsibility for preserving good indoor air quality rests with the building operations and maintenance functions. *School systems must establish a comprehensive facilities maintenance program*

The office that supports this program should be involved before a new school or one that has undergone major renovation is accepted. This will enable its staff to understand the building systems as designed and installed

Program Management

In order to implement a maintenance operations program, three elements that must be provided:

1. *Administrative Support* from the highest level of the organization, including a firm commitment from the school board and/or supervisors must be solicited;
2. *Staffing* by trained, and competent personnel;
3. *Budgetary Allocations* to provide the operations and maintenance staff with the resources to provide the comprehensive services necessary to maintain indoor air quality.

The following areas need to be addressed and documented in a written program:

1. Inventory

A. What are the major building systems?

- i Electrical
- ii. HVAC
- iii Humidification
- iv. Incineration
- v. Plumbing
- vi. Special Areas:
  - Loading Docks
  - Food Services
  - Art Areas
  - Theatre Crafts
  - Automotive Repair Shops
  - Industrial/Vocational Shops
  - Duplicating and Copy Rooms
  - Teacher Lounges
  - Gymnasiums-Pools
  - Laboratories
  - Storage Facilities

2. Systems Description

A description of the systems, their specifications, control parameters, and design should be part of a Comprehensive Facilities Maintenance Plan. This is a particularly important and often overlooked program element It is of crucial importance to both existing and new staff in the building

3. Operational Plan

A written operations manual should describe how to actually run the building systems The plan should provide a detailed step by step procedure covering operation from start up to shutdown. This document will be an essential reference for day to day activities and is a useful training document for new employees.

The written operational plan should cover the building system instrumentation that will gather information or data on physical plant system performance It should list design criteria; performance criteria: acceptable ranges for fluctuations in gauges. meters. and recorders. and trouble shooting strategies Information on the frequency of both routine and preventive maintenance should be part of the document.

4. Comprehensive Preventive Maintenance Plan

A The Concept

Preventive maintenance should be incorporated into any indoor air quality program It is vital to periodically check systems to prevent small deficiencies from blossoming into major costly outages For example. oiling a bearing on a fan system on a monthly basis will extend the useful lifetime of the unit and prevent the potential loss of make-up or exhaust air necessary for adequate indoor air quality

B Maintenance Scheduling

Scheduling periodic maintenance can be an important determinant of indoor air quality Both the frequency and timing are important For example. biological growth of fungi and bacterial organisms have often been isolated from a unit window ventilator with condensation pans In some environmental studies. these organisms have been shown to cause disease in building occupants Since school system unit ventilators run throughout the school year, they will accumulate an increasing bioload as the year progresses and will potentially be disseminating biologically active aerosols to the buildings occupants If the school system waits until June to clean and disinfect these units. they may pose a greater risk to building occupants than if they were to disinfect these units several times during the year

Preventive maintenance must be tied to the buildings utilization schedule For example. painting, coil cleaning or other projects involving the use of volatile organic chemicals should be scheduled to minimize the number of people potentially exposed These activities are best done when there are few occupants and the facility has the opportunity to air out

5. A Materials Management Program

It is important to understand that the chemicals used in housekeeping. maintenance. operations. pest control. and cafeteria services can effect air quality and. subsequently. the health of a building's occupants The chemicals used in the building should be inventoried and a material safety data sheet obtained from the manufacturers or distributors *If the chemical composition is not specifically stated. the school has an obligation to reject the material and thereby not subject the building's population to unknown and potentially harmful effects*

The chemical composition must be evaluated with regard to hazardous ingredients and also hazardous reaction potential based upon the use or application Wherever possible. materials. chemicals. and reagents that present the lowest toxic potential should be used. By this. it is meant that if two floor strippers are evaluated. their solvent compositions should be compared on the basis of acute toxicity. concentration to be used in the task. and vapor pressure Consideration must also be given to materials that present a risk of carcinogenicity. mutagenicity. or toxicity to a specific organ in the body.

Less toxic materials should be substituted for more toxic materials. In general. water soluble materials should be given preference to organic solvent systems. Materials that are higher in flash point and/or have a lower vapor pressure are also preferred For example. latex. water-based paints are less noxious than oil-based paints If oil based paints must be used. special low odor paints and or ventilation practices can be employed. Sulfuric acid based drain cleaners have resulted in the emission of hydrogen sulfide gas in some institutions. sodium hydroxide drain cleaners might be preferable.

Minimize the quantities of potentially hazardous materials purchased, stored, and dispensed. One way of doing the latter is to evaluate the frequency of certain procedures For example. one institution issued a contract to an outside firm to perform pest control in cafeteria and food storage areas. The outside firm was most anxious to appear conscientious and competent. In their zeal, they undertook a spray application program every five days. The compound selected for use had a 75 day half life (i.e., if one pound were distributed in the area. 75 days later half a pound would still be left on the surfaces). Within a short period of time there were no insects to be seen. nevertheless. the company continued to apply the insecticide. increasing the build-up of indoor environmental insecticide concentrations In addition. stored concentrated stock solutions were found to be leaking and emanating vapors that were captured and circulated by the building HVAC system.

6. Roofs

Poorly drained roofs may be a potential source of poor indoor air quality. The architects designing facilities should take special care to ensure that roofs are sound and well sloped. Minimally sloped roofs invariably pool water and leak or require extensive maintenance involving adhesives or tars. These materials frequently enter the air intakes. The adhesives commonly used are potent central and peripheral nervous system toxins. The roofing tars are known to contain sensitizing agents, carcinogenic and mutagenic polynuclear aromatic compounds.

These materials may be particularly harmful to children with growing bodies. Roofing operations, therefore, should be undertaken when the exposures to building occupants can be minimized. The best time is when the school is unoccupied. Wherever feasible, enclosed day tankers of tars should be used instead of open kettles to minimize the evolution of organic vapors. The tar tanks should be located as far from air intakes as possible and preferably downwind from the building. If such measures are not feasible, then certain air intakes should be temporarily blocked while provisions for supplemental uncontaminated outside air are made using portable fans.

Pooling on roofs resulting in stagnant, standing water can support the growth of algae, bacteria, and possibly viruses that can be drawn into building air systems. Leaks in roofs result in water damage or accumulation in ceiling tiles, rugs, or internal wall spaces. Fungi and bacteria that opportunistically capitalize on this moisture have been found to be responsible for allergies and respiratory disease. Consequently, when roofs are sloped inadequately or roof repairs are postponed, indoor air quality can easily be compromised. Water-damaged materials must be removed and replaced in a timely fashion before they serve as a substrate for biological growth.

In buildings that contain asbestos surface or acoustical treatments, water damage represents a particular health threat. Water can delaminate asbestos coatings, fireproofing, or decorative treatments. The weight of water-soaked asbestos may be sufficient to separate the coating from the substrate. Upon impact at the floor, free fibers of asbestos can be released into the room and distributed throughout the entire building.

In buildings where asbestos material has been encapsulated with a bridging agent, the weight of water from a leaking roof can bring portions of the encapsulated asbestos down. The resultant fiber release from the interior of the encapsulated material then creates a hazardous condition.

7. Condensation Pans

For years, chloroben (dichlorobenzene) has been in common usage as an algaecide in condensation pans. Normally it is mixed in a 1 to 4 ratio with water, and a cup is placed into the condensation pan on a monthly basis. One institution had to evacuate pregnant office staff with symptoms of nausea, headaches and malaise after a maintenance application of one gallon of pure cloroben into an operating air handling system. The organic compound volatilized and created airborne concentrations in excess of 200 parts per million (ppm). Chloroben has been associated with changes in bone marrow and blood cells. It often contains a manufacturing contaminant, benzene, that has been associated with leukemia. This substance is inappropriate in school settings. This unfortunate incident highlights the importance of understanding that "more is not necessarily better."

Condensation pans must be periodically cleaned and checked to ensure that they are draining. If an algaecidal treatment is not periodically administered, the drain lines can become blocked and must be reamed out. Non-draining condensation pans can provide an ideal dark moist environment for biological growth within air distribution systems.

8. Welding, Brazing, Cutting or Soldering

Maintenance operations, automotive repair, and theater or craft procedures involving welding, cutting, brazing, or soldering should be performed in ventilated facilities dedicated to those tasks. Often, however, these operations cannot be done in such a controlled setting and field operations must be undertaken. Welding, cutting, soldering, and brazing evolve toxic gases and particulates that should be vented outdoors. If this is not possible or impractical, then filtration is needed. To protect indoor air quality a portable system equipped with a high efficiency particulate filter backed with an activated carbon filter should be used. It is essential that such systems be equipped with a flexible capture hood to entrain environmental contaminants at their source.

9. Mechanical Systems

Pulleys, belts, bearings, dampers, heating and cooling coils, and other mechanical systems must be checked periodically. A checklist should be developed that is custom tailored for the particular building. This will assist the maintenance and operations staff when performing inspections. Pulleys and belts should be tightened as needed and changed prior to failure. Bearings should be lubricated or repacked to prevent major failure of vital system components. Air distribution dampers and baffles should be cleaned and cleared of debris periodically. Failure to perform these activities will result in an increase in resistance causing a decrease in air supply.

The air distribution duct network should have access ports to facilitate vacuuming deposited dust and particulate matter. It may be necessary at some point in the building's lifespan to use a dilute solution of bleach (sodium hypochlorite 5%) to decontaminate the inner surfaces of air ducts. This procedure is particularly useful if tobacco combustion products have condensed on the interior surfaces of the duct resulting in a "stale" air condition. This type of building maintenance task can not be performed if the duct has an internal fibrous noise insulating lining. Interior duct insulation should be avoided if at all possible. In addition, air filters must be changed periodically.

Building ventilation distribution networks are systems. The common practice of arbitrarily adjusting the dampers or baffles to accommodate complaints from one area should be avoided. By changing the air flow in one area, the system balance is shifted and distribution throughout the entire network will be effected. If there are complaints, it is recommended that the buildings air handling system be evaluated as a whole. Annual air balancing should be performed to confirm that the HVAC system and distribution network are adequate and meet design specifications.

In order for the building ventilation system to function properly, the control mechanisms must operate correctly. Gauges must be in calibration, sensors must engage at designated ranges, and transmission lines must not be defective. Pneumatic and hydraulic transmission lines should be checked for leaks. The control mechanisms should be included in the annual preventive maintenance program. They should be checked more frequently if the ventilation system does not perform as expected.

10. Vacuuming

Normal industrial vacuums emit particles and fibers in their exhaust. An improvement in performance can be obtained if they can be fitted with a high efficiency particulate airfilter (HEPA). HEPA vacuums should be selected in areas that might have spores or microorganisms. HEPA vacuum filtration ensures that potentially toxic or harmful aerosols are not dispersed while responding to a problem. HEPA vacuums are also recommended for use in automotive and industrial shops and in craft activities that generate dusts, fumes, or particulates. Dry sweeping in these areas should be curtailed.

11. Electrical Transformers

Electrical transformers that contain polychlorinated biphenyls (PCBs) must be checked monthly and inspected for leaks. The EPA has estimated that the risk of a transformer fire is on the order of 4-5/1000 units over a transformers lifetime. The operations and maintenance program should contain a plan to either delist these units to PCB concentrations below 50 ppm or dispose of the liquid and metal carcass. The EPA has enacted regulations requiring network transformers to be decontaminated or scrapped by 1990. The EPA regulations require establishing an institution inventory of transformers and capacitors that contain more than 50 ppm of polychlorinated biphenyls. The transformers, capacitors, and transformer vaults must be labeled as specifically directed in the EPA regulations. Local fire departments must be supplied with a list of the location and description of the electrical components containing PCBs. A log book of monthly inspections of transformer vaults must be maintained as well as manifests documenting approved disposal.

Operations and maintenance procedures need to be drafted to maintain these units until the threat of a fire or PCB uncontrolled release can be eliminated. Ventilation to the transformer vaults may need to be modified to prevent toxic combustion products from being transported to the main areas of the building. Floor drains should be sealed in the vault areas and the areas posted in compliance with federal regulations. The operations and maintenance staff needs to have a working and written contingency plan for handling fires and spills of polychlorinated biphenyls.

The EPA regulations do not specifically require that PCB fluorescent light ballasts be handled as hazardous materials. Ballasts manufactured through 1978 may contain a small PCB capacitor. Ballast failure can volatilize both PCBs and the asphalt tar used to encapsulate the ballasts. Measurable quantities of PCBs have been documented by the EPA as long as a year post failure. Asphalt tars have been associated with symptoms of upper respiratory irritation. It is recommended that these type of ballasts be phased out as repairs and modifications are made in the buildings lighting system. Small quantities of ballasts can be disposed of as ordinary solid waste.

12. Drains

Drains in laboratories must be kept clear and in working order. Sediment in drain traps can provide an area where conditions support the growth and accumulation of biological organisms. In laboratory areas, broken mercury thermometers have often led to the pooling of metallic mercury in the sink traps. This phenomenon can chronically introduce mercury vapors into the indoor air. Acute exposures to plumbers and maintenance personnel must also be considered. Substitution of non mercury thermometers and gauges in laboratories is an easy preventive solution to this problem.

The antisiphon traps in sinks must contain water to prevent noxious odors from the sanitary sewer lines from migrating back into the indoor air spaces. Sinks and drains that are used infrequently can dry out allowing a path for gases to enter. Cupsinks in laboratory fume hoods and on benches frequently dry out and have often been found to be the sources of odors. This problem can be resolved and prevented by periodically running water in these drains, plugging unused drains with a rubber stopper, or using a non-toxic liquid with a low vapor pressure such as ethylene glycol to fill the antisyphon drain.

13. Building Use Changes

Special care must be exercised when building space utilization is changed. Renovation, redesign, or changes in building use can create situations that may lead to compromises in indoor air quality. For example, if a mimeograph or copy machine is brought into a small closet or other unventilated space chemical emissions such as mineral spirits or ozone may suddenly become problems. Impacts on heat load and noise levels must also be anticipated if new equipment is added to an already existing area.

A common renovation problem arises when additional personnel need to be accommodated in a space. Office or instructional areas are often partitioned and additional furniture and equipment installed. Anticipate the need to modifying the air distribution in these situations. Conversely, when partitions are removed creating new spaces, the ventilation distribution and balance must be revised. Care must be taken to ensure that, in the final design, air supplies are not located too near the exhausts so that short circuiting does not occur.

14. Pipe Leaks

Pipe leaks can occur through corrosion, mechanical failure, or because of the expansion of water due to freezing temperatures. In any case of leakage, repair or replacement of the damaged pipe section must be performed immediately. It is important that any and all leaked water be quickly removed and disposed of by pouring into a sanitary or storm drain. It is prudent to have available wet vacuums, submersible pumps, and squeeze brooms and mops to handle water emergencies. Water damaged ceiling tiles, rugs, insulation, or laggings must also be dried or removed and replaced in a timely fashion to prevent mold from growing. Following storms, it is good practice to inspect the building for discolored ceiling tiles or leaks as signs of water problems. Freezing can be prevented by ensuring that pipes that are potentially subjected to subfreezing temperatures are insulated or that the immediate spaces are connected to the heated interior of the building.

15. Filters

Mechanical equipment for ventilation, heating, and air conditioning contain filter media or screens to collect particulate matter from contaminating the coils, fans and interior housings and duct work. Originally, the primary consideration was to protect the system from contamination and loss in efficiency resulting in equipment shutdown and extensive cleaning. Recognition is now given to the role filters can play in improving indoor air quality.

Filters are primarily classified into three (3) types, mechanical filtration, adsorption, and electrostatic. Corresponding examples of each are as follows, fiberglass filters seen in our home furnaces, self-contained filter fans seen in motel bathrooms that contain a charcoal filter, and large units usually placed on incinerators to remove charged particulate matter.

School systems are primarily concerned with mechanical filtration filters. Commonly used are the replaceable fiberglass filter media, the mechanical screen media that requires cleaning and recoating, and bag type filters on large air handling equipment. This filter equipment performs the function of coil protection, reduction of particulate matter to the air supplied to the occupied spaces, and reducing dirt contamination to ducts and accessory components. Filters are rated by efficiency, air flow resistance, and contaminant holding capacity. The method of entrapment is by impingement that locks the particulates within the filter. Filters have a life expectancy rated in hours when placed in use for a given air flow with expected contaminants. This life expectancy can be reduced by contaminants reaching the filter from events like severe dry spells blowing excessive dirt or interior dust producing activities.

Filters in air handling heating units should be changed based upon the pressure drop in the system and according to the manufacturers recommendations. In many cases, filters are not being changed this frequently. Consider what this means to the operation of the equipment and the occupants of the space:

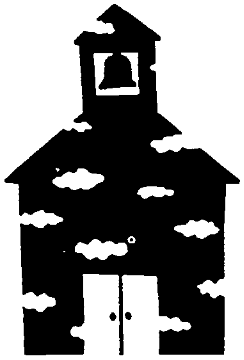
1. Equipment efficiency is reduced and more energy is required to run the fan for pulling the air through the filter.

2. Some contaminants pass through an overloaded filter clogging the coils and entering the occupied spaces.

3 Over an extended period of time the dirt collection on the coils will diminish the thermal transfer efficiency of the unit resulting in higher energy consumption.

4 Contaminants on the coils can become a breeding ground for bacterial and fungus growth.

The above comments on air handling heating units are applicable to all types of equipment containing ventilation. heating, and/or air conditioning coil systems. One must consider the expense of extensive cleaning to return this equipment to proper operation as compared to the cost of replacing filters on a scheduled basis. All filters are not equal. In procuring replacement filter media, it is important to specify the proper filter media for the equipment that it will be installed on. Remember the characteristics of air filters: efficiency, air flow resistance, and contaminant holding capacity Consider these characteristics in developing your specifications for filter media replacement and the development of your schedule for replacing filters in your equipment. The results of these considerations are a healthier environment, energy savings, and reduced costs for unscheduled cleaning of coil and duct systems



Building Planning and Design

Codes and Standards

The following codes and standards are useful references to those involved in the planning and design of educational facilities. Some may, in fact, be mandated directly by State or local law or by reference in adopted codes. Many jurisdictions adopt a code in an amended form to meet specific objectives.

Thermal Environmental Conditions for Human Occupancy—ASHRAE Standard 55-1981. The standard specifies temperature and humidity conditions desirable for the comfort of healthy people.

Ventilation for Acceptable Indoor Air Quality—ASHRAE Standard 62-1981. Now in the revision process, an earlier edition of this standard, 62-1973, has been used extensively as the basis for ventilation air requirements in model codes.

HVAC Duct System Design—SMACNA 1985. This manual prescribes techniques for design of air distribution systems.

Energy Conservation in New Building Design—ASHRAE Standard 90A-1980. This standard, now undergoing revision, provides design guidance for energy efficient building design. It is the basis for the Basic Energy Conservation Code.

Energy Conservation in Existing Buildings—Institutional ASHRAE Standard 100.5-1981. This standard provides guidelines for reducing energy use in existing institutional buildings including schools.

Air Conditioning and Ventilating Systems—NFPA Standard 90A. This standard is the primary reference for design of air distribution systems for effective fire safety. The basis for most building codes.

Basic/National Building Code BOCA—1984. This model building code has been adopted by the State of Maryland and most counties within the state. It is amended by some jurisdictions to meet specific objectives.

Basic Mechanical Code—BOCA- 1984. This model code specifically addresses mechanical systems. It has been adopted by many jurisdictions in Maryland.

Basic Energy Conservation Code—1984. This code is similar to ASHRAE Standard 90A in code format and has been adopted by many state jurisdictions.

Siting

Environmentally poor building sites can continually present negative influences on the indoor air quality of a school. Effects of various site factors are discribed below

Roadways

Schools located near streets and highways may have elevated levels of lead and carbon monoxide in the indoor air. Road surfaces can also produce dirt and dust within a school building. Factors that influence the potential impact of roadways are the proximity of the roadway, prevailing meteorological conditions, and patterns of road usage.

Vegetation

Shrubbery and trees must be used carefully since they can offer both advantages and disadvantages to the building environment. Vegetation can reduce wind-induced air infiltration and capture particulates carried by outdoor air. Hedges on the edge of school site can capture some road contaminants. On the other hand, vegetation can be a significant source of allergens. If planted low and close to a building, vegetation can encourage mold growth and distribute pollen directly into air intakes or other building openings.

Soil

Radon arises from the radioactive decay of certain elements in the soil. Radon levels in the indoor air depend upon the concentration of radon sources in the soil, the potential for migration into the building, and the air exchange rate of the structure. Below grade building levels are more susceptible to radon contamination. Unvented crawl spaces are also potential problems. There is a test to examine soil for radon, however, there is no agreement on how to interpret these tests and apply the findings to school building siting or design.

School planners also have to consider prior usage of a site or adjacent sites before purchasing property for school use. Of particular concern are the prior use of chemicals as well as previous landfill and hazard waste disposal sites.

Ventilation

Introduction

If the source of an indoor pollutant cannot be avoided or reduced, ventilation becomes the primary means of control of air contaminants within occupied spaces. Properly filtered outside air is normally sufficiently free of building or occupant generated contaminants (such as carbon dioxide, bacteria, and tobacco smoke) to offer the means for diluting those contaminants. In the absence of strong sources, contaminant levels can be held to acceptable levels by air supplied at the appropriate rate and well distributed. Recirculated air, when filtered or otherwise purified to remove contaminants, is also used for effective dilution and control. Removal of contaminants at the generation source through exhaust ventilation, e.g., hood exhaust in a science classroom, is another effective way to control indoor air quality.

Outdoor Air

The outdoor air employed for ventilation should not have contaminants exceeding concentration limits stated in the National Ambient Air Quality Standards (NAAQS) as established by the U.S. Environmental Protection Agency and enforced by the Maryland Department of the Environment.

If outdoor air gaseous and particulate contaminant concentrations are known to exceed the maximum levels established by the EPA NAAQS, the air should be treated by filtration and sorption or other proven gas removal methods to reduce contaminants to acceptable levels.

Air inlets and exhaust air outlets at the building exterior should be located to avoid contamination of the ventilation air supply. Contaminants from sources such as cooling towers, sanitary vents, vehicular exhaust from parking garages, loading docks, and street traffic should be avoided. Where soils contain high concentrations of radon, ventilation practices that place crawl spaces, basements, or underground ductwork under negative pressure could increase radon concentrations in buildings and should be avoided.

Basis of Control of Indoor Contaminants

Providing appropriately treated outdoor air at a sufficient rate to dilute contaminants that are generated internally by building occupants, processes, or building materials is a means of achieving acceptable indoor air quality. Indoor air quality is usually considered acceptable if outdoor air of acceptable quality is supplied to the occupied space at the rates prescribed in Table 2. Generally, the contaminants generated within a space are assumed to be related to the occupants and their activities.

The provision of acceptable outdoor air at the rates indicated in Table 2 is intended to achieve an acceptable level of indoor air quality by controlling CO_2 to a concentration of 1,000 ppm or less. CO_2, not itself considered a harmful contaminant at this concentration, is used as a surrogate measure for other contaminants common to those occupied spaces, including some particulates and odors. The outdoor air being supplied should be appropriately treated and cleaned to reduce dusts, pollens, smoke, and other particulate or gaseous contaminants to an acceptable level

Table 2
Outdoor Air Requirements For Ventilation*

Applications	Estimated Max. Occupancy People/1,000 Ft.²	Outdoor Air CFM/ Person	CFM/ Ft.²	Notes
Classrooms	50	15	-	
Laboratories	30	20	-	Note 1
Training Shops	30	20	-	Note 1
Music Rooms	50	15	-	
Libraries	20	15		
Corridors	-	-	0.1	
Auditoriums	150	15		
Smoking Lounges	70	60	-	
Office Space	7	20	-	
Conference Rooms	50	20	-	Note 2
Reception Areas	60	15	-	
Locker Rooms	-	-	0.5	
Gymnasiums (Playing Floors)	30	20	-	
Swimming Pools	30	20		Note 3
Spectator Areas	150	15		
Public Restrooms	-	50	-	Note 4
Darkrooms	-	-	0.5	
Kitchens	20	15		Note 5
Cafeteria	100	15		

Note 1 Special contaminant control systems may be required for processes or functions
Note 2 Supplementary tobacco smoke removal equipment may be required.
Note 3 Higher values may be required for humidity control.
Note 4 Value given is cfm per water closet or urinal.
Note 5 Make-up air for hood exhaust may require more ventilation air The sum of outdoor air and transfer air of acceptable quality from adjacent spaces should provide an exhaust rate of not less than 1.5 cfm per ft²

* Table 2 and other material contained in these guidelines have been extracted from proposed ANSI ASHRAE Standard 62-1981R published in draft form for public review dated July 15 1986 It must be recognized that certain data and material ultimately published in the completed standard may differ from that contained in the draft

Exhaust air from one space sometimes can be used as supply air to another space where different contaminants are generated (corridors and office spaces exhausted through toilet rooms or adjacent areas exhausted through kitchens); this exhaust air should then be considered equivalent to acceptable outdoor air.

A space may require ventilation to remove contamination generated within the space, but unrelated to human occupancy (e.g., outgassing from buil ng materials or furnishings). For these cases, Table 2 lists quantities of cfm/ft² or an equivalent term. If human carcinogens or other harmful contaminants are suspected to be present in the occupied space, other relevant standards or guidelines requiring higher ventilation rates (e.g., OSHA, EPA) must take precedence over these guidelines However, in general, every effort should be made to eliminate highly toxic materials from the school If suitable substitutes can not be found, well-engineered local exhaust systems should be employed if appropriate.

Where several rooms are supplied from a single ventilation system, those rooms with high ventilation rate requirements, such as conference rooms, may not receive an adequate amount of outside air. This situation often results when the amount of outside air is determined by summing the requirements of the areas served by the system For example a conference room may require supplemental or independent ventilation to ensure that the amount of outside air per person is

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sufficient to achieve the indoor quality.

The estimated maximum occupancy density figures given in Table 2 are a guideline that may be helpful where more precise information is not available. In some cases it may be difficult to derive an estimated maximum occupancy density figure because the number of persons cannot be estimated accurately or varies considerably.

Where peak occupancies are less than three hours, the outdoor air flow rate (i.e., cfm/person or cfm/ft²) may be based on the average occupancy level for the area during the period the system is operating, provided the average occupancy level is not less than half the maximum occupancy figure for that particular area. Automatic dampers or fan operations can control the quantity of outdoor air to sufficiently dilute airborne contaminants to an acceptable level. The system can be operated so the dilution is achieved before people arrive (lead occupancy) or after they arrive (lag occupancy).

If the source of contaminants are related to occupants, such as a build up of carbon dioxide, the system will have to supply an outdoor air supply at a rate high enough to overtake the rate at which contaminants are generated. During this interim period, people should not experience discomfort from the build up of contaminants. When contaminants are generated inside the building independently of the occupancy, the system should be operated so sufficient outside air dilutes the contaminants before the people arrive

Where contaminants are occupant related, instruments may be used to sense the level of CO_2 in the building and automatically regulate the amount of outside air brought into the ventilation system. Thus the system only draws enough outside air necessary to maintain the contaminant level below a set level for any given time. This provision has the potential for significant energy savings

When spaces are unoccupied for long periods of time, ventilation is not generally required unless necessary to avoid the accumulation of contaminants harmful or obnoxious to incoming occupants, the building or its contents. Ventilation should be introduced before people arrive when necessary to control building generated contaminants

Natural Ventilation

Natural ventilation is defined as the movement of air into and out of a space through intentionally provided openings such as windows and doors, through non-powered ventilators, or by infiltration

Natural ventilation in Maryland schools is normally a supplementary rather than the primary means of ventilation. The ability to provide ventilation through operable windows is desirable for emergency use; for example, as heat relief in the absence of air conditioning or for purging smoke from a fire. If employed, natural ventilation should not prevent reasonable control of the thermal environment or otherwise impair the intended use of the space.

Space Distribution

Ventilation air should be distributed uniformly within the occupied zone of a building space.

The amounts of outdoor air listed in Table 2 assume good mixing with recirculated air in the supply air ventilation system, and uniform distribution within the occupied zone. Ventilation effectiveness can be stated as the ratio of the amount of outdoor air reaching the occupants compared to the total amount of outdoor air supplied to the space. Ideally, the ventilation effectiveness of a space should approach unity (1.0)

If the air distribution allows the ventilation air to bypass the occupant as it moves from supply outlet to point of exhaust, the ventilation effectiveness will be less than 1.0.

Ventilation effectiveness of the air distribution within an area determines the capability of the supply air to limit the concentration of contaminants. The value can be less than 1.0 for both constant and variable air volume (VAV) systems However, effectiveness may decrease for VAV systems as air flow is reduced. Supply air flow reduction occurs in VAV systems in response to a reduced thermal load (not necessarily coincident with reduced contaminant generation),therefore, the capability to control contaminant levels may be lowered.

A space with good air distribution and with supply and return locations that will minimize chances of short circuiting supply air to the return outlets can be expected to have a ventilation effectiveness near 1.0. Inferior space air distribution and VAV systems operating at reduced flow can result in ventilation effectiveness of 50 percent or less.

When ventilation is less than 100 percent effective, outdoor air flow should be increased in an inverse proportion to compensate.

Variable Air Volume Systems

Variable air volume systems are commonly designed to (1) maintain a constant outdoor air supply to the air conditioning system (not to each space served by the system) or (2) vary the outdoor air supply in proportion to total supply air.

VAV systems should provide a minimum total air flow to an individual space at least equal to the outdoor air rate stated in Table 2 for the maximum occupancy anticipated.

System control should also assure that the system outdoor air quantity not be reduced below that necessary to avoid excessive contaminant levels as the total system air flow responds to space temperature control demand.

System Distribution

Microbial contamination can originate from water reservoirs in the air conditioning distribution system and cooling towers. Condensate pans in air supply units should be designed for self-drainage to preclude the build-up of such contamination. Provision should be made to permit access and periodic cleaning of cooling coils and condensate pans in central air handling and room units. Where humidification is necessary, steam is the preferred moisture source, but contamination from boiler water or steam supply additives should be avoided. Recirculating water sprays and associated reservoirs require frequent maintenance and blowdown, and their application in educational facilities should be limited to special situations. Mineral contamination can also occur due to evaporation of aersoling humidifiers and sprays; a demineralized make-up water source may be required. If the relative humidity in occupied spaces and low velocity ducts and plenums exceeds 70 percent, fungal growth and contamination can dramatically increase. Entrainment of moisture drift from cooling towers into the make-up air and building vents should be avoided. Water in cooling tower systems should be treated with bacteriocide. Performance of the treatment should be monitored.

Ventilating ducts and plenums should be constructed and maintained to minimize accumulation of dirt and moisture thereby inhibiting growth and dispersion of microorganisms through the HVAC system. They should be fabricated to minimize bends and internal lips or projections at the joints. Such structures cause turbulent loses in the system and become sites of dirt accumulation. Likewise insulating the duct helps avoid cold surfaces that lead to moisture deposits. Internal linings should be avoided or their use minimized. Access to the interior of ductwork should be provided at key locations for inspections and cleaning.

Particulate and gaseous contaminants from local sources within a space should be captured, collected, and removed as close to the source as practical; for example, bench and hood exhaust in chemistry laboratories, photography darkrooms, art studios, and vocational shops

An adequate make-up air source, such as an inlet from adjacent space or outdoors, should be provided for local exhaust, clothes dryers, and combustion equipment. Contaminated air should not be recirculated, discharged into attics, crawl spaces, or near outdoor air intakes.

Recirculation, Filtration and Purification

Airborne particle contaminants vary in size. Microorganisms, dusts, fumes, smoke, and other particulate matter may be captured by air filters. Many bacteria (99 percent exceed 1 micrometer in size) are attached to larger particles such as human skin flakes. Viruses generally occur in clusters or on other particles. Tobacco smoke consists of particulates in the respirable range and gases. Indoor air quality is greatly improved when particulates are removed from both outdoor and recirculated air. Thus the ventilation system should always employee filters or some other effective air cleaning device.

Removal of particulate contaminants from both outdoor and recirculated air contributes significantly to indoor air quality by reducing the concentration of such impurities within the occupied space. Therefore, the recirculation of air employing filters or other effective air cleaning techniques to materially reduce the concentration of particulates generated within the building will improve the indoor air quality.

Filters used should have been rated for efficiency, i.e. tested in accordance with ASHRAE Standard 52-76. Higher efficiency filters (above 30 percent) can be effective at reducing levels of respirable particles. Filters can also be specified based upon their removal efficiency for particles of a specific particle size.

Filter efficiencies in the order of 30 to 50 percent can frequently be justified, though slightly higher in cost than those of lower performance, because of the improvement obtainable with indoor air quality.

Dust collectors may be wet, dry, or electrostatic as required by particle size and loading

Control of gaseous contaminants, where necessary because of poor outdoor air quality or internal generation, usually requires methods based on sorption with or without oxidation. Such methods are generally expensive but may be tailored to deal with a specific contaminant. Commonly used sorbents are activated charcoal and potassium permanganate. The maintenance procedures attendant with such purification techniques are complex and require special attention. In addition, sorption methods do not work well when they are applied to large areas or used to control high levels of contaminants

Building Materials

Some building materials may produce varying amounts of air contaminants. The decisions that facility planners and architects make concerning building materials can increase or decrease the number of air contaminant sources This section discusses many common building materials and their relationship to indoor air quality.

Pressed Wood Products

School construction frequently uses pressed wood products in a variety of applications Particle and chip-boards are composed of processed wood often bound together by amber colored glue composed of urea-formaldehyde. The materials are pressed together to form a hard. smooth board that can be used to form cabinets, wall sheathing, and furniture. Plywood and wall paneling are built up in layers of thin wood shaved from logs and bound intermittently with the same type of glue used in particle board.

Since pressed wood products are in many cases much cheaper or more desirable than their alternatives, they have become very popular, especially true in prefabricated or otherwise mass produced products such as cabinetry

Newly manufactured urea-formaldehyde products are believed to release much more formaldehyde than do products which have been allowed to age. The half-life for these materials is from two to five years and aging may eventually render most formaldehyde-emitting materials harmless Higher temperatures and higher humidity are known to increase overall emission rates from these materials. Most formaldehyde-related complaints have been associated with newly built and/or renovated structures. In view of the significant increases in release rates for formaldehyde-containing materials when they are exposed to heat and humidity, these materials should not be placed in areas where heat and humidity are expected.

Federal regulation (CFR 24 Part 3280) addresses formaldehyde emission from pressed wood products used in manufactured homes. Any buyer can obtain plywood and particleboard that would comply with this standard if specified in the construction documents The National Particleboard Association and the Hardwood Plywood Manufactures Association have a voluntary standard for formaldehyde emission (NPA 8-86 and HPMA FE-86) which equate to the federal standard.

Concrete, Brick, and Rock

The main pollutant of concern from the presence of concrete, brick or rock products is radon gas. However, truly hazardous radon emanation rates are rare. Studies and surveys of concrete used in various parts of the United States have shown that emanation rates from random concrete samples have only small magnitudes. Rates for brick and block are, typically, even lower.

Gypsum Board

Gypsum is a major component of wall-board (sheet rock). Athough it has been theorized that gypsum made with phosphorus-containing material would produce significant amounts of radon, surveys have indicated that no significant increase in indoor levels of radon have been attributed to this source.

Roofing Materials

Asbestos-containing roofing felts have been used in construction since the early 1900s and continue to be used today. Typically, roofing felts are used as an underlayment for shingles to ensure waterproofness of the roof. Roofing felts are commonly 10-15 percent asbestos and may become friable as they age and deteriorate.

Building, Pipe, and Duct Insulation

The primary insulation materials to have an adverse impact on indoor air quality are:

- Urea-formaldehyde foam insulation (UFFI); and
- Sprayed, troweled, or pre-formed asbestos-containing acoustical, fireproof, and thermal insulation.

In the past, UFFI was used as an insulation material because of its many desirable properties. UFFI could be injected as a liquid into existing walls and then foamed to drastically increase its volume, enabling it to completely fill any voids in wall spaces. The precise formulations used in these applications were usually proprietary, but, essentially, UFFI consisted of the same glue used in various pressed wood products, a strong acid used to cure the glue, and a foaming chemical called a surfactant. These agents were mixed at the injection point and immediately introduced into the wall to be insulated.

Environmental factors and improper formulation can lead to significant emissions of formaldehyde from this type of foam insulation. High humidity increases the decomposition rate of the polymer, leading to formaldehyde release. Excess resin in the mixture will also evaporate over a period of time, since it is not chemically bound. In addition, temperatures above that of a normal room will significantly aggravate both of these conditions UFFI has now been banned in Canada and parts of the United States.

Asbestos has been used in a wide variety of building materials. Asbestos can give off very small fibers when it is disturbed or degraded. The fibers will float in the air and, when inhaled, may become lodged in the lungs. In light of the hazards posed by the presence of asbestos fibers in the air, it is essential to avoid the use of these materials in new construction.

Caulks, Sealants, and Adhesives

These compounds are used in a variety of applications. Caulks are used around windows and doors to lower infiltration rates through building envelopes. Caulks are also used in bathrooms around showers, water fixtures, and tile to prevent water leakage. Sealants are commonly used to waterproof surfaces and roof joints Adhesives are used to install asphalt tile, to secure wall and floor panels, and to fulfill a variety of miscellaneous needs

VOC emissions from sealants, adhesives, and caulks are difficult to characterize. A large number of different compounds have been found to be emitted from these materials. The composition and intensity of the emissions vary depending on the compound. In large part, these emissions depend on the type of solvent used in the specific formulation for each compound. Also, emission rates tend to be highest during the curing period. Studies to date indicate that it would be prudent to reduce the use of these materials to the extent possible and provide adequate ventilation when in use.

Floor Coverings, Carpets, and Vinyl Products

Adhesives used to apply flooring often contains VOCs capable of causing health problems The main contaminant emanating from carpet is formaldehyde used as glues in carpet backings Vinyl products can off-gas plasticizers. Both these emissions diminish dramatically over time. Wool fibers can cause allergic reactions in sensitized individuals. Vinyl asbestos tile remains in many school and office buildings. Acceptable work and disposal practices must be used when repairing, removing, or otherwise disturbing this material.

Paints

Paints are highly variable mixtures of VOCs, and it is difficult to predict emission rates VOC release is shortterm during the curing process with much lower levels over a long period of time. Paint should be applied and cured only in well-ventilated conditions.

Thermal Environment

Air Temperature

The air temperature in a space that is likely to produce acceptable comfort to a majority of occupants is dependent upon several interacting variables. They include individual physiology, clothing, activity, and preference. For classrooms and offices where students, faculty, and staff are mainly sedentary, 68° to 76°F represents a range of acceptability during winter. During summer, the range of acceptability will be higher. The effects of other variables upon the acceptable level of air temperature are discussed below.

Radiant Temperature

The body transfers heat to and from surrounding surfaces, such as walls or windows, by radiation. The rate of exchange is dependent upon the temperature difference between the body, the space geometry, building construction, and the location of the individual. A space enclosed even partially by cold walls will require a higher air temperature for comfort than one with surfaces at space temperature, especially for those seated near the cold surfaces For example, students seated near a large window without a source of heat to warm the glass surface will notice radiant heat loss to that surface during cold weather. They will generally prefer a warmer room or more clothing than others in the room farther away from the outside wall. Radiation to the body to or from the cold or hot surfaces may be asymmetrical (e.g., radiation on the back, but not the front) to a degree that discomfort will result regardless of adjustments in air temperature Such discomfort can occur where a person is seated in direct sunlight or close to a large, unheated or unshaded single-pane glass window.

Uniformity

Air temperature within a room generally increases from floor to ceiling If a sufficiently large difference exists in the occupied zone so that the temperature at the head is more than 5°F higher than near the floor, discomfort may result Good air mixing, and insulation of wall and floor surfaces can reduce temperature differences

Floor Temperature

To minimize foot discomfort, the surface temperature of the floor should be between 65°F and 84°F. Floors of occupied spaces above unheated areas require adequate insulation. Similarly, floors above boiler rooms may require insulation, if not for foot comfort, to control heat gain to the space above.

Temperature Change

Some space temperature controls can produce sufficiently large changes or rapid rates of change in the operative temperature (as defined by ASHRAE) of a space that will cause discomfort. Control strategies that may cause this phenomena are two position (on-off), wide dead band (a large space temperature span between modes of air conditioning when the control provides neither heating nor cooling), and wide proportioning band (requiring a large air temperature change at the control to vary the heating or cooling from minimum to maximum capacity). For example, a prolonged off-cycle for a control of a heater on an outside wall could result in down drafts at the wall and a large change in temperature, especially in the lower level of the occupied zone close to the wall.

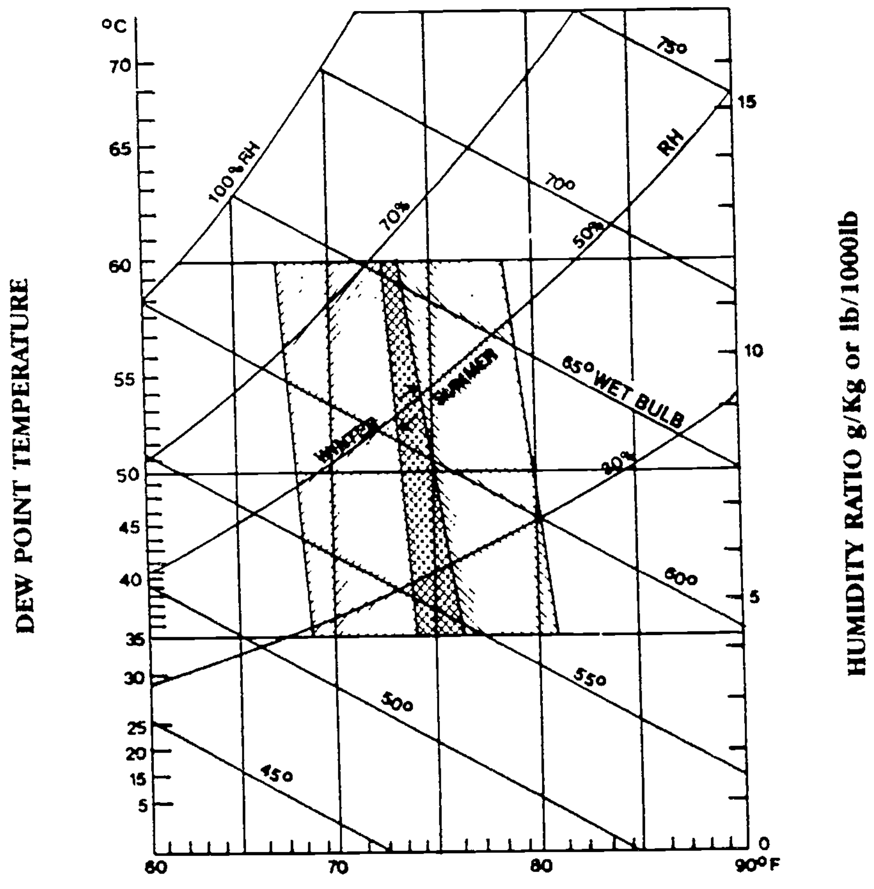
Humidity

In educational facilities the thermal effect of humidity on the comfort of sedentary individuals is small. If the humidity level is too high or low, concerns may arise over mold or bacteria growth and respiratory health effects. It is usually necessary to limit humidity levels in winter to prevent condensation on windows, metal sash and uninsulated walls.

Comfort Chart

Figure 1, taken from the ASHRAE Standard 55-1981, describes generally acceptable ranges of temperature and humidity for lightly clothed, mainly sedentary adults.

Figure 1



Acceptable ranges of operative temperature and humidity for persons clothed in typical summer and winter clothing, at light, mainly sedentary, activity.

Air Movement

While little or no air movement may be necessary to achieve thermal comfort, the dilution of contaminants within the occupied zone or subzones will require effective dilution with adequate amounts of ventilation air (outdoor or recirculated air appropriately conditioned by filtration, purification or both). Supply and return air distribution systems serving occupies zones should be designed and operated to achieve effective ventilation and temperature uniformity during all operating modes during the occupancy period. In winter, average air movement above 30 feet per minute in the occupied zone may result in uncomfortable drafts.

Clothing

The insulation value of clothing varies depending upon the season and the outdoor climate: indoor clothing worn in winter can be twice that worn in summer. Thus the comfort range of operative temperatures is higher in summer than in winter. Since this shifting of the comfort temperature range is usually consistent with energy conservation it also is a sound basis for operation and, where necessary, seasonal adjustments of space thermostat settings. Additionally, appropriate attire to the season should be encouraged to promote comfort and effective energy use.

Activity Level

The range of comfortable operative temperatures shift downward as the average physical activity level and metabolic rate become higher than the level for lightly clothed, mainly sedentary activity upon which Figure 1 is based. For equal clothing insulation, industrial arts shops with higher levels of activity than the average classroom could have comfort ranges 3°F below the typical classroom. However, this shift in the comfort range could be materially offset by shedding of some clothing—a common occurrence with the onset of greater physical activity.

Zoning

Building spaces with dissimilar heating and cooling load characteristics, such as amount of window exposure, occupancy patterns, and internal energy sources should have independent means of temperature control. Interior spaces generally should not be on the same temperature control zone as spaces on the perimeter of the building. In winter, interior spaces frequently may require cooling while perimeter spaces may require cooling or heating.

Interior spaces, such as offices, may be grouped on a common zone when the thermal load characteristics and occupancy profiles are quite similar. Classrooms, libraries and gymnasiums should be zoned separately.

Where a satisfactory thermal environment must be provided for certain sections of a school building at times when most of the building is unoccupied and unused, separate systems with independent control of heating and cooling will be necessary. For example, it would be uneconomical to air condition an entire school building in summer months when only the office staff may be at work and require comfort conditions.

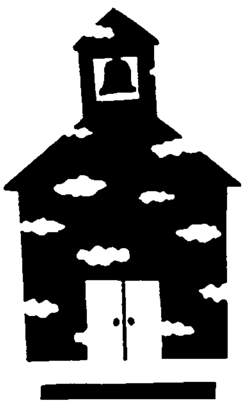
Specific Educational Programs

In the design process for public school facilities, architects, planners, engineers, and educators must be aware of the potential health hazards associated with specific educational activities. The following table addresses each activity, its potential indoor air contaminants, and recommended control methods for eliminating or reducing potential health hazards.

Specific Educational Programs (Table 3)

	Potential Contaminants	Control Methods
VISUAL ARTS AREAS	Art materials that may affect indoor air quality and personal health include: Clays containing silica dust, fumes and gases produced during kiln firing, painting, pigments in powdered form, varnishes and lacquers, stone, wood, metal, plastic, wax, acids, inks, solvents	1 Never work with products when the composition is unknown; 2 Obtain material safety data sheets on products used; 3 Use less hazardous substitutes for hazardous materials, i.e., asbestos-free talcs, lead-free glazes, moist premixed rather than powdered pigments, glazes, and colorants; 4 Develop a list of materials not to be used, e.g., benzene, carbon tetrachloride, tetrachloroethylene, chloroform, trichloroethylene, carbon disulfide, dioxane, and phenol; 5 If at all possible, provide educational activities that do not require respirators; 6 Use appropriate protective equipment, such as gloves, face shields, and aprons. If respirators are used, the requirements in OSHA regulation 29 CFR1910.134 must be met; 7 Maintain good housekeeping; 8 Follow approved methods of disposing of hazardous substances according to Maryland Department of the Environment Regulations. 9 Mechanical. Local exhaust (a minimum of 100 fpm, average, across the face of the hood) must be provided when working with hazardous materials. This includes the use of canopy hoods over kilns, movable exhaust hoods for welding, spray booths for air brush and paint spraying, and slot hoods or enclosed hoods for acid etching.
THEATER CRAFT AREAS	Theater crafts including props, scenery, lighting, and costume areas use or produce a wide variety of toxic materials. These materials include powdered pigments and dyes, fireproofing chemicals, various types of plastic resin coating systems, spray adhesives and glues, welding and soldering materials, sawdust, floor waxes, metal rouge, powdered metals, vermiculite, and paints.	1 Purchase only materials that have labels. 2 Obtain material safety data sheets for all products. 3 Substitute water-based products when possible; 4 Choose products in solution rather than powdered form. 5 Use appropriate protective equipment, i.e., gloves, goggles. 6 Label containers 7 Keep containers closed when not in use; 8 Mechanical. Theater workshop areas and backstage areas should be given the same consideration for ventilation as industrial education and visual arts laboratories. Provisions should be made to accommodate the various types of activities inherent to theater operations, i.e., welding, spray painting, cutting, and milling. Theater operations should have a local exhaust system for processes that produce airborne contaminants.
INDUSTRIAL/ VOCATIONAL SHOPS	Industrial/Vocational education operations which have potential health hazards include machining, ceramic coating, dry grinding, forming and forging, grinding operations, molten metals, open surface tanks, paint spraying, plating, vapor degreasing, gas furnaces or oven heating operations (annealing, baking, drying, etc.), high temperatures for hot casting, unlagged steam pipes, process equipment, wet grinding, and gas or electric arc welding.	1 Substitute a less harmful material for one that is dangerous to health. 2 Change or alter a process to minimize student contact; 3 Isolate or enclose a process or work operation to reduce the number of persons exposed. 4 Use wet methods to reduce generation of dust in operations. 5 Use appropriate personal protective devices as recommended by the manufacturer 6 Exercise good housekeeping, including cleanliness of the work place, waste disposal, and adequate washing. 7 Mechanical (a) Industrial arts facilities must be thermally treated for year-round use with special attention being given to mechanically forced air systems that provide for the ventilation and circulation of fresh air. The amount of ventilation air required is dependent upon the types of activities to be conducted. This should be determined early in the design process, because it is important for student and teacher comfort and the protection of equipment from rust and corrosion damage due to excess humidity; (b) Special consideration must be given to local exhaust from labs for special activities, such as for fumes generated by welding, furnaces, masonry dust, and spray painting. Polyester or stainless steel exhaust hoods and ducts are recommended for fumes from the use of plastic materials. (c) An exhaust system must be provided for each welding booth area. Each welding booth should meet, at a minimum, MOSHA standards. (d) A means of exhausting engine fumes to the outside must be provided in instructional areas where internal combustion engines are used. (e) Separate HVAC controls for industrial arts laboratories should be provided if evening programs or use of the industrial arts facility is planned at times other than during the school day. (f) An exhaust system with HEPA filters should be used when changing brake linings

	Potential Contaminants	Control Methods
WELDING AND CUTTING AREAS	A number of potentially hazardous materials are employed in fluxes, coatings, coverings, and filler metals used in welding and cutting or are released to the atmosphere during welding and cutting. These include, but are not limited to, cadmium, fluorine compounds, zinc, lead, beryllium, mercury, chlorinated, chrome, hydrocarbons, carbon monoxide.	1 Store flammable gas cylinders and oxygen cylinders in storage separated by 20 feet or a barrier 5 feet high having a one hour fire resistance rating. 2 Secure and store cylinders where they cannot be knocked over. 3 Keep valve protective caps in place when cylinders are used. 4 Conduct all welding and cutting at a safe distance from flammable hazards. 5 Shut off valves when cylinders are not being used. 6 Protect nearby students from ultraviolet welding flash. A welding screen area is a useful technique in this regard. 7 Keep exposure from cutting and welding fumes within acceptable limits. Use local exhaust to meet acceptable limits. 8 Mechanical (a) A local exhaust system is the most effective means of control for airborne contaminants produced by welding or cutting. Local exhaust can be provided by several types of equipment including fixed enclosures (booths), freely movable hoods, and down-draft benches. After a system is installed and set in operation, its performance should be checked to see that it meets engineering specifications, correct rate of air flow, duct velocities, and negative pressures (see MOSHA 1910.252)
SPRAY BOOTHS	Spray booths are commonly used for spray painting. Some booths are used for bleaching, cementing, glazing, metalizing, cleaning, or welding. Flammable materials, vapors, mists, combustible residues, dust, or deposits are common contaminants.	1 Use noncombustible material such as steel, concrete, or masonry in construction. 2 Design spray booths to direct air flow toward the exhaust outlet. 3 Construct the interior surfaces of spray booths to be smooth and continuous without edges and designed to prevent pocketing of residues, facilitate cleaning, and washing without injury. 4 Keep the interior surfaces of booths free of combustible deposits (see MOSHA 1910.107). Noncombustible removal coatings are available. 5 Provide explosion-proof lights and switches. Keep portable lamps away from spray operations. 6 Keep sprinkler heads clean. 7 Make sure that belts and pulleys inside the booth are fully enclosed. 8 Ground electric driving apparatus. 9 Mechanical (a) General—All spraying areas should be provided with mechanical ventilation adequate to remove flammable vapors, mists, or powders to a safe location and to control combustible residues. Mechanical ventilation should be kept in operation at all times while spraying operations are being conducted and for a sufficient time thereafter to allow vapors from drying coated articles and drying finishing material residue to be exhausted. (b) Ventilating and exhaust systems should be in accordance with the standard for blower and exhaust systems for vapor removal NFPA No 31. (c) Ensure that electric motors for exhaust fans inside booths or ducts are explosion-proof. (d) Assure a ventilation rate across the face of the paint spray booth at least 100 fpm
SCIENCE LABS	Explosives, corrosives, flammable liquids, toxic chemicals, oxidizing materials, gases, vapors, mists, smoke, solvents, and nonionizing radiation are common contaminants.	1 Secure all compressed gas cylinders. 2 Have appropriate equipment and materials available for spill control. 3 If possible, purchase chemicals in class-size quantities only. 4 Label all chemicals accurately with date of receipt or preparation, initiated by the person responsible, and pertinent precautionary information on handling. 5 Follow all directions for disposing residues and unused portions of reagents. 6 Store flammable liquids in small quantities. 7 Maintain a complete inventory of chemicals. 8 Use diluted substances rather than concentrates whenever possible. 9 Use instructional techniques which require the least quantity of materials. 10 Use films, videotapes, and other methods rather than experiments involving hazardous substances. 11 Storage Facilities (a) Never store chemicals in aisles. (b) Install chemical storage shelves with lips, and never used stacked boxes in lieu of shelves. (c) Use only explosion-proof refrigerators for lab storage. (d) Flammable and toxic chemicals require a carefully planned cabinet or room. The room/cabinet must be separately ventilated. Rooms must contain smoke and heat detectors, explosion-proof lighting, static free switches, and electrical outlets. Rooms should be air conditioned and humidity controlled. 12 Mechanical (a) Laboratory hoods are expected to capture all gases or aerosols released within it. (b) The location of the hood is very important. Whenever possible, they should be located along an outer wall and far from any doorway to avoid turbulence from opening and closing doors. Placing hoods on outer walls also allows for easy placement of ducting to the outside with a minimum of bends and elbows. Outside exhaust must be located to avoid re-entry into the building by way of open windows, fresh-air intake, etc. (c) Regularly check hoods for proper air flow
TEACHER'S LOUNGE	Contaminants include cigarette smoke, cooking odors, carbon monoxide, furniture and rug odors, formaldehyde, cleaning fluids, and duplicating fluid.	1 Prohibit smoking or have two separate lounges. 2 Clean up daily, including vacuuming. 3 Use the least hazardous cleaning agents when possible. 4 Mechanical (a) Mechanical ventilation should be based upon the projected number of employees using the facility and the types of equipment to be installed, e.g., stove, refrigerator, microwave oven. Follow the latest ASHRAE standard for cfm per person. (b) Stoves should have local exhaust.
DUPLICATING AND COPYING AREAS	Contaminants include methyl alcohol (methanol), ozone, and ammonia.	1 Wash exposed skin after each duplicating run. 2 Allow duplicating paper to dry before collating and stapling. 3 Allow only properly trained staff to use equipment. 4 Do not use duplicating fluid as a cleanup solvent. 5 Avoid spilling, develop spill procedures that follow the manufacturers recommendations. 6 Mechanical. Provide adequate ventilation as recommended by the manufacturer.
PHOTO LABS	Contaminants include toners, aromatic hydrocarbons, ozone, heat.	1 Follow manufacturers recommendations. 2 Obtain material safety data sheets on toners and carriers. 3 Follow manufacturers guidelines for minimum acceptable floor space. 4 Mechanical. Provide adequate ventilation to meet manufacturers recommendations in all rooms where photographic products are used.



Case Studies

The following case studies are discussed to illustrate typical examples of indoor air quality problems in schools

Case 1:

Students and faculty in the science wing of a middle school began to experience headaches, eye, nasal irritation, and chest tightness associated with an intermittent foul odor. Since a source was not apparent, the problem was thought to be due to discontented teachers. Considerable hostility resulted, with the ensuing conflict between the parent-teacher association, the administration, and teachers union well documented in the local paper.

Visits to the school rooms indicated no improper use of science equipment and adequate thermal control and humidity.

An outside consulting group distributed a symptom questionnaire that confirmed the symptoms. Lung function tests were normal. One weekend an indicator smoke was injected into the sewer system and emerged in the ventilation ducts of the rooms. Review of the building indicated improper sealing of the sewage system during construction. Sealing of the waste ducts resolved the odor and the symptoms.

Comment: Often indoor air complaints begin with the recognition of an odor and irritation. In this case, the selection of an outside consulting group was important for several reasons.

1. The source of the problem was not initially identified.
2. The symptoms persisted.
3. Considerable hostility and bad press had occurred that might have been avoided by an earlier consultation.

Case 2:

Faculty members complained of extreme fatigue and lethargy as well as dry mouth and eyes These symptoms occurred in the late fall and early spring, particularly in the afternoon.

Review of the rooms indicated an average temperature of 83°F. The symptoms occurred in rooms that faced west and had sun in the afternoon.

Shades were installed to decrease radiant heat and temperature adjusted to 72°F Symptoms were resolved.

Comment: Thermal discomfort is a common and readily resolvable cause of indoor air problems. Thermal discomfort is well recognized to cause decreased productivity. Hot, sleepy students can not learn. A visit to the room at the time of symptoms is the way to recognize this problem.

Case 3:

The teacher and students in several classrooms suddenly detected an acrid odor and developed tearing of the eyes and coughing. The teacher immediately evacuated the classroom and took the students to the gymnasium. Investigation revealed a truck carrying chlorine gas had been in an accident. Students were evacuated from the school for the day until the spill was cleaned up.

Comment: The outside environment can pose an immediate and sudden danger. Disaster plans are important.

Case 4:

A student with asthma began developing wheezing while at school, requiring several trips to the nurse and sick time. Investigation indicated that remodeling was occurring in the adjacent hall and paint fumes were entering the classroom. The painting was then scheduled for non-school hours, and the student had no further exacerbations.

Comment: A range of organic vapors, including cologes and perfumes, can exacerbate asthma.

Case 5:

Teachers complained of eyes, nose, and throat irritation in classrooms located on the first floor. They noted intermittent odors of unclear origin. Investigation of the building indicated that science rooms were located on the next floor, above the classroom where symptoms occurred. When a cologne was poured down the drain in the science lab, the odor was discernible in the classroom below. The drain in an unused sink in the back of the classroom was found to be improperly sealed. The odor and symptoms were resolved with sealing of the drain.

Comment: Ingenuity can be used to trace fugitive odors and irritants.

Case 6:

A school secretary developed nasal stuffiness and itching of the eyes in the spring and fall. Evaluation of this condition by an allergist indicated that the secretary was allergic to oak trees and rag weed. Treatment of allergies improved the symptoms.

Comment: Upper respiratory symptoms can be caused by allergies. It is important to distinguish between work-related and non-work-related conditions.

Case 7:

A grade school teacher developed eye itching, nasal congestion, and wheezing associated with being in his classroom. The symptoms had not occurred previously. Careful review of the classroom environment indicated that the symptoms began when the class started a project on animals and began keeping guinea pigs in the room. Removal of the animals resolved the symptoms

Comment: Just as there are people allergic to cats and dogs, there are people allergic to small animals.

Case 8:

A group of teachers in an administration building developed recurrent mucous membrane irritation, sinusitis, and fatigue requiring frequent absences. All were located along a single corridor.

Administration failed to respond to calls asking that the problem be addressed. The teachers called in an consultant who cultured legionella from the water supply. The building was evacuated, and newspaper headlines appeared.

Review of the history of the symptoms and serology indicated that symptoms were not due to legionella infection. However, water leaks and flooding had been occurring for several years and obvious profuse mold growth was present in rugs, on ceiling tiles, and in filters from heaters.

The carpets were removed, filters changed, and duct work cleaned. Landscaping, roof repairs, and sealing prevented future leaks. The original teachers were unable to return to that office area without a rapid recurrence of symptoms, confirmed by medical evaluation. New occupants have not yet developed symptoms.

Comment: Because a possible pollutant is identified doesn't mean that it is the cause of the problem. A systematic evaluation may be required, drawing upon the knowledge of experts.

Case 9:

A teacher began to experience eye, nasal irritation, and fatigue while at work. He initially ignored the symptoms, but then found he had difficulty concentrating and could hardly teach, particularly in the afternoon. Over several months a pattern developed: symptoms would occur after working six hours on Monday, four hours Tuesday, two hours Wednesday. By Wednesday evening he would crawl into bed, sleep until noon Thursday On Friday he would return to work but would

3

again experience irritation and fatigue that would gradually resolve over the weekend. His erratic work pattern caused him to disciplined by the principal and to be labeled a "problem teacher."

Medical evaluation confirmed chronic upper respiratory irritation and symptom diaries confirmed a work-associated pattern. He had previously been an excellent teacher and did not abuse drugs or alcohol. Review of his work location indicated that his classroom had poor ventilation and frequent water leaks. It was a basement room that had previously been used for storage, but was converted to a classroom because of lack of space.

On recommendation by a physician, he was moved to a new classroom. His symptoms resolved and he returned to full productivity.

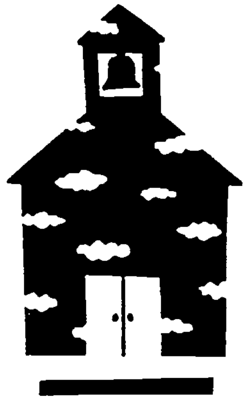
Comment: On rare occasions, individuals may develop marked and disabling symptoms in specific environments. If a review of the location demonstrates no remedial cause, relocation may be necessary.

Case 10:

A clerical worker in a school district began to develop nasal congestion and shortness of breath while at work. The symptoms became progressively more severe and required repeated physician visits, lost work, and daily medication. Medical evaluation indicated her lung function was reduced to 70 percent of normal values and blood tests showed positive IgG precipitins (a blood protein indicating an allergic reaction) against the mold aspergillus niger. Air samples from her work environment indicated the presence of high levels of aspergillus niger in the ventilation system in her office.

She was removed from her office. Over six months her lung function improved and her symptoms resolved.

Comment: This is an unusual example of a serious, mold-induced lung condition.



Existing Statutory Authority And Government Activity

Federal Government

The Environmental Protection Agency is the lead agency within the federal government for control of air pollution. The legal mandate for EPA's authority is derived primarily from the Clean Air Act that gives EPA responsibility for "ambient air," a term interpreted to mean that portion of the atmosphere external to buildings. The U.S. General Accounting Office (GAO) concurs with this interpretation, but has acknowledged that indoor air pollution has received little support precisely because no one federal agency has jurisdiction over nonindustrial indoor environments.

In addition to the Clean Air Act, several other statutes are interpreted to allow the EPA to take action on indoor air quality. The Toxic Substances Control Act (TSCA) is aimed at controlling hazardous air pollutants. EPA has already used this statute to require asbestos management in schools and is currently considering the need for regulatory action to deal with the issue of formaldehyde exposures. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) provides a mandate for the regulation of pesticides, including their application indoors. The Uranium Mill Tailings Radiation Control Act (UMTRCA) applies to uranium mill tailings, especially as they are used for landfill in residential areas or in the construction of dwellings. Because such uses could lead to elevated radon concentrations indoors, EPA has established guidelines for acceptable radon concentrations inside homes built in high risk areas. The Safe Drinking Water Act (SDWA) might also be used to deal with indoor radon problems in instances where drinking water is derived from radon-emitting substrata. Because volatile organic compounds and radionuclides from hazardous waste sites can migrate through the soil and enter nearby buildings, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or "Superfund" Authority could also be used to address certain indoor air quality problems.

Congress appropriated $2 million in fiscal year 1984 for EPA to intensify its research efforts on indoor air quality. Another $2 million was appropriated by Congress for fiscal year 1985. Overall, current funding for indoor air quality research constitutes about 3 percent of EPA's total air pollution research budget.

Besides EPA, a number of other federal agencies have responsibility for specific aspects of nonindustrial indoor air quality. The Occupational Safety and Health Administration (OSHA) is responsible for safeguarding workers' health in the workplace. Nevertheless, most OSHA activities have focused on industrial work environments, with relatively little attention given to problems in nonindustrial settings, such as building-related illnesses in office buildings.

The Department of Energy (DOE) is responsible for energy conservation programs that affect residences and new buildings DOE has funded studies to develop, evaluate, and standardize measurement techniques, as well as research to examine human health effects from organic vapors, airborne particles, and radon. The Bonneville Power Administration (BPA) in Oregon is currently financing a project to measure a variety of indoor pollutants inside both new and existing buildings within its service area and to determine the impact of weatherization measures on indoor air quality.

Ensuring that consumer products are safe and do not present unreasonable health risks is the responsibility of the Consumer Product Safety Commission (CPSC) CPSC has banned the use of asbestos-containing spackling compounds, proposed a ban of urea-formaldehyde foam insulation (overturned in court), and initiated studies of emissions from unvented combustion appliances, including kerosene heaters and gas-fired space heaters

The Department of Housing and Urban Development (HUD) establishes building standards for HUD funded projects and material standards for mobile home construction HUD has required that indoor radon concentrations in high natural radium areas of Montana and South Dakota be below established minimums before home buyers qualify for HUD-assisted financing. HUD refused to approve FHA-financed loans for new home construction on reclaimed phosphate lands in Florida, due to possibility of elevated indoor radon levels HUD recently promulgated regulations specifying formaldehyde-emission limitations for plywood and particle-board products

The Federal Trade Commission (FTC) is responsible for ensuring that consumer advertising contains accurate, truthful, and useful information The FTC recently charged two manufacturers of room air cleaners with falsely advertising that their devices effectively remove tobacco smoke and other pollutants from indoor air In reaching consent agreements with the FTC, both companies agreed not to misrepresent the capabilities of their air cleaners

During 1983, the Congressionally-mandated interagency Committee on Indoor Air Quality (CIAQ) was established to coordinate federal research activities. Representatives from EPA, DOE, the Department of Health and Human Services (DHHS), and CPSC serve as co-chairs. Among the other federal agencies involved in the CIAQ are BPA, the Department of Defense, FTC, the General Services Administration (GSA), the National Aeronautics and Space Administration, the National Bureau of Standards, OSHA, the Tennessee Valley Authority, and the Department of Transportation The CIAQ is presently compiling an inventory of federal indoor air research to identify needed research by both the public and private sectors

State and local health agencies have been more active than federal agencies in dealing with indoor air quality issues Massachusetts, for instance, banned the use of urea-formaldehyde foam insulation, and both Minnesota and Wisconsin have promulgated formaldehyde standards in new mobile homes. In California, the sale and operation of unvented combustion space heaters for use in residential buildings is prohibited. Many state and local governments (primarily cities) have instituted anti-smoking ordinances

Through the Pesticide Applicators Law Section within the Department of Agriculture, the State of Maryland regulates the use of pesticides in schools and other buildings In 1979, Maryland became involved with asbestos hazards in school buildings mainly through a technical assistance program for local school officials The state has developed resources to investigate low level formaldehyde exposure and formaldehyde has been measured in several schools in response to complaints No specific regulations regarding indoor air pollution have been enacted, however. Maryland is still active in the technical assistance aspects of indoor air pollution investigations A list of consultants working in the indoor air pollution field has been developed and is available from the Maryland Department of the Environment School officials seeking technical information on indoor air pollution matters may call the Maryland Department of the Environment at (301)225-5755

State and local health departments are the agencies that deal closely with citizens concerns and questions about indoor air quality In recent years, complaints about inadequate indoor air quality and requests for information about specific indoor pollutants (i.e., formaldehyde and asbestos) have increased significantly A recent national survey revealed that 32 states have a program or staff responsible for evaluating exposures to one or more indoor air pollutants Twenty-nine states have programs to assess nonin

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