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LAKELAND JR-SR HIGH SCHOOL
JERMYN, PENNSYLVANIA

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SUMMARY

In January 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from the superintendent of the Lakeland School District. The superintendent and employees were concerned about the occurrences of "bacterial" diseases among employees of the Lakeland Junior-Senior High School in Jermyn, Pennsylvania. NIOSH investigators collected information from employee interviews in May 1992 and from employee questionnaires in August and November 1992, and conducted a site visit to the school on December 21-22, 1992.

The symptoms reported most frequently by school employees during the summer and the school year were eye strain, eye irritation, nasal/sinus congestion, and excess fatigue. Nearly all symptoms were reported by a higher percentage of employees during the school year than during the summer when school was not in session. A possible building-related symptom was defined as any symptom that occurred less than once a week during the summer and increased in frequency to once a week or more during the school year. Excessive fatigue (35%), eye irritation (30%), nasal or sinus congestion (28%), and eye strain (25%) were the most frequently reported symptoms that met this definition.

Possible building-related symptoms reported by employees were grouped into one of the following categories: mucous membrane irritation, respiratory symptoms, or non-specific symptoms. At least one symptom in the group was reported, respectively, by 50%, 25%, and 43% of employees. The prevalences of all grouped symptoms were higher among employees who reported that unsatisfactory working conditions were present at least once a week during the four weeks prior to the school-year questionnaire. Environmental conditions were most strongly related to non-specific symptoms and least strongly related to respiratory symptoms. The environmental conditions with the strongest and most consistent associations with symptoms were too little air movement, unpleasant odors, and unclean work areas.

On the day of the NIOSH survey, the general classroom environments appeared in fair condition; all classrooms were well lit and visible surfaces were mostly clean. "Mold and mildew" odors described by faculty were not evident during the NIOSH survey. Bacterial and fungal counts in bulk samples collected from water-stained ceiling tiles, interior ventilation system lining, and wall paint did not indicate a significant problem with microbiological contamination.

Carbon dioxide (CO_2) concentrations in most areas of the school increased over the course of the day. Numerous CO_2 measurements in mid-morning and mid-afternoon were at or exceeded the ASHRAE recommendation of 1000 parts per million. The practice of setting the variable speed fans in the ventilating units to the lowest setting contributed to the elevated CO_2 concentrations. Indoor temperatures and relative humidity levels during occupied times bordered the lower limits recommended in the ASHRAE guidelines. Non-conformity with these guidelines was primarily the result of indoor relative humidity levels in the mid 20s throughout the school.

NIOSH investigators did not find a consistent pattern of "bacterial" disease that could be related to environmental conditions in the school. Symptoms of mucous membrane irritation and nonspecific symptoms (such as fatigue, headache) reported by school employees, however, were related to their perceptions of unpleasant working conditions within the building, particularly insufficient air movement and unclean work areas. Employees' reports of insufficient air movement were consistent with low fan speed settings, which contributed to CO_2 concentrations in excess of the ASHRAE criterion. Recommendations to provide an adequate supply of outside air and maintain temperature and humidity levels in accordance with ASHRAE guidelines are presented in Section VII.

KEYWORDS: SIC 8211 (Elementary and secondary schools), indoor environmental quality, IEQ, thermal comfort, carbon dioxide, microbial contamination

I. INTRODUCTION

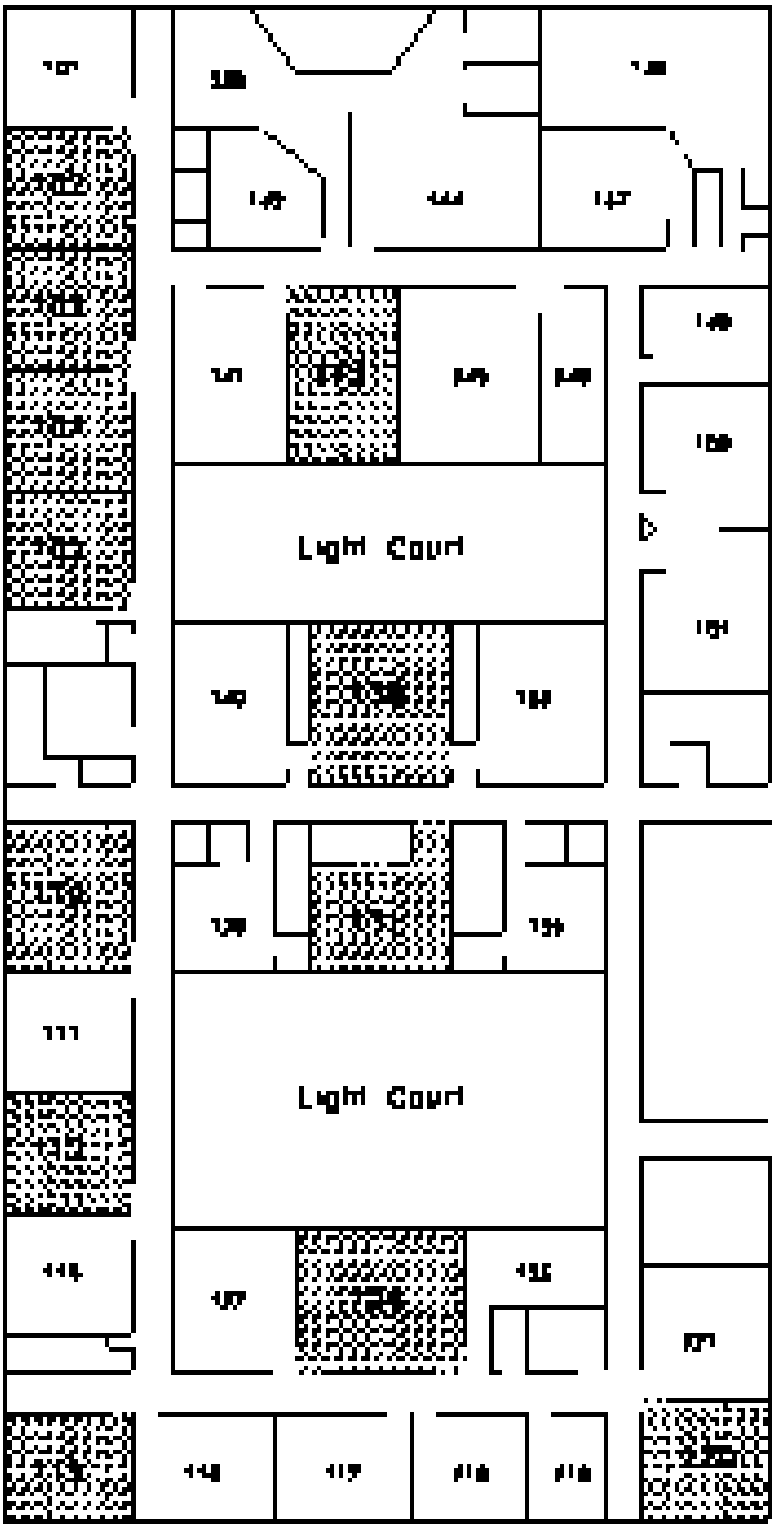
In January 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from the superintendent of the Lakeland School District. According to the request, the superintendent and employees were concerned about the occurrences of "bacterial" illnesses among employees of the Lakeland Junior-Senior (Jr-Sr) High School in Jermyn, Pennsylvania. NIOSH investigators collected information from employees by telephone interviews in May 1992 and from questionnaires mailed to employees in August and November 1992, and conducted a site visit to the school on December 21-22, 1992.

II. BACKGROUND AND DESCRIPTIVE INFORMATION

Lakeland Jr-Sr High School is a single-story, masonry building in a mixed rural/agricultural area in Jermyn, Pennsylvania. The school was occupied in 1974. The estimated occupancy during 1992 was 800; the adult staff (including teachers) accounted for approximately 10% of the total population. The student population at the time of the survey was approximately 726. All classrooms are located in the south wing of the school complex. A sketch of the evaluated areas of the building is shown in Figure 1 (not to scale).

The building was designed to provide each classroom with a minimum of one windowed wall with a view to the outdoors. All windows are sealed. In response to reports of water incursion (i.e., roof leaks) throughout the building, a new roof was installed in 1981. At that time, carpets and water-damaged ceiling tiles were also replaced.

Each classroom is designed with a "through-the-wall" package ventilating unit (heat only). Each ventilating unit is capable of providing a pre-set volumetric ratio of recirculated room and outdoor air. Maintenance personnel indicated that the outdoor air component was set at 10%. In addition, the fan can be set on one of three operating speeds. For each ventilating unit, outdoor air mixes with return air and then passes through low efficiency, metal mesh filters. This filtered, mixed air is passed by heated coils before being delivered to the occupied space. A pressure relief ventilation system in the building corridors is designed to compensate for the constant volume of outdoor air being introduced into the building through each classroom. Diffuser grates to a common building corridor plenum are located above the entrance door to each classroom. Room air diffuses through the grate, into the common plenum, and then is exhausted through the roof.



NOTE: Shaded areas indicate environmental sample locations.

Figure 1. Floor Plan of Evaluation Area
(Lakeland Jr-Sr High School)

Specialty classrooms (i.e., Power Technology, Graphic Arts, Industrial Materials, Automotive, Physical Science, Chemistry, and Physics) are designed with dedicated exhaust systems, including fume hoods (Chemistry) and local exhaust ventilation (Power Technology and Industrial Arts), in addition to ceiling exhaust diffusers.

III. EVALUATION METHODS

Medical Evaluation

In April 1991, a representative of the Lakeland Education Association (LEA) provided the NIOSH medical investigator with the names and telephone numbers of nine employees with "bacterial" diseases. These individuals were interviewed by telephone and relevant medical records were requested from physicians for those individuals who had seen a physician about the suspected building-related illness.

Based on the employee interviews, the NIOSH investigators determined that a site visit to the school was needed. The visit was scheduled for December 1992 to ensure that employees had spent sufficient time in the building during the new school year to accurately reflect current concerns and conditions.

The school principal provided the names and addresses of the 78 school employees. A questionnaire was sent to employees in August 1992 when school was not in session. If no response to the initial letter was obtained within three weeks, a reminder letter was sent with a second copy of the questionnaire. The questionnaire asked about the occurrence of any of 13 symptoms (irritation, nasal congestion, headaches, etc.) during the past four weeks. These symptoms commonly are reported by occupants of "problem buildings." Employees were also asked about a history of certain physician-diagnosed illnesses, illnesses experienced during the past year, and the presence of water damage in their work area during the past school year.

In November 1992, the NIOSH medical officer sent a followup questionnaire to all individuals on the August mailing list. Employees were asked about the same symptoms as on the initial questionnaire and, similarly, were asked about the occurrence of these symptoms during the preceding four weeks. In addition, employees were asked whether these symptoms tended to get worse, stay the same, or get better when they were away from work. Employees also were asked about environmental comfort (too hot, too cold, unusual odors, etc.) in the building during the preceding four weeks.

During the December 1992 site visit, 14 school employees were interviewed at their request. They described their concerns about the physical environment in the school and about the symptoms and illnesses that they felt were related to conditions in the building.

Environmental Evaluation

Indicators of occupant comfort (i.e., carbon dioxide (CO_2) concentration, temperature, and relative humidity) were collected at each sample location for

three rounds of sampling beginning at approximately 7:00 a.m., followed by subsequent sampling rounds at 10:00 a.m. and 3:00 p.m. CO_2 was measured using a Gastech RI 411 CO_2 monitor (Gastech, Inc., Newark, California). This portable, battery-operated instrument uses a non-dispersive infrared absorption detector to measure CO_2 in the range of 0-4975 ppm, with a sensitivity of ±25 ppm. Instrument zeroing was performed prior to and after use, as was calibration with a known concentration (800 parts per million) of CO_2 span gas (Alphagaz, Division of Liquid Air Corporation, Cambridge, Maryland). Temperature and RH were measured using a Vaisala HM 34 temperature and humidity meter (Vaisala Oy, Helsinki, Finland). This meter is capable of providing direct readings for dry-bulb temperature and RH, ranging from -4 to 140°F and 0 to 100%, respectively. Instrument calibration is performed monthly using primary standards. Chemical smoke was used to visualize airflow in the evaluated area and to determine potential pollutant pathways to this area.

Bulk samples were collected from interior locations (i.e., Rooms 102, 103, 104, and 110) and analyzed for bacterial and fungal content. These samples included interior ventilation system lining, ceiling tiles, and wall paint.

IV. EVALUATION CRITERIA

NIOSH investigators have completed nearly 1500 investigations of the occupational indoor environment in a wide variety of non-industrial settings. The majority of these investigations have been conducted since 1979.

The symptoms and health complaints reported to NIOSH by building occupants have been diverse and usually not suggestive of any particular medical diagnosis or readily associated with a causative agent. A typical spectrum of symptoms has included headaches, unusual fatigue, varying degrees of itching or burning eyes, irritations of the skin, nasal congestion, dry or irritated throats, and other respiratory irritations. Typically, the

workplace environment has been implicated because workers report that their symptoms lessen or resolve when they leave the building.

A number of published studies have reported a high prevalence of symptoms among occupants of office buildings.[1-5] Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building-related occupant complaints.[6,7] Among these factors are imprecisely-defined characteristics of heating, ventilating, and air-conditioning (HVAC) systems, cumulative effects of exposure to low concentrations of multiple chemical pollutants, odors, elevated concentrations of particulate matter, microbiological contamination, and physical factors such as thermal comfort, lighting, and noise[8-13]. Indoor environmental pollutants can arise from either outdoor sources or indoor sources.

There are also reports describing results which show that occupant perceptions of the indoor environment are more closely related to the occurrence of symptoms than any measured indoor contaminant or condition.[14-16] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[16-19]

Less often, an illness may be found to be specifically related to something in the building environment. Some examples of potentially building-related illnesses are allergic rhinitis, allergic asthma, hypersensitivity pneumonitis, Legionnaires' disease, Pontiac fever, carbon monoxide poisoning, and reaction to boiler corrosion inhibitors. The first three conditions can be caused by various microorganisms or other organic material. Legionnaires' disease and Pontiac fever are caused by *Legionella* bacteria. Sources of carbon monoxide include vehicle exhaust and inadequately-ventilated kerosene heaters or other fuel-burning appliances. Exposure to boiler additives can occur if boiler steam is used for humidification or is released by accident.

Problems that NIOSH investigators have found in the non-industrial indoor environment have included: poor air quality due to ventilation system deficiencies, overcrowding, volatile organic chemicals from furnishings, emissions from office machines, structural components of the building and contents, tobacco smoke, microbiological contamination, and outside air pollutants; comfort problems due to improper temperature and relative humidity (RH) conditions, poor lighting, and unacceptable noise levels; adverse ergonomic conditions; and job-related psychosocial stressors. In most cases, however, these problems could not be directly linked to the reported health effects.

Standards specifically for the non-industrial indoor environment do not exist. NIOSH, the Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH) have published regulatory standards or recommended limits for occupational exposures.[20-22] With few exceptions, pollutant concentrations observed in non-industrial indoor environments fall well below these published occupational standards or recommended exposure limits. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published recommended building ventilation design criteria and thermal comfort guidelines.[23,24] The ACGIH has also developed a manual of guidelines for

approaching investigations of building-related complaints that might be caused by airborne living organisms or their effluents.[25]

Measurement of indoor environmental contaminants has rarely proved to be helpful in determining the cause of symptoms and complaints except where there are strong or unusual sources, or a proven relationship between contaminants and specific building-related illnesses. The low-level concentrations of particles and variable mixtures of volatile organic chemicals usually found are difficult to interpret and usually impossible to causally link to observed and reported health symptoms. However, measuring ventilation and comfort indicators such as CO_2, temperature and RH, has proven useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems.

NIOSH and the Environmental Protection Agency (EPA) jointly published a manual on building air quality, written to help prevent environmental problems in buildings and solve problems when they occur.[26] This manual suggests that indoor environmental quality (IEQ) is a constantly changing interaction of a complex set of factors. Four of the most important elements involved in the development of IEQ problems are: 1) a source of odors or contaminants; 2) a problem with the design or operation of the HVAC system; 3) a pathway between the contaminant source and the location of the complaint; 4) and the building occupants. A basic understanding of these factors is critical to preventing, investigating, and resolving IEQ problems.

The basis for measurements made during this evaluation are listed below.

Carbon Dioxide

Carbon dioxide (CO_2) is a normal constituent of exhaled breath and, if monitored, may be useful as a screening technique to evaluate whether adequate quantities of fresh air are being introduced into an occupied space. The ANSI/ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality, recommends outdoor air supply rates of 20 cubic feet per minute per person (cfm/person) for office spaces and conference rooms, 15 cfm/person for reception areas, and 60 cfm/person for smoking lounges, and provides estimated maximum occupancy figures for each area.[23]

Indoor CO_2 concentrations are normally higher than the generally-constant ambient CO_2 concentration (range 300-350 ppm). When indoor CO_2 concentrations exceed 1000 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected. Elevated CO_2 concentrations suggest that other indoor contaminants may also be increased.

Temperature and Relative Humidity

The perception of comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperatures. Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. ANSI/ASHRAE Standard 55-1992 specifies conditions in which 90% or more of the

occupants would be expected to find the environment thermally comfortable.[24] Assuming low air movement, 50% RH, and sedentary job tasks, the temperatures recommended by ASHRAE range from 68-75°F in the winter and from 73-79°F in the summer. ASHRAE also recommends that RH be maintained between 30 and 60%.

Microbiological Contaminants

Microorganisms (including fungi and bacteria) are normal inhabitants of the environment. The saprophytic varieties (those utilizing non-living organic matter as a food source) inhabit soil, vegetation, water, or any reservoir that can provide an adequate supply of a nutrient substrate. Under the appropriate conditions (optimum temperature, pH, and with sufficient moisture and available nutrients) saprophytic microorganism populations can be amplified. Through various mechanisms, these organisms can then be disseminated as individual cells or in association with soil or dust particles or water droplets. In the outdoor environment, the levels of microbial aerosols will vary according to the geographic location, climatic conditions, and surrounding activity. In an indoor environment where there is no unusual source of microorganisms the level of microorganisms may vary somewhat as a function of the cleanliness of the HVAC system and the numbers and activity level of the occupants. Generally, the indoor levels are expected to be below the outdoor levels (depending on HVAC system filter efficiency), with similar microbial species.[27-28]

Some individuals manifest increased immunologic responses to antigenic agents encountered in the environment. These responses and the subsequent expression of allergic disease is based, partly, on a genetic predisposition.[7] Allergic diseases typically associated with exposures in indoor environments include allergic rhinitis (nasal allergy), allergic asthma, allergic bronchopulmonary aspergillosis (ABPA), and extrinsic allergic alveolitis (hypersensitivity pneumonitis).[27] Allergic respiratory diseases resulting from exposures to microbial agents have been documented in agricultural, biotechnology, office, and home environments.[30-37]

Symptoms vary with the type of allergic disease: (1) allergic rhinitis is characterized by bouts of sneezing; itching of the nose, eyes, palate, or pharynx; nasal stuffiness with partial or total airflow obstruction; and rhinorrhea (runny nose) with postnasal drainage; (2) allergic asthma is characterized by episodic wheezing and shortness of breath due to reversible bronchial narrowing; (3) ABPA is characterized by cough, lassitude, low grade fever, wheezing, and occasional expectoration of mucous.[27,38] Heavy exposures to airborne microorganisms can result in an acute form of extrinsic allergic alveolitis which is characterized by chills, fever, malaise, cough, and dyspnea (shortness of breath) appearing 4 to 8 hours after exposure. Onset of the chronic form of extrinsic allergic alveolitis is thought to be induced by a continuous low-level exposure, and onset occurs without chills, fever, or malaise but is characterized by progressive shortness of breath with weight loss.[39]

Acceptable levels of airborne microorganisms have not been established, primarily due to the varying immunogenic susceptibilities of individuals. Relationships between health effects and environmental microorganisms must be determined through the combined contributions of medical, epidemiologic, and environmental

evaluation.[25] The current strategy for environmental evaluation involves a comprehensive inspection of the building to identify sources of microbial contamination and routes of dissemination. In those locations where contamination is visibly evident or suspected, bulk samples may be collected to identify the predominant species (fungi, bacteria, and thermoactinomycetes).

V. MEDICAL RESULTS

In May 1992, telephone interviews were conducted with all nine employees identified as having "bacterial" diseases. Seven individuals described symptoms of respiratory allergies and severe sinus congestion, the latter requiring antibiotic treatment in a few cases. Additional problems, each described by one or two employees, were diarrhea, stomach problems, and lung disease. The review of available medical records corroborated employees reports but did not reveal any consistent pattern of medical diagnoses. Employees and LEA representatives described poor housekeeping, stagnant air, and a history of roof leaks in the school causing standing water in some areas.

During the December site visit, interviews were conducted with 14 employees. Many of the interviewed employees reported experiencing health symptoms while in the building. Commonly reported symptoms included frequent headaches, eye irritation, nasal congestion, and severe fatigue at work. Several employees suffered from chronic bouts of sinusitis and acute bronchitis that required periodic treatment with antibiotics. Others reported frequently experiencing sinus congestion, recurrent colds, or nosebleeds. Some employees were concerned about mold growth in various locations in the building.

Fifty-six (72%) of the employees responded to the summer questionnaire, and 47 (60%) responded to the school-year questionnaire. Among all respondents, 40 persons returned both questionnaires. Response rates to the school-year questionnaire were comparable between individuals with illnesses in the preceding 12 months (colds, bronchitis, sinusitis) and those without these illnesses.

Thirty respondents reported signs of water damage in their work area during the previous school year. The frequencies of bronchitis, sinus infection, and colds were higher among those who saw signs of water damage than among those who did not (Table 1). Only the difference for colds, however, was statistically significant.

The remainder of this section will describe the results for the 40 employees who returned both questionnaires. For medical and environmental questions, the condition was considered to be absent if the answer was missing.

Respondents included 21 men and 19 women. The average age of the respondents was 45 years (range: 34 - 68). Respondents had worked in the school for an average of 16 years (range: 2 - 33), and had worked in their current room or work area for an average of 12 years (range: <1 - 27).

Table 1
Frequency of Employee Illnesses During the Past Year
as Reported in August 1992
Lakeland Junior-Senior High School
HETA 92-126

Reported Illnesses	Signs of Water Damage	
	Yes (30 respondents)	No (26 respondents)
	No. (%)	No. (%)
Bronchitis	7 (23)	4 (15)
Sinus infection	19 (63)	10 (38)
Colds[1]	18 (60)	5 (19)
Diarrhea	2 (7)	3 (12)

[1] The difference between those with and those without water damage was statistically significant (chi-square, p=.002).

The majority of questionnaire respondents worked in carpeted areas (74% during the previous year; 65% during the current year). Whereas 21 employees (53%) reported signs of water damage in their work area during the previous school year, only 8 employees (20%) reported water damage during the current school year. During the school year, most employees felt that their current work area was inadequately cleaned (64%).

Table 2 shows the questionnaire results describing the frequency of 13 symptoms often reported by occupants of "problem buildings."

Table 2
Employee Symptoms Among 40 Employees:
Responses to Summer and School-year Questionnaires
Lakeland Junior-Senior High School
HETA 92-126

Symptom	Summer[1] No. (%)	School Year[1] No. (%)	Building-related[2] No. (%)	Improved Away From Work No. (%)[3]
Eye irritation	6 (15)	16 (40)	12 (30)	10 (83)
Wheeze	1 (3)	3 (8)	2 (5)	2 (100)
Headache	5 (13)	10 (25)	7 (18)	6 (86)
Sore throat	4 (10)	10 (25)	6 (15)	3 (50)
Excess fatigue	6 (15)	18 (45)	14 (35)	10 (71)
Chest tightness	1 (3)	6 (15)	5 (13)	2 (40)
Nasal/sinus congestion	8 (20)	16 (40)	11 (28)	3 (27)
Cough	4 (10)	10 (25)	7 (18)	3 (43)
Eye Strain	12 (30)	18 (45)	10 (25)	7 (70)
Difficulty concentrating	0 (0)	5 (13)	5 (13)	3 (60)
Dry throat	4 (10)	10 (25)	8 (20)	5 (63)
Dizziness	4 (10)	5 (13)	3 (8)	3 (100)
Shortness of breath	1 (3)	2 (5)	2 (5)	1 (50)

[1] Number (percentage) of employees reporting that symptom occurred at least once a week during past four weeks.
[2] Number (percentage) of employees reporting that symptom occurred less than once a week during the summer and increased in frequency to once a week or more during the school year.
[3] Number (percentage) of employees with possible building-related symptom that gets better when they are away from work.

The first column of Table 2 shows the number and percentage of the 40 respondents who reported the frequent (at least once a week) occurrence of symptoms during the four weeks prior to the summer questionnaire. Eye strain (30%), nasal or sinus congestion (20%) , excess fatigue (15%), and eye irritation (15%) are the most commonly reported symptoms.

The second column of Table 2 shows the number and percentage of the 40 respondents who reported the frequent (at least once a week) occurrence of symptoms during the four weeks prior to the school-year questionnaire. As during the summer, eye strain (45%), excess fatigue (45%), eye irritation (40%), and nasal or sinus congestion (40%) are the most commonly reported symptoms during the school year. All symptoms except dizziness were reported by a higher percentage of employees during the school year than during the summer.

The third column of Table 2 shows the number and percentage of the 40 employees who were considered to have a possible building-related symptom. These symptoms are those that occurred less than once a week during the summer and increased in frequency to once a week or more during the school year. Eye irritation (30%), excessive fatigue (35%), nasal or sinus congestion (28%), and eye strain (25%) are the most commonly reported symptoms that meet this definition. Some employees reported frequent symptoms in the summer, but these symptoms either disappeared or decreased in frequency during the school year. The number and percentage of employees with possible building-related symptoms that got better when the employee left work is shown in the fourth column of Table 2. The majority of employees with a possible building-related symptom reported that the symptom got better when they were away from work, with the exception of chest tightness, cough, and nasal or sinus congestion.

Most of the symptoms in the questionnaire can be placed into groups according to their causal and temporal characteristics. These groups include: (a) symptoms of mucous membrane irritation (which usually are associated with acute discomfort), such as eye irritation, sore or dry throat, and nasal stuffiness; (b) respiratory symptoms (which may be related to illnesses that require prolonged recovery times after leaving the building), such as wheeze, chest tightness, cough, and shortness of breath; and (c) non-specific symptoms, including headache, excess fatigue, difficulty concentrating, and dizziness.

Table 3 shows the number and percentage of the 40 respondents who reported at least one symptom in the group that met the definition of a possible building-related symptom. Overall, symptoms of mucous membrane irritation (50%) and non-specific symptoms (43%) were reported by a higher percentage of employees than respiratory symptoms (25%).

Table 3
Symptoms Among 40 Employees:
Responses to Summer and School-year Questionnaires
Lakeland Junior-Senior High School
HETA 92-126

Symptom Group	No. (%)[1]

Symptoms of mucous membrane irritation	20 (50)
Respiratory symptoms	10 (25)
Non-specific symptoms	17 (43)

[1] Number (percentage) of employees who reported at least one possible work-related symptom in the group.

Table 4 shows the questionnaire results describing the frequency of symptoms of work-related stress among the 40 respondents. Approximately one-half of all employees reported at least one of these symptoms. Stress symptoms were reported by two-thirds of teachers, but only 30 percent of other school employees. Sixteen (42%) of 38 respondents also indicated that they felt the school administrators were "not at all" concerned about indoor environmental problems in the school.

Table 4
Symptoms of Work-related Stress Among 40 Employees:
Responses to School-year Questionnaire
Lakeland Junior-Senior High School
HETA 92-126

Symptom	No. (%)[1]
"Emotionally drained"	18 (45)
"Burned out from work"	16 (40)
"Used up at end of day"	23 (58)
Any stress symptom	23 (58)

[1] Number (percentage) of employees reporting that the symptom occurred at least once a week

Table 5 shows the results of employee reports regarding environmental conditions in their work areas as reported during the school-year questionnaire. The most commonly reported complaints about conditions that occurred at least once a week in the preceding four weeks were that there was too little air movement (60%), the temperature was too cold (55%), the air was too dry (45%), and there were odors in the building (45%).

Table 5
Environmental Concerns Among 40 Employees:
Responses to School-year Questionnaire
Lakeland Junior-Senior High School
HETA 92-126

Condition	In Past 4 Weeks	Condition	In Past 4 Weeks
	No. (%)		No. (%)

Too much air movement	4 (0)	Too dry	18 (45)
Too little air movement	24 (60)	Tobacco odors	0 (0)
Too hot	9 (23)	Chemical odors	10 (25)
Too cold	22 (55)	Other odors	18 (45)
Too humid	2 (5)		

[1] Number (percentage) of employees reporting that the condition occurred at least once a week

The associations between building-related symptoms and environmental complaints (only those reported by ten or more employees were analyzed), as well as reports of work-related stress, are shown in Table 6. A statistic called the odds ratio (OR) is used to measure the strength of an association. An OR less than 1 means that there is a negative association and an OR greater than 1 means that there is a positive association. The statistical significance is judged by the 95% confidence interval (CI). If the CI does not include the value 1, the OR is considered to represent a statistically significant difference between the two groups (those with and without the symptoms) being compared.

Table 6

Relationship between Reported Work-related Symptoms
and Environmental Complaints:
Responses to School-year Questionnaire
Lakeland Junior-Senior High School
HETA 92-126

Environmental Complaint	Symptoms		
	Non-specific	Mucous Membrane	Respiratory
	Odds Ratio (95% CI)[1]	Odds Ratio (95% CI)	Odds Ratio (95% CI)
Too little air	30 (3.2, 1339)	6.0 (1.2, 33)	1.8 (0.3, 13)
Temperature too cold	5.1 (1.1, 27)	3.5 (0.8, 16)	4.6 (0.7, 49)
Air too dry	4.2 (0.9, 20)	3.5 (0.8, 16)	2.3 (0.4, 13)
Chemical odors	2.6 (0.5, 15)	3.1 (0.5, 21)	2.7 (0.4, 16)
Other unpleasant odors	6.8 (1.4, 35)	5.6 (1.2, 28)	4.0 (0.7, 28)
Unclean work area	25 (2.7, 1116)	8.5 (1.6, 59)	7.9 (0.9, 369)
Work-related stress	4.2 (0.9, 23)	2.9 (0.7, 13)	2.0 (0.4, 14)

[1] 95% confidence interval

Employees with building-related symptoms were more likely than employees without such symptoms to report that unsatisfactory working conditions were present at least once a week during the four weeks prior to the school-year questionnaire . The relationship between environmental conditions reported by employees and symptoms was strongest for non-specific symptoms and weakest for respiratory symptoms. The environmental conditions with the strongest and most consistent associations with symptoms were too little air movement, unpleasant odors, and unclean work areas. Employees with non-specific symptoms were 30 times more likely than those without these symptoms to report a feeling of too little air movement, seven times more likely to report unpleasant odors, and 25 times more likely to report an unclean work area. These associations were statistically significant. Although the association between non-specific symptoms and job stress was not statistically significant, the association was of sufficient strength and the frequency of job stress was high enough to warrant concern. Employees with mucous membrane symptoms were six times more likely than those without these symptoms to report a feeling of too little air movement, six times more likely to report unpleasant odors, and nine times more likely to report an unclean work area. These associations were statistically significant. Because age was related to the occurrence of many symptoms and environmental complaints, further analyses were done to determine whether the observed relationships could be explained by age differences. The results of

statistical analyses that controlled for the effects of age showed that, although the magnitude of the associations decreased somewhat and some associations were no longer statistically significant, the pattern of associations remained the same.

VI. ENVIRONMENTAL RESULTS AND OBSERVATIONS

The general classroom environments appeared in fair condition; all classrooms were well lit and visible surfaces were mostly clean. Reports from faculty indicated the presence of "mold and mildew" odors in specific classrooms including Room 101, 102, 103, 104 and 105. NIOSH investigators could not detect the presence of these odors at the time of the survey. Evidence of water damage on ceiling tiles and wall paint was observed in Room 102, 103, and 110. Specialty classrooms (Chemistry, Physics, Woodshop, Graphic Arts, etc.) were observed to be relatively clean. Specific problems were noted, however, in the chemical storage room adjacent to the Chemistry classroom. Chemical containers had ruptured, had no posted date of expiration, were missing labels, and were inappropriately stored.

A physical inspection of the package ventilating units was conducted in Rooms 103 and 104. The inspection did not reveal any visible evidence that would indicate a microbial contamination source. The filters appeared free of debris accumulation; the interior unit insulation was in good shape; and the heating coils and the area directly beneath were absent of standing water and/or "slime." Reports from maintenance personnel indicated that the filters were changed four times per year. Smoke tubes used to document the air flow patterns in the school showed positive pressure (air flow <u>out</u> of classrooms) in relation to the common hallways which is consistent with the design of the ventilation system. Specialty classrooms exhibited negative pressure (air flow <u>into</u> classrooms) in relation to the common hallway.

Microbiologic analysis of the bulk samples are reported in Table 7. The fungi identified included *Aspergillus*, *Alternaria*, *Cladosporium*, *Penicillium* and unidentified yeasts. Bacteria identified in the bulk samples included *Acinetobacter radioresistans*, *Bacillus brevis*, *Pseudomonas viridilvida*, *Thermoactinomyces*, and unidentified gram (-) rods. These fungal taxa and bacterial species are normal constituents of most indoor and outdoor environments and were found at low concentrations. One bulk sample (Room 104, ventilation system door lining) exhibited slightly elevated levels of fungi and bacteria. The concentration observed indicates the presence of a small reservoir of fungi and bacteria but their existence may be more indicative of sedimentation from "normal" outdoor/indoor sources as opposed to flourishing fungal cultures. The predominance of *Thermoactinomyces* may be the direct result of contributions from outdoor influences; *Thermoactinomyces* are common flora in rural/agricultural environments. Although, there are no established criteria regarding "acceptable" concentrations of fungi and/or bacteria in ventilation system interiors, the concentrations observed do not indicate that there is a significant problem with regard to microbiological contamination.

Environmental CO_2 measurements are presented in Figure 2. Measurements were made at twelve locations throughout the evaluated area (Figure 1, Page 4). Carbon dioxide concentrations ranged from 350 to 450 ppm during the first measurement period (~7:00 a.m.), from 425 to 1725 ppm during the second measurement period (~10:00 a.m.), and from 425 to 1500 ppm during the third measurement period (~3:00 p.m.). The highest concentration observed was 1725 ppm collected in Room 126 during the second measurement period. The first measurement period was selected at a time when the building was unoccupied, as evidenced by the low CO_2 concentrations. During the second and third measurement periods, the measured CO_2 concentrations in Rooms 102, 103, 104, 105, 112, 120, 126, and 131 and in Rooms 102, 103, 112, 115, 126, 131, and 138, respectively, were at or exceeded the ASHRAE criterion of 1000 ppm of CO_2 for indoor environments.

Table 7
Results of Bulk Sample Analyses
Lakeland Junior-Senior High School
HETA 92-126

Sample Location	Total Fungi*	Taxa Rank	Total Bacteria*	Taxa Rank
Room 102 (ceiling tile)	45	Clad	ND	---
Room 102 (wall paint)	60	Pen	90	Bac>UnID
Room 103 (ceiling tile)	245	Yea=Pen=Clad>Asp	75	Bac
Room 103 (wall paint)	50	Pen=Clad	104	Bac
Room 103 (vent system lining)	900	Clad>Yea=Asp=Pen	385	Bac
Room 104 (ceiling tile)	1530	Yea>Pen>Clad>Alt	160	TA>Bac
Room 104 (vent system lining)	ND	----	ND	----
Room 104 (vent system door lining)	224,000	Clad>>Alt>Asp	1435	TA>Bac>Ac
Room 110 (ceiling tile)	40	Pen	160	Ps

Asp = *Aspergillus*
Alt = *Alternaria*
Clad = *Cladosporium*
Pen = *Penicillium*
Yea = unidentified yeasts

Ac = *Acinetobacter radioresistans*
Bac = *Bacillus brevis*
Pseudo = *Pseudomonas viridilvida*
TA = *Thermoactinomyces*
UnID = Unidentified Gram (-) rod

*Results presented as Colony Forming Unit per gram of material (CFU/gm)

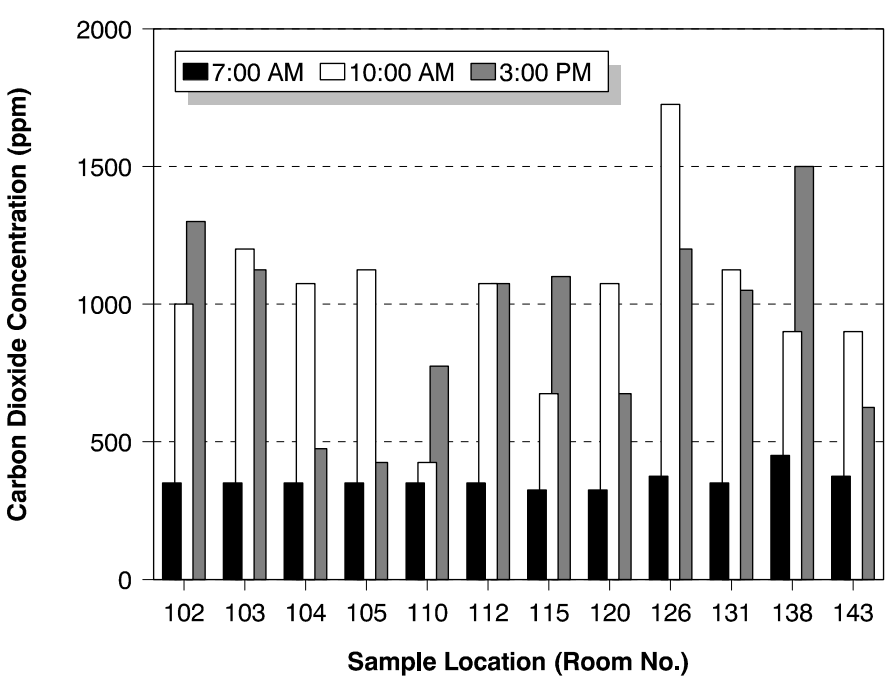


Figure 2. Carbon Dioxide Measurement Results

According to the original building design specifications, each package ventilating unit is designed to provide a combined total of 1250 cubic feet per minute (cfm) of recirculated and outdoor air. For the standard classrooms, the ventilating units were designed to provide 300 cfm of outdoor air, which is in contrast to maintenance personnel reports of a 10% outdoor air setting. For the specialty classrooms (i.e., Chemistry and Biology classrooms), the ventilating units were designed to provide up to 760 cfm of outdoor air. These original design specifications are capable of conforming to the ASHRAE (62-1989) criterion of 15 cfm/person for classrooms and 20 cfm/person for laboratories of outdoor air given a maximum occupant load of 20 and 38, respectively. Maintenance personnel reported that in many instances the variable speed fans in the ventilating units were reduced to the lowest setting at the request of occupants and for energy conservation. This reduction in the fan speed decreases the amount of outdoor air being supplied to the occupied spaces and results in elevated CO_2 concentrations.

Temperatures ranged from 64.7 to 72.8°F during the first measurement period (~7:00 a.m.), from 68.5 to 73.3°F during the second measurement period (~10:00 a.m.), and from 67.3 to 72.7°F during the third measurement period (~3:00 p.m.) (Figure 3). The relative humidity (RH) levels for all measurement periods were fairly stable in the mid 20s (Figure 4). During occupied times, the indoor temperatures and relative humidities are bordering the lower limits recommended in the ASHRAE thermal comfort chart (Figure 5.) The ASHRAE

thermal comfort chart specifies the acceptable (10% dissatisfaction criteria) ranges of operative temperature and humidity for persons clothed in typical summer and winter clothing, performing mainly sedentary activity.[24] Non-conformity to the ASHRAE thermal comfort criterion was primarily the result of indoor relative humidity levels in the mid 20s. Low humidity levels in the winter are not uncommon in the absence of humidification.

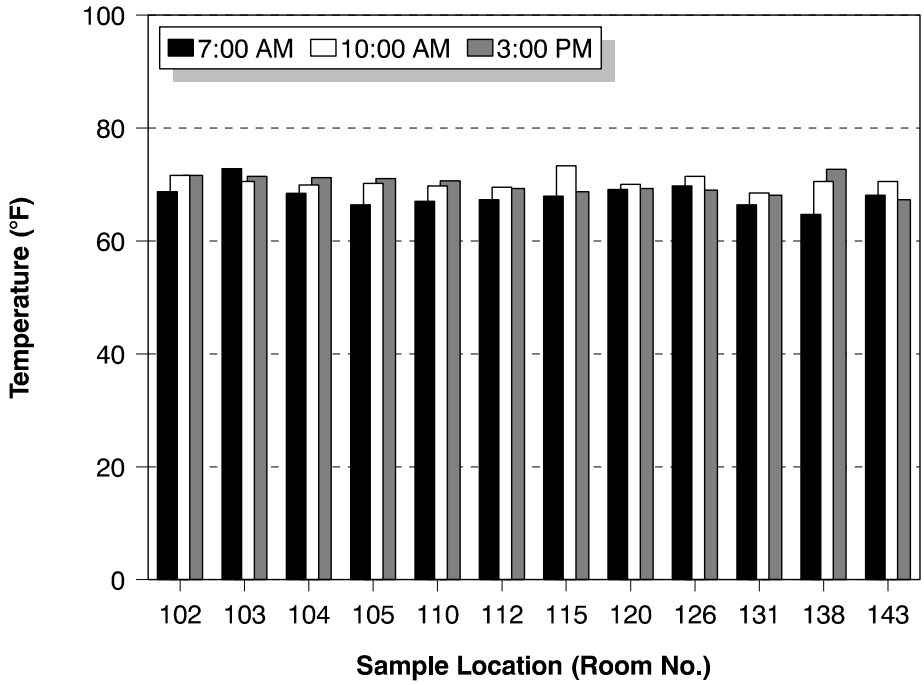


Figure 3. Temperature Measurement Results

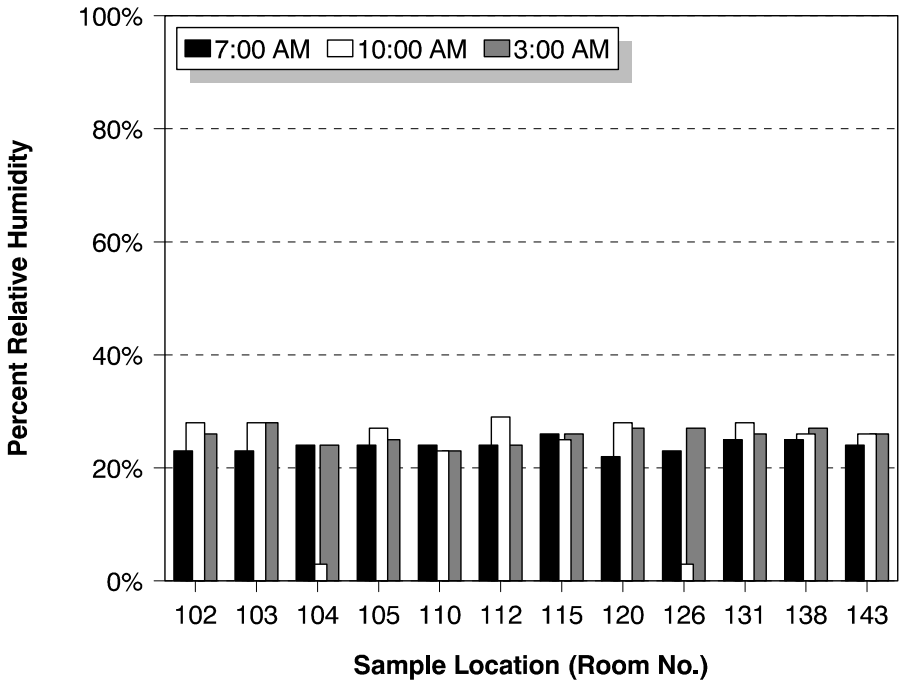


Figure 4. Relative Humidity Results

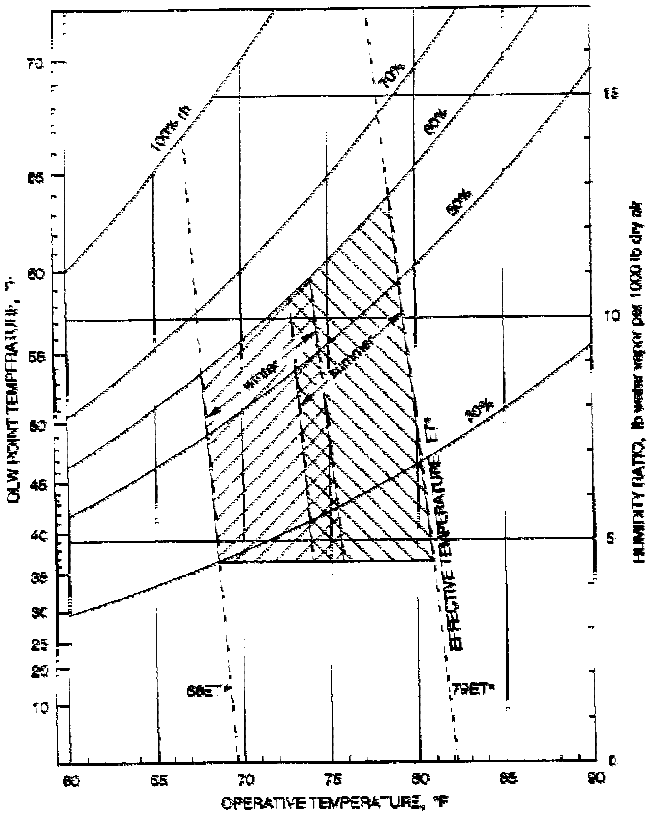


Figure 5. ASHRAE Thermal Comfort Chart

VII. CONCLUSIONS AND RECOMMENDATIONS

NIOSH conducted a survey at the Lakeland Jr-Sr High School in Jermyn, Pennsylvania because of a request by school administrators who were concerned about the adequacy of the ventilation in the building and about illnesses employees were experiencing at work. The questionnaire survey showed that many employees had frequently experienced symptoms (e.g., eye irritation or strain, nasal or sinus congestion, excess fatigue) while in the building, but did not experience these symptoms as much during the summer months. A substantial proportion of the symptomatic employees reported that their symptoms tended to get better when they were away from the building. NIOSH investigators did not find a consistent pattern of "bacterial" disease that could be related to environmental conditions in the school.

Reports of building related health complaints have become increasingly common in recent years; unfortunately the causes of these symptoms have not been clearly identified. As discussed in the criteria section of this report, many factors are suspected (e.g., volatile organic compounds, formaldehyde, microbial proliferation within buildings, inadequate amounts of outside air etc.). While it has been difficult to identify concentrations of specific contaminants that are associated with the occurrence of symptoms, it is felt by many researchers in the field that the occurrence of symptoms among building occupants can be lessened by providing a properly maintained interior environment. Adequate control of the temperature is a particularly important aspect of employee comfort.

Environmental conditions and deficiencies found by the NIOSH investigators may help explain some of the symptoms reported by the Lakeland Jr-Sr High School employees. Based on the results and observations of this evaluation, the following recommendations are offered to correct those deficiencies and optimize employee comfort.

- Printing activities in the Graphic Arts classroom should be conducted in a room with a dedicated exhaust system to minimize solvent exposures to other personnel. Additionally, all dedicated exhaust systems should be checked for proper operation and the ability to meet original design specifications.

- Reports from the maintenance personnel indicated that the system fans in some AHU units were set at the minimum setting at the request of occupants and to improve energy efficiency. According to the original design specifications, the lower fan settings are not capable of conforming to the ASHRAE guideline of 15 cubic feet per minute of outside air per person for classrooms. Additionally, ASHRAE has established criteria for acceptable air quality for other school environments (i.e., libraries, training shops, etc.) that require special consideration. These areas should be assessed to determine whether their ventilation meets ASHRAE criteria.

- Any visible or suspected microbial contamination requires remediation efforts. Remediation should include removal of the contaminated material or clean-up with a high efficiency particulate air filter (HEPA) vacuum and decontamination with an effective chemical agent (i.e., 5-10% solution of bleach).

- Due to the lack of air-conditioning (and windows that do not open), thermal comfort complaints may increase during the early fall and late spring. Monitoring should be conducted during these seasonal time periods to ensure conformity to the ASHRAE thermal comfort criteria.

- All AHUs should be turned on for a period (for example, 1 hour) prior to building occupancy to reduce contaminant build-up resulting from non-use during nights and weekends. Additionally, AHU thermostats should be adjusted to provide temperatures that conform to the ASHRAE guidelines.

- Chemicals stored in the room adjacent to the Chemistry classroom should not be arranged in alphabetical order. Alphabetical categorization can result in incompatible chemical agents (i.e., acids and bases) occupying adjacent space. In the event of accidental breakage this could produce hazardous reactions. Additionally, chemicals that are out of date or unnecessary should be disposed of as hazardous waste through the appropriate mechanism.

Two other areas warrant attention. The school administration should consider employee's needs for stress management training. Additionally, mechanisms should be established for addressing employee concerns about work-related health and safety issues. Effective communication can help prevent indoor environmental quality problems and resolve problems cooperatively if they do arise.[26]

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