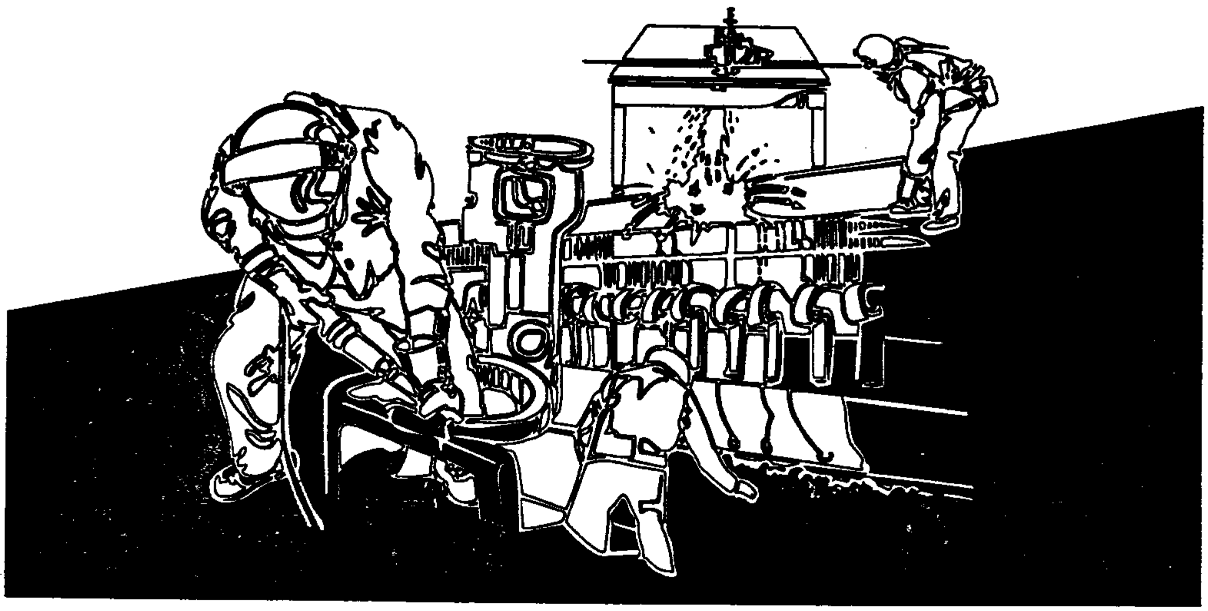
CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH HEALTH HAZARD EVALUATION REPORT

HETA 92-166-2318
PENNSYLVANIA DEPARTMENT OF REVENUE
HARRISBURG, PENNSYLVANIA



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer and authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 92-166-2318
MAY 1993
PENNSYLVANIA DEPARTMENT OF REVENUE
HARRISBURG, PENNSYLVANIA

NIOSH INVESTIGATORS:
GREGORY A. BURR, CIH
ROBERT MALKIN, DDS, Dr.PH.
MATTHEW K. KLEIN, PE

SUMMARY

In February 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from employees of the Pennsylvania Department of Revenue (PDR), Harrisburg, Pennsylvania. The request concerned health effects such as "headaches, body aches, dizziness, sinus problems, flu symptoms, low energy levels, and constant colds" thought to be related to the work environment.

An opening conference was held April 23, 1992, with management and union officials and several of the employees who initially requested this evaluation. A walk-through inspection was conducted on floors 4, 5, 8, 9 and 10; these areas were selected to represent various combinations of occupant density, office layout, and job activities performed. On September 2-3, 1992, a follow-up evaluation was conducted which included measurements for carbon dioxide (CO_2), temperature, and relative humidity (RH) throughout the workday. General area air samples were also collected to measure levels of volatile organic compounds (VOCs), minerals, and metals at various locations in the building. The medical portion of this evaluation consisted of a survey and individual interviews with PDR employees. A NIOSH mechanical engineer conducted an examination of the heating, ventilating, and air-conditioning (HVAC) systems servicing this office tower.

All of the CO_2 concentrations measured at PDR on September 2-3, 1992, were below 1,000 parts per million (ppm), suggesting that the office areas were being adequately ventilated with outside air on the days of the evaluation. The temperature and RH levels measured on September 2-3, 1992, ranged from 75 → 80°F and 48 → 67% RH. In some areas the temperature and RH levels exceeded the summer comfort range recommended by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE).

The VOCs identified in concentrations above those in field blanks included acetone, toluene, xylene, pentane, hexane, tetrachloroethane, and 1,1,1-trichloroethane. The presence of these compounds in the parts per billion range is not unusual for a non-industrial work place. None of the 30 elements analyzed for in the air samples collected exceeded any applicable exposure limit. There was also the possibility of re-entrainment and recirculation of secondary cigarette smoke from office areas where smoking was permitted.

The results of the questionnaire surveys revealed symptom and comfort complaint prevalence rates typical of what is reported in other buildings investigated because of employee complaints. Symptoms most often reported included: tired or strained eyes; stuffed nose/sinus congestion; dry, itching or irritated eyes; tiredness; headache; and dry throat. Employees associated their symptoms with perceived low humidity, high temperature, and too little air. A total of 75% of the employees reported having one or more of the symptoms asked in the questionnaire; 65% of the employees had two or more symptoms; and 54% reported having three or more symptoms. There was no difference between floors with respect to the total number of reported symptoms per employee. There was no difference in age or years worked in the building and the number of symptoms reported by employees, but workers who had three or more symptoms were more likely to have worked more hours on a computer than employees with two or less symptoms.

Several potential problems associated with the air handling units were observed, such as leaking control valves, out-of-calibration controllers, incorrectly selected or placed sensors, and malfunctioning control systems, were observed during this evaluation. Over-humidification of the occupied space at PDR was possible. Finally, changes in furnishings and interior construction, along with tampering with diffusers, may have affected the air distribution in parts of the building and, consequently, the occupants' thermal comfort.

The environmental sampling revealed air concentrations of CO_2, VOCs, minerals, and metals which are typical of those measured in other non-industrial work places. The PDR smoking policy at the time of this evaluation was judged ineffective by NIOSH investigators in controlling environmental tobacco smoke (ETS). Temperature and RH levels on some floors exceeded the thermal comfort range recommended by ASHRAE. Symptoms were associated with employee perceptions of low humidity, high temperature, and too little air but they could not be accounted for by any identified exposure or environmental condition in the building. Some of the recommendations included in this report concern implementing a more effective smoking policy, minimizing pesticide spraying in the office areas, and evaluating the current ventilation systems for possible improvements in the building's temperature and humidity control.

Keywords: SIC 9311 (Public Finance, Taxation, and Monetary Policy), indoor environmental quality, IAQ, carbon dioxide, temperature, humidity, ventilation, volatile organic compounds, IEQ.

INTRODUCTION

In February 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from employees at the Pennsylvania Department of Revenue (PDR). This agency is located on floors 3 through 12 in the 16-story Strawberry Square office complex in downtown Harrisburg, Pennsylvania. The request concerned health effects such as "headaches, body aches, dizziness, sinus problems, flu symptoms, low energy levels, and constant colds." The requestors believed that their health problems were due to some environmental exposure at the building. These problems were not perceived by the employees to be localized to one portion of the building.

During the initial visit to the building on April 23, 1992, an opening conference was held with management and union officials and several of the employees who initially requested this evaluation. The majority of PDR employees are represented by the American Federation of State, County, and Municipal Employees (AFSCME), Locals 2545 and 2456. Following this meeting, a brief walk-through inspection was conducted on floors 4, 5, 8, 9 and 10; these areas were selected to represent various combinations of occupant density, office layout, and work activities performed. Also, the main air handling units (AHUs) located in the mechanical room on the third floor were qualitatively examined.

Based on the information obtained from the initial visit, an environmental and medical follow-up evaluation was conducted on September 2-3, 1992. The environmental survey included measurements for carbon dioxide (CO_2), temperature, and relative humidity (RH) throughout the workday. General area air samples were collected at various locations in the building for volatile organic compounds (VOCs), minerals, and metals. The medical evaluation consisted of a questionnaire and individual interviews with PDR employees. A NIOSH mechanical engineer, working with representatives from PDR, the Harristown Development Corporation, and the Pennsylvania Bureau of Buildings and Grounds (BB&G), conducted a qualitative examination of the heating, ventilating, and air-conditioning (HVAC) systems servicing this office tower.

An interim report, containing the results from the CO_2, temperature, and RH measurements, as well as a discussion of the medical interview results, was distributed on September 24, 1992. A second interim report, containing the results from the air samples collected for VOCs, minerals, and metals, was disseminated on December 14, 1992.

BACKGROUND

The PDR is located in Strawberry Square, a large office, shopping, and entertainment complex completed in 1987 and located in downtown Harrisburg. The two-story lobby/atrium of this complex houses an assortment of restaurants and small shops. The PDR, with an estimated 1200 permanent workers, is situated on floors 3-12 of a 16-story office tower located adjacent to the shopping and entertainment atrium. As with many other state or federal revenue agencies, additional temporary workers are hired by PDR between January and June to process tax returns during the peak tax filing time.

Each floor is approximately 33,000 square feet (ft^2) in size. The 16-story office tower has a glass and brick exterior on all four sides and a forced air heating and cooling system. A variable air volume (VAV) system provides heating and cooling for the perimeter of the building, while a constant volume system (CV) services the interior (core) portions of the structure. Steam for the heating coils is purchased from a power generating facility operated by the city of Harrisburg. During the winter months, the building is humidified, using steam purchased from the city. According to information provided by PDR and BB&G officials, some corrosion inhibitors (such as diethylaminoethanol [DEAE] and cyclohexylamine) are used to treat the steam. The outside air (OA) intakes for the main AHUs are located on the third floor. Additional information on the air handling units, control systems, and air flow distribution patterns may be found in Appendix A.

On at least one floor, PDR workers were permitted to smoke at their immediate workstation (with approval of the other employees in the immediate area). Other floors restricted smoking to restrooms and/or the lunch/breakroom.

EVALUATION CRITERIA

A number of published studies have reported a high prevalence of symptoms among occupants of office buildings (Kreiss, 1984; Gammage, 1985; Burge, 1987). NIOSH investigators have completed over 700 investigations of the indoor environment in a wide variety of settings. The majority of these investigations have been conducted since 1979.

The symptoms reported 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.

Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building-related occupant complaints (Kreiss, 1989; Norback, 1990). 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 (Morey, 1989; Molhave, 1986; Burge, 1989; Nagda, 1991). Reports are not conclusive as to whether increases of outdoor air above currently recommended amounts ($\geq$15 cubic feet per minute per person) are beneficial (Nagda, 1991). However, rates lower than these amounts appear to increase the rates of complaints and symptoms in some studies (Jaakkola, 1991). Design, maintenance, and operation of HVAC systems are critical to their proper functioning and provision of healthy and thermally comfortable indoor environments. Indoor environmental pollutants can arise from either outdoor or indoor sources (Levin, 1989).

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 the measurement of any indoor contaminant or condition (NIOSH, 1991). Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints (Boxer, 1990; Baker, 1989).

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 office furnishings, 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 conditions, poor lighting, and unacceptable noise levels; adverse ergonomic conditions; and job-related psychosocial stressors. In most cases, however, no cause of the reported health effects could be determined.

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 (CDC, 1988; OSHA, 1989; ACGIH, 1991). With few exceptions, pollutant concentrations observed in the office work environment 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 (ASHRAE, 1981 and 1989). The ACGIH has also developed a manual of guidelines for approaching investigations of building-related symptoms that might be caused by airborne living organisms or their effluents (ACGIH, 1989).

Measurement of indoor environmental contaminants has rarely proved to be helpful, in the general case, in determining the cause of symptoms and complaints except where there are strong or unusual sources, or a proved relationship between a contaminant and a building-related illness. However, measuring ventilation and comfort indicators such as carbon dioxide (CO_2), temperature, and RH is useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems.

EVALUATION METHODS

ENVIRONMENTAL

Carbon Dioxide

During the follow-up site visit on September 2-3, 1992, CO_2 measurements were obtained throughout the workday on floors 4 through 6 and 8 through 12. Although identical in size, these floors provided a cross-section of the differences in occupant density and office design which varied from floor to floor. To facilitate tracking the changes in CO_2 throughout the day and to eventually compare these levels to results obtained from a questionnaire given to some of the PDR employees, each floor was divided into ten quadrants (labelled A through J). Figure 1 shows a typical floor diagram and the location of these quadrants. Table 1 lists the number of permanent, part-time, and temporary employees per floor (as of 9/2/92) and the departments located on each of the floors.

Carbon dioxide is a normal constituent of exhaled breath and, if monitored, can be used as a screening technique to evaluate whether adequate quantities of outside air are being introduced into an occupied space. ASHRAE's most recently published ventilation standard, ASHRAE 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 15 cfm/person for reception areas, classrooms, libraries, auditoriums, and corridors (ASHRAE, 1989). Maintaining the recommended ASHRAE outdoor air supply rates when the outdoor air is of good quality, and there are no significant indoor emission sources, should provide for acceptable indoor air quality.

Indoor CO_2 concentrations are normally higher than the generally constant ambient CO_2 concentration (range 300-350 parts per million [ppm]). Carbon dioxide concentration is used as an indicator of the adequacy of outside air supplied to occupied areas. 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. It is important to note that CO_2 is not an effective indicator of ventilation adequacy if the ventilated area is not occupied at its usual level.

Real-time CO_2 levels were determined using Gastech Model RI-411A, Portable CO_2 Indicator. This portable, battery-operated instrument monitors CO_2 via non-dispersive infrared absorption with a range of 0-4975 ppm, and a sensitivity of 25 ppm. Instrument calibration was performed daily prior to use with a known concentration of CO_2 (800 ppm span gas).

Temperature and Relative Humidity

Temperature and RH measurements were collected during the follow-up visit because these parameters affect the perception of comfort in an indoor environment. The perception of thermal comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperature (NIOSH, 1986). 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 55-1981 specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally acceptable (ASHRAE, 1981). Assuming slow air movement and 50% RH, the operative temperatures recommended by ASHRAE range from 68-74°F in the winter, and from 73-79°F in the summer. The difference between the two is largely due to seasonal clothing selection. ASHRAE also recommends that RH be maintained between 30 and 60% RH (ASHRAE, 1981). Excessive humidities can support the growth of microorganisms, some of which may be pathogenic or allergenic. Real-time temperature and RH measurements were conducted 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.

Volatile Organic Compounds

Ten general area air samples were collected on September 2-3 for volatile organic compounds (VOCs). The term "VOCs" describes a large class of chemical compounds which are organic (i.e., containing carbon) and have a sufficiently high vapor pressure to allow some of the compound to exist in the gaseous state at room temperature. There are literally thousands of unique chemical compounds which are VOCs, including formaldehyde and other aldehydes, which are emitted in varying concentrations from numerous indoor sources including but not limited to carpeting, fabrics, adhesives, solvents, paints, cleaners, waxes, cigarettes, and combustion sources.

Carbotrap 300® thermal desorption tubes were used for collection and were analyzed using a gas chromatograph and mass spectrophotometer detector (GC/MS). The thermal tubes consist of three sorbents (Carbotrap C, Carbotrap, and Carbosieve S-III) which are used for trapping organic compounds over a wide range of volatility. Substances such as acetone, toluene, pentane, hexane, etc., will be captured with this sorbent tube. NIOSH uses this method as an extremely sensitive and a very specific quantitative screening technique; it will identify the VOCs present on the sample in the parts per billion range.

Elements

Ten general area air samples were collected on September 2-3 from various locations on four floors and submitted for the quantitative determination of 30 different minerals and metals, based on the NIOSH Sampling and Analytical Method No. 7300 (inductively-coupled plasma/atomic emission spectrophotometry).

Microbial Agents

Visible evidence of microbial contamination, such as standing or leaking water, was not apparent at PDR. Monitoring for airborne microbial contamination was not performed.

MEDICAL

The medical evaluation included interviews with employees and administration of a questionnaire survey. Interviews were conducted with 18 employees who had notified the union that they wished to talk to the NIOSH investigators. Additionally, two group interviews, composed of 12 and 14 employees, were conducted. A copy of the questionnaire survey used in this evaluation may be found in Appendix B.

The questionnaire survey was conducted on floors 5, 9 and 10 where, according to management, a total of 511 employees worked. These floors were selected because employees from these areas, according to the union, had reported a higher number of symptoms. Each employee who was present at work on September 1-3, 1992, was given a questionnaire at his or her work station and asked to complete it during the day. NIOSH investigators were available on the floor to answer any questions and assist the employees. The questionnaire was placed in a sealed envelope and collected at the end of the day.

For the purpose of determining prevalence rates*, a symptom reported to occur "1-3 days per week in the last four weeks" or "every or almost every workday" was considered to be present and "1-3 days in the last four weeks" or "not in the last four weeks" were considered to be absent. A lack of response to a given question was considered the same as an absent symptom. For computation of correlations, the data were left in the original categories and questions not answered were not included. Statistical analyses were performed using the Chi-Square test, unless otherwise noted.

VENTILATION

The inlet area for the outside air, the outside air plenum area, and AHUs nos. 7, 8, 10, and 11 were inspected for factors which may contribute to indoor environmental quality problems such as cleanliness, debris, standing water, and biocontaminants. The air tightness of plenums was evaluated. Air filters were checked for type, proper installation, general condition, improper maintenance, and bypassing. The cooling coils were checked for cleanliness, plugging, and carryover. Condensate pans were checked for proper drainage (tilt toward drains), debris, standing water, physical condition, and evidence of biogrowth. The condensate drain lines were checked for proper design and installation and examined for plugging and proper drainage into sanitary lines. Any evidence of improper maintenance practices were noted.

Readings from the instrument gages of the AHUs which monitored the supply and return air flow rates and the outside, mixed, return, supply, and preheat coil discharge air temperatures were recorded during the survey. Three sets of readings (morning, mid-day, and afternoon) were recorded on September 2, 1992, and two sets (morning and afternoon) on September 3, 1992. These readings were subsequently examined to identify potential control system problems and problematic trends.

---

* In this report, prevalence rates describe the *percentage* of PDR employees with symptoms.

RESULTS

ENVIRONMENTAL

Temperature and Relative Humidity Levels

Table 2 contains the temperature and RH levels measured on September 2-3, 1992. On September 3, the temperature in several offices ranged up to 77°F and the humidity exceeded 60% RH, conditions which are outside the summer comfort range recommended by ASHRAE. Relative humidity levels preferably should be maintained between 30 and 60% to minimize growth of allergenic or pathogenic organisms (ASHRAE, 1989). Differences in temperature and, especially, RH were noted between floors (and occasionally on the same floor).

Carbon Dioxide Levels

As shown in Table 3, all of the CO_2 concentrations measured during this survey were well below 1,000 ppm, suggesting that these office areas were being adequately ventilated with outside air on September 2 and 3, 1992. These CO_2 levels could increase, however, with the introduction of temporary workers during the peak tax filing season.

Volatile Organic Compounds

Table 4 lists the airborne compounds detected in this evaluation. Organic compounds identified above blank levels included acetone, toluene, xylene, pentane, hexane, tetrachloroethane, and 1,1,1-trichloroethane. The presence of these compounds in the *parts per billion* range is not unusual for a non-industrial workplace. Monitoring for VOCs in other non-industrial buildings have revealed similar compounds at these extremely low concentrations. While Freon 22® had been an issue of concern by several PDR employees, it should be noted that this chemical was not detected in any of the air samples.

Elements

Table 5 summarizes the results from the air samples collected for various minerals and metals. None of the 30 elements analyzed for in these air samples exceeded any applicable exposure limit. In fact, airborne concentrations of most (27 of the 30 elements) were below detectable levels. While sodium, calcium, and iron were detected in several samples, the levels of these substances were just above their respective minimum detectable concentrations.

MEDICAL

Interviews

The interviews revealed that workers perceived numerous environmental deficiencies in the building, including a lack of fresh air, poor air quality, odors (particularly gas and diesel exhaust), dryness of the air, dust, glare, and cigarette smoke odors. Reported symptoms included headache, eye irritation, sinus and head congestion, cough, dizziness, confusion, losing one's voice, headache, throat dryness, lightheadedness, and chest tightness. Employees reported that symptoms had increased in severity with the installation of cloth-covered fiberboard partitions that divided the workstation into individual cubicles. Employees stated that the partitions disrupted air flow at their workstation, and resulted in feelings of stuffiness.

Employees also reported that environmental conditions deteriorated in the midafternoon each work day when they felt that there was no outside air entering the building. Building managers reported that the air intakes (located on the third floor) were routinely closed in the afternoon to prevent exhaust fumes from entering the air intakes during the evening rush hour. Interviewed employees reported that they were unaware of this decision and felt that it would have helped them if they understood what was occurring.

Questionnaire

A total of 429 questionnaires were distributed and 416 (120 men and 295 women) were returned for a 94% response rate. Overall, the questionnaire results are consistent with the findings of the employee interviews. The results concerning symptom prevalence (for all symptoms) are presented in Table 6. Employees were also questioned about environmental conditions in the building and their responses are given in Table 7. These questions dealt with the employees' *perception* of their environment, which is not always supported by actual conditions in the building. Employees reported the building as uncomfortable, with temperatures being either "too hot" or "too cold," on the day of the survey and the measured temperature, in some areas of the building, approached the upper limit of the ASHRAE guideline. On the other hand, far more employees felt the building was "too dry" rather than "too humid" on the day that NIOSH investigators were in Harrisburg, yet the RH in part of the building exceeded the ASHRAE comfort guidelines. Finally, a majority reported "too little air," even though the environmental data (CO_2 concentrations) indicate adequate outside air.

For further statistical analysis of the questionnaire data, only the six most prevalent symptoms (tired or strained eyes, stuffed nose/sinus congestion, dry/itching eyes, tiredness/fatigue, headache, and dry throat) were considered because of the marked decrease in symptom prevalence in subsequent symptoms. As shown in Table 8, an analysis using *Kendall Tau b* correlation coefficients was performed to examine whether or not these perceived environmental conditions were correlated with symptoms. Employee perceptions of being "too hot," "too dry," or having "too little air" were found to be statistically significantly correlated with the following symptoms: dry, itching eyes, stuffy nose, tiredness/fatigue, strained eyes, and headache (p=0.0001). Furthermore, perceptions of being too humid, having too little air, or being too cold while at work were also significantly correlated with symptoms.

The number of symptoms reported by individual workers is listed in Table 9. A total of 75% of the employees reported having one or more of the symptoms asked in the questionnaire, 65% of the employees had two or more symptoms, and 54% reported having three or more symptoms.

Employees who reported three or more symptoms were analyzed with regards to age, gender, years worked in the building, and hours per day spent working on a computer to determine if those factors were related to symptom reporting in that group. There was no statistically significant difference in age or years worked in the building and the number of symptoms reported, but employees who had three or more symptoms were more likely to have worked more hours on a computer than employees with two or less symptoms (5.0 hours as compared to 4.5).

There was no statistically significant difference between the total number of reported symptoms per employee and the floor on which the employee worked (p=0.332). Each floor was divided into four geographic administration to determine if prevalence rates differed within a floor. On each floor, there was no statistically significant difference between zones with respect to reporting symptoms "today."

Table 10 shows the differences between reporting of individual symptoms when the data were evaluated by the floor on which the respondent worked. Statistically significant differences were evident for only two symptoms, dry throat and strained eyes (decreased prevalence among employees on the 10th floor).

The effects of perceived deficiencies in lighting were analyzed in two manners. In the first analysis, the original questionnaire responses "much too bright" and a "little too bright" were combined to create a new variable termed "too bright." Likewise, the variables "much too dim" and "a little too dim" were combined to create a new variable termed "too dim." These combined variables were then used to assess the role that perceived dimness or brightness played on symptom reporting. Of the 46 employees reporting that their work area was "too bright," 67% (31) reported nose/sinus problems compared to 44% (102) of the 229 employees who perceived the lighting "just right" (p=0.005). Of the 135 employees who found the work area "too dim" 56% (75) reported tiredness/fatigue compared to 37% (85) of the 220 who found the work area to have proper lighting ($p=0.001$) and 56% (75) reported strained eyes as compared to 44% (101) who reported proper lighting ($p=0.035$).

The second lighting analysis combined the questionnaire responses "much too dim" and "much too bright" to form a new variable called "very bad lighting." Similarly, the responses "a little too dim" and "a little too bright" were used to create the variable "not too bad lighting" in order to determine whether or not symptom reporting was related to the magnitude of perceived lighting deficiencies. Using the *Mantel-Haenzel* Chi-square statistic, linear relationships were found between increased perceived lighting deficiencies (just right, not too bad, and very bad) and the following symptoms: strained eyes ($p<0.001$), dry/irritated eyes ($p=0.018$), tiredness/fatigue ($p<0.001$), dry throat ($p<0.001$), and headache ($p=0.001$) (see Table 11). The role played by glare on computer workstations and reporting of lighting deficiency is not known; however, glare was reported as a problem during the employee interviews.

Employees in private offices reported statistically significantly fewer symptoms (except for nose/sinus problems) than employees working in open space office designs, with or without partitions (see Table 12). It was postulated by NIOSH investigators that employees in private offices might have different job categories and that such a difference might account for differential reporting of symptoms. Job category was analyzed to determine whether employees in different job categories were more likely to report symptoms. Although managers and professional staff were more likely to be in private offices, job category (either managerial, professional, technical, secretarial/clerical, or other) was not related to the reporting of any of the analyzed symptoms.

The quality of sleep reported by employees was also statistically significantly related to reporting of symptoms (see Table 13). Increasing restless and disturbed sleep was correlated with increased reporting of all studied symptoms, as well as the environmental parameters "too little air," "too hot," and "too dry."

The detection of odors in the work area was found to be highly correlated with the occurrence of every symptom. The correlations were strongest for detecting chemical odors and "other" odors ($p=0.0001$) but was also true for tobacco smoke odors ($p<0.0052$).

OTHER OBSERVATIONS

Pesticide spraying with chlorpyrifos (Dursban®), an organophosphate insecticide, occurred while the NIOSH investigators were at the building. Spraying started at approximately 5:30 pm on September 2, 1992, after most employees were off the floor. The insecticide was being used because of employee reports of insect bites while at work. The spraying was performed by an outside contractor, who was observed wearing a NIOSH-approved half-face air purifying respirator equipped with an organic vapor cartridge.

DISCUSSION

ENVIRONMENTAL RESULTS

Carbon Dioxide, Temperature, and Relative Humidity

All of the CO_2 levels measured during this survey were well below 1,000 ppm, suggesting that these office areas were being adequately ventilated with outside air on September 2 and 3, 1992. As Table 2 showed, the temperature and RH levels measured on September 2-3, 1992, ranged from 75 to 80°F and 48 to 67% RH, conditions which were in some instances outside of the summer comfort range recommended by ASHRAE. Relative humidity levels preferably should be maintained between 30 and 60% to minimize growth of allergenic or pathogenic organisms (ASHRAE, 1989).

Volatile Organic Compounds (VOCs)

The VOCs identified above "blank" levels included acetone, toluene, xylene, pentane, hexane, tetrachloroethane, and 1,1,1-trichloroethane. The presence of these compounds in the parts per billion range is not unusual for a non-industrial workplace.

Indoor environmental quality studies have measured wide ranges of VOC concentrations in indoor air as well as differences in the mixtures of chemicals which are present. Research also suggests that the irritating potency of these VOC mixtures can vary. *Neither NIOSH nor the Occupational Safety and Health Administration currently have specific exposure criteria for VOC mixtures in the nonindustrial environment.* Research conducted in Europe suggests that complaints by building occupants may increase when VOC concentrations increase. Table 14 lists guidelines which some researchers have used to associate solvent-like exposures to employee discomfort or irritation. When using these guidelines, however, it should be emphasized that the highly variable nature of these complex VOC mixtures can greatly affect their irritancy potential. For example, the VOC mixtures which were studied by Molhave are not the same as those VOC mixtures which were measured during this evaluation.

Elements

None of the 30 elements in the air samples collected during this evaluation exceeded any applicable exposure limit and airborne concentrations of most (27 of the 30 elements) were below detectable levels. Not unexpectedly, sodium, calcium, and iron were detected in several samples; however, the levels of these substances were just above their respective minimum detectable concentrations.

TABLE 14
SUGGESTED VOC GUIDELINES

Total Concentration (mg/m^3)	Irritation and Discomfort	Exposure Range
<0.16	No irritation or discomfort	Comfort range
0.16 - 3	Irritation and discomfort possible *(if other exposures interact)*	
3 - 25	Irritation and discomfort probable; headache possible	Discomfort range

Source: Molhave, L [1986]. Indoor air quality in relation to sensory irritation due to VOCs. ASHRAE paper 2954.

QUESTIONNAIRE RESULTS

The results from the questionnaire illustrate the relationship of perceived environmental conditions and symptoms reporting. Symptoms appear to be related to the individual perception of improper humidity and temperature levels in the work environment regardless of measured parameters, as different people may report similar symptoms with completely different perceptions of their environment. A building may be too hot for some employees and may be too cold for others. In addition, it is conceivable that an area of a floor might be, at times, hotter than another and might result in these seemingly contradictory responses. However, NIOSH investigators found little difference in measured temperature and humidity between zones on a given floor.

Many employees (46.9%) felt that the building was too dry when it was arguably too humid (60% RH) on the days measurements were conducted. This occurrence has been reported by other researchers. A controlled study of subjects exposed to different humidity levels found that they were not able to judge air humidity levels. However, a relationship was found between temperature and humidity. As humidity decreased, subjects were more likely to perceive the temperature as decreased and vice versa (Andersen et. al., 1973). In another paper, Andersen et. al. (1974) found no relationship between low humidity levels and nasal mucous flow but found increased reporting of discomfort in subjects exposed to 9% humidity for 72 hours, with increased reporting (that was not statistically significant) of dryness of studied body surfaces (eyes, nose, mouth, pharynx, hands, face, lips, and hair). In a previous NIOSH investigation, *perceived* low humidity in indoor environments was associated with dryness of the eyes, nose, and throat (NIOSH, 1991).

PDR employees in Harrisburg may be experiencing symptoms that they related to humidity, although the feeling of discomfort may have been due to another source. Although there were many associations between perceived environmental conditions and various symptoms, these conditions would not by themselves plausibly account for the high prevalence of symptoms. The etiology of the symptoms is presently unknown. The results, however, do give insight into how different employees perceive how they are affected by their work environment and may serve as a guide in improving that environment.

Even though the building appeared not to meet ASHRAE comfort guidelines with respect to humidity on the days NIOSH investigators measured conditions at the PDR, it must be emphasized that those measurements only reflect one day's conditions. The indoor environmental conditions may vary depending on local outdoor environmental conditions or with fluctuations in the operation of the heating and cooling system. In addition, NIOSH investigators did not measure the individual worker's micro-environment. A given employee, in an individual office or in an office surrounded by partitions, may experience markedly different environmental conditions than those measured by NIOSH investigators. Although NIOSH investigators measured adequate ventilation in the work site as a whole, as determined by CO_2 concentration in the air, some employees reported a lack of adequate circulation of air in their work space. areas of the building.

The exact role played by sleep quality on the reporting of symptoms is not known from this analysis. Employees' may be so concerned over their illnesses that they are unable to sleep, or conversely, the employees lack of sleep may be make them more irritable,, more aware of bodily discomfort and more intolerant of variations in their environment. Finally, both the sleep disturbances and other symptoms may be manifestations of some other health problem, unrelated to the building's physical environment.

The decrease in reported symptoms among employees in private offices is interesting in that it seems to argue against a building-wide environmental problem as a cause for the health complaints. Private offices are serviced by the same air handling systems as the open plan offices, and any postulated toxic substance brought into the building or distributed within the building would be brought to private offices as well. Although there were no differences between job category and reporting of symptoms, it is conceivable that those employees with private offices are the most senior and might have different job characteristics than less senior employees. In addition, the spread of viral respiratory diseases (colds, influenza) would more readily occur in open plan offices because of both the lack of physical barriers and the increased number of people a given employee might be in contact with during a work day.

VENTILATION ASSESSMENT

Air Handling Unit Inspection

Outside Air Intakes

The Strawberry Square Complex had an exterior facade constructed to resemble pilasters. These pilasters were situated in front of the outside air (OA) intakes to hide them from street-level view. This facade area had a floor area level with the floor of the outside air plenum. Pigeon nests and dung piles were observed on the facade floor, next to entrance to the OA air plenum behind every pilaster. These locations were behind the facade and apparently were the most protected from the weather. One of the nests still had squabs in it; the other nests were empty.[b]

One pigeon nest, along with several dead adult pigeons (in various stages of decomposition), were observed inside the OA plenum. No live pigeons, however, were observed in this plenum area. It was conjectured that the pigeons entered the plenum through tears in the screen material covering the outside air entrance. The screens which covered these OA entrances had a 1" x 1" opening. While a mixture of leaves and pigeon feathers plugged some of the lower sections of the screens, the air flow into the plenum did not appear to be adversely affected. Some bird feathers, however, were getting past the screen.

All of the OA damper systems appeared to function. However, HDC personnel stated that the OA dampers were closed during rush hour traffic (about 3:30 to 5:00 p.m. Monday through Friday) to reduce employee complaints about vehicular/diesel exhaust odors. The OA intakes, it should be noted, were situated on the third floor and overlooked the street. Some of the mixed air plenums which were examined had dust on the walls and damper louvers. Pigeon feathers were observed inside the mixed air plenums.

<u>Air Filters</u>

The cardboard-framed prefilters did not have gaskets between the filters or between the filters and filter racks. All of the AHUs examined had several prefilters collapsed inward toward the bag filters. Dust loading on the filter rack of the prefilters suggested that some air was bypassing the prefilters. All of the prefilters had a medium dust loading (loaded with some debris but without a filter cake). Some prefilters had pigeon feathers impacted on their outer surface.

Several prefilters were randomly removed to inspect the bag filters. The filter media of two bags in AHUs nos. 10 and 11 were pinched between the filter frames and racks. This incorrect installation decreases the effectiveness of the bag filter and could shorten the life of the filter media. Neither the filter rack nor the filter frames had gaskets to prevent air from bypassing the filters. Harristown Development Corporation personnel changed filters on a time schedule. The

---

[b] Based on recommendations made to PDR management in a closing conference held on September 3, 1992, these areas were subsequently cleaned of this debris.

manufacturer of the filters, however, recommended filter changing based on an increase in the pressure drop across the filter bank.

Heating and Cooling Units

Pigeon feathers were visible on the upstream face of all of the preheat coils examined. Given the higher efficiency of the bag filters, feathers should not have been in this area. It was speculated that feathers could have reached the preheat coil plenum area after being knocked off of the air filters during change-out. Another possible route of entry could be through mechanical room doors left open while the AHUs were operating or feathers inadvertently carried into the plenum area by maintenance personnel.

The cooling coils were visually examined and appeared to be relatively clean, although some had pigeon feathers on their upstream faces. HDC personnel reportedly cleaned these coils once per year. When compared to the coils in AHUs nos. 7, 8, and 10, several coils in AHU #11 appeared to be installed upside down. The bases of these inverted coils had more corrosion than the bases of the properly installed coils. Poorer water drainage in the improperly installed coils was suspected to be the cause of this corrosion.

Condensate Pans

Standing water was observed in all of the condensate pans which were examined. In two units, water had spilled from the pan onto the floor. In another unit, water from a condensate pan had been blown onto sound attenuators situated downstream of the coils. A check of several condensate pans with a bubble level revealed that in all instances the pans had warped, creating areas of poor drainage.

All of the condensate pans examined had visible corrosion, with some units corroded to the point of flaking rust. Rust scale ringing the drain opening or plugging the drain lines of some units was one reason for poor drainage. In fact, debris in one unit's drain lines could not be removed with a water jet from a hose.

In addition to warped pans and plugged drain lines, standing water in the condensate pans may have also been due to insufficient depth of the traps in the drain lines. For example, if the trap depth is not greater than the suction static pressure on the drain line, water cannot drain from the unit. A typical sign of this problem is drainage from the unit after the fan is turned off (the suction static pressure is eliminated, thus allowing the water to drain). Installation constraints at PDR prevented traps from being greater than 5" in depth. Since the design static pressure rating for the fans in AHUs nos. 8 and 10 was equal to 10" water gage, these units may have inadequate trap depth.

Ventilation System Maintenance

In all of the units inspected, grease was observed on the tips of the vaneaxial fan blades.* In one unit the blades of a damper downstream of the fan had grease on its surface, apparently left after mechanics had greased the fan bearings. All of the units had air leakage through cracks around the access doors. Door gaskets were nonexistent or needed replacement.

Analysis of Readings Obtained From AHU Instrument Gages

Readings obtained from the AHU gages which monitored the supply and return air flow rates and the outside, mixed, return, supply, and preheat coil discharge air temperatures indicated several potential problems, such as leaking valves, out-of-calibration controllers, incorrectly selected or placed sensors, or malfunctioning control systems. In many cases, for the same AHU the preheat coil discharge air temperatures were *higher* than the mixed or supply air temperatures, indicating that the preheat coils were heating the air. However, for the same AHU the supply air temperatures were *lower* than the preheat coil discharge temperatures, indicating that the cooling coils were cooling the air. *These two coils should not be operating at the same time.*

According to the gages on AHU #8, the return air flow rate was consistently higher than the supply air flow rate, indicating that the zones serviced by this unit were under a *slight negative pressure* in relation to the surrounding areas. It is preferable to maintain occupied spaces at a *slight positive pressure* (to their surroundings) to reduce the infiltration of unfiltered outside air.

The mixed air temperatures of AHUs nos. 8, 10, and 11 were greater than either the return or outside air temperatures. The mixed air temperatures should be between the supply and outside air temperatures. Disparity between the sensors for these different air streams could affect operation of the economizer system, resulting in potential temperature control problems.

Finally, the OA temperature readings were not the same for all of the units. These temperature readings should be nearly identical since the sensors should be monitoring comparable air streams. This disparity suggests a calibration problem with some of the temperature sensors.

---

* Centrifugal forces would push the grease from the fan shaft area toward the tips of the blades.

Humidification

Over-humidification of the occupied space at PDR was considered possible because humidity levels were monitored by the control system in the return air duct instead of the occupied space. This arrangement makes controlling the actual humidity levels in a particular zone difficult since air from all of the zones is mixed in the common return air plenum. To avoid this problem many modern ventilation systems monitor the humidity levels in the occupied space.

Humidification systems must be carefully planned and properly maintained to assure that indoor environmental quality is not adversely affected (IAQ Update, 1991). From an indoor environmental quality perspective, steam humidifiers are the preferable method for commercial spaces, since the heating of the water kills nearly all of the microorganisms (IAQ Update, 1991). While the PDR offices are humidified using such a system, the steam obtained from the city of Harrisburg may contain small amounts of anti-corrosion agents such as diethylaminoethanol [DEAE] and cyclohexylamine. Chemicals such as DEAE and cyclohexylamine, in sufficient concentrations, are irritants of the skin, mucous membranes, and eyes (Cornish, 1965). It is preferable that the steam humidifiers have a separate water supply which is free from these potentially irritating cleaning agents.

Air Distribution

It was reported that the building was originally designed for open architecture and that, over the years, floor to ceiling partitions and private offices were added. It was also reported that PDR employees had covered and/or removed parts of the diffusers in several occupied spaces. Harristown Development Corporation personnel stated that two or three surveys had been made through the entire building to repair diffusers.

Changing furnishings, altering interior construction, and tampering with diffusers can affect the air distribution and, consequently, the occupants' thermal comfort. The high percentage of the "too little air" complaints by employees (see Table 7) suggest that thermal comfort is a problem. Other indications of thermal comfort problems are "too hot" and "too cold" complaints reported in the PDR maintenance logs, and questionnaire responses describing the air as being too dry, despite the humidity levels being about 60%.

OTHER ISSUES

Smoking Policy

The PDR smoking policy at the time of this evaluation was judged ineffective by NIOSH investigators in controlling environmental tobacco smoke (ETS). This conclusion was based on the possibility of re-entrainment and recirculation of secondary cigarette smoke from office areas where smoking was permitted. Reports from the Surgeon General, the National Research Council, and the Environmental Protection Agency (EPA) have concluded that exposure to ETS may be associated with a wide range of health (e.g., lung cancer) and comfort (e.g., eye, nose, and throat irritation and odor) effects (HEW, 1979; HHS, 1982, 1983, 1984, 1986; NRC, 1987). NIOSH has determined that ETS may be related to an increased risk of lung cancer and possibly heart disease in occupationally exposed workers who do not smoke themselves (CDC, 1991).

Diesel Exhaust Odors

Some PDR employees reported intermittent diesel (or vehicular exhaust) odors in their office areas. The likely source of these odors is through the OA intakes located on the third floor. The downtown location of the office building, along with the location of the OA intakes on the third floor, creates a situation where transient exhaust odors would be nearly impossible to prevent totally. In an effort to minimize the opportunity for exhaust odors to enter the building, the OA intakes were closed daily between approximately 3:30. This action was taken to reduce the possible infiltration of automobile and truck exhaust into the building during rush hour traffic.

Pesticide Usage

According to PDR management, Dursban® (chlorpyrifos) has been applied in the building as part of a regularly scheduled program of insect control. On occasion, the insecticide spraying is performed during normal working hours while employees were present.

Dursban has also been sprayed in the building in response to employee reports of being bitten while at work. While no insects had been sighted, management representatives felt that the insects were "dust or paper mites." There is no such insect as a paper mite, and dust mites do not bite, although they are implicated in allergic reactions (asthma, rhinitis) in susceptible individuals.

CONCLUSIONS

Reports of health complaints among occupants of non-industrial buildings 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 potentially contributory 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 that the occurrence of symptoms among building occupants can be lessened by providing a properly maintained interior environment.

In this evaluation no specific exposures were identified that would help explain the symptoms reported by PDR employees. For example, the low levels of acetone, toluene, xylene, pentane, hexane, 1,1,1-trichloroethane, and tetrachloroethane measured at PDR have been detected in other nonindustrial indoor environments. The presence of these compounds in the parts per billion range is not unusual. Exposure to these individual chemicals at such low concentrations would not be expected to cause health effects in the majority of the population. Air concentrations of a variety of minerals and metals measured levels during this evaluation were generally below the detection limits for this analytical method. None of the CO_2 levels measured during this evaluation exceeded 1000 ppm, a guideline NIOSH investigators use to determine if sufficient outside air is being introduced to occupied spaces of a building.

The results of the questionnaire surveys revealed the prevalence of symptoms typical to what is reported in "problem" buildings (Mendell and Smith, 1990; Burge et. al, 1987). Symptoms were associated with employee perceptions of low humidity, high temperature, and too little air.

RECOMMENDATIONS

1. Pesticide spraying should be minimized. Other procedures, such as keeping cafeterias clean and sealing cracks in walls, should be the primary means of insect control. Potent organophosphates should not be used if less toxic insecticides (for example boric acid for cockroach control) are effective. Use of **any** insecticide in an attempt to control mites, or other insects in the absence of objective evidence of infestation, is inappropriate.

2. Trucks and other vehicles should be prohibited from idling at the building's loading dock. Employees reported that there was a sign to that effect but that it was routinely ignored by drivers making deliveries.

3. Exposure to ETS is one of the most important indoor air quality problems, contributing both particulates and gaseous contaminants. A smoking cessation program may be necessary to assist those employees who are current smokers. If smoking is permitted, it should be restricted to designated smoking lounges (CDC, 1991). These lounges should be provided with a *dedicated exhaust system* (room air directly exhausting to the outside), an arrangement which eliminates the possibility of re-entrainment and recirculation of any secondary cigarette smoke. In addition, *the smoking lounge should be under negative pressure relative to surrounding occupied areas*. The ventilation system supplying the smoking lounge should be capable of providing at least 60 cfm of

outdoor air per person. This air can also be obtained from the surrounding spaces (transfer air).

4. Microorganisms which cause infectious diseases such as psittacosis and cryptococcosis have been identified in pigeon droppings and excreta of other birds. Because of this hazard, the areas near the outside air intakes for the office building should be kept clear of contaminants such as bird droppings, dead birds, and feathers. If future cleaning of these areas is required, the waste products and other bird debris should first be disinfected prior to removal. Wetting this debris with a sodium hypochlorite solution made by mixing 14 ounces of a 5% hypochlorite (chlorine) bleach in a gallon of water (a 1:10 dilution resulting in a free chlorine concentration of 5,000 ppm) should provide acceptable disinfection. Employees removing this debris should wear NIOSH approved air purifying respirators equipped with (as a minimum) high efficiency particulate air (HEPA) cartridges. Respirators which offer a higher degree of protection, such as full-face piece, powered air purifying respirators, may be warrented in situations where there is heavy contamination and the clean-up effort is extensive. To avoid contamination of the duct work and AHUs, the HVAC systems should not be operated while these contaminated areas are disinfected and cleaned.

5. Communication between management and employees should be increased to facilitate the exchange of concerns about environmental conditions at the building. Employees should be made aware of the problems with the building and decisions that must be made by state and building managers to address those problems. An example is the report by employees that there is a decrease of fresh air in the late afternoon that affects comfort and results in increased symptoms. Management told NIOSH investigators that the air intakes were closed at that time to prevent automobile exhaust odors from entering the building during rush hour when there is increased traffic in front of the building. Employees reported that they were unaware of this decision and felt that it would help them if they understood what was occurring.

The following recommendations pertain to the ventilation systems.

6. All of the air filters should be checked for correct installation. Masking tape should be used to seal air gaps between the prefilters. The filters should be changed based on the manufacturer's recommended maximum pressure drop across the filters. Preferably, this change should occur when the building is unoccupied and the AHUs not operating. Filters should be double bagged inside the unit for disposal. Debris knocked off the filters should be removed before the units are actuated.

7. Condensate pans should be tilted so that all bottom areas of the pan tilt toward the drains.

8. Condensate drain lines should be cleared of debris. Traps should be fixed to allow proper drainage of water from the condensate pans.

9. Excess grease and other materials, such as rags and parts, should be cleaned out of the AHUs after maintenance.

10. Sensors, controllers and thermostats should be cleaned and calibrated.

11. All components of the AHUs should be placed on a preventive maintenance (PM) schedule. This schedule should include: policing of units for debris accumulations; checks on systems to ensure proper operation; checks on the filters for bypassing and general condition; yearly cleaning and calibration of control systems; cleaning of coils, condensate pans and drains. Condensate pans and drains should be inspected at least monthly and maintained as needed. Equipment manufacturers should initially be consulted for recommended PM practices and time frames for other components. Eventually, experience will dictate a time frame for PM functions that is applicable to the building's mechanical systems.

12. A mechanical audit should be performed to evaluate whether the current mechanical systems' design is adequate for the current construction and uses of the building. This audit should include new calculations of the thermal load on and in the building, and test and balance checks of all mechanical system components. The audit report should include all of the collected data and calculations, assumptions used for the calculations, and complete descriptions of the instruments and computer models that were used.

13. Ventilation firms should be consulted to evaluate the current systems for possible improvements to the building's temperature and humidity control. To ensure that future problems do not occur, proposals by the firms should be evaluated considering universality of components, and, for direct digital control systems, use of standardized program languages and equipment interfaces.

REFERENCES

1. ACGIH [1991]. Threshold limit values for chemical substances in the work environment for 1991-1992. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

2. ACGIH [1989]. Guidelines for the assessment of bioaerosols in the indoor environment. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

3. Andersen I, Lundqvist GR, Proctor DF [1973]. Human perception of humidity under four controlled conditions. Arch Environ Health 26:22-27.

4. Andersen I, Lundqvist GR, Jensen PL, Proctor DF [1974]. Human response to 78 hour exposure to dry air. Arch Environ Health 29:319-324.

5. ASHRAE [1981]. Thermal environmental conditions for human occupancy. American National Standards Institute/ASHRAE standard 55-1981. Atlanta, GA: American Society for Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

6. ASHRAE [1989]. Ventilation for acceptable indoor air quality, standard 62-1989. Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

7. Baker DB [1989]. Social and organizational factors in office building-associated illness. Occupational Medicine: State of the Art Reviews 4(4):607-624.

8. Boxer PA [1990]. Indoor air quality: a psychosocial perspective. JOM 32(5):425-428.

9. Burge HA [1989]. Indoor air and infectious disease. Occupational Medicine: State of the Art Reviews 4(4):713-722.

10. Burge S, Hedge A, Wilson S, Bass JH, Robertson A [1987]. Sick building syndrome: a study of 4373 office workers. Ann Occup Hyg 31:493-504.

11. CDC [1988]. NIOSH recommendations for occupational safety and health standards 1988. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. MMWR 37 (supplement S-7).

12. CDC [1991]. NIOSH current intelligence bulletin 54-environmental tobacco smoke in the workplace (lung cancer and other effects). Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 91-108.

13. Cornish H [1965]. Oral and inhalation toxicity of 2-diethyl aminoethanol. Am Ind Hyg Assoc J 26:479-485.

14. Gammage RR, Kaye SV, eds. [1985]. Indoor air and human health: Proceedings of the Seventh Life Sciences Symposium. Chelsea, MI: Lewis Publishers, Inc.

15. HEW [1979]. Smoking and health: a report of the Surgeon General. Office on Smoking and Health. Washington, D.C.: U.S. Department of Health, Education, and Welfare, U.S. Government Printing Office.

16. HHS [1982]. The health consequences of smoking -- cancer: a report of the Surgeon General. Office on Smoking and Health. Washington, D.C.: U.S. Department of Health and Human Services, U.S. Government Printing Office.

17. HHS [1984]. The health consequences of smoking -- chronic obstructive lung disease: a report of the Surgeon General. Office on Smoking and Health. Washington, D.C.: U.S. Department of Health and Human Services, U.S. Government Printing Office.

18. HHS [1983]. The health consequences of smoking -- cardiovascular disease: a report of the Surgeon General. Office on Smoking and Health. Washington, D.C.: U.S. Department of Health and Human Services, U.S. Government Printing Office.

19. HHS [1986]. The health consequences of involuntary smoking: a report of the Surgeon General. Office on Smoking and Health. Washington, D.C.: U.S. Department of Health and Human Services, U.S. Government Printing Office.

20. IAQ Update [1991]. The role and control of humidity in IAQ. Indoor Air Quality Update. Arlington, MA: Cutter Information Corporation, Vol. 4(7):1-5.

21. Jaakkola JJK, Heinonen OP, Seppänen O [1991]. Mechanical ventilation in office buildings and the sick building syndrome. An experimental and epidemiological study. Indoor Air 1(2):111-121.

22. Kreiss KK, Hodgson MJ [1984]. Building associated epidemics. In: Walsh PJ, Dudney CS, Copenhaver ED, eds. Indoor air quality. Boca Raton, FL: CRC Press, pp. 87-108.

23. Kreiss K [1989]. The epidemiology of building-related complaints and illness. Occupational Medicine: State of the Art Reviews 4(4):575-592.

24. Levin H [1989]. Building materials and indoor air quality. Occupational Medicine: State of the Art Reviews 4(4):667-694.

25. Mendell MJ, Smith AH [1990]. Consistent pattern of elevated symptoms in air-conditioned office buildings: a re-analysis of epidemiologic studies. Am J Pub Hlth 80:1193-1198.

26. Molhave L, Bach B, Pedersen OF [1986]. Human reactions to low concentrations of volatile organic compounds. Environ Int 12:167-176.

27. Morey PR, Shattuck DE [1989]. Role of ventilation in the causation of building-associated illnesses. Occupational Medicine: State of the Art Reviews 4(4):625-642.

28. Nagda NI, Koontz MD, Albrecht RJ [1991]. Effect of ventilation rate in a health building. In: Geshwiler M, Montgomery L, and Moran M, eds. Healthy buildings. Proceedings of the ASHRAE/ICBRSD conference IAQ'91. Atlanta, GA: The American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

29. National Research Council Committee on Indoor Air Quality [1987]. Policies and procedures for control of indoor air quality. National Academy Press, Washington, D.C., 75 pages.

30. NIOSH [1986]. Criteria for a recommended standard: occupational exposure to hot environments, revised criteria. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86-113.

31. NIOSH [1991]. Hazard evaluation and technical assistance report: Library of Congress, Washington D.C. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 88-364-2104.

32. NIOSH [1991]. Hazard evaluation and technical assistance report: Library of Congress, Washington. D.C. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 88-364-2104.

33. Norbäck D, Michel I, Widstrom J [1990]. Indoor air quality and personal factors related to the sick building syndrome. Scan J Work Environ Health 16:121-128.

34. OSHA, Code of Federal Regulations [1989]. OSHA Table Z-1. The Occupational Safety and Health Administration's General Industry Standards, 29 CFR 1910.1000. Washington, DC: U.S. Government Printing Office, Federal Register.

AUTHORSHIP AND ACKNOWLEDGMENTS

Evaluation Conducted By:	Gregory A. Burr, CIH Supervisory Industrial Hygienist Industrial Hygiene Section
	Robert Malkin, DDS, Dr.PH Medical Officer Medical Section
	Matthew K. Klein, PE Mechanical Engineer
Report Prepared By:	Gregory A. Burr, CIH Supervisory Industrial Hygienist Industrial Hygiene Section
	Robert Malkin, DDS, Dr.PH Medical Officer Medical Section
Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations, and Field Studies

DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report have been sent to:

1. Pennsylvania Department of Revenue
2. American Federation of State, County, and Municipal Employees Local 2545
3. American Federation of State, County, and Municipal Employees Local 2456
4. OSHA Region III
5. NIOSH

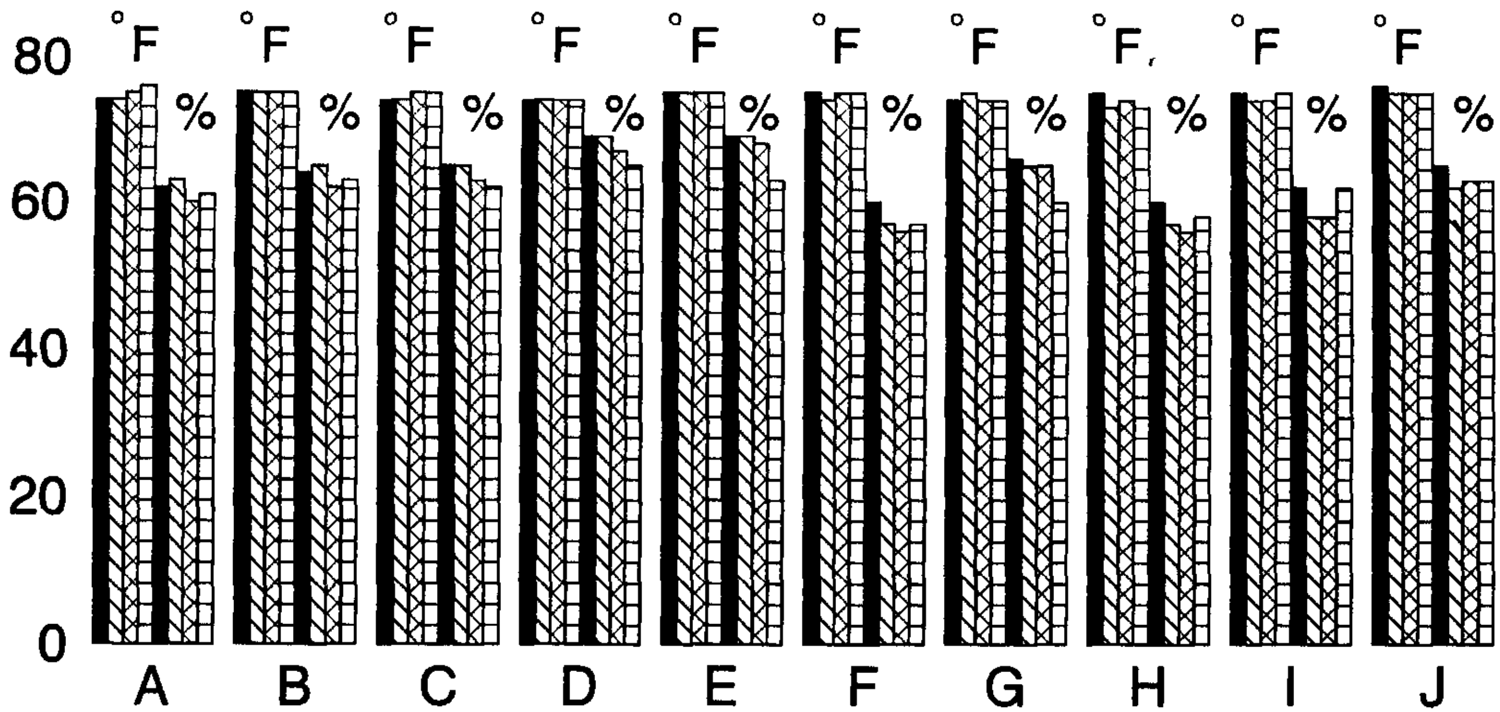
For the purpose of informing affected workers, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE 1

EMPLOYEE COMPLEMENT BY FLOOR
PENNSYLVANIA DEPARTMENT OF REVENUE
HARRISBURG, PENNSYLVANIA
HETA 92-166

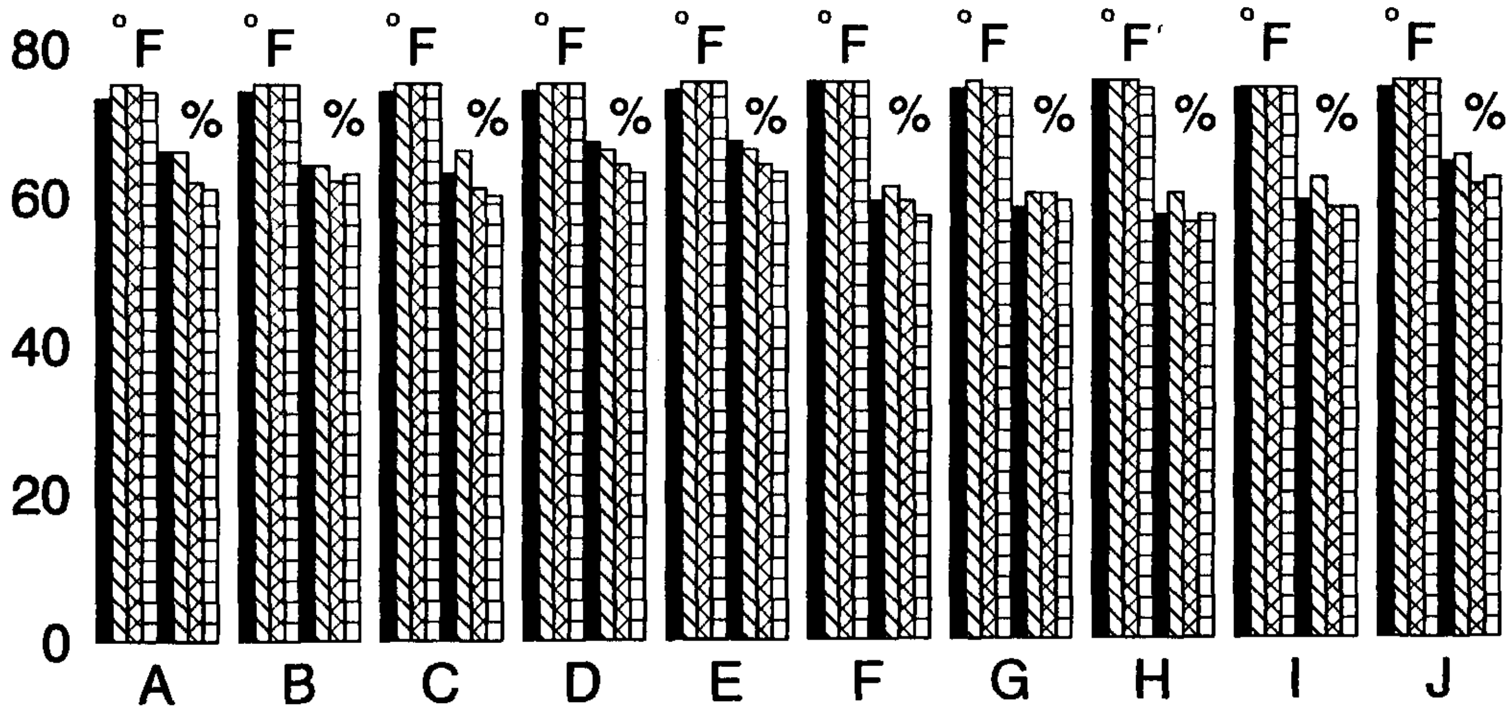
BUREAU	FULL-TIME	PART-TIME	TEMPORARY
4TH FLOOR - Corporation Taxes - Receipts and Control - Comptroller's Office	94	21	0
5TH FLOOR - Data Reduction	139	3	2
6TH FLOOR - Individual Taxes - Motor Fuel Taxes - Comptroller's Office	171	7	0
7TH FLOOR - Corporation Taxes	124	7	3
8TH FLOOR - Computer Services - Data Reduction	214	0	4
9TH FLOOR - Business Trust Fund Taxes - Compliance - Data Reduction	218	8	0
10TH FLOOR - Audits - Board of Appeals - CATS - Data Reduction - Legal Bureau	154	0	1
11TH FLOOR - Executive Offices - Fiscal Management - Legislative Liaison - Bureau Policy/Analysis - Management Analysis - Personnel - Comptroller's Office	151	1	2
12TH FLOOR - Administrative Services - CATS - Compliance	142	5	0

Table 2
Temperature and Relative Humidity Levels - 4th Floor
HETA 92-166: Pennsylvania Department of Revenue



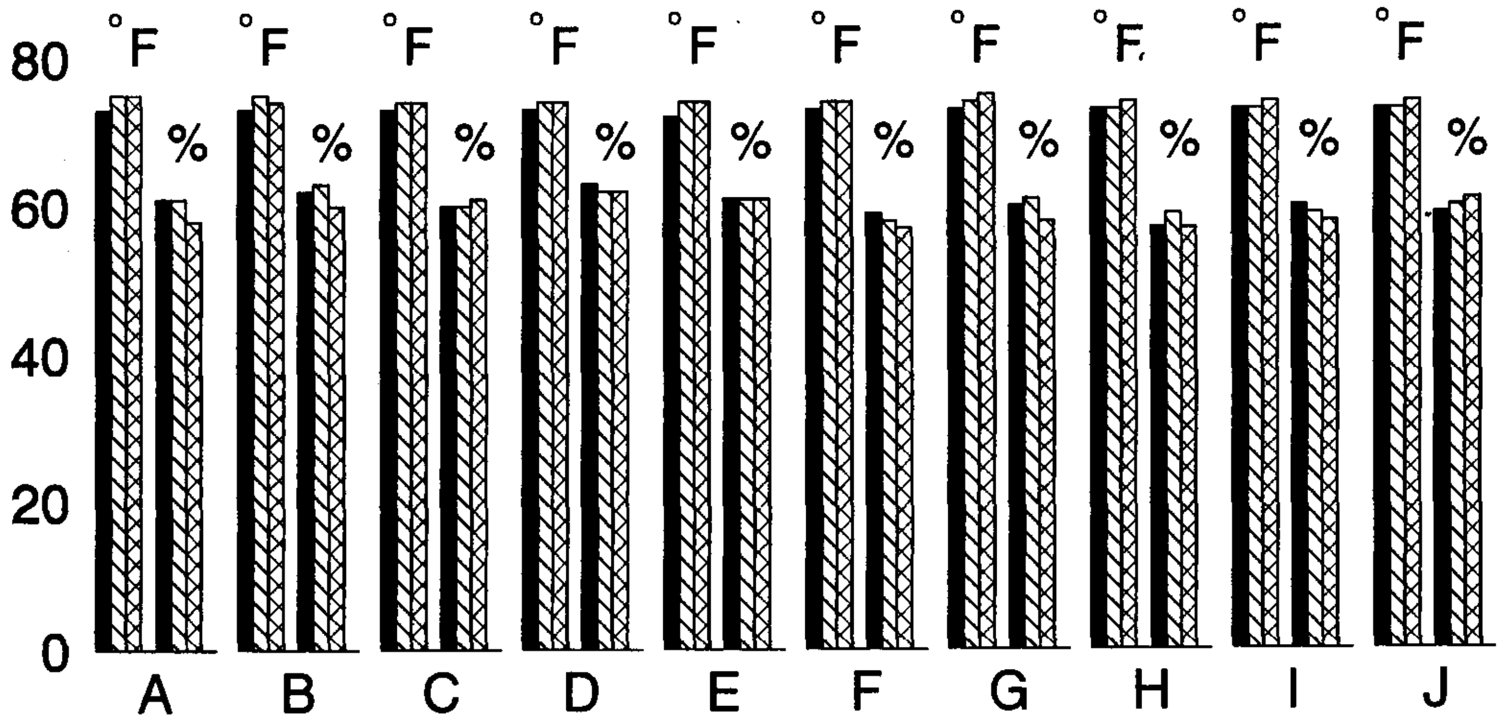
		A	B	C	D	E	F	G	H	I	J	
Temperature	■ (solid)	74	75	74	74	75	75	74	75	75	76	0831 to 0902
Temperature	▧ (diagonal)	74	75	74	74	75	74	75	73	74	75	1100 to 1121
Temperature	⊠ (crosshatch)	75	75	75	74	75	75	74	74	74	75	1352 to 1410
Temperature	⊟ (grid)	76	75	75	74	75	75	74	73	75	75	1605 to 1626
Rel. Humidity	■ (solid)	62	64	65	69	69	60	66	60	62	65	0831 to 0902
Rel. Humidity	▧ (diagonal)	63	65	65	69	69	57	65	57	58	62	1100 to 1121
Rel. Humidity	⊠ (crosshatch)	60	62	63	67	68	56	65	56	58	63	1352 to 1410
Rel. Humidity	⊟ (grid)	61	63	62	65	63	57	60	58	62	63	1605 to 1626

Table 2, Continued
Temperature and Relative Humidity Levels - 5th Floor
HETA 92-166: Pennsylvania Department of Revenue



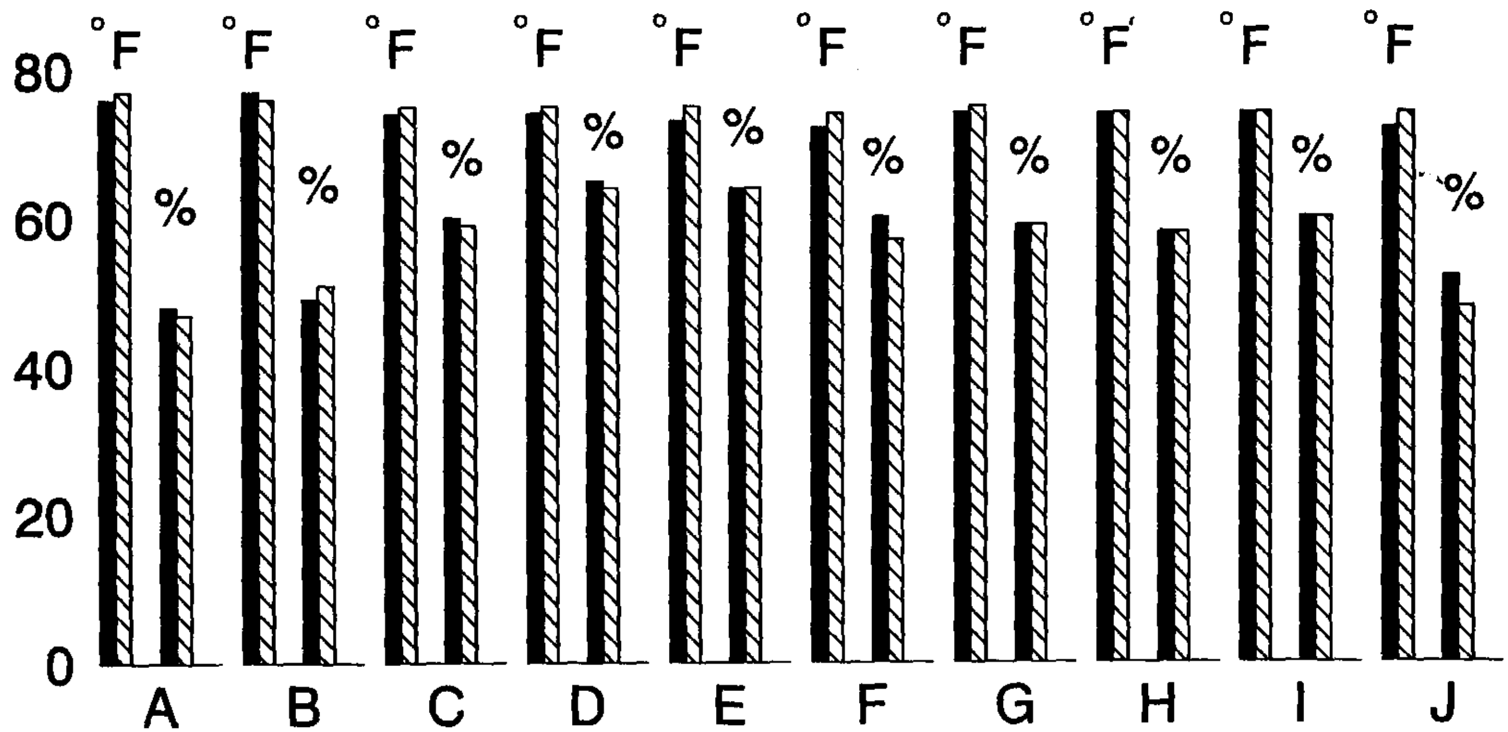
	A	B	C	D	E	F	G	H	I	J	
Temperature ■	73	74	74	74	74	75	74	75	74	74	0743 to 0825
Temperature ▨	75	75	75	75	75	75	75	75	74	75	1028 to 1051
Temperature ⊠	75	75	75	75	75	75	74	75	74	75	1320 to 1344
Temperature ⊟	74	75	75	75	75	75	74	74	74	75	1537 to 1559
Rel. Humidity ■	66	64	63	67	67	59	58	57	59	64	0743 to 0825
Rel. Humidity ▨	66	64	66	66	66	61	60	60	62	65	1028 to 1051
Rel. Humidity ⊠	62	62	61	64	64	59	60	56	58	61	1320 to 1344
Rel. Humidity ⊟	61	63	60	63	63	57	59	57	58	62	1537 to 1559

Table 2, Continued
Temperature and Relative Humidity Levels - 6th Floor
HETA 92-166: Pennsylvania Department of Revenue



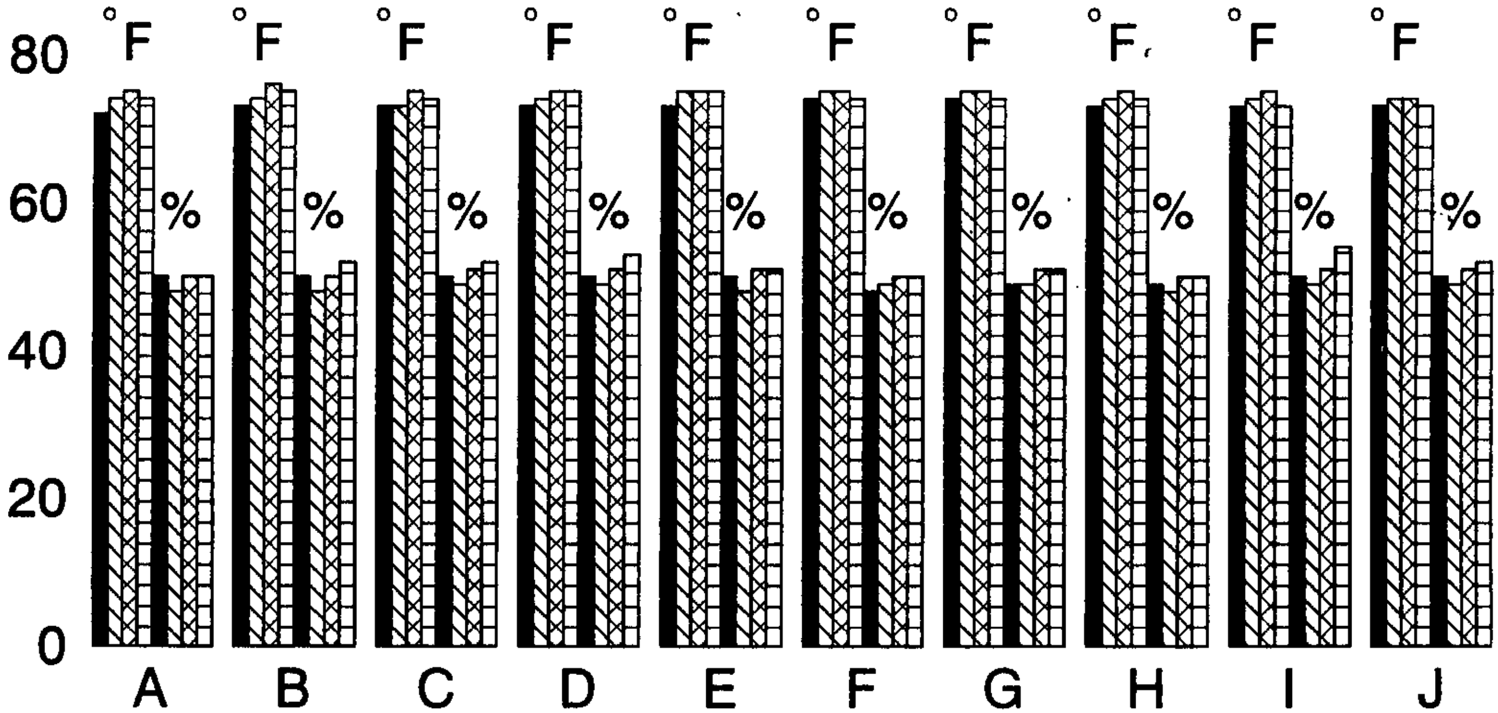
	A	B	C	D	E	F	G	H	I	J	
Temperature (solid)	73	73	73	73	72	73	73	73	73	73	0745 to 0810
Temperature (hatched)	75	75	74	74	74	74	74	73	73	73	1033 to 1054
Temperature (cross-hatched)	75	74	74	74	74	74	75	74	74	74	1328 to 1345
Temperature (open)	0	0	0	0	0	0	0	0	0	0	No sample taken
Rel. Humidity (solid)	61	62	60	63	61	59	60	57	60	59	0745 to 0810
Rel. Humidity (hatched)	61	63	60	62	61	58	61	59	59	60	1033 to 1054
Rel. Humidity (cross-hatched)	58	60	61	62	61	57	58	57	58	61	1328 to 1345
Rel. Humidity (open)	0	0	0	0	0	0	0	0	0	0	No sample taken

Table 2, Continued
Temperature and Relative Humidity Levels - 8th Floor
HETA 92-166: Pennsylvania Department of Revenue



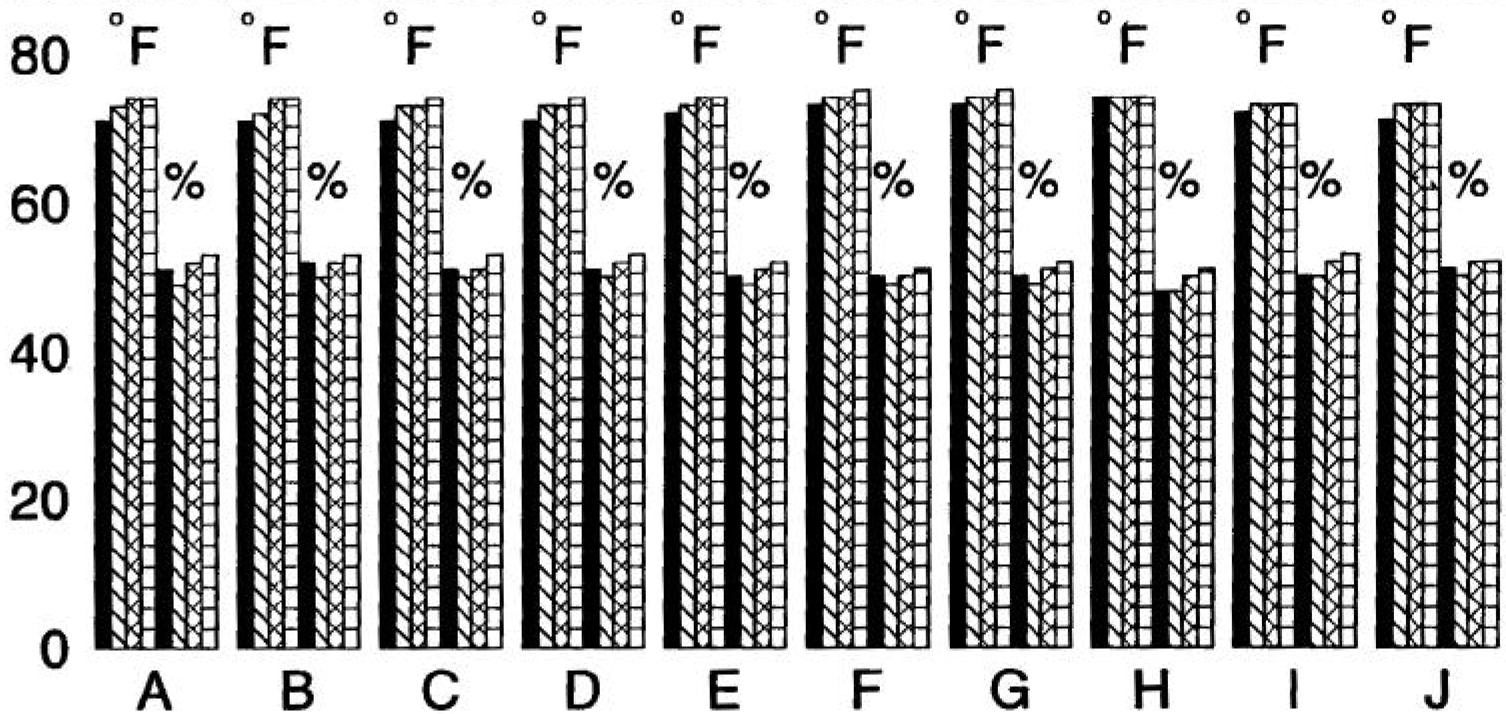
	A	B	C	D	E	F	G	H	I	J	
Temperature (solid)	76	77	74	74	73	72	74	74	74	72	0818 to 0822
Temperature (hatched)	77	76	75	75	75	74	75	74	74	74	1102 to 1129
Temperature (cross-hatched)	0	0	0	0	0	0	0	0	0	0	No samples taken in afternoon
Temperature (open)	0	0	0	0	0	0	0	0	0	0	
Rel. Humidity (solid)	48	49	60	65	64	60	59	58	60	52	0818 to 0822
Rel. Humidity (hatched)	47	51	59	64	64	57	59	58	60	48	1102 to 1129
Rel. Humidity (cross-hatched)	0	0	0	0	0	0	0	0	0	0	No samples taken in afternoon
Rel. Humidity (open)	0	0	0	0	0	0	0	0	0	0	

Table 2, Continued
Temperature and Relative Humidity Levels - 9th Floor
HETA 92-166: Pennsylvania Department of Revenue



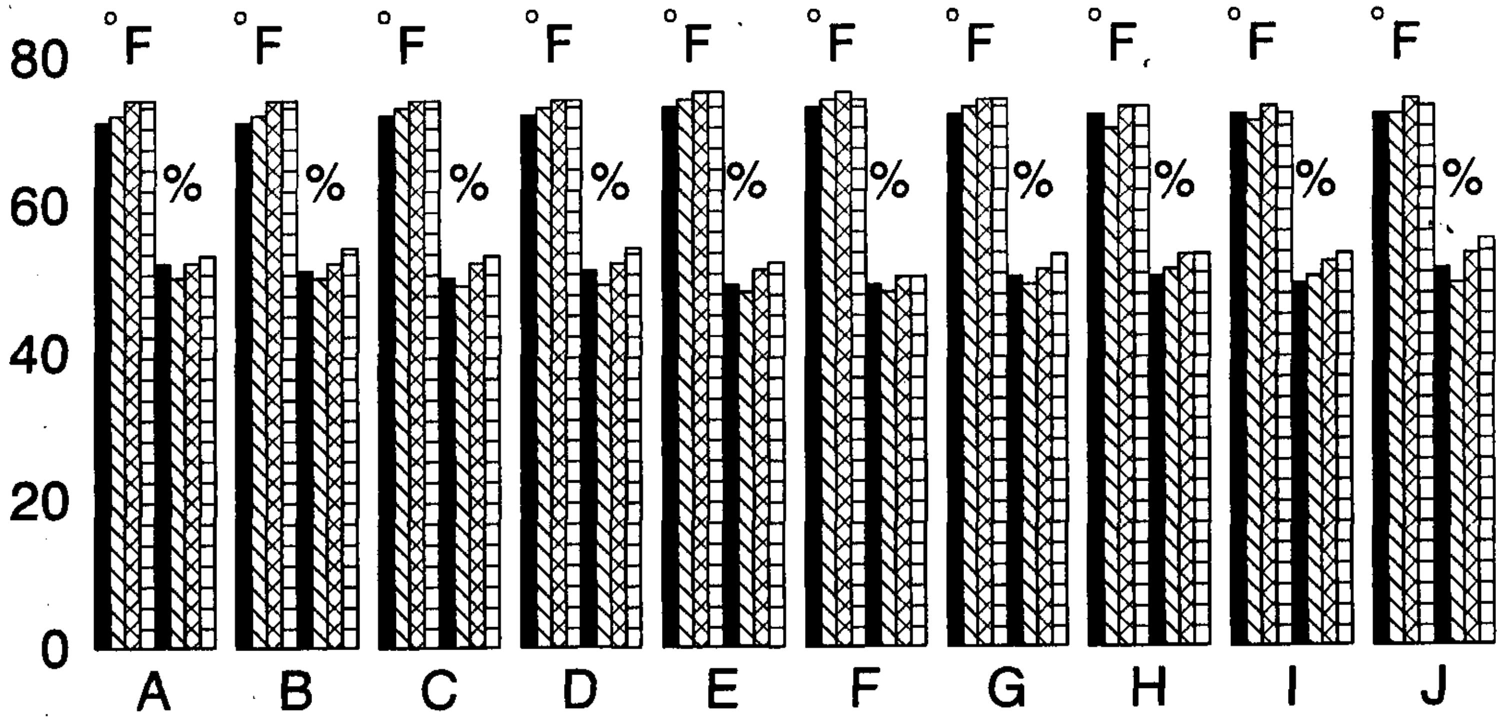
	A	B	C	D	E	F	G	H	I	J	
Temperature (solid)	72	73	73	73	73	74	74	73	73	73	0813 to 0840
Temperature (diagonal)	74	74	73	74	75	75	75	74	74	74	1142 to 1208
Temperature (crosshatch)	75	76	75	75	75	75	75	75	75	74	1428 to 1451
Temperature (grid)	74	75	74	75	75	74	74	74	73	73	1637 to 1656
Rel. Humidity (solid)	50	50	50	50	50	48	49	49	50	50	0813 to 0840
Rel. Humidity (diagonal)	48	48	49	49	48	49	49	48	49	49	1142 to 1208
Rel. Humidity (crosshatch)	50	50	51	51	51	50	51	50	51	51	1428 to 1451
Rel. Humidity (grid)	50	52	52	53	51	50	51	50	54	52	1637 to 1656

Table 2, Continued
Temperature and Relative Humidity Levels - 10th Floor
HETA 92-166: Pennsylvania Department of Revenue



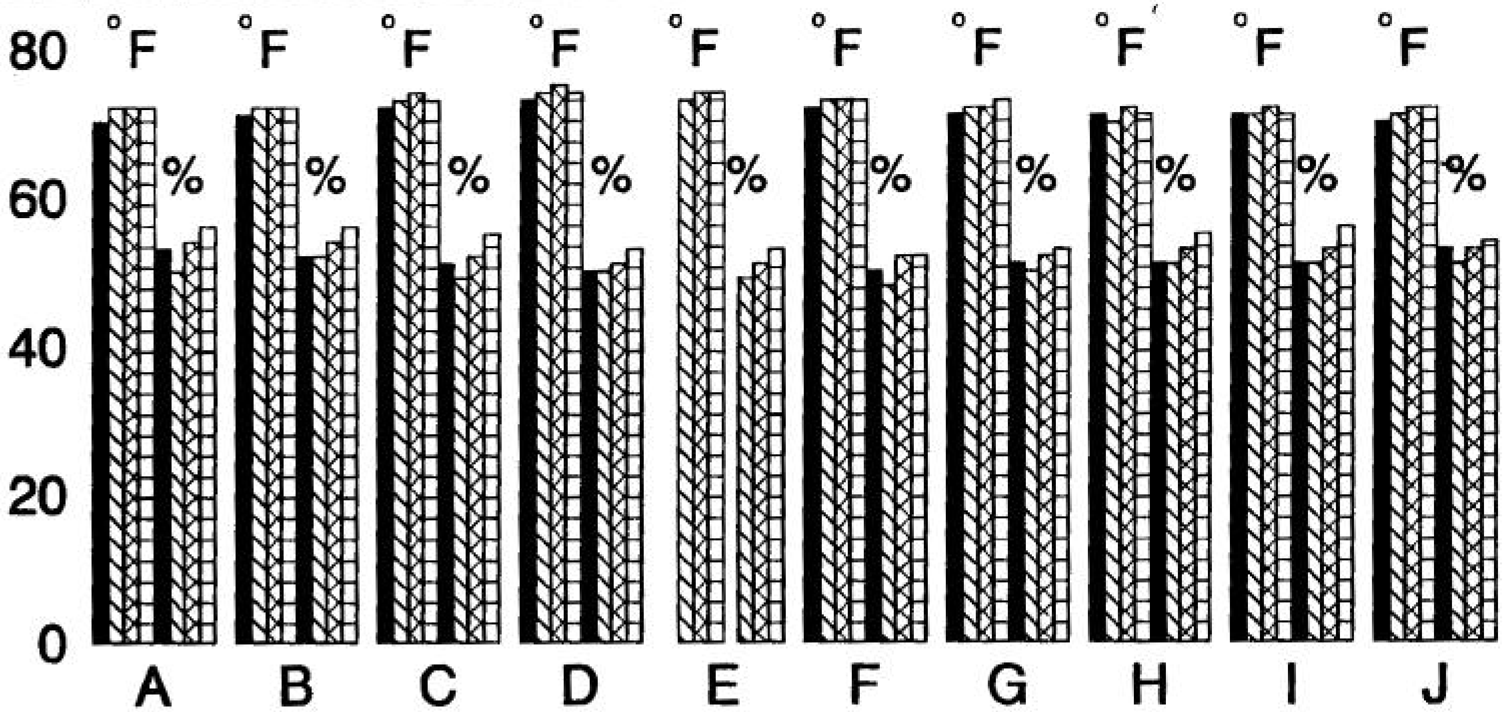
	A	B	C	D	E	F	G	H	I	J	
Temperature ■	71	71	71	71	72	73	73	74	72	71	0745 to 0809
Temperature ▧	73	72	73	73	73	74	74	74	73	73	1105 to 1130
Temperature ⊠	74	74	73	73	74	74	74	74	73	73	1402 to 1421
Temperature ⊟	74	74	74	74	74	75	75	74	73	73	1557 to 1630
Rel. Humidity ■	51	52	51	51	50	50	50	48	50	51	0745 to 0809
Rel. Humidity ▧	49	50	50	50	49	49	49	48	50	50	1105 to 1130
Rel. Humidity ⊠	52	52	51	52	51	50	51	50	52	52	1402 to 1421
Rel. Humidity ⊟	53	53	53	53	52	51	52	51	53	52	1557 to 1630

Table 2, Continued
Temperature and Relative Humidity Levels - 11th Floor
HETA 92-166: Pennsylvania Department of Revenue



	A	B	C	D	E	F	G	H	I	J	
Temperature ■ (solid)	71	71	72	72	73	73	72	72	72	72	0828 to 0918
Temperature (diagonal)	72	72	73	73	74	74	73	70	71	72	1035 to 1057
Temperature (crosshatch)	74	74	74	74	75	75	74	73	73	74	1434 to 1459
Temperature (horizontal)	74	74	74	74	75	74	74	73	72	73	1615 to 1637
Rel. Humidity ■ (solid)	52	51	50	51	49	49	50	50	49	51	0828 to 0918
Rel. Humidity (diagonal)	50	50	49	49	48	48	49	51	50	49	1035 to 1057
Rel. Humidity (crosshatch)	52	52	52	52	51	50	51	53	52	53	1434 to 1459
Rel. Humidity (horizontal)	53	54	53	54	52	50	53	53	53	55	1615 to 1637

Table 2, Continued
Temperature and Relative Humidity Levels - 12th Floor
HETA 92-166: Pennsylvania Department of Revenue

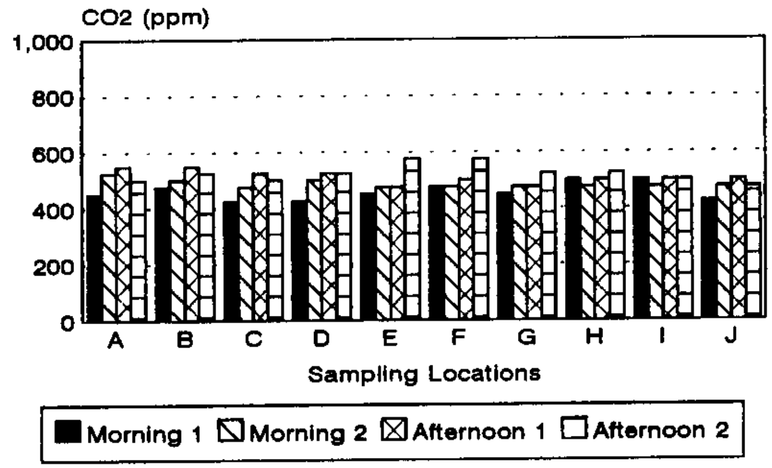


	A	B	C	D	E	F	G	H	I	J	
Temperature ■	70	71	72	73		72	71	71	71	70	0756 to 0753
Temperature ▧	72	72	73	74	73	73	72	70	71	71	1000 to 1032
Temperature ⊠	72	72	74	75	74	73	72	72	72	72	1405 to 1430
Temperature ⊟	72	72	73	74	74	73	73	71	71	72	1545 to 1607
Rel. Humidity ■	53	52	51	50		50	51	51	51	53	0756 to 0753
Rel. Humidity ▧	50	52	49	50	49	48	50	51	51	51	1000 to 1032
Rel. Humidity ⊠	54	54	52	51	51	52	52	53	53	53	1405 to 1430
Rel. Humidity ⊟	56	56	55	53	53	52	53	55	56	54	1545 to 1607

Table 3

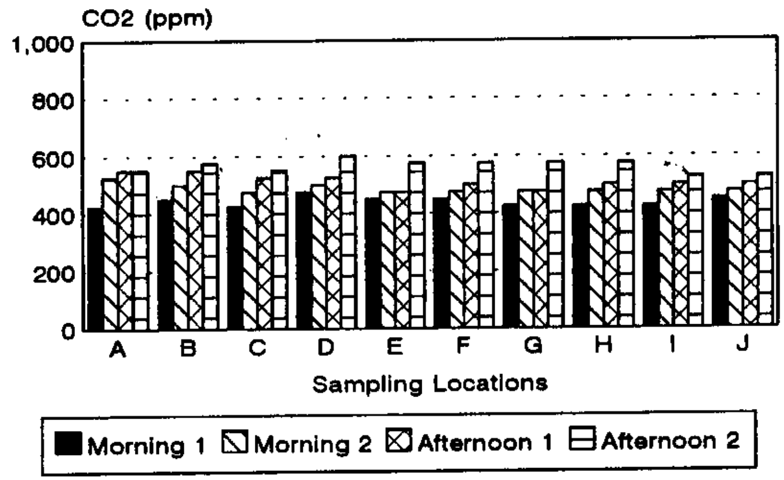
Carbon Dioxide Levels
HETA 92-166: Pennsylvania Department of Revenue

Carbon Dioxide Levels 4th Floor



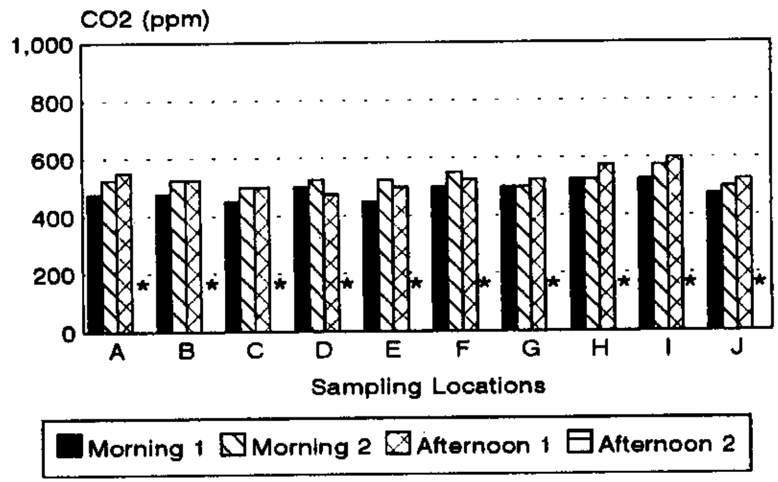
9/3/92

Carbon Dioxide Levels 5th Floor



9/3/92

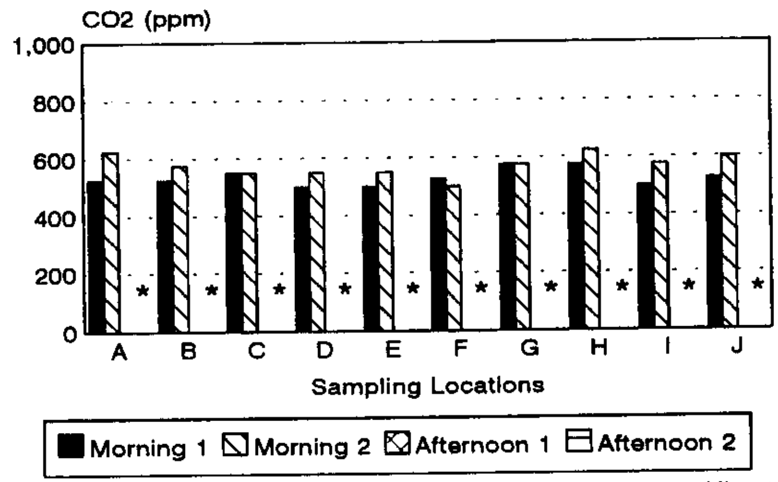
Carbon Dioxide Levels 6th Floor



9/3/92

* No sample taken

Carbon Dioxide Levels 8th Floor



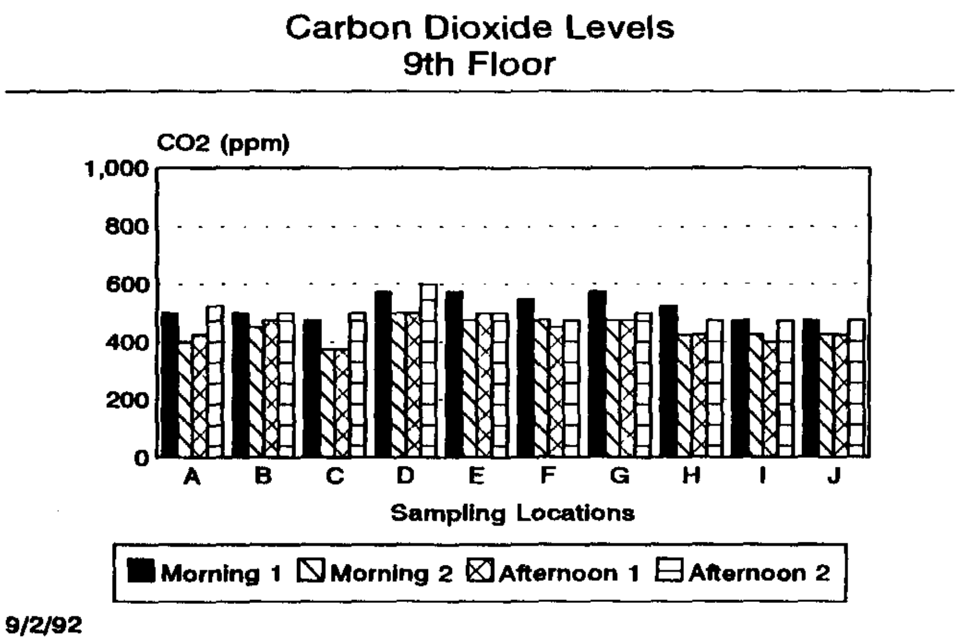
9/3/92

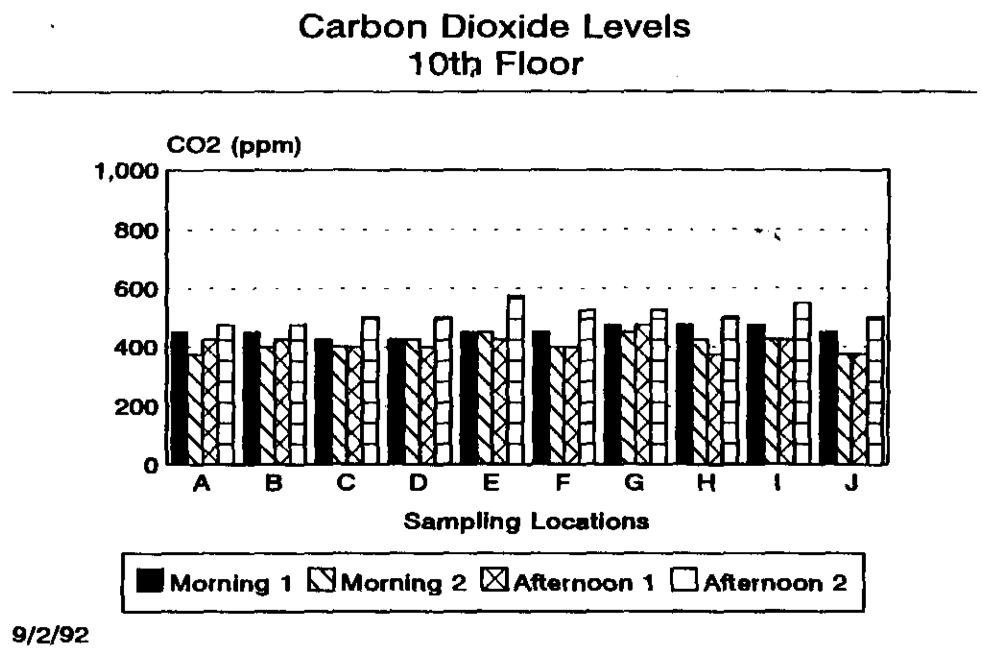
* No samples taken in the afternoon

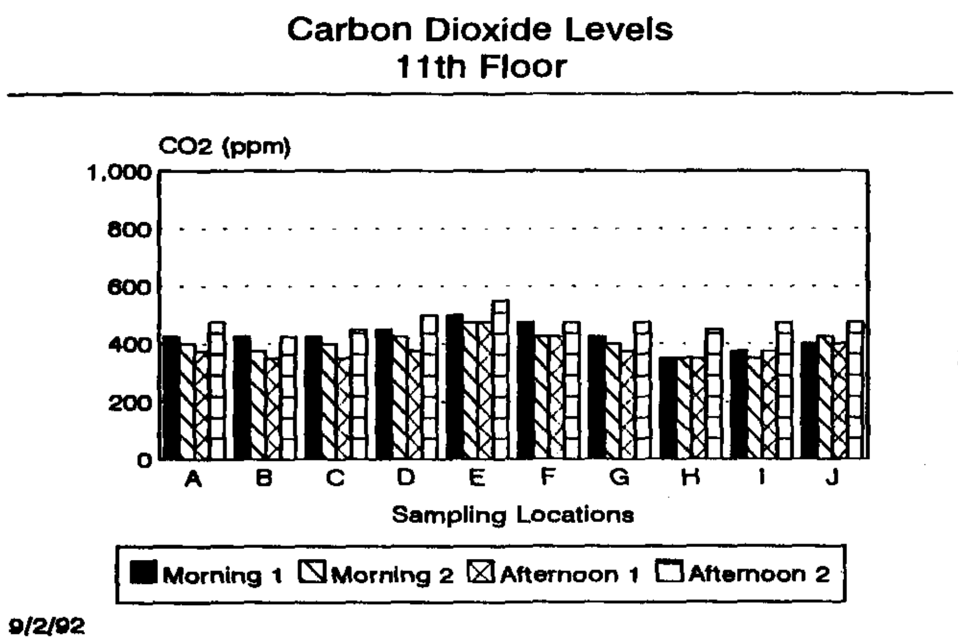
Table 3, Continued

Carbon Dioxide Levels

HETA 92-166: Pennsylvania Department of Revenue







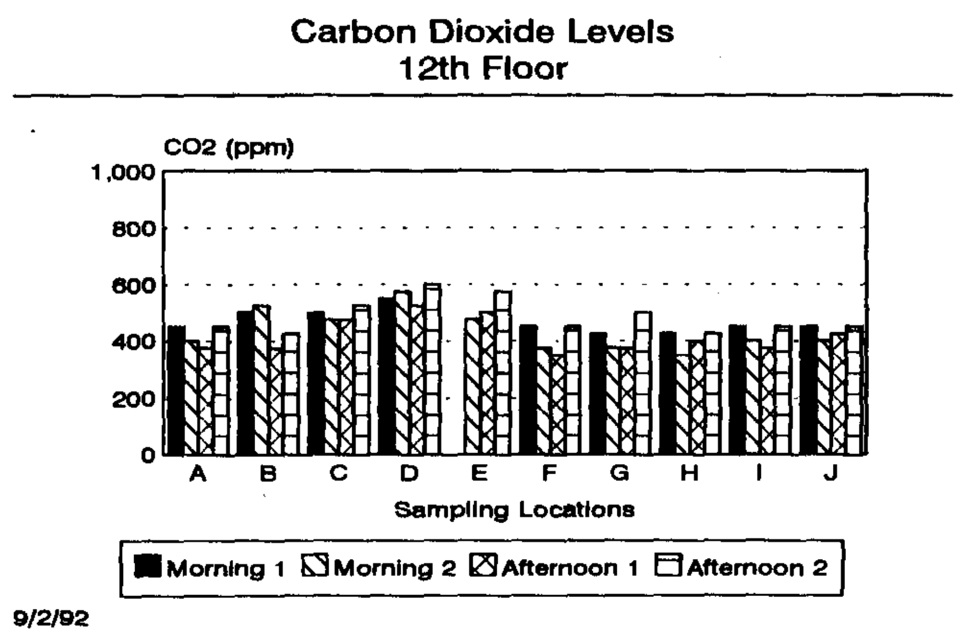


Table 4
Quantitation of Selected Volatile Organic Compounds
September 2-3, 1992
Pennsylvania Department of Revenue
HETA 92-166

Sample No.	Location	Sample Period	Sample Volume (liters)	Concentration (parts per billion)							
				Acetone	Methyl Chloroform	Benzene	Tetrachloroethylene	Toluene	Xylene	Pentane	Hexane
TD-1	9th Floor: Employer Tax Area (directly outside of H. Epler's office)	9:23 am to 3:10 pm	34.7	3.20	0.47	1.45	†	4.52	1.53	4.40	1.39
TD-2	9th Floor: Employer Tax Area (Credit Refund and Transfer)	9:30 am to 3:14 pm	34.4	4.41	†	1.28	†	4.48	1.41	35.5*	1.32
TD-4	10th Floor: Board of Appeals (Office of E. Rothermel)	9:50 am to 3:32 pm	34.2	8.38	0.49	1.28	0.32	3.26	1.01	‡	1.66
TD-5	12th Floor: Bureau of Compliance (Clearance Collection Division)	10:24 am to 3:42 pm	23.3	‡	‡	‡	‡	4.68	‡	‡	‡
TD-6	3rd Floor: HVAC Area (near outside air intake)	8:38 am to 4:54 pm	49.6	1.44	†	1.39	0.18	5.20	1.35	2.46	1.20
TD-7	12th Floor: Central Records (Hard Copy)	9:40 am to 4:00 pm	38.0	5.00	6.29	1.40	6.59	5.04	1.46	4.38	1.42
TD-8	9th Floor: Lien Control	10:00 am to 4:14 pm	37.4	4.28	3.74	1.34	4.33	4.90	1.42	4.00	1.44
TD-9	8th Floor: Bureau of Computer Services (Planning Section)	1:21 pm to 4:19 pm	17.8	3.32	6.40	1.32	6.95	5.23	1.30	4.20	1.92
Minimum Detectable Concentration (assuming a 35 liter air sample)				0.90	0.26	0.45	0.21	0.38	0.33	◆	0.41

Comments:

1. Compounds analyzed for but not detected by this analytical method included carbon tetrachloride, trichloroethane, 4-methyl-2-pentanone, methyl cellosolve, cellosolve, butyl cellosolve, Freon 22, and tetrahydrofuran.
2. A pump failure occurred with Sample No. TD-3. This sample had been placed on the 9th Floor in the Bureau of Compliance, Bankruptcy Division. No results are reported for this sample.
3. A pump failure occurred at 233 minutes with Sample No. TD-5. Sampling volume calculated using this sample period.

† Below current detection limit.
‡ Undetected.
* Value reported is an estimation due to the high concentration of this analyte. The actual amount may be higher.
◆ No accurate detection limit can be obtained for this analyte due to questionable stability with this compound on Carbotrap adsorbent.

Table 5
Quantitation of Selected Minerals and Metals
September 2-3, 1992
Pennsylvania Department of Revenue
HETA 92-166

Sample No.	Location	Sample Period	Sample Volume (liters)		Concentration (milligrams per cubic meter)		
					Calcium	Iron†	Sodium
M-1	9th Floor: Employer Tax Area (directly outside of H. Epler's office)	9:23 am to 3:10 pm	694		‡	‡	‡
M-2	9th Floor: Employer Tax Area (Credit Refund and Transfer)	9:30 am to 3:14 pm	688		‡	0.001†	0.015
M-3	9th Floor: Bureau of Compliance (Bankruptcy Division)	9:40 am to 3:23 pm	686		‡	0.001†	†
M-4	10th Floor: Board of Appeals (Office of E. Rothermel)	9:50 am to 3:32 pm	684		‡	0.001†	‡
M-5	12th Floor: Bureau of Compliance (Clearance Collection Division)	10:24 am to 3:42 pm	636		‡	0.001†	‡
M-6	3rd Floor: HVAC Area (near outside air intake)	8:38 am to 4:54 pm	992		0.004	0.001†	‡
M-7	12th Floor: Central Records (Hard Copy)	9:40 am to 4:00 pm	760		†	†	†
M-8	9th Floor: Lien Control	10:00 am to 4:14 pm	748		†	†	†
M-9	8th Floor: Bureau of Computer Services (Planning Section)	1:21 pm to 4:19 pm	356		†	†	0.028
Minimum Detectable Concentration (assuming an average air sample size of 700 liters)					0.004	0.001	0.014

Comments:

‡ Not detected.

† *The values reported for iron should be considered zero after field blank correction.*

Other elements analyzed for (*but not detected in any of the air samples*) included the following minerals and metals:

Aluminum	Arsenic	Barium	Beryllium	Cadmium	Cobalt
Chromium	Copper	Lithium	Magnesium	Molybdenum	Nickel
Lead	Phosphorus	Platinum	Selenium	Silver	Tin
Tellurium	Thallium	Titanium	Tungsten	Vanadium	Yttrium
Zinc	Zirconium				

(The minimum detectable concentrations for these various elements (assuming an average air sample size of 700 liters) ranged from 0.001 mg/m^3 to 0.014 mg/m^3.)

Table 6
Symptom Prevalence on September 2-3, 1992
Pennsylvania Department of Revenue
HETA 92-166

Symptom	% Reporting Symptom "Frequently" Over the Last 4 Weeks	% Reporting Symptom on Day Questionnaire Was Administered	% Reporting Symptom "Frequently" Over the Last 4 Weeks Who Improved Away From Work
Tired or strained eyes	50.3	46.9	79.5
Stuffed nose/sinus congestion	46.8	42.8	65.1
Dry, itching or irritated eyes	45.7	43.7	78.6
Unusual tiredness, fatigue, or drowsiness	44.8	36.1	73.3
Headache	34.8	33.4	79.5
Dry throat	26.9	26.0	77.6
Cough	15.3	16.8	60.2
Concentration problems	13.9	12.7	58.4
Dizziness or lightheadedness	12.5	9.4	66.7
Sore throat	11.5	12.7	59.7
Shortness of breath	6.2	6.0	58.7
Chest tightness	4.8	4.6	66.2
Wheezing	4.8	4.6	61.4

Table 7
Perceived Environmental Conditions on September 2-3, 1992
Pennsylvania Department of Revenue
HETA 92-166

Environmental Parameter	% Reporting Condition	% Reporting Condition on Day Questionnaire Was Administered
Too much air	12.1	13.4
Too little air	61.1	54.8
Too hot	34.8	33.4
Too cold	24.2	23.6
Too humid	19.2	19.0
Too dry	51.3	46.9
Tobacco smoke odors	22.9	17.5
Other odors	25.9	24.6

Table 8

Kendall Tau b Correlation Coefficients
Environmental Parameters and Symptoms
September 2-3, 1992
Pennsylvania Department of Revenue
HETA 92-166

	Dry Throat	Dry Eyes	Stuffed Nose	Tired/ Fatigue	Strained Eyes	Headache
Too much air	0.197[1] 0.0001[2]	0.138 0.0001	0.128 0.0001	0.073 0.0001	0.1223 0.0032	0.160 0.0001
Too little air	0.167 0.0001	0.175 0.0001	0.20177 0.0001	0.31119 0.0001	0.196 0.0001	0.292 0.0001
Too hot	0.197 0.0001	0.230 0.0001	0.264 0.0001	0.242 0.0001	0.262 0.0001	0.265 0.0001
Too cold	0.198 0.0001	0.077 0.0550	0.132 0.0010	0.108 0.0067	0.143 0.0004	0.185 0.0001
Too dry	0.333 0.0001	0.243 0.0001	0.208 0.0001	0.257 0.0001	0.272 0.0001	0.280 0.0001
Too humid	0.204 0.0001	0.090 0.0276	0.1610 0.0001	0.142 0.0004	0.176 0.0001	0.14883 0.0002

[1] The first number in each cell is the Tau correlation coefficient.
[2] The second number in each cell is the p-value. The p-value is the probability of obtaining a tau correlation coefficient larger than the one actually calculated from the data.

Table 9

Number of Symptoms Reported by Employees
September 2-3, 1992
Pennsylvania Department of Revenue
HETA 92-166

Number of Symptoms	Frequency	Percent
0	106	25.5
1	39	9.4
2	47	11.3
3	48	11.5
4	34	8.2
5	42	10.1
6	45	10.8
7	25	6.0
8	14	3.4
9	8	1.9
10	7	1.7
11	1	0.2

Table 10

Reported Symptoms Prevalence by Floor
September 2-3, 1992
Pennsylvania Department of Revenue
HETA 92-166

Symptom	5th Floor (%)	9th Floor (%)	10th Floor (%)	p
Strained eyes	57.3	54.4	37.9	0.004
Dry throat	36.6	28.3	16.1	0.002
Dry throat today	30.0	28.9	17.7	0.047

Table 11
Percent of Employees Reporting Symptoms
Under Different Perceived Lighting Conditions
September 2-3, 1992
Pennsylvania Department of Revenue
HETA 92-166

	Nose/Sinus Problems	Strained Eyes	Dry/Itching/ Irritated Eyes	Tiredness/ Fatigue	Headache	Dry Throat
Just right	25	44	41	37	28	21
Not too bad	55.5	55	49	52	42	32
Very bad	51.4	74	60	63	49	49
p	0.091	<0.001	0.018	<0.001	0.001	<0.001

Table 12

Percentage of Employees Reporting Symptoms in Different Office Designs
September 2-3, 1992
Pennsylvania Department of Revenue
HETA 92-166

Type of Design	Nose/Sinus Problems	Dry Eyes	Strained Eyes	Tiredness/ Fatigue	Dry Throat	Headache
Private	37.5	25	20.8	16.7	12.5	18.8
Open (with partitions)	50	49	53.9	46.1	28.0	26.6
Open (without partitions)	50.5	44	53.33	53.3	28.22	35.2
p	0.323	0.005	<0.001	<0.001	0.017	0.007

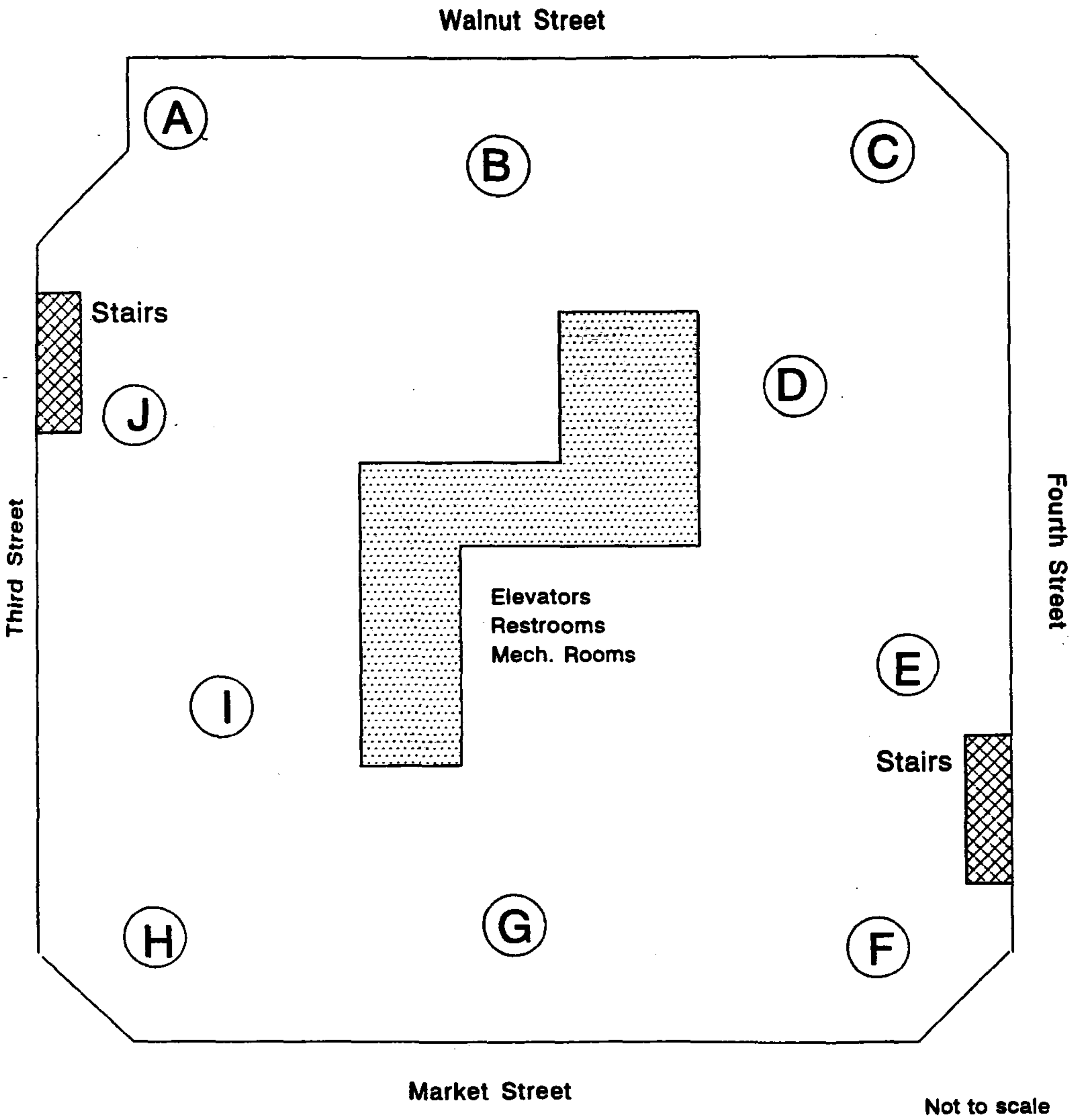
Table 13
Number and Percentage of Employees
Reporting Disturbed Sleep
and Symptoms Frequently over the Last 4 Weeks
September 2-3, 1992
Pennsylvania Department of Revenue
HETA 92-166

Symptom	Degree of Sleep Disturbance					
	Not at All	A Little Bit	Moderately	Quite a Bit	Extremely	p
Dry/irritated eyes	23 (12%)	72(38%)	52(27%)	35(18%)	9(5%)	0.002
Headache	17(12%)	45(31%)	43(30%)	32(22%)	8(6%)	0.001
Tiredness/fatigue	23(12%)	61(33%)	53(29%)	34(18%)	14(8%)	<0.001
Nose/sinus problems	16(13%)	60(30%)	62(31%)	43(21%)	12(6%)	<0.001
Strained eyes	26(12%)	68(33%)	63(30%)	38(18%)	14(7%)	<0.001
Dry throat	14(13%)	36(32%)	28(25%)	26(23%)	8(7%)	0.008

Figure 1

Typical Floor Diagram and Sampling Locations

HETA 92-166: Pennsylvania Department of Revenue, Harrisburg, Pennsylvania



APPENDIX A
Description of the Ventilation System
Pennsylvania Department of Revenue
HETA 92-166

Air Handling Units

Four air handling units (AHUs) serviced floors 1 through 16. All of these systems were built-up high pressure fan systems consisting of the following: an economizer damper system; a minimum outside air (OA) damper system; prefilter and secondary bag filter systems; steam preheat coils; chilled water cooling coils; two controlled-pitch vaneaxial supply air fans; a double-jacketed, in-duct steam humidification system; hot water reheat coils; four sets of sound attenuators; and one controlled-pitch vaneaxial return fan. The economizer system included outside, return, and relief air damper systems. The minimum OA damper system was a dedicated damper system for providing the required ventilation air for the building.

As the time of this survey, 2" thick, cardboard-framed, panel prefilters with an estimated ASHRAE dust spot efficiency of about 20% were used in the AHUs. Secondary bag filters, having a 65% ASHRAE dust spot efficiency, provided additional filtration. Pressure sensors located both upstream and downstream of the filter system alarmed the computer when the pressure drop surpassed preset limits, indicating that the filters should be changed. It should be noted that the Harristown Development Corporation (HDC) has changed to a higher-efficiency secondary filter since this survey.

The preheat coil configuration was different between the all four AHUs. Air handling units nos. 8 and 10 had their coils located just downstream of the humidification system and in variable air volume (VAV) terminals serving the south zones. According to the mechanical drawings, AHU #7 had only one reheat coil located in a branch duct on the 10th floor, while AHU #11 had 11 coils in branch ducts serving various floors and areas.

Sound attenuators were used to reduce fan noise since the ducts did not have a fiberglass lining. These sound attenuators were located both upstream and downstream of the fans.

Air Flow Distribution

All of the AHUs were located in a mechanical room situated on the third floor. The OA plenum for the AHUs was positioned in the northwestern face of the building and hidden from street-level view behind the building facade. Two shafts in the central area of the building contained both supply and return ducts which extended from the mechanical room up and through all of the other floors. The ceiling space on all floors served as the return air plenum. Short sections of ducts connected the ceiling plenum area to the main return ducts inside the shafts.

The perimeter sections of the floors were divided into four zones that were serviced by AHUs nos. 8 and 10, both of which were VAV systems. The southwest and southeast perimeter zones of all floors were serviced by AHU #8, while AHU #10 serviced the northeast and northwest perimeter zones. Each fan in these AHUs supplied the same zone on all floors.

The core sections of the building were divided into two zones, serviced by AHUs nos. 7 and 11. Air handling unit #7 serviced the southwest zones of all floors while AHU #11 serviced the northeast zones. Both fans in these constant volume systems supplied the same zone on each floor.

Ceiling-mounted "air bars," a type of linear slot diffuser, supplied air to the occupied spaces on the floors. The air bars were aligned parallel to the exterior walls of the building, except in the southwest core and southwest perimeter zones where they were perpendicular to the walls. Finned tube radiators were in the northern corner and the western-most section of the southwest side of the building. These radiators were located in the floor at the base of the walls.

Control Systems

The temperature control systems for the mechanical systems were very complex. Local sensors controlled the thermal parameters but a central computer remotely reset some sensor set points, such as the supply air temperatures. All of the AHUs had sensors in the supply air duct, downstream of the AHUs that controlled the supply air temperatures. Temperature sensors in each of the four supply ducts of AHUs nos. 8 and 10 independently controlled each duct's air temperature. However, for each unit, the zone with the greatest cooling demand controlled the operation of that unit's cooling coil. If the other zone serviced by the unit did not need as much cooling, the reheat coils heated the air in the duct to that zone to compensate for the difference.

"Solar sensors" on each side of the building could reset the supply air temperature set points for AHUs nos. 8 and 10. The change in set point either increased or decreased the supply air temperature for each perimeter zone to correspond to the outside heat load on the respective face of the building. AHUs nos. 7 and 11 had only one supply air temperature sensor per unit. These sensors were reset only by computer command.

Thermostats on the inside faces of the exterior walls controlled the operation of the VAV terminal servicing that zone and, if the terminal had one, its reheat coil. Reheat coils in branch ducts servicing the core zones were controlled by thermostats in the areas serviced by those ducts. Temperature sensors, which provided measurements to the central computer, were on the inside face of each of the exterior walls on even-numbered floors. The sensors were located in the middle of each wall.

The minimum OA dampers opened fully upon actuation of their unit's supply air fans. No other sensor input, except from the fire control system, controlled the operation of the OA dampers. Temperature sensors, located in the supply air downstream of the AHUs and in the mixed air, controlled the operation of the economizer dampers.

Enthalpy sensors, which sense the dry bulb and dew point temperatures and calculate the total heat content of the air, were located in the return air duct of each AHU control. These sensors determined whether to place the AHU into the cooling mode. For example, when the total heat of a unit's return air was less than the total heat of the outside air (measured by an enthalpy sensor in the outside air), the cooling mode was actuated for that unit. In the cooling mode, chilled water circulated to the unit and the relief and outside air dampers closed while the return air damper remained opened. The minimum OA damper setting was not affected when a unit enters into this cooling mode.

A humidity sensor was located in each AHU's return air controls. The outside air temperature reset the humidification system's set point. A high limit sensor in the supply air downstream of the humidification system overrode the main humidification control system to decrease the humidification if the supply air humidity surpassed the high limit set point. The building was not being humidified during this evaluation.

Control systems monitored the return and supply air flow rates for each AHU and adjusted the return air flow to maintain a set difference between the supply and return air flows. Normally, the return air flow was less than the supply air flow. This positively pressurized the building to prevent drafts and infiltration of contaminated outside air.

APPENDIX B

September, 1992

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

INDOOR AIR QUALITY AND WORK ENVIRONMENT

SYMPTOMS SURVEY

THE PENNSYLVANIA DEPARTMENT OF REVENUE SURVEY - HARRISBURG, PA (HE 92-166)

The National Institute for Occupational Safety and Health (NIOSH) is part of the United States Public Health Service and the division of the Centers for Disease Control (CDC) that is concerned with workplace health and safety. We are here at the request of the employees, to evaluate the environment of your workplace and any possible health concerns. Measurements of a variety of environmental conditions are being taken in your work area throughout the day.

To help determine how these measurements relate to your comfort and health, please complete the attached questionnaire. Your participation in this part of the evaluation of this building is voluntary, but very important. Your completed questionnaire will be collected and analyzed by NIOSH investigators and your responses WILL NOT BE SEEN BY MANAGEMENT OR UNION REPRESENTATIVES.

We would prefer you place your name on the questionnaire in the event further questions or follow-up may be necessary. HOWEVER, THIS IS OPTIONAL ON YOUR PART.

After completing the questionnaire, please place and seal it in the attached envelope and place the envelope in a prominent spot on your desk and it will be collected from you, or return it to a study investigator.

YOUR FULL NAME (Optional-Please Print):______________________________

"BY COMPLETING THIS QUESTIONNAIRE, I INDICATE MY CONSENT TO PARTICIPATE IN THIS STUDY. I UNDERSTAND CONFIDENTIALITY WILL BE MAINTAINED."

THANK YOU FOR YOUR PARTICIPATION IN THIS STUDY.

NIOSH INDOOR ENVIRONMENTAL QUALITY SURVEY
(HETA 92-166)

I.D. Number _ _ _ _ (1-4)
Location Code _ _ _ _ (5-8)
(leave blank)

Today's Date: ____/____/____ (9-14)

This survey is being conducted to determine the environmental quality of your office building. This questionnaire asks about how you think your office environment affects you. Please answer the questions as accurately and completely as you can, regardless of how satisfied or dissatisfied you are with conditions in the office.

ALL OF YOUR ANSWERS WILL BE TREATED IN THE STRICTEST CONFIDENCE.

I. WORKPLACE INFORMATION

1. How long have you worked *in this building*, to the nearest year?

_ _ years (15-16)

How long have you worked *at this location in the building*?

_ _ years _ _ months (17-20)

2. On average, how many hours a week do you work *in this building*?

_ _ hours per week (21-22)

3. What floor do you work on?

_ _ floor (23-24)

4. How comfortable is the chair at your workstation?

1 _ Very comfortable (25)
2 _ Reasonably comfortable
3 _ Somewhat uncomfortable
4 _ Very uncomfortable
5 _ Don't have one specific chair

5. In general, how clean is your workspace area?

1 _ Very clean (26)
2 _ Reasonably clean
3 _ Somewhat dusty or dirty
4 _ Very dusty or dirty

6. About how many hours a day do you work with a computer or word processor, to the nearest hour?

_ _ hours per day (27-28)

II. INFORMATION ABOUT HEALTH AND WELL-BEING

1. **Have you ever been told by a doctor that you have or had any of the following?**

	YES (1)	NO (2)
Migraine		(29)
Asthma		(30)
Eczema		(31)
Hay fever		(32)
Allergy to dust		(33)
Allergy to molds		(34)

2. **Does the presence of tobacco smoke in your work environment bother you?**

1__ Yes (35)
2__ No

3. **Do you consider yourself especially sensitive to the presence of chemicals in your work environment (e.g., fumes from office machines, carpets)?**

1__ Yes (36)
2__ No

4. **What is your tobacco smoking status?**

1__ never smoked (37)
2__ former smoker
3__ current smoker

5. **What type of corrective lenses do you usually wear at work?**

1__ none (38)
2__ glasses
3__ contact lenses
4__ both (glasses and contacts)

6. **How old were you on your last birthday?**

__ __ years (39-40)

7. **Are you:**

1__ male (41)
2__ female

During the **LAST FOUR WEEKS YOU WERE AT WORK**, how often have you experienced each of the following symptoms while working **in this building**?

- If you answer "Not in Last 4 Weeks" for a symptom, please move down the page to the next symptom.

During the **LAST FOUR WEEKS YOU WERE AT WORK**, what happened to this symptom at times when you were away from work? (eg, holidays, weekends)

While at work **TODAY**, did you experience this symptom?

SYMPTOMS	Not in Last 4 Weeks (1)	1-3 days in last 4 weeks (2)	1-3 days *per wk* in last 4 wks (3)	Every or Almost Every Workday (4)	Got Worse (1)	Stayed Same (2)	Got Better (3)	YES (1)	NO (2)
dry, itching, or irritated eyes									[illegible]
wheezing									[illegible]
headache									[illegible]
sore throat									[illegible]
unusual tiredness, fatigue, or drowsiness									[illegible]
chest tightness									[illegible]
stuffy or runny nose, or sinus congestion									[illegible]
cough									[illegible]
tired or strained eyes									[illegible]
difficulty remembering things or concentrating									[illegible]
dry throat									[illegible]
dizziness or lightheadedness									[illegible]
shortness of breath									[illegible]
In the LAST FOUR WEEKS, how often have any of these symptoms either reduced your ability to work or caused you to stay home or leave work early? Please Check ONLY ONE of the four boxes to the right.				[illegible]					

III. DESCRIPTION OF WORKPLACE CONDITIONS

During the **LAST FOUR WEEKS YOU WERE AT WORK**, how often have you experienced each of the following environmental conditions while working in this building? • If you answer "Not in Last 4 Weeks" for a condition, please move down the page to the next condition.					TODAY, <u>while working at your usual workstation,</u> did you experience this environmental condition?		
CONDITIONS	**Not in Last 4 Weeks (1)**	**1-3 days in last 4 weeks (2)**	**1-3 days *per wk* in last 4 wks (3)**	**Every or Almost Every Workday (4)**	**IN THE MORNING (1)**	**IN THE AFTER-NOON (2)**	**NOT TODAY (3)**
too much air movement							(82 83)
too little air movement							(84 85)
temperature too hot							(86 87)
temperature too cold							(88 89)
air too humid							(90-91)
air too dry							(92-93)
tobacco smoke odors							(94 95)
chemical odors (e.g., paint, cleaning fluids, etc.)							(96-97)
other unpleasant odors (e.g.. body odor, food odor, perfume)							(98 99)

IV. INFORMATION ABOUT YOU AND YOUR JOB

1. What is your job category?

(100)

1__ Managerial
2__ Professional
3__ Technical
4__ Secretarial or Clerical
5__ Other (specify) __________

2. All in all, how satisfied are you with your job?

(101)

1__ Very satisfied
2__ Somewhat satisfied
3__ Not too satisfied
4__ Not at all satisfied

3. What is the highest grade you completed in school?

(102)

1__ 8th grade or less
2__ Some high school
3__ High school graduate
4__ Some college
5__ College degree
6__ Graduate degree

4. Please rate the lighting at your workstation.

__ Much too dim
__ A little too dim
__ Just right
__ A little too bright
__ Much too bright

(103)

5. How satisfied are you with the conversational privacy at your workstation?

__ Very satisfied
__ Somewhat satisfied
__ Not too satisfied
__ Not at all satisfied

(104)

6. To the nearest hour, how much sleep do you normally get on a worknight (Sunday through Thursday)?

___ ___ hours (105)

7. In the last 4 weeks, has your sleep been restless or disturbed?

___ not at all
___ a little bit
___ moderately
___ quite a bit
___ extremely

(106)

8. How many caffeinated beverages do you normally drink during a day (include at work and away from work; one beverage equals 6 ounces of coffee or tea or 12 ounces of caffeinated soft drink)?

___ ___ beverages (107)

9. Which best describes the space in which your current workstation is located?

__ Private office
__ Open space with partitions
__ Open space without partitions
__ Other (specify) __________

(108)