

(SCHOOL DISTRICT)

**INDOOR ENVIRONMENT  
MANUAL**

(SCHOOL DISTRICT)

(Street Address)

(City, State, Zip Code)

(Date of Manual/Revised Date)

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## 1.0 INTRODUCTION

The (School District) is committed to providing an indoor environment that is safe, healthful, and conducive to learning. The District's on-going safety and health program includes the proper management of the indoor environment. Additionally, it is the intent of the District to comply with all Federal, State, and Local regulations pertaining to the management of the indoor environment.

The presence of indoor environment stressors such as air contaminants, thermal discomfort, poor lighting, and noise can result in employee and student symptoms of discomfort or illness. The occurrence of these symptoms may affect the building occupants' health and well-being. Fortunately, these indoor environment problems can usually be mitigated or avoided through the improvement of ventilation, building maintenance, and control of contaminant emission sources. Acceptable indoor environments, energy management, and a conducive learning environment are parallel goals—not mutually exclusive.

This manual provides a summary of some of the causes and effects of indoor environment problems and provides guidance for the evaluation and mitigation of building occupant concerns. In addition, this manual establishes recommendations for minimizing indoor environment problems in facilities operated and maintained by the (School District's) Facilities and Maintenance Department.

The success of the indoor environment program is contingent upon the concerted team effort of all employees, students and parents of the (School District). As with all programs implemented by the District, comments, questions and input are encouraged.

## 2.0 HEALTH AND COMFORT CONCERNS

A building and its occupants form an environment that, together with the physical and chemical qualities of the environment, determine the overall responses of the occupants. A fundamental objective of environmental control is not only to prevent the existence of harmful or unpleasant conditions, but to provide for the comfort and well-being of the occupants.

Stressors are air contaminants or physical factors that influence occupant comfort and health. Air contaminants include gases, vapors, fumes, dusts, or mists. They are usually characterized by their concentration in air. Physical factors such as temperature, lighting, noise, and vibration are usually characterized by their amplitude such as temperature, illuminance, or sound pressure level.

In most cases, occupant responses within the District's buildings are not caused by intensive exposure to specific stressors. Instead, responses are commonly due to exposure to multiple stressors or physical factors.

When an occupant is exposed to an environmental stressor, physiological response (i.e., strain) results as a function of the occupant's susceptibility. Strains depend on the concentrations or intensities of the stressors and the exposure times. Thus, for some stressors that result in cumulative doses, strains from long-term exposures to low-level contaminant concentrations may have more severe effects than short-term exposures to high—level concentrations. Individual susceptibilities may be influenced by factors such as age, sex, genetics, psyche, and physical condition.

Table 1 shows the relationships that exist between thermal, air quality, lighting, and noise stressors and several symptoms frequently reported in problem buildings. In order to adequately investigate problem buildings it is necessary to assess all of these environmental stressors.

**Table 1**  
**Occupant Symptoms Environmental Stressors**

Symptom	Stressor			
	Thermal	Air Quality	Lighting	Noise
Headache	√	√	√	√
Dizziness	√	√	√	√
Drowsiness	√	√	√	√
Fatigue	√	√	√	√
Nausea	√	√	√	√
Eye Irritation	√	√	√	
Respiratory Irritation			√	√

### 3.0 TYPES OF IRRITANTS AND STRESSORS

Most indoor air irritants or stressors can be classified as gases or vapors, particulates (nonviable and viable), thermal (including humidity), lighting, and acoustics. Each of these irritants is discussed below.

#### 3.1 Gases and Vapors

Indoor environment investigations have associated various gaseous and vaporous irritants with occupant symptoms or potential health effects. Among the air contaminants that seem to be frequently implicated or mentioned are carbon monoxide, oxides of nitrogen, ozone, formaldehyde, volatile organic compounds, pesticides and radon.

Carbon monoxide is an odorless, colorless gas that is a byproduct of combustion processes. In buildings, carbon monoxide concentrations are usually not elevated unless there are unventilated sources of combustion in the building or if inadequate pressurization control allows carbon monoxide to enter the building (from sources such as parking lots). At low concentrations, carbon monoxide can cause fatigue and symptoms such as headaches and dizziness.

Nitrogen oxides are also associated with improperly ventilated combustion sources such as gas boilers, gas stoves, kerosene heaters, and diesel engines. In buildings, oxides of nitrogen may enter the building from external combustion sources through improperly located outdoor air intakes. The primary symptoms of exposure to oxides of nitrogen are eye, nose, and throat irritation. Elevated nitrogen oxide contaminants occur relatively infrequently in school buildings.

Formaldehyde is a pungent chemical used widely in the production of office furnishings and construction materials. Possible health effects from formaldehyde include eye and upper respiratory tract irritation.

Health risks from other volatile organic compounds (VOCs) which are similar to formaldehyde, include mucous membrane irritation, central nervous system symptoms (i.e., solvent encephalopathies), and malignant effects.

Solvent encephalopathy, a group of symptoms attributed to volatile organic compound exposure, has been the subject of extensive research. Acute and chronic forms—with headaches, irritability, fine-motor deficits, and difficulty in concentrating—are the major characteristics.

Pesticides include compounds used in and around buildings to control insects, rodents, and fungi. These materials are usually found in the form of sprays, liquids, powders, crystals, pellets, and fogs.

The percentage of actual pesticide compounds in the applied materials is usually small, with the bulk of each material being the carrier or inert ingredients. In some cases, carrier compounds may cause occupant discomfort or symptoms. Because pesticides and their carriers are often organic materials, pesticide applications may increase VOC concentrations in buildings.

While radon is not able to be detected sensorially, its decay products (progeny) are ubiquitous in nature. While there are a number of possible sources of radon including soil, building materials, potable water, and outdoor air—the primary source of radon in buildings is the soil surrounding the building substructure. Little is known about the distribution of radon in buildings. However, in general, radon concentrations in commercial buildings are usually less than those found in homes. These lower radon concentrations may be a result of the much smaller ratio of surface area in contact with soil to building volume and mechanical ventilation systems that maintain buildings at a slightly positive air pressure with respect to the building's exterior.

### 3.2 Particulates

Particulate concentrations may be classified as nonviable or viable.

Nonviable particulates include solid particulates such as dusts and fumes and particulates such as fogs, mists, and smoke that have a vapor phase. One useful way of characterizing these particulates is by aerodynamic size. For example, respirable suspended particulate (RSP) is a term used to describe particulates which have a mere aerodynamic diameter of 10 micrometers ( $\mu\text{m}$ ) or less. RSP is of particular interest in the environment evaluation because it represents the fraction of airborne particulates that are capable of entering the lower (alveolar) regions of the lungs. Particulates larger than 10 micrometers are efficiently removed by the upper respiratory passages (e.g., nose, trachea). The term total suspended particulates (TSP), by comparison, refers to particulate distributions up to 100  $\mu\text{m}$  mass median aerodynamic diameter.

Viable particulates include fungi, bacteria, and viruses. Concentrations of airborne viable particulates are typically expressed as colony-forming units (CFU) per cubic meter ( $m^3$ ) of air (i.e., CFU/ $m^3$ ). Viable particulates may become airborne within the occupied space by transport from the outdoor air or contaminated heating, ventilating, and air conditioning (HVAC) systems, by entrainment of dust, and/or emission from the occupants. Dust is generally used to describe a complex indoor contaminant that includes molds, bacteria, mites, pollen, human and animal hair, dandruff, textiles, leftover food, and decomposed materials.

Microbiological contaminants may affect the health and comfort of building occupants through infection, the production of toxic or objectionable metabolites, and by causing allergic response.

There is growing evidence that biological aerosols contribute to the symptoms generally termed Sick Building Syndrome (SBS). The moldy odor often associated with microbial contamination results from VOCs released during microbial growth on environmental substrates. While little studied, some of these volatile compounds can be respiratory irritants and may produce symptoms similar to those discussed previously under VOC health risks.

Allergic response among building occupants has also been associated with microbiological growth. In most cases, the microbiological growth was a result of inadequate maintenance and moisture control within the building or the HVAC system. The two most serious hypersensitivity diseases caused by exposure to airborne antigens are asthma and hypersensitivity pneumonitis.

Allergic asthma is characterized by reversible narrowing of the lower airways in response to antigen or other irritant challenge. Symptomatic attacks are episodic, occurring upon exposure to appropriate allergen and/or irritant exposure. There are few published accounts of ventilation system or other building system contamination resulting in epidemics of allergic asthma. However, pre-existing asthma may be exacerbated by the wide range of pollutants present in modern building environments. An estimated three percent of the U.S. population suffers from asthma.

Hypersensitivity pneumonitis, also called extrinsic allergic alveolitis, is characterized by inflammation of the lung occurring as a result of exposure to antigens such as fungal or bacterial contaminants. Epidemics in office buildings have occurred that were clearly the result of microbiological contamination in ventilation systems and portable humidifiers. Hypersensitivity pneumonitis, like most allergies, resolves with cessation of exposure to the antigen.

### 3.3 Stressors

#### 3.3.1 Thermal Stressors

Thermal stressors in building environments may be a result of inadequate temperature control, air movement, and humidification.

Temperature control in buildings is probably the greatest cause of occupant complaints. The response of the human body to temperatures outside the thermal comfort zone include shivering and blood vessel constriction in cool environments and sweating and blood vessel dilation in warm environments. Individual preferences for comfortable air temperatures vary.

Even in cases where air temperatures are within the comfort range, occupant discomfort is likely if substantial radiant temperature sources exist. For example, where sunlight is shining directly on occupants, they may experience thermal discomfort even though the air temperature is in the comfort range. Similarly, a radiant source such as a cold window in the winter may create thermal discomfort, unacceptable thermal gradients, and undesirable convection air currents.

Air movement may also modify the occupant's response in an environment where air temperature would normally be comfortable. Exposure to relatively fast-moving air near supply air discharges may result in a sensation of excessive cold. By the same token, the lack of perceptible air movement often results in complaints of stagnant air.

### 3.3.2 Lighting Stressors

Occupant discomfort can be caused by improper lighting conditions within work areas. For example, excessive glare at the work station of a video display terminal (VDT) operator may result in headache and eye irritation. The qualities of lighting that should be considered to provide an acceptable environment include illumination level, contrast, color, and glare.

### 3.3.3 Acoustic Stressors

Conditions of unacceptable noise levels may contribute to occupant symptoms of discomfort. Sources include machinery noise from building systems or adjacent operations, air noise from supply air diffusers, noise from office equipment and phones, voices, and other noisy interruptions.

## 4.0 SOURCES OF CONTAMINANTS

### 4.1 Outdoor Sources

The environment immediately outside of the building envelope may contain contaminants that can enter the indoor environment. Evaluation of the sources and contaminants in this environment deserves special consideration as these sources or the contaminants may cause elevated indoor contaminant concentrations. Thus, factors such as location of cooling towers or stacks from stationary combustion plants in relation to make-up air intakes, can highly influence the quality of the indoor air. Outdoor contaminants may be characterized as originating from above-grade or below-grade sources.

#### 4.1.1 Above-Grade Sources

Above-grade sources influence the quality of the outdoor air used for ventilation of the occupied spaces. Above-grade sources include:

- Vehicular traffic such as at loading docks, bus pickup and drop off areas and refuse pick-ups.
- Stationary combustion plants such as central heating plants.
- Heat rejection equipment such as cooling towers and air-cooled condensers.

- Exhaust systems such as toilet exhaust fans, fume hood discharges, or general exhausts.
- Waste systems such as plumbing vents, liquid and sump discharges, and solid waste facilities.
- Landscaping such as dirt fill, berms, grass, plants, shrubs, trees and waterways.

#### 4.1.2 Below-Grade Sources

Below-grade sources, primarily in the soil surrounding the building substructure, are another source of indoor pollutants. Dispersion of contaminants from the soil to the occupied spaces is dependent upon the nature of the contaminant, the type of soil, and other factors in soil such as moisture content, pH, and temperature. Soil gases may diffuse through air channels in the soil, while other contaminants may be transported with the movement of soil water. Various pathways exist through which these soil contaminants may enter the building, including structural cracks in building foundations and unsealed joints around floor drains, floor-wall connections, and pipe sleeves.

Examples of below-grade sources include:

- Soil surrounding the building substructure. Soil gases can diffuse through air channels in the soil and other chemical and biological contaminants can be transported with the movement of soil water. Some contaminants exist naturally in the soil (e.g., radon). However, many others are due to factors such as fertilizers, biocides, sewage, and industrial waste.
- Services such as natural gas, domestic water, and sewage systems that transport contaminants into the occupied spaces.

#### 4.2 Indoor Sources

Many of the contaminants contained in outdoor air and numerous other contaminants are generated within the building itself. These contaminants include products of combustion, microbiological contaminants, and VOCs. The primary sources of contaminants generated within the building are the occupants, building materials, and processes conducted indoors.

##### 4.2.1 Occupants

Examples of environmental stressors created directly by occupants include noise from talking or walking on hard floors, heat, moisture, and contaminants generated and dispersed by the occupants. Although they may seem to be of relatively little importance when compared with stressors generated by other building sources, control of occupant-generated environmental stressors is an important step in assuring acceptable indoor environmental control.

Contaminants generated by occupants include gases and vapors, and viable and nonviable particulates. The net generation rates of these contaminants are influenced by the activity, personal hygiene, diet, state of health, clothing, and use of personal hygiene products of the occupants. The most common contaminants emitted by building occupants are discussed below.

Carbon dioxide (CO<sub>2</sub>) is emitted in exhaled air as a byproduct of human metabolism. While indoor air concentrations of CO<sub>2</sub> normally do not get high enough to elicit symptoms, CO<sub>2</sub> concentrations are often measured to serve as an indicator of ventilation sufficiency.

Water vapor is emitted by respiration and by perspiration through skin surfaces.

Other gaseous and vaporous contaminants generated by occupants include a range of organic compounds such as acetone, butyric acid, acetic acid, methyl alcohol and ethyl alcohol, as well as inorganic compounds such as ammonia and hydrogen sulfide. The total generation rate of these compounds can exceed several hundred milligrams per day per person.

Particulates are generated by respiratory functions, by emission from the body surfaces, and by discharge of body wastes. Microscopic droplet nuclei are emitted in large numbers when people talk, cough, sneeze, spit, or blow their noses. Viable organisms can easily attach to these droplet nuclei and become airborne. Skin flakes, each containing an average of four viable bacteria, have been reported to shed at the rate of 7 million per minute.

#### 4.2.2 Building Materials

The materials that enclose the occupied spaces and that are incorporated in the furnishings of the space are normally considered to be passive elements within the building. However, these materials may also be sources of acoustic, visual, and thermal stressors as well as air contaminants.

Although noise is seldom generated by building materials, the acoustic properties of these materials greatly influence the way noise is transmitted, absorbed, and reflected in a building. Similarly, the quality of lighting is significantly affected by light transmission through windows and by light absorption and reflection by building materials. In addition, the extent that building materials transfer or store heat affects the rate of heat transfer to and from buildings or the time that heat may be transferred.

Air contaminants generated by building materials include gases, vapors, viable and nonviable particulates, and radionuclides. The net generation rates of these contaminants are influenced by the mass of the material, the surface area exposed to the work environment, the thermal conditions of the materials and the interior spaces, and the vapor pressure gradients of the contaminants from the material to the interior spaces. Sources of these contaminants include masonry and wood products; thermal and acoustic insulation fabrics such as carpeting, drapery, upholstery, and wallpaper; and paints and adhesives. Two of the most common contaminants emitted from building materials are formaldehyde and VOCs.

#### 4.2.3 Processes

The processes conducted within the various areas of the building may be the primary source of air contaminants to which the occupants may be exposed. Some of the processes that must be considered within buildings include:

- Combustion processes of vented and un-vented boilers or furnaces, gas appliances, generators, welding, brazing, etc.
- Personal grooming, including washing and the use of solvents and pressurized aerosols.
- Housekeeping, such as floor cleaning and dusting.
- Food preparation, food serving, food disposal, and dishwashing.
- Laboratory procedures and processes (including film developing and processing).
- Office work, including the use of electronic equipment and copy machines.
- Environmental control of occupied spaces, including heating and cooling coils, humidifiers, dehumidifiers, and air cleaners.
- Maintenance of facilities and equipment, including the use of pesticides and insecticides.

Air contaminants generated by indoor processes include gases and vapors, and viable and nonviable particulates. Net generation rates from selected indoor processes are discussed below.

Housekeeping activities can disperse viable and nonviable particulates at rapid rates and increase exposure to building occupants. Gases and vapors contained in housekeeping products may be emitted in the occupied space at relatively rapid rates and increase exposure of the occupants.

Office procedures can expose occupants to gaseous, vaporous, and particulate contaminants and ionizing and non ionizing radiation. Most photocopy machines disperse small diameter carbon particles as copies are produced. Furthermore, ozone may be generated at rates ranging from 2 to 158  $\mu\text{g}/\text{minute}$ , with typical rates of 15 to 45  $\mu\text{g}/\text{minute}$ . Organic compounds from toners and developer fluids that are used in wet-type photocopiers have been estimated to be emitted at a net generation rate of 25 grams per hour during the workday. Some toners used in photocopying machines have been reported to contain mutagens, possibly due to trace amounts of nitropyrene. Formaldehyde-based resins (e.g., urea-formaldehyde, phenol-formaldehyde, or melamine-formaldehyde) are used in inks and in paper coatings.

Ironically, environmental control systems can also become sources of gaseous, vaporous and particulate contamination of the spaces they are designed to control. The reason that these systems become sources is usually lack of proper maintenance. Gases and vapors may easily be transported from one room to another by the HVAC system if the zones are within a common HVAC system and gaseous removal devices (e.g., activated charcoal filtration) are not present. Components within the HVAC system that have wetted surfaces (e.g., cooling coils, humidifiers, and dehumidifiers) may also enhance the accumulation and subsequent suspension of particulate contamination. Bacteria, molds, fungi, amoebae, and protozoa have been recovered from these wetted surfaces and implicated in diseases such as humidifier fever and hypersensitivity pneumonitis. However, little is known about the generation rates of viable particulates from these devices.

Air cleaners can also be the source of particulates. Media-type cleaners gain removal efficiency as they are loaded, but can emit large rates of particles if they are overloaded (i.e., breakthrough) or if care during maintenance is not given to the proper removal of the devices from the airstreams.

## 5.0 INDOOR ENVIRONMENT STANDARDS AND PERFORMANCE CRITERIA

ASHRAE 62-1989 is the primary recommended standard for providing an acceptable environment in buildings. It contains both a prescriptive and performance method for achieving acceptable indoor environment standards. Standard ASHRAE 55-1992 is the primary standard for providing acceptable thermal conditions in buildings and contains only a prescriptive standard. The ACGIH Bioaerosol Committee has provided guidelines for the assessment of microbial air contaminants in office environments.

### 5.1 ASHRAE 62-1989 VENTILATION FOR ACCEPTABLE INDOOR ENVIRONMENT

The purpose of the ASHRAE ventilation standard is: "To specify IAQ and minimum ventilation rates which will be acceptable to human occupants and will not impair health."

#### 5.1.1 Ventilation Rate Procedure

The ventilation rate procedure contains five parts:

1. Method is given for evaluating the acceptability of the outdoor air to be used for ventilation. This method includes a four-step procedure to ascertain acceptability.
  - Step 1. Contaminants in the outdoor air should not exceed the National Ambient Air Quality Primary Standards (Table 1 in ASHRAE 62-1989).
  - Step 2. Concentrations of other contaminants in the outdoor air should not exceed guidelines contained in the tables in Appendix C of ASHRAE 62-1989.
  - Step 3. If outdoor air contains contaminants that are not listed in Table 1 or Appendix C of the standard, these concentrations should not exceed 1/10 of the TLVs used in industry or other values obtained from expert consultation.
  - Step 4. If, after completing Steps 1-3 there is still a reasonable expectation that the air contains contaminants, sampling is required.
2. If outdoor air concentrations *exceed* acceptable conditions according to part 1 above, the air should be *treated* to achieve acceptability before it is used for ventilation.
3. Indoor air is considered acceptable if the occupied space is ventilated with acceptable outdoor air according to the rates specified in Table 2 of the Standard. An excerpt from this table is shown in Table 2 of this report. The minimum recommended ventilation rate is specified as 15 cfm per person.

**Table 2**  
**ASHRAE 62-1989 Outdoor Air Requirements for Ventilation**

<b>Application</b>	<b>Outdoor Air Requirement</b>
Classrooms	15 cfm/person
Libraries	15 cfm/person
Offices	20 cfm/person
Laboratories	20 cfm/person
Auditoriums	15 cfm/person

4. Acceptable environment can also be provided by a mixture of outdoor and recirculated air if the recirculated air is treated by the appropriate air cleaners. An equation is given that specifies the required recirculation air flow rate for ventilation as a function of the desired reduction in outdoor air flow rate and the selected efficiency of the air cleaner in terms of the contaminant to be controlled (see Appendix E of ASHRAE 62-1989 for assistance in calculating air-flow requirements for commonly used air-distribution systems).
5. Criteria for variable occupancy are also given in terms of lead and lag times for starting ventilation systems as functions of room volume (i.e., air capacity) and required ventilation rates per person during occupancy.

#### 5.1.2 Indoor Environment Performance Criteria

The alternative air quality procedure contains two parts—*health-oriented objective* measurements and *comfort-oriented subjective* evaluation.

1. Objective measurements of contaminants detected within occupied spaces are not to exceed the concentrations specified in 5.1.1 of the Ventilation Rate Procedure. In addition, contaminants of indoor origin should not exceed concentrations listed in Table 3 or Appendix C of ASHRAE 62-1989. It should be noted that methods of measurement of various contaminants are not specified in this standard.
2. Subjective evaluation of the acceptability of the occupied space is also required. ASHRAE 62-1989 guidelines state:

*The air can be considered acceptably free of annoying contaminants if 80 percent of a panel of at least 20 untrained observers deem the air to be not objectionable under representative conditions of use and occupancy.*" (Each observer is to enter the space as a normal visitor and render an independent judgment within 15 seconds).

Performance criteria in the air quality procedure were intended to be compatible with and complementary to the prescriptive criteria in the ventilation rate procedure.

A CO<sub>2</sub> concentration of 1,000 ppm should be considered a correlate only for other contaminants that cause discomfort, annoyance, irritation, or illness. Unacceptable concentrations of indoor contaminants can occur when CO<sub>2</sub> concentration is <1,000 ppm. Conversely, if methods are used to control the other gases and vapors, CO<sub>2</sub> concentration up to 2,500 ppm may be acceptable.

The amount of outdoor air specified in Table 2 of the ASHRAE 62-1989 may be reduced by recirculating air where offending contaminants have been removed or converted to less objectionable form. The amount of outdoor air required depends on contaminant generation in the space, contaminant concentrations in the indoor and outdoor air, filter location, filter efficiency for the contaminants in question, ventilation effectiveness, supply-air circulation rate, and the fraction recirculated.

Filters that are effective for removing particles may be generally ineffective in removing gases and vapors. Therefore, when designing a filtration system, consideration must be given to contaminants that are poorly filtered or unfiltered. The ventilating rate may be reduced only until some contaminant reaches its maximum acceptable limit.

## 5.2 ASHRAE 55-1992 THERMAL ENVIRONMENTAL CONDITIONS FOR HUMAN OCCUPANCY

The standard ASHRAE 55-1992 specifies the combination of factors necessary for thermal comfort in the building environment. The standard considers environmental parameters (temperature, radiant heat, humidity, and air movement) and personal parameters (clothing and activity level). The standard combines the above parameters into acceptable ranges of operative temperature and humidity for summer and winter conditions.

The thermal environmental performance criteria for maintenance of comfort conditions are listed in Table 3.

**Table 3**  
**Thermal Environmental Performance Criteria**  
**for Maintenance of Comfort Conditions**

Parameter	Guidelines
Operative temperature (Winter) relative humidity)	69 to 76 degrees Fahrenheit (at 30%
Operative temperature (Summer) relative humidity)	73 to 79 degrees Fahrenheit (at 50%
Dew point (summer)	> 35 degrees Fahrenheit (winter) < 62 degrees Fahrenheit
Relative humidity	30 to 50 % (winter) 30 to 60 % max.(summer)
Air movement	≤ 30 feet per minute (winter) ≤ 50 feet per minute (summer)

Vertical temperature gradient 67 inches above the floor	$\leq 5$ degrees Fahrenheit between 4 and
Radiant temperature horizontally $< 18$ degrees Fahrenheit vertically	$< 9$ degrees Fahrenheit

### 5.3 ACGIH BIOAEROSOL COMMITTEE GUIDELINES

The recommendations of the ACGIH Bioaerosol Committee *Guidelines for Assessment and Sampling of Saprophytic Bioaerosols in the Indoor Environment* contain protocols for the evaluation of suspected microbiological contamination problems in buildings. A summary of key recommendations in this document follows:

- A pre-assessment of building-related illness should be done to determine if air sampling is warranted.
- A walk-through of the building should be done to look for potential amplification sites for microbiological contamination.
- Air sampling should be conducted with a volumetric sampling device such as a calibrated sieve-type impactor. Settling plate counts are worthless as a means of assessing bioaerosol concentration.
- Care should be taken selecting nutrient media to be used and the laboratory that will provide the analysis.
- Samples should be collected at selected indoor sites and at a representative outdoor site.
- Indoor bioaerosol concentrations should generally be less than one-third of concentrations found outdoors and should be qualitatively similar.
- Remedial action, if necessary, should include removal of water sources, removal or cleaning of grossly contaminated materials, and institution of a preventive maintenance program.

### 5.4 INDOOR ENVIRONMENT PERFORMANCE CRITERIA

Air contaminant exposure standards and guidelines such as OSHA PELs and TLVs of the ACGIH are normally adequate to protect against health effects among industrial workers. However, the use of these criteria to determine the acceptability of indoor air in non-industrial areas is not recommended. In most cases, occupants of non-industrial buildings will report discomfort or symptoms at concentrations well below industrial exposure standards. Therefore, a higher air quality criteria should be used to evaluate indoor environmental complaints.

Examples of recommended indoor environmental criteria for air contaminants are shown in Table 4. Where specific contaminants are not mentioned, a general rule of thumb is to not exceed one-tenth of the contaminant's TLV or twice its odor threshold (whichever is less).

**Table 4**  
**Recommended Upper-Limit Indoor Air Quality Criteria for Contaminants**

Key:  $\mu\text{g}/\text{m}^3$  = micrograms per cubic meter, ppm = parts per million

Contaminant	IAQ Criteria
Carbon dioxide	1,000 ppm
Carbon monoxide	5 ppm
Respirable suspended particulate (PM <sub>10</sub> )	50 $\mu\text{g}/\text{m}^3$
Volatile organic compounds	300 $\mu\text{g}/\text{m}^3$
Formaldehyde	0.1 ppm
Contaminant	IAQ Criteria
Cat Allergen ( <i>Felis domesticus</i> )	8 $\mu\text{g}$ /gram of dust
Dog Allergen ( <i>canis familiaris</i> )	10 $\mu\text{g}$ /gram of dust
Dust Mite Allergens ( <i>dermatophagoides farinae</i> and <i>pteronysinus</i> )	2 $\mu\text{g}$ /gram of dust
Cockroach Allergen ( <i>blattella germanica</i> )	2 units/gram of dust

## 6.0 INVESTIGATING INDOOR ENVIRONMENT CONCERNS

A questionnaire and/or survey may be used to interview occupants and characterize symptoms or discomfort according to the location in the building (see Appendices C and D).

Table 5 is to serve as a guide to conducting an environment walk-through evaluation of the building central HVAC systems and occupied spaces. This table does not, however, attempt to include all of the possible causes for indoor environment concerns.

**Table 5**  
**Indoor Air Quality Investigation**

<b>Observation</b>	<b>Potential Problems</b>	<b>Possible Solution</b>
Too hot in summer Too cold in winter	Thermal discomfort	Increase supply air flow Increase coil capacity Relocate thermostats Lower or raise coil temperature
Too cold in summer Too hot in winter	Thermal discomfort	Calibrate thermostats Relocate thermostats Subdivide zone
Too humid	Occupant discomfort Microbiological contamination	Calibrate humidistat Increase cooling coil capacity Lower chilled water temperature
Too dry	Occupant discomfort Static electricity problems	Calibrate humidistat Provide humidification
Little detectable air movement Still air Stuffy air	Occupant discomfort	Provide maintenance to system Rebalance supply air distribution Provide return air grilles Balance exhaust with outside air intake Provide minimum position for VAV boxes
Lingering odors	Occupant discomfort Occupant symptoms	Determine and remove sources of odors Increase outdoor air to building
Moldy odors	Microbiological contaminants	Find and remove microbiological contaminants Remove moisture sources Inspect air handling unit (AHU) and supply ducts and clean if necessary
Strong odors	Occupant discomfort Occupant symptoms	Remove or ventilate odor sources Increase ventilation
No air movement	Occupant discomfort	Check shutdown and startup times of the AHU Review load-shedding practices Increase fan capacity Provide minimum setting for VAV boxes Rebalance airflow
Return air velocity is weak	Poor air distribution	Provide return air fan
Too few return air grilles	Poor air distribution	Provide more return air
Supply diffusers located too close to return grilles	Poor ventilation efficiency	Separate supply diffuser and return air grille

Outdoor air intake located near contaminant sources Ambient outdoor air contains excessive contaminants	Introduction of contaminants to occupied spaces	Relocate the outdoor air intake Provide filtration of outdoor air contaminants
Air filters are dirty	Air flow reduced Particulate breakthrough Microbiological contamination	Replace filters more frequently
Cooling or heating coils are dirty	Reduced coil efficiency Reduced air flow	Clean coils Increase filter efficiency if necessary
Excessive standing water in the condensate pan	Microbiological contamination	Provide drainage at lowest part of pan Unplug drain
Internal thermal liner of AHU or supply ducts soiled or have microbiological contam.	Amplification of microbiological contamination	Clean or remove soiled material Reinsulate on exterior of AHU or duct
There is a musty odor in the air handling unit or supply air ducts	Microbiological contamination	Determine location of microbiological contamination and clean or remove the contaminated surfaces
Humidification system is resulting in wet liner odors	Microbiological contamination	Provide maintenance switch from water spray to humidification
Boiler steam is used for humidification	Boiler steam additives contaminate supply air	Use potable water as steam source
In distributed heat pump system, outdoor air is not delivered close to heat pumps	Reduced outdoor air in supply air	Extend outdoor air ducts to each heat pump
HVAC system hours of operation out of sync with occupancy	Thermal and contaminant control may not be adequate	Reset system timers to provide best contaminant dilution and thermal comfort for occupants
HVAC system uses common air return	Contaminants from other areas of building may be distributed throughout building	Control contaminants at sources
Fans are shut off during occupied periods as a load shedding technique	Reduced ventilation to occupied spaces	Eliminate or adjust load-shedding to minimize occupant discomfort
Outdoor air dampers have no minimum position (dampers close tight)	Low dilution rates Elevated air contaminant concentrations	Set min. air damper position to provide 15 to 20 cfm per person outdoor air to occupied spaces (ASHRAE 62-1989)
Air handling unit controls are not functioning properly	Inadequate HVAC system performance	Provide mechanical maintenance to AHU, sensors, controls & dampers

Variable air volume boxes have tight shut off	Reduced outdoor air to occupied spaces	Provide VAV boxes with minimum stop at 30% of max. air flow.
---	--	--

## 7.0 PREVENTIVE MEASURES

### 7.1 Low Emission Products and Materials

Indoor environment conditions may be affected during the various phases of a building's life-design, construction, commissioning, occupancy, and remodeling. However, thoughtful planning and design offers the greatest opportunity to minimize potential indoor environment concerns. For example, air contaminant concentrations, particularly VOCs and formaldehyde, can be minimized in new or remodeled buildings through the use of materials and products with low contaminant emissions. Therefore, it is advisable to specify such low-emitting products during the building design phase.

Before procurement of materials and products, suppliers should submit a list of all chemicals used in the manufacture of the products with identification of the chemicals considered to be carcinogens by the International Agency for Research on Cancer, a description of the procedures used by the manufacturer to minimize emissions of VOCs from its products, a description of the emission testing done, and the results of these tests.

Recently published guidelines for the procurement of low-emitting office materials and products are shown in Table 6.

**Table 6**  
**U. S. Environmental Protection Agency Classification**  
**of Low-Emitting Materials and Products**

Key: m<sup>2</sup> = square meter, m<sup>3</sup> = cubic meter, mg/hr = milligrams per hour, VOC = Volatile organic compound

<b>Material or Product</b>	<b>Maximum VOC Emissions</b>
Flooring materials	0.60 mg/hr per m <sup>2</sup>
Floor coatings *	0.60 mg/hr per m <sup>2</sup>
Wall materials	0.40 mg/hr per m <sup>2</sup>
Wall coatings *	0.40 mg/hr per m <sup>2</sup>
Moveable partitions	0.40 mg/hr per m <sup>2</sup>
Office furniture	2.50 mg/hr per workstation
Office machines (central)	0.25 mg/hr per m <sup>3</sup> of space
Ozone emissions from office machines (central)	0.01 mg/hr per m <sup>3</sup> of space

Ozone emissions from office machines (personal)	2.50 mg/hr per workstation
Office machines (personal)	0.10 mg/hr per workstation

- \* Immediately after application, many varnishes, paints, waxes, and other wet coatings have emission factors substantially higher than this. These coatings might still be considered "low-emitting" if their emission factors drop below this level within several hours. However, the presence of other surfaces that absorb coating vapors and subsequently re-emit them complicates the classification of coatings.

## 7.2 Heating, Ventilating and Air Conditioning (HVAC) Commissioning

Before occupancy of a new building and periodically throughout the life of the building, the HVAC systems should be commissioned or recommissioned to verify and document system performance. The recommended procedure for carrying out this commissioning process is contained in ASHRAE 1-1989 *Guideline for Commissioning of HVAC Systems*.

## 7.3 Ventilation System Performance Recommendations

- Prior to occupancy, the HVAC systems should be tested, adjusted, and balanced to ensure that system air flows are within design specifications. If occupancy is phased in or if significant remodeling which affects the central supply air delivery systems is done in the building, the systems should be rebalanced to assure design air flow conditions.
- The HVAC systems should provide outdoor air to the occupied spaces at a rate in accordance with ASHRAE 62-1989 and not less than 15 cfm/m<sup>3</sup> during all occupied periods. Before occupancy and after system balancing, tracer gas testing should be done to determine the actual amount of outdoor air being brought into the occupied spaces.
- HVAC Systems should have the capacity to provide up to 100 percent outdoor air in the supply air.

## 7.4 Facility Site Selection

The outdoor air at a proposed facility site should meet or exceed the EPA National Ambient Air Quality Standards, and should not have unusually high concentrations of microbiological concentrations, and unusual odors. In geographical areas where outdoor air contamination is excessive, the facility design should be capable of removing contaminants by HVAC system air filtration devices before entering the HVAC supply air.

## 7.5 Indoor Environment Contaminant Control

During the installation of building materials or during remodeling or maintenance processes that emit substantial quantities of air contaminants, the central HVAC systems should be operated with minimal or no recirculation of air. Ventilation for construction projects should be operated continually for at least one week after the completion of the construction work. Whenever possible, maintenance or remodeling projects that create substantial air contaminants should be done during times when most of the building is vacant.

Other major point sources of air contaminants should be provided with local exhaust ventilation.

Frequent Material Safety Data Sheet (MSDS) reviews should be conducted for all products used at the facility, to ensure against contaminants entering the environment.

#### 7.6 Maintenance and Housekeeping

Maintenance of HVAC systems and their controls are an integral part of eliminating problems. Routine preventive maintenance on HVAC systems will assure adequate delivery of ventilation air and thermal comfort to occupants while minimizing contaminant sources within the systems. The following items are recommended as a minimum for HVAC maintenance:

- Primary air filters should be changed at least quarterly, and more frequently if necessary. These air filters should have a minimum 30 percent ASHRAE dust spot efficiency rating.
- The coils and condensate drain pan should be cleaned at least annually. The condensate drain line of each unit should be checked quarterly during the cooling season to assure that it is not plugged and that water is draining properly. Fan coil units, unit ventilators, and heat pump units should be inspected and cleaned at least annually.
- The porous insulation on the interior surfaces of air handling units should be inspected at each filter change. Where visible microbiological growth is evident, the contamination should be removed or the contaminated section of the liner should be replaced.
- The mechanical integrity of control sensors, motors, and dampers should be checked at least annually. If necessary, thermostats should be checked and calibrated every year.

Housekeeping tasks, such as vacuuming, floor stripping and polishing, carpet cleaning, dusting, and use of odorous cleaning agents should be done after normal work hours, as much as practical. Preference should be given to the use of cleaning agents that contain the lowest concentrations of toxic or irritating chemicals. Care should be taken to assure that cleaning agents are properly diluted before use.

#### 7.7 On-Going Tests/Monitoring

Even with the continuous steps taken by the staff to minimize problem areas, a schedule for testing and monitoring has been established under the normal preventative maintenance work order system as indicated by the frequency in Table 7.

**Table 7  
Tests/Monitoring**

<b>Contaminant/Condition</b>	<b>Location</b>	<b># Samples</b>	<b>Frequency</b>
Carbon Dioxide	All District Bldgs.	2	Monthly
Carbon Monoxide	All District Bldgs.	2	Monthly
Air Temp	All District Bldgs.	2	Monthly
Humidity	All District Bldgs.	2	Monthly

## APPENDICES

- A Acronyms
- B Glossary of Terms
- C Occupant Questionnaire
- D Indoor Environment Quality Survey

**APPENDIX A - ACRONYMS**

ACGIH	American Conference of Governmental Industrial Hygienists
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
BRI	Building Related Illness
cfm	cubic feet per minute
cfu/m <sup>3</sup>	colony forming units per cubic meter
ETS	Environmental Tobacco Smoke
HVAC	Heating, Ventilating, and Air Conditioning
IAQ	Indoor Air Quality
MSDS	Material Safety Data Sheet
m <sup>2</sup>	square meter
m <sup>3</sup>	cubic meters
mg/hr	milligrams per hour
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
ppm	parts per million
RSP	Respirable Suspended Particulate
SBS	Sick Building Syndrome
TLV	Threshold Limit Values
TSP	Total Suspended Particulates
VDT	Video Display Terminal
VOC	Volatile Organic Compound

## APPENDIX B - GLOSSARY OF TERMS

American Conference of Governmental Industrial Hygienists	A professional organization of industrial hygienists who work primarily in governmental agencies or educational institutions. ACGIH publishes recommended occupational exposure limits called threshold limit values (TLV) for hundreds of chemical substances and physical agents.
American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)	An international membership organization dedicated to advancing the arts and sciences of heating, ventilating, air conditioning, and refrigerating. ASHRAE publishes standards' guidelines, and technical bulletins on mechanical ventilation and related subjects.
Building related illness (BRI)	Medical disorders, such as hypersensitivity pneumonitis or Legionnaires Disease, which are caused by exposure to contaminants or agents within buildings and are characterized by clinical signs of illness such as fever, infection, changes in lung function, and allergic response, and a slower recovery than <i>sick building syndrome</i> .
Cubic feet per minute (cfm)	A measure of air flow.
Colony forming units per cubic meter (cfu/m <sup>3</sup> )	A measurement of airborne microorganisms.
Duty cycling	The turning on and off of equipment as a means of saving energy.
Exhaust air	Air removed from a space and not reused therein
HVAC system	Heating, ventilating, and air conditioning system.
Hypersensitivity Pneumonitis	An allergic response, characterized by an asthma-like reaction, which may be caused by inhalation of organic particulates such as mold spores or bacterial contaminants.
Load shedding when	An energy management practice of shutting off selected electrical loads (e.g., HVAC fans) of a site total electrical load approaches the demand limit.
Mixed air	Air that contains a mixture of fresh air and return air that will be conditioned and used as supply air for a space.

Outdoor air	Air taken from the external atmosphere and therefore, not previously circulated through the system (sometimes referred as "fresh air").
Permissible exposure limit (PEL)	Allowable occupational exposure limits for chemical and physical agents set by Occupational Safety and Health Administration (OSHA). PELs are usually more applicable to industrial operations than to commercial office buildings.
Recirculated Air	Air removed from a conditioned space and intended for reuse as supply air.
Return air	See recirculated air.
Respirable suspended particulate (RSP)	Airborne particles of approximately 10 micrometers or less aerodynamic diameter which may reach the lower lung regions during respiration.
Sick Building Syndrome (SBS)	A disorder characterized by a substantial number of occupants (e.g., 20% to 30%) within an indoor space reporting symptoms such as eye or throat irritation, headache, tiredness, nausea, dizziness, and sinus congestion which occur while in the building and diminish shortly after leaving the building.
Supply air	Air delivered to the conditioned space that is used for ventilation, cooling, heating, humidification, or dehumidification.
Threshold limit values (TLV) the office buildings.	Recommended occupational exposure limits for chemical and physical agents established by American Conference of Governmental Industrial Hygienists. TLVs are usually more applicable to industrial operations than to commercial office buildings.
Volatile organic compound (VOC) be	A term used to collectively describe the many carbon containing gases and vapors that may present in air.
Video display terminal (VDT)	Common term for cathode ray tube view screen and associated hardware used with computers and as a dumb terminal.

**APPENDIX C - OCCUPANT QUESTIONNAIRE**

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We are assessing your work environment to help ensure acceptable indoor environment.  
Please assist us by completing this questionnaire as accurately as possible and returning it to

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Thank you for your help.

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1. Please complete the following regarding your office location.

Building \_\_\_\_\_

Floor \_\_\_\_\_

Department \_\_\_\_\_

Room Number \_\_\_\_\_

2. How long have you been at this location? \_\_\_\_\_

3. Please complete the following about your work area:

	Seldom or Never	Occasionally	Frequently	Usually or Always
Temperature too hot in summer				
Temperature too hot in winter				
Temperature too cold in winter				
Temperature too cold in summer				
Insufficient air movement				
Stuffy air				
Dust on surfaces				
Tobacco smoke				
Musty odors				
Other unpleasant odors				
Air too dry in winter				
Air too humid in summer				
Lighting is too bright				
Lighting is too dim				
Too many shadows				
Too much glare				
Glare on VDT screen				
Noisy interruptions				
Distracting sounds				

4. List any symptoms which seem to occur or worsen while at work.

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5. These symptoms occur (circle one, if applicable):

- Daily or almost daily
- Frequently
- Occasionally

6. When do these symptoms seem to occur? (circle items that apply)

- a. All day long
- b. Worse in morning
- c. Worse in afternoon
- d. Worse on certain days. Which days? \_\_\_\_\_

e. Worse during certain operations. Which operations?

f. Worse during certain times of the year. When?

7. Please make additional comments about discomfort or symptoms that you have experienced at work, and your perceptions of the environmental quality of your work area.

Your Name: \_\_\_\_\_

## APPENDIX D - INDOOR ENVIRONMENT QUALITY SURVEY

(School District)  
Indoor Environment Quality Survey

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### Cover Sheet

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Requested by: \_\_\_\_\_ Date Requested: \_\_\_\_\_

Performed by: \_\_\_\_\_ Date Completed: \_\_\_\_\_

1. Building name: \_\_\_\_\_

2. Building address: \_\_\_\_\_

3. Space: Owned \_\_\_\_\_ Leased \_\_\_\_\_

4. Space maintained by: \_\_\_\_\_

5. Location of problem: Floor \_\_\_\_\_ Suite \_\_\_\_\_ Room \_\_\_\_\_

6. Contact person: \_\_\_\_\_ Phone: \_\_\_\_\_

7. Symptoms present: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

8. Occurrence of symptoms: Continuous \_\_\_\_\_

Only certain hours \_\_\_\_\_

9. Specific occupant comments: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

10. Recommendation to check: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

## Mechanical-Preliminary

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Requested by: \_\_\_\_\_

Date Requested: \_\_\_\_\_

Performed by: \_\_\_\_\_

Date Completed: \_\_\_\_\_

### A. Interior Environment

- |    |  |                          |                            |
|----|--|--------------------------|----------------------------|
| 1. | Space:   | Temperature _____ °F     | Humidity _____             |
|    |  | Noticeable airflow _____ | Thermostat set point _____ |
| 2. | Diffusers:   | Dirty _____              | Covered/adjusted _____     |
| 3. | Ceiling:   | Dirty _____              | Stained _____              |
| 4. | Windows:   | Operable _____           | Solar film _____           |
|    |  | Window wet _____         | Cracked _____              |
|    |  | Shades available _____   | Shades open _____          |
| 5. | Walls:   | Dirty _____              | Stained _____              |
|    |  | Visible mold _____       | Cracks _____               |
| 6. | Carpet:  | Dirty _____              | Stained _____              |
|    |  | Visible mold _____       | Evidence of water _____    |
| 7. | Lighting:  | Consistent _____         | Lenses dirty _____         |
| 8. | Acoustics: Identify source (i.e., above ceiling, etc.) _____ |                          |                            |
|    | _____  |                          |                            |
|    | _____  |                          |                            |
| 9. | Restrooms:   | Dirty _____              | Exhausted _____            |
|    |  | Odor _____               |                            |

## 10. Miscellaneous:

Note general smells (i.e., diesel, perfume, flowers, etc.) \_\_\_\_\_

\_\_\_\_\_

Note general "feel" (i.e., stuffy, musty, enclosed, etc.) \_\_\_\_\_

\_\_\_\_\_

11. Other Comments: \_\_\_\_\_

**B. Mechanical Space**

## 1. Air distribution source:

Identity/label \_\_\_\_\_ Location \_\_\_\_\_

2. Air handling unit Operating \_\_\_\_\_

3. Damper operators Linkage connected \_\_\_\_\_

4. Filters: Dirty \_\_\_\_\_ Wet \_\_\_\_\_

5. General Condition of AHU Room (i.e., cleanliness, wet, used for storage, etc.)

\_\_\_\_\_

\_\_\_\_\_

*Consult with Building Maintenance Personnel to Answer the Following Questions:*

6. Outside air source: Number of sources \_\_\_\_\_  
Location (Ground/Roof) \_\_\_\_\_

7. Type of air system: Dual Duct \_\_\_\_\_  
Multizone \_\_\_\_\_ VAV \_\_\_\_\_  
Constant \_\_\_\_\_ Package units \_\_\_\_\_  
volume \_\_\_\_\_  
Fan coil \_\_\_\_\_ Other \_\_\_\_\_  
Does air system have humidification? \_\_\_\_\_

8. Type of cooling plant: Chilled water \_\_\_\_\_ Direct expansion \_\_\_\_\_  
Water cooled \_\_\_\_\_ Air cooled \_\_\_\_\_

If system has a cooling tower, what kind of chemicals are used? \_\_\_\_\_

\_\_\_\_\_

9. Type of heating plant:  
Steam \_\_\_\_\_  
Electric \_\_\_\_\_ Hot water \_\_\_\_\_

10. What are the HVAC system operating hours?  
Monday-Friday \_\_\_\_\_ to \_\_\_\_\_  
Saturday \_\_\_\_\_ to \_\_\_\_\_  
Sunday \_\_\_\_\_ to \_\_\_\_\_  
Other comments: \_\_\_\_\_

11. Miscellaneous  
Do you have sumps? \_\_\_\_\_ Location \_\_\_\_\_

**C. Exterior Condition**

1. Outside air intake: Dirty \_\_\_\_\_

2. Check surrounding area contaminants:  
Exhaust fan \_\_\_\_\_  
Cooling tower \_\_\_\_\_ Loading dock \_\_\_\_\_  
Autos/delivery vehicles \_\_\_\_\_ Other \_\_\_\_\_

3. Identify construction activities: \_\_\_\_\_  
\_\_\_\_\_

4. Other comments: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**Mechanical-Detailed**

Requested by: \_\_\_\_\_ Date Requested: \_\_\_\_\_

Performed by: \_\_\_\_\_ Date Completed: \_\_\_\_\_

**A. General Information**

1. Review design documents: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

2. Identify control strategies: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_
3. Any major renovations: \_\_\_\_\_  
 \_\_\_\_\_  
 When did they occur? \_\_\_\_\_
4. Any major operating changes: \_\_\_\_\_  
 \_\_\_\_\_  
 When did they occur? \_\_\_\_\_
5. Who is responsible for cleaning interior of building? \_\_\_\_\_  
 \_\_\_\_\_  
 How often is cleaning done? \_\_\_\_\_

#### B. Exterior Conditions

1. Outside air intake:  
 Condition \_\_\_\_\_ Obstructions \_\_\_\_\_  
 Cleanliness \_\_\_\_\_ Other \_\_\_\_\_
2. Surrounding contaminants: Exhaust fans within 10 feet  
 Plumbing vents \_\_\_\_\_ Cooling tower \_\_\_\_\_  
 Truck/Auto \_\_\_\_\_ Loading dock \_\_\_\_\_  
 Construction \_\_\_\_\_ Dumpster \_\_\_\_\_  
 Other \_\_\_\_\_
3. Cooling tower:  
 Basin dirty \_\_\_\_\_ Visible algae \_\_\_\_\_  
 Overflow utilized \_\_\_\_\_ Makeup operational \_\_\_\_\_  
 Conductivity \_\_\_\_\_ Support condition \_\_\_\_\_  
 sensor \_\_\_\_\_
4. Check water treatment log book: \_\_\_\_\_ Chemical type \_\_\_\_\_  
 Frequency of use \_\_\_\_\_ Chemical stored on site \_\_\_\_\_  
 Location \_\_\_\_\_

### C. Air Handling Equipment

1. Outside air dampers:  
Open \_\_\_\_\_ Operator \_\_\_\_\_  
Connected \_\_\_\_\_
2. Source of return air:  
Plenum \_\_\_\_\_ Direct ducted \_\_\_\_\_
3. Filter:  
Dirty \_\_\_\_\_ Rack condition \_\_\_\_\_  
Type \_\_\_\_\_ Mfr./Model No. \_\_\_\_\_  
Wet \_\_\_\_\_ Other \_\_\_\_\_
4. AHU exterior condition: \_\_\_\_\_
5. Interior liner condition:  
Dirty \_\_\_\_\_ Wet \_\_\_\_\_  
Mold \_\_\_\_\_ Other \_\_\_\_\_
6. Drain Pan:  
Dirty \_\_\_\_\_ Clogged \_\_\_\_\_  
Fungus \_\_\_\_\_ Other \_\_\_\_\_
7. Fan Condition:  
Blades dirty \_\_\_\_\_
8. Motor horsepower:  
Supply \_\_\_\_\_ HP  
Return \_\_\_\_\_ HP
9. Ductwork:  
Leaks \_\_\_\_\_ External insulation \_\_\_\_\_
10. Pipe insulation:  
Torn/missing \_\_\_\_\_ Wet \_\_\_\_\_
11. Humidifier:  
Present \_\_\_\_\_ Operational \_\_\_\_\_  
Discharge orifice condition \_\_\_\_\_  
Downstream duct/liner condition \_\_\_\_\_
12. Check the following water sources, if applicable:  
Condensation drain \_\_\_\_\_ Sump \_\_\_\_\_  
Backflow preventer \_\_\_\_\_ Makeup water \_\_\_\_\_  
Chemical treatment \_\_\_\_\_ Other \_\_\_\_\_
13. Water damage visible:  
Walls \_\_\_\_\_ Ceiling \_\_\_\_\_

**D. Plant Equipment**

- |  |   |
|--|---|
| 1. Boiler flues:<br>Odors _____<br>Condition<br>(rust, etc.) _____ | Apparent leaks _____<br>Soot _____<br>Other _____ |
| 2. Fuel tanks:<br>Odors _____<br>Condition<br>(rust, etc.) _____   | Apparent leaks _____<br>Soot _____<br>Other _____ |
| 3. Sumps:<br>Uncovered _____                                       | Algae _____                                       |
| 4. Combustion Air opening:<br>Dirty _____                          | Odors _____                                       |

**E. Interior Condition**

- |   |   |
|---|---|
| 1. Verify exhaust:<br>Restrooms _____<br>Storage _____  | Custodial Closet _____                                      |
| 2. Space:<br>Temperature _____ °F<br>Noticeable airflow _____<br><br>CO <sub>2</sub> level _____<br>Infiltration from surrounding space _____ | Humidity _____ %RH<br>Thermostat<br>setpoint _____          |
| 3. Baseboard heaters:<br>Utilized _____   | Dirty _____   |
| 4. Ceiling mounted equipment:<br>Heating cell _____<br>Filters _____  | Cooling coil _____<br>Drain pan _____<br>VAV operator _____ |
| 5. Ductwork:<br>Leaks _____<br><br>Flex duct properly supported _____   | External<br>insulation _____                                |
| 6. Water apparent above ceiling: _____  |   |
| 7. Diffusers:<br>Heating cell _____   | Covered/adjusted _____                                      |
| 8. Ceiling:<br>Dirty _____<br>Missing Tiles _____   | Stained _____<br>Visible mold _____                         |

9. Windows:  
Operable \_\_\_\_\_ Solar film \_\_\_\_\_  
Wet interior \_\_\_\_\_ Cracked \_\_\_\_\_  
Shades available \_\_\_\_\_ Shades open \_\_\_\_\_
10. Walls:  
Dirty \_\_\_\_\_ Stained \_\_\_\_\_  
Visible mold \_\_\_\_\_ Cracks \_\_\_\_\_
11. Carpet:  
Dirty \_\_\_\_\_ Stained \_\_\_\_\_  
Visible mold \_\_\_\_\_ Evidence of wear \_\_\_\_\_
12. Lighting:  
Consistent \_\_\_\_\_ Lenses dirty \_\_\_\_\_  
Light level \_\_\_\_\_ VDTs present \_\_\_\_\_
13. Acoustics: Identify source (i.e., above ceiling, etc.) \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
14. Other comments: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_