HEALTH HAZARD EVALUATION REPORT

HETA 93-0737
PRINCETON HIGH SCHOOL
CINCINNATI, OHIO

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I. SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) conducted a Health Hazard Evaluation (HHE) at Princeton High School in Cincinnati, Ohio, at the request of the local union, Princeton Association of Classroom Educators (PACE). Faculty and students were experiencing allergy and asthma problems, and eye, nose, and throat irritation. The symptoms seemed to decrease when not in the school. The NIOSH HHE consisted of a medical questionnaire and an environmental evaluation of two areas of the school, the office area, and one of the classroom wings. The questionnaire revealed that 57% of the office employees had experienced one or more symptoms that had decreased when away from the building. The environmental evaluation revealed levels of carbon dioxide in excess of 1,000 parts per million (ppm) in the evaluated classroom wing, which suggests an inadequate supply of outside air. Also, the air handlers that were inspected all contained significant amounts of microbial growth in their drain pans. Recommendations are made to clean-up and improve the heating, ventilating, and air-conditioning (HVAC) system.

Negligence in the periodic cleaning and upkeep of the air handling units in Princeton High School has allowed for significant microbial contamination in the units. Microbes and dust can cause several types of allergic reactions, including allergic asthma. It is believed that cleanup and subsequent proper maintenance of the air handling units, and introduction of the proper amounts of outside air will significantly reduce some of the indoor air quality complaints at Princeton High School.

KEYWORDS: SIC 8211 (Elementary and Secondary Schools), indoor air quality, microbial contamination, carbon dioxide, indoor environmental quality, IEQ, IAQ.

II. INTRODUCTION

On March 9, 1993, the National Institute for Occupational Safety and Health (NIOSH) received a request for health hazard evaluations (HHEs) at the schools within the Princeton School District, Cincinnati, Ohio, from the president of the local union, Princeton Association of Classroom Educators (PACE). Faculty and staff in the school district were experiencing asthma and allergy problems, and eye, nose, and throat irritation, which they believed to be work-related. The employees also perceived that there was excessive absenteeism among both the faculty and the students. The health problems, according to the workers, seemed to lessen at home and over the breaks. The union requested that NIOSH perform indoor air quality surveys to try to identify the problem(s) and to offer recommendations. Because of economic and time constraints, it was agreed that NIOSH would evaluate one of the schools in the district, and the recommendations could then be applied to the other schools. At the request of the union president, Princeton High School was evaluated on September 16, 1993.

III. BACKGROUND AND DESCRIPTIVE INFORMATION

Princeton High School is a 301,481 square foot building that houses about 2000 students and 200 staff. The original building was constructed in 1958, and was expanded to its current size by the additions of three wings -- a wing was added sometime in the 1960's, another in 1976, and another in 1990. Most of the brick and concrete building is a single story, but the 1976 wing (400 wing) has a second floor and the main hallway (100 wing) has three floors. Many of the rooms are interior and thus do not have windows, and even a few of the exterior rooms, such as in the 400 and 440 wings, do not have windows.

Prior to 1976, there was no air conditioning in the school. Heat was provided by piped hot water from a boiler system. Currently, the administrative office area, the art wing, the music wing, the 400 wing, and the new 600 wing have multizone package air handling units (AHUs), and the remaining classrooms have individual heat and air-conditioning ventilation units. The AHUs and the interior classrooms with single ceiling units have rooftop outside air (OA) intakes, while the exterior classrooms have through-the-wall units with OAs on the outside wall of the building. The amount of OA introduced into the building is pneumatically controlled by thermostat setting in the winter, and is reportedly fixed at 10% (older units) or 15% (newer, 1977 units) during the cooling season. The AHUs have ducted supplies and returns, while the individual units have no ducted supplies, just one supply vent and one return vent on the unit. All of the systems are controlled by a computer and turned off at 1630 hours and back on again at 0700 hours. Throughout the day, each wing's units or AHU is cycled off for 10 minutes each half-hour to save on energy bills. This results in no air flow one-third of the time.

Since the school is large, a specific evaluation area was selected for inspection and measurements. The union president recommended the 440 wing, the office area, and the music wing. Both the 440 wing and the office area were evaluated because there had been several complaints in both areas and each had a different type of ventilation system. The music area was not evaluated in detail since it was not occupied all day, but its AHU was inspected. Some of the 400/500 wing heating, ventilating, and air-conditioning (HVAC) systems were also inspected at the request of the maintenance personnel.

Figure 1. Floor Diagram of Princeton High School
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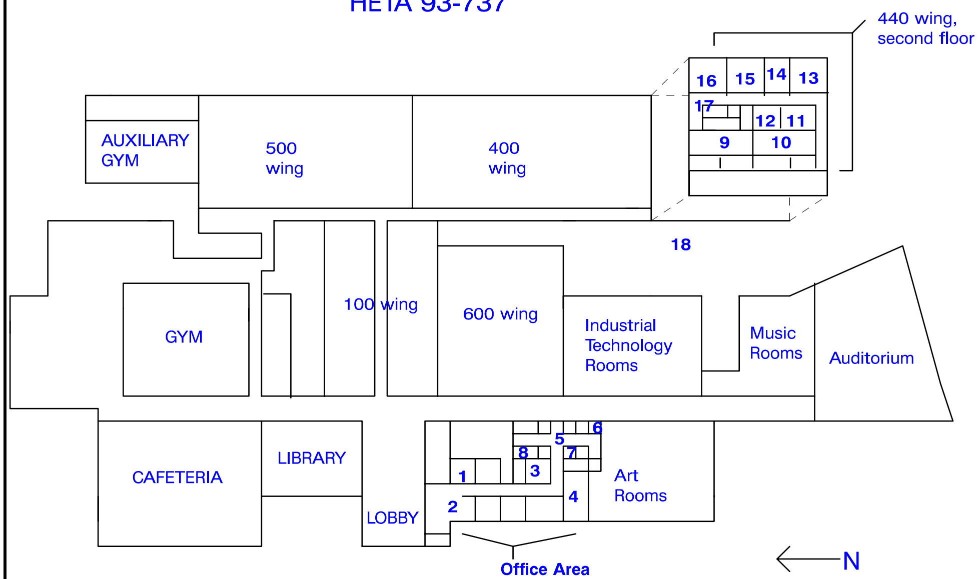


Evaluated areas were the second floor of the 440 wing and the office area. The numbered locations indicate where carbon dioxide levels, temperature, and relative humidity were measured.

The 440 wing is the second floor of the 1976 addition and consists of six classrooms, two offices, and two biology laboratories with defunct greenhouses (Figure 1). The four exterior classrooms have through-the-wall ventilation units with OA intakes on the outside walls, and the two interior classrooms have ceiling ventilation units with rooftop OA intakes. The biology labs have larger ceiling units with OA intakes through the walls. These OAs are reportedly fixed at a minimum of 50% OA because of the nature of the laboratory work in the rooms. For example, one of the labs has several aquariums containing various fish and amphibians, and terrariums containing snakes and other reptiles. Each of the AHUs in the labs has four ducted supply vents and one ducted return. The supply vents and the return are all on the back walls of the labs. When the doors between the labs and the greenhouses are opened, outside air is introduced into the labs from holes and leaks in the greenhouse walls.

The office area is located to the right of the main entrance on the west side of the building (Figure 1). The administrative staff, registrar, counselors, and data processing staff are all in this area. Most of the offices are enclosed, except for the front desk secretarial work area and the two secretarial office spaces in the counseling and data processing section. A roof-top package AHU supplies the office area.

IV. EVALUATION METHODS

During the site visit on September 16, 1993, the environmental evaluation consisted of collecting information using standardized checklists and inspection forms. These forms were grouped to address the whole building, the evaluation area, and the HVAC system. Descriptive information for the building (age, size, construction, location, etc.), the area to be evaluated (size, type of office space, cleaning policies, furnishings, pollutant sources, etc.), and the HVAC systems (type, specifications, maintenance schedules, etc.) were included. Inspections of the evaluated area and HVAC systems were conducted to determine current conditions. The purpose of the environmental investigation was to obtain information required to classify the building, determine the condition of building systems, and document the current indoor environmental status. A return visit was made on October 7, 1993, to inspect the AHUs and ventilation units in more detail after the class day was over and the units were not operating. At this time the drain pans and interior of the units were inspected.

In addition to collecting the standardized information described above, indicators of occupant comfort were measured. These indicators were carbon dioxide (CO_2) concentration, temperature (T), and relative humidity (RH). Chemical smoke was used to visualize airflow in the evaluated area and to determine potential pollutant pathways to this area.

Real-time CO_2 concentrations were measured using a Gastech Model RI-411A, portable CO_2 indicator. This portable, battery-operated instrument uses a non-dispersive infrared absorption detector to measure CO_2 in the range of 0-4975 parts per million (ppm), with a sensitivity of ±25 ppm. Instrument zeroing and calibration were performed prior to use with zero air and a known concentration of CO_2 span gas (800 ppm).

Real-time temperature and humidity measurements were made using a Vaisala, Model HM 34, battery-operated meter. 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.

Also, questionnaires were distributed to the 19 faculty working in the 440 wing and the office area, five teachers, and 14 office staff in the office area. The questionnaire asked if the employee had experienced, while at work on the day of the survey, any of the 13 symptoms (irritation, nasal congestion, headaches, etc.) commonly reported by occupants of "problem buildings." The questionnaire also asked about the frequency of occurrence of these 13 symptoms while at work in the building during the four weeks preceding the survey, and whether these symptoms tended to get worse, stay the same, or get better when they were away from work. The final section of the questionnaire asked about environmental comfort (too hot, too cold, unusual odors, etc.) experienced while the employees were working in the building during the four weeks preceding the questionnaire administration.

V. EVALUATION CRITERIA

Indoor environmental quality (IEQ) is affected by the interaction of a complex set of factors which are constantly changing. Four elements involved in the development of IEQ problems are:

- sources of odors or contaminants,
- problems with the design or operation of the HVAC system,
- pathways between contaminant sources and the location of complaints,
- and the activities of building occupants.

A basic understanding of these factors is critical to preventing, investigating, and resolving IEQ problems.

The symptoms and health complaints reported to NIOSH by non-industrial 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. Usually, 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 high prevalences 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 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 than any measured indoor contaminant or condition to the occurrence of symptoms.[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 <u>Legionella</u> 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 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, machines, structural components of the building and contents, tobacco smoke, microbiological contamination, and outside air pollutants; comfort problems due to improper temperature and 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 been 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 mixtures of organic materials 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. The basis for measurements made during this evaluation are listed below.

Carbon Dioxide

Carbon dioxide 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 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, and 15 cfm/person for classrooms, libraries, auditoriums, and reception areas, 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 of temperatures between 68°F to 74°F in the winter and 73°F to 81°F in the summer, and RHs between 30% and 60%, in which 80% or more of the occupants would be expected to find the environment thermally comfortable.[24]

Biological Contamination

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 ample 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/dust or water particles. In the outdoor environment, the levels of microbial aerosols will vary according to the geographic location, climatic conditions, and surrounding activity. In a "normal" indoor environment, 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 consistently similar ranking among the microbial species.[26,27]

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.[28] 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).[10] Allergic respiratory diseases resulting from exposures to microbial agents have been documented in agricultural, biotechnology, office, and home environments.[29-36]

Individual symptomatology varies with the disease. Allergic rhinitis is characterized by paroxysms 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. Allergic asthma is characterized by episodic or prolonged wheezing and shortness of breath in response to bronchial (airways) narrowing. Allergic bronchopulmonary aspergillosis is characterized by cough, lassitude, low-grade fever, and wheezing.[10,37] Heavy exposures to airborne microorganisms can cause an acute form of extrinsic allergic alveolitis which is characterized by chills, fever, malaise, cough, and dyspnea (shortness of breath) appearing four to eight hours after exposure. In the chronic form, thought to be induced by continuous low-level exposure, onset occurs without chills, fever, or malaise and is characterized by progressive shortness of breath with weight loss.[38]

Acceptable levels of airborne microorganisms have not been established, primarily because allergic reactions can occur even with relatively low air concentrations of allergens, and individuals differ with respect to immunogenic susceptibilities. The current strategy for on-site evaluation of environmental microbial contamination involves an inspection to identify sources (reservoirs) of microbial growth and potential 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). In limited situations, air samples may be collected to document the presence of a suspected microbial contaminant. Air sample results can be evaluated epidemiologically by comparing those from the "complaint areas" to those from non-complaint areas, or by relating exposure to immunologic findings.

VI. RESULTS AND OBSERVATIONS

Environmental Results

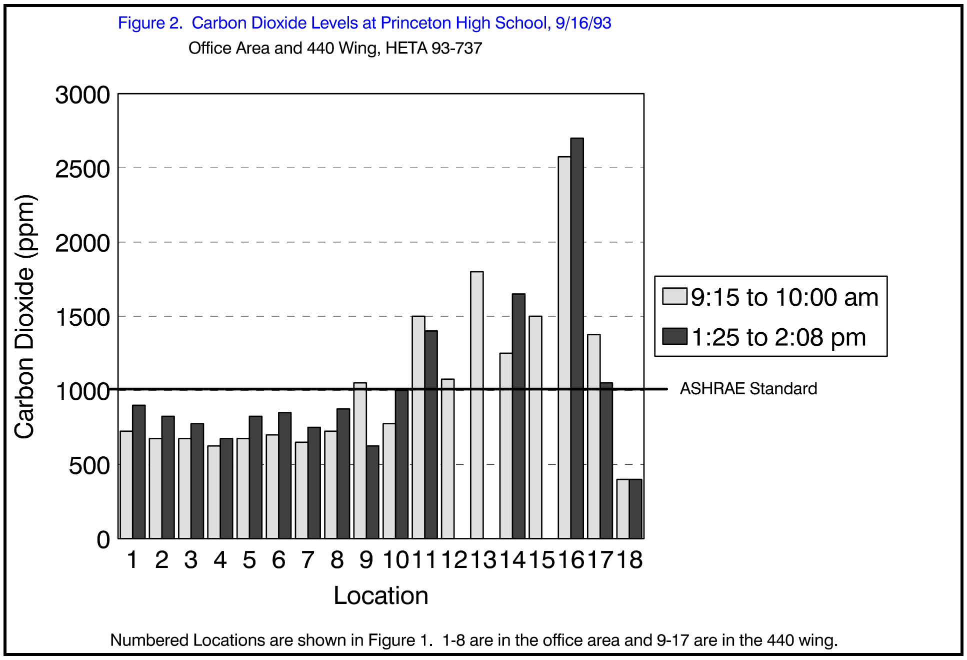
The school was in relatively good physical condition, and the evaluated areas were generally clean and sufficiently lighted. Yet, several of the ceiling panels had moisture stains, and a few were contaminated with an unidentified black growth. Some of the office area supply vents were covered by filters that had been tacked up to the outside.

The head of maintenance reported that the air handlers and ventilation units in the school had not been maintained since their installation, most of which occurred in 1977. The air filters in the units have only recently been changed on a routine schedule, which began in March 1993, when an extra maintenance person was transferred from another school in the district. The new maintenance person had a written schedule and records for filter changing (every other month) and unit inspection and "cleaning." In the summer of 1993, he "cleaned" all the units, as well as the supply vents, by a "blowing out" process. The cleaning did not include vacuuming with a high efficiency particulate air filter (HEPA) vacuum or cleaning of the drain pans. This cleaning or "blowing out" was planned for every summer.

Several of the AHUs and ventilation units were inspected. The filters were in relatively good condition, but the filter frames allow for a significant amount of bypass. The filters are one-inch fiberglass filters with an efficiency of approximately 15%. The coils were somewhat dirty in all of the inspected units, and several had microbial growth near the bottom. All of the inspected drain pans had significant amounts of microbial growth and were either moist or contained standing water. The AHU drain pans had a spray-on foam-type insulation coating their surface. The roof-top AHUs drained onto the roof, often creating puddles, a condition which could result in the growth of microorganisms.

Spot samples of the microbial growth were taken from several of the AHUs that supply the office area and the music wing, and from single unit ventilators in rooms 412 and 458. Identified were fungus species of penicillium and aspergillus, and bacteria species of corynebacterium, bacillus, micrococcus luteus, and an unidentified gram-positive rod. These fungi and bacteria are not normally hazardous to healthy individuals, but they can elicit allergic responses.

The 400 and 500 wings are supplied by single unit ventilators in each room that have OA intakes on the roof. This roof-top consists of a layer of rubber covered by stones. Between the rubber and the stones there appears to be a layer of microbial growth. The OA intake openings face down at the roof-top and draw air approximately one foot above its surface.



Environmental CO_2 measurements are presented in Figure 2. Measurements were made at eight locations in the office area, each classroom, the hallway in the 440 wing, and outside (Figure 1). CO_2 concentrations in the office area ranged from 625 to 700 ppm during the morning measurement period (9:15 to 9:30 am), and from 675 to 900 ppm during the afternoon period (1:25 to 1:40 pm). CO_2 concentrations in the 440 wing ranged from 775 to 2575 ppm during the morning measurement period (9:35 to 10:00 am), and from 625 to 2700 ppm during the afternoon period (1:55 to 2:10 pm). The outdoor concentration was 400 ppm at both times. The highest measurement in the office area was 900 ppm, measured at Location 1, an enclosed office, during the afternoon period. Most of the classrooms and the hallway in the 440 wing had concentrations above the ASHRAE guideline of 1000 ppm in both the morning and the afternoon. One biology lab was below 1000 ppm in the morning and the other was below in the afternoon when the doors to the greenhouse were open. Three of the rooms were locked and not in use during the afternoon. Temperatures in the office area ranged from 72 to 75°F throughout the day, and the RH ranged from 41 to 45% in the morning and 38 to 42% in the afternoon. Temperatures in the 440 wing ranged from 70 to 74°F throughout the day, and the RH ranged from 47 to 58% in the morning and 52 to 58% in the afternoon. Only one classroom and the hallway had temperatures of 73-74°F, the rest were 70 to 72°F. The outdoor temperature increased from 62 to 73°F between these time periods, and the RH decreased from 66 to 49%. The temperatures and relative humidities are all within the recommended guidelines.

Questionnaire Results

During the visit, questionnaires were distributed to the 14 office employees at work on that day and to the five teachers in the 440 wing. Eighteen employees (five male, eight female, and one who did not answer the question in the office area, and three male and one female in the 440 wing) returned questionnaires. Eight of the office workers were between 40 and 59 years old, one was between 20 and 29, two were between 30 and 39, and two were over 59 years old. Three of the teachers were between 40 and 59 years old and one was over 59. Two of the office workers and three of the teachers were former smokers, and 12 had never smoked. The office workers had been employed in the building for a range of two months to 19 years, with an average of 7.8 years. They worked on a computer for an average of three hours/day (range 0.5 to six hours/day). Twelve of the 14 do not use a glare guard on their computer screens. The teachers had worked in the building for an average of 17.5 years and worked 40 to 45 hours per week. They used a computer no more than two hours/day.

The questionnaire results for the office employees are shown in Table I. The first column of Table I shows the percentage of the 14 respondents who reported the occurrence of symptoms while at work on the day of the survey. The second column shows the percentage of employees who reported experiencing the respective symptom once a week or more often while at work during the four weeks preceding the survey. Headaches and tension, irritability, or nervousness were the most commonly reported symptoms (57% and 50%, respectively). Others were dry, itching, or irritated eyes, unusual tiredness, fatigue, or drowsiness, runny nose or congestion, tired, strained eyes, and dizziness or lightheadedness (29% to 43%). Most of the symptoms were experienced by fewer workers the day of the survey than during the past four weeks.

The third column shows the percentage of employees who reported experiencing the respective symptom once a week or more often while at work during the four weeks preceding the survey and also reported that the symptom tended to get better when they were away from work. This latter criterion has, in some studies of indoor air quality, been used to define a "building related" symptom, but it is possible that a symptom which does not usually improve when away from the building could also be due to conditions at work. The reported "building-related" frequent symptom prevalences shown in column three, are somewhat lower than the corresponding symptom prevalences over the last four weeks shown in the second column, and are highest for headaches, tired, strained eyes, and dizziness or lightheadedness. The symptoms of dry, itching, or irritated eyes and runny nose or sinus congestion were experienced by 29% of the employees at least once a week for the last four weeks, and also reported by 29% as getting better when away from work. Overall, 57% (eight of the 14) respondents reported having one or more symptoms that had occurred at work one or more days a week during the preceding four weeks and tended to get better when away from work.

Table II shows results of employee reports regarding environmental conditions at their workstations on the day of the survey and during the four weeks preceding the survey. Column one shows the results for the day of the survey. It shows that 43% of the respondents perceived that the ventilation system was not providing sufficient air movement, 29% thought it was too hot, and 21% felt that it was too cold during at least part of their work day. Twenty-nine percent also reported "other unpleasant odors."

The second column shows the responses to the questions about environmental comfort conditions experienced in the facility during the four weeks preceding the survey. Adverse environmental conditions (too hot, too cold, odors, etc.) were considered "frequent" if they were reported to occur at work once a week or more often. The results are generally somewhat higher than those shown in the first column for workstation environmental conditions experienced during the day of the survey. Forty-three percent of the respondents perceived insufficient air movement, 29% reported too much air movement, 57% frequently were too hot, 43% were frequently too cold, and 43% frequently sensed other unpleasant odors.

Table I
Symptoms Experienced at Work
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Symptoms of 14 Workers	Experienced on Day of Survey While at Work 9/16/93	Frequently Experienced Last Four Weeks While at Work	Have Frequent Symptoms that Improve When Away from Work
Dry, itching or irritated eyes	14%	29%	29%
Wheezing	0%	0%	0%
Headache	21%	57%	43%
Sore or dry throat	21%	14%	7%
Unusual tiredness, fatigue, or drowsiness	21%	36%	21%
Chest tightness	0%	7%	7%
Stuffy nose or sinus congestion	14%	29%	29%
Cough	14%	21%	14%
Tired or strained eyes	21%	36%	36%
Tension, irritability, or nervousness	21%	50%	29%
Pain or stiffness in back, shoulders, or neck	14%	36%	7%
Sneezing	7%	21%	14%
Difficulty remembering things or concentrating	0%	21%	14%
Dizziness or lightheadedness	14%	43%	36%
Feeling depressed	0%	7%	7%
Shortness of breath	0%	0%	0%
Nausea or upset stomach	7%	29%	7%
Dry or itchy skin	0%	29%	7%

Table II
Description of Workplace Conditions
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Conditions	Experienced at Work During Day of the Survey 9/16/93 (14 workers)	Frequently Experienced While at Work During Previous Four Weeks (14 workers)
Too much air movement	14%	29%
Too little air movement	43%	43%
Temperature too hot	29%	57%
Temperature too cold	21%	43%
Air too humid	14%	29%
Air too dry	21%	29%
Tobacco smoke odors	0	7%
Chemical odors (e.g. paint, cleaning fluids)	0	14%
Other unpleasant odors (e.g. body odor, food odor, perfume)	29%	43%

Since the 440 wing contained so few teachers, the questionnaire results are not presented as percentages of response. Three of the four respondents reported unusual tiredness, fatigue, or drowsiness, chest tightness, and runny nose or congestion as occurring at least once per week during the previous four weeks. Two reported the tiredness and the congestion as improving away from work, and one reported that the chest tightness lessened away from work. All of the other symptoms were reported as occurring at least once per week during the past four weeks by two of the four teachers, except dizziness, depression, and nausea which were not reported by any of them. Two of the teachers reported that some of their experienced symptoms lessened when away from work. On the day of the survey, only two of the teachers reported the occurrence of any of the symptoms.

Three of the teachers felt that generally there was too little air movement, and two reported that it was too little the day of the survey. Two reported that it was frequently too hot, and two felt that it was frequently too cold. The temperature on the day of the survey was fine to all but one who felt that it was too cold. Two teachers also reported frequent chemical odors and other unpleasant odors, but no chemical odors were experienced on the day of the survey and only one experienced other unpleasant odors that day. One of the four teachers reported not experiencing any of the symptoms or environmental conditions during the past four weeks.

VII. SUMMARY

NIOSH conducted a survey at Princeton High School at the request of the local union. Employees were concerned about the number of staff and students developing allergies and asthma, and employees were also experiencing eye, nose, and throat irritation. The questionnaire survey showed that many employees had frequently experienced symptoms (e.g., headache, eye irritation, runny nose or congestion) while in the building. A substantial proportion of the symptomatic employees reported that their symptoms tended to get better when they were away from the building. Fifty-seven percent of the office employees reported having frequently experienced one or more such "building-related" symptoms during the four weeks preceding the administration of the questionnaire, and that the symptoms appeared to lessen at home. Thermal comfort was also a significant concern among the employees. On the questionnaires, 57% of the office employees reported frequently being too hot while at work during the four weeks preceding the survey, and 43% reported frequently being too cold while at work during the same period.

The measured temperatures and RHs were within the comfort ranges currently recommended by ASHRAE. While the CO_2 levels in the office area were below the ASHRAE recommendation of 1000 ppm, CO_2 levels in the 440 wing frequently exceeded the criteria. This indicates that an adequate amount of fresh air is not being introduced to these classrooms. Also, the biology labs in this wing reportedly receive 50% outside air. Unless there is sufficient exhaust, this could create a positive pressure in these rooms, resulting in air flow from the labs into the hallways and other rooms. Odors and contaminants could migrate into other rooms from the biology labs.

The fact that the AHUs and ventilation units have been neglected may have contributed to some of the allergy and asthma symptoms experienced by the employees. Having not been maintained since they were installed in 1977, the AHUs are currently a source of dust and microbial contamination. Their housing and coils are dirty, and some coils exhibit visible microbial growth. The drain pans contain standing water and large amounts of microbial growth. Dust and microorganisms (including fungi and bacteria) can elicit allergic responses and cause allergic respiratory diseases.[29-36] Any allergic response depends on genetic predisposition, prior exposure to the allergen, and the concentration of the allergen. Typical allergic responses include: rhinitis -- runny nose and eyes with nasal stuffiness; allergic asthma; allergic bronchopulmonary aspergillosis (ABPA) -- cough, lassitude, low grade fever, wheezing, and occasional expectoration of mucous containing fungal elements; and extrinsic allergic alveolitis -- chills, fever, malaise, cough, shortness of breath appearing four to eight hours after an acute exposure, or progressive shortness of breath with weight loss induced by a continuous low-level exposure.

Volatile organic compounds are also produced by fungi during their digestion processes. These compounds result in the characteristic "moldy" odors associated with fungi and they may cause irritation.

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. A properly operated and maintained ventilation system and adequate control of the temperature is a particularly important aspect of employee comfort.

VIII. CONCLUSIONS AND RECOMMENDATIONS

The NIOSH evaluation identified some environmental deficiencies at the Princeton High School, as well as a major problem with HVAC maintenance. Based on the results and observations of this evaluation, the following recommendations are offered to correct those deficiencies and optimize faculty and student comfort.

1. The drain pans in the AHUs and single ventilation units contain large amounts of microbial growth. They must be cleaned and disinfected as soon as possible. This must be done when the system is off and there are no occupants in the building. Clean-up can be accomplished with a vacuum containing a HEPA filter once the organisms have been killed by desiccation or fumigation. Disinfection is another method of clean-up, and common cleaners are chlorine-generating materials, hydrogen peroxide, alcohol, and regulated biocides. Adequate skin protection and ventilation is essential during remediation since many cleaners and biocides can be harmful to humans. The Environmental Protection Agency (EPA) can provide information on different biocides and their applications on inanimate surfaces. After cleaning, the pans must be rinsed thoroughly before turning the systems back on to avoid spreading the irritating cleaning vapors throughout the supplied rooms. Since the AHU drain pans are coated with an uneven surface insulation, it would be difficult to completely clean and disinfect them. Thus, consideration should be given to purchasing new drain pans for these systems or replacing the linings with a new lining.

   Since the CO_2 levels were rather high in the measured classrooms, consideration should be given to increasing the amount of OA introduced. ASHRAE Standard 62-1989 recommends 15 cubic feet per minute (cfm) per person of OA in classrooms and 20 cfm per person of OA in laboratories.[23]

   A ventilation contractor should be retained to evaluate the cleaning of and overall condition of the HVAC systems in the whole school. The contractor could also determine the amount of OA necessary and make appropriate recommendations.

2. Once the drain pans are cleaned or replaced, the AHUs and ventilation units must be inspected on a routine schedule (preferably monthly). This inspection should include the drain pans, the coils, the fan, the housing, and the filters. Anything dirty should be cleaned, and the filters should most likely be changed. The entire AHU or ventilation unit should be thoroughly cleaned at least twice a year.

3. Consideration should be given to using filters with a higher efficiency. Efficiency is a measure of the amount of fine particles that are trapped by the filter. It is these finer particles that are more related to potential health problems. The current filters only have an efficiency of approximately 15%. Choosing a pleated filter with a 30 to 40% efficiency could significantly decrease the amount of dust in the building. Dust constituents can be allergens and thus decreasing the amount of dust, may help to decrease the number and severity of allergic reactions.

4. Since the HVAC system has been neglected and there is considerable microbial growth in the AHUs, it is possible that there is growth in the ducts as well. It is recommended that the ducts be professionally inspected and cleaned, if necessary, to ensure that any contamination is eliminated.

5. The AHUs on the roof drain onto the roof top, often resulting in a puddle next to the AHUs. Since the OA intakes are on the same side of the units as the drains, it is possible that microbial growth in the puddles could be drawn into the AHUs and distributed throughout the supplied rooms. To avoid this, the drains should be connected to the sewer lines like the drains from the inside units are, or be piped off the roof to drain into the ground.

6. The roof-top surface over the 400/500 wing should be cleaned and redesigned to avoid creating a moist and protected environment for microbial growth. Water can accumulate on top of the rubber and beneath the rocks, creating an environment for microbial proliferation, and the OA intakes can potentially introduce the microbes or their byproducts into the building.

7. Several of the ceiling panels had evidence of water damage and some had microbial growth on them. Any wetted materials should be cleaned or replaced. The cause of the moisture or leak should be fixed to prevent further damage.

8. These recommendations about proper HVAC maintenance and operation, and increased filter efficiency can be applied to all the schools in the Princeton School District.

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