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Rehabilitation Services Commission
Columbus, Ohio

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PREFACE

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Ronald M. Hall , Kenneth F. Martinez, and Elena Page of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies. Desktop publishing was performed by Robin Smith. Review and preparation for printing were performed by Penny Arthur.

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Highlights of the NIOSH Health Hazard Evaluation

Evaluation of indoor air quality at the Rehabilitation Services Commission (RSC)

NIOSH investigators visited the RSC building in Columbus, Ohio to evaluate the indoor air quality. They inspected the building's interior and exterior, and all air- handling units. They measured moisture in building materials and general indoor air quality comfort parameters. They interviewed 29 employees to assess symptoms potentially related to the work environment.

What NIOSH Did

- We checked the building's interior and exterior for moisture problems.
- We looked at the air-handling units (AHU).
- We measured moisture throughout the building.
- We measured temperature, relative humidity, and carbon dioxide in the building..
- We talked to employees regarding health concerns related to the work environment.
- We looked at the medical records of employees known to have certain illnesses.

What NIOSH Found

- Some AHUs did not drain very well (standing water was in a few of the units).
- A bathroom exhaust fan was not working during our survey.
- AHUs appeared clean and provided good air filtration, but did not provide enough outside air during our evaluation.
- Reported symptoms included asthma, and eye, nose, and throat irritation.

What Rehabilitation Services Commission Managers Can Do

- Bring in more outside air by adjusting outside air intakes on AHU's.
- Clean drain pans on AHUs and, if necessary, adjust them to allow for better drainage of water.
- Fix the bathroom exhaust fan and periodically check bathroom exhaust fans to make sure they are working.
- Promptly replace any water-damaged material.
- Improve communication and address employee concerns.

What the Rehabilitation Services Commission Employees Can Do

- Do not use ion-generating or electrostatic precipitator air cleaners. These may produce ozone and cause respiratory symptoms.
- Employees who have health concerns about work should consult their doctor.
- Employees should talk to the safety committee about work-related health concerns.

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SUMMARY

On May 5, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a request from employees at the Rehabilitation Services Commission (RSC) regarding indoor air quality problems at the RSC building in Columbus, Ohio. Health concerns included chronic sinus infections, allergies, asthmatic bronchitis, and chronic pulmonary problems. On July 11 and 12, 2000, NIOSH investigators conducted a walk-through inspection of the building's interior and exterior, and of the air handling units (AHU). Measurements to detect moisture incursion and general indoor air quality comfort parameters were also made. NIOSH physicians interviewed 29 employees to assess health complaints potentially related to the work environment.

Moisture measurements on the inside of the exterior walls and the concrete slab did not indicate a chronic water incursion problem. The AHUs appeared clean and provided good air filtration. The condensate pans on some of the AHU were not draining properly. The building was under positive pressure; the cafeteria was under negative pressure to minimize odors in the building. One non-functional bathroom exhaust fan was identified. Several carbon dioxide measurements exceeded 800 ppm, indicating an inadequate supply of outdoor air. The AHUs were recently switched from a manual adjustment system to a computer- controlled system. Although the computer-controlled system indicated air intakes at 10%, they were actually closed.

Thirteen of the 29 employees interviewed reported a physician diagnosis of asthma. Six of these employees reported a consistent increase in symptoms related to being in the workplace. In addition to asthma, 10 of the 29 employees interviewed reported upper respiratory symptoms or mucous membrane irritation temporally related to the work environment. Ten of the 29 reported having positive allergy tests for dust mites. Four employees reported no symptoms related to work.

Medical records were obtained for three individuals who reported being diagnosed with asthma since beginning work at the RSC, and who reported a consistent increase in symptoms related to being at work. One of the three had information in the medical record possibly consistent with a diagnosis of asthma, but no evidence of a decrement in lung function at work; two did not have documented evidence of asthma.

Among the 29 persons interviewed, the most frequently reported observation was that the work environment was dusty and the cloth-covered cubicles were dirty. Several persons complained of odors from the kitchen. In addition, several employees reported the use of ion-generating or electrostatic precipitator air cleaners (these air cleaners may produce ozone) at their desks.

There was no evidence of a significant indoor air quality problem at the RSC building. Minor problems were noted, including a non-operational bathroom exhaust fan, a deficiency in supplied outdoor air, and the use of ozone generating air cleaners. Reported symptoms included asthma, and eye, nose, and throat irritation. Recommendations include repair of the bathroom fan, adjusting the outside air dampers to increase the supply of outdoor air, and elimination of ozone-generating air cleaners.

Keywords: SIC 9199 (General Government, Not Elsewhere Classified) indoor air quality, indoor environmental quality, HVAC systems, asthma.

TABLE OF CONTENTS

INTRODUCTION

On May 5, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request from employees at the Rehabilitation Services Commission (RSC) regarding indoor air quality (IAQ) problems at the RSC building in Columbus, Ohio. Health concerns included chronic sinus infections, allergies, asthmatic bronchitis, and chronic pulmonary problems.

On July 11-12, 2000, NIOSH investigators conducted a site visit at the RSC building. An opening conference was held with RSC management, facility maintenance personnel, union representatives, and concerned employees. Information was obtained relating to the building and the history of the concerns involving IAQ issues. A walk-through inspection of the building's interior and exterior focused on the eight heating, ventilating, and air-conditioning (HVAC) units located on the roof and on past moisture incursion. Temperature, relative humidity (RH), and carbon dioxide (CO_2) were measured inside the building on July 12, 2000. Private medical interviews were conducted to assess health complaints potentially related to the work environment. A closing conference was held on July 12, 2000, during which preliminary findings were discussed.

BACKGROUND

Building and Ventilation System Description

The RSC is located in a 12-year-old one-story brick and glass structure with approximately 142,000 square feet (ft^2) of indoor floor space. The building is occupied mainly during the hours between 7:00 a.m. and 6:00 p.m. Over 600 employees work in the RSC building. The majority of the office space is open, with rows of cubicles separated by carpeted partitions approximately four feet in height. The cubicles are equipped with typical office furniture, including video display terminals and keyboards. The entire building is carpeted, with the exception of the main hallway (located through the center of the building) and the cafeteria area. Smoking is not permitted inside the RSC building.

The ventilation system consists of eight large variable-air-volume HVAC units (each with a capacity of providing 18,000 cubic feet per minute) mounted on the roof. Return air is supplied through an open plenum above the ceiling. The temperature and amount of outdoor air introduced into the building are automatically controlled. During our survey, the night-time temperature controls were set at 68°F for a low temperature and 78°F for a high temperature. The outside air intake for each of the HVAC units was set at 10% during the time of our evaluation. Each HVAC unit was equipped with 60% - efficient bag filters.

METHODS

Industrial Hygiene Evaluation

NIOSH investigators inspected the interior and exterior of the building for evidence of water damage and microbial contamination to identify potential sources of contamination and pathways for moisture vapor intrusion. The eight HVAC units mounted on the roof of the building were also inspected.

Indicators of occupant comfort were measured in various locations. Real-time CO_2, temperature, and RH measurements were taken using a hand-held, battery operated, TSI Q-Track (Model 8550) IAQ monitor. This portable monitor uses a non-dispersive infrared absorption (NDIR) sensor to measure CO_2 in the range of 0-5000 parts per million (ppm). It is capable of measuring temperature in the range of 32 to 122°F, with an accuracy of 1°F. This instrument also measures RH in the range of 5 to 95%, with an accuracy of ±3%. Temperature and RH measurements were also collected and logged for a continuous 24-hour

period using HOBO H8 Pro Series loggers. These battery-operated loggers use an internal temperature sensor and external RH sensor. The operating range is -22 to 122°F for temperature and 0 to 100% RH.

Moisture measurements were collected along the floor and drywall near the exterior perimeter of the building using a non-destructive Tramex Moisture Encounter (Tramex Ltd., Shankill, Co. Dublin, Ireland). This meter operates by using low-frequency electronic transmitters (5-25 kilohertz [kHz]). When moisture is present the resistance decreases and the meter displays a signal. Additional moisture incursion measurements were collected using a Delmhorst Instrument Company Moisture Tester, Model BD-9. This meter provides direct readings for moisture content in the range of 8 to 50% on wood. A reference scale is used for comparative readings on non-wood materials. This portable instrument uses the amount of electrical conductivity in the material being tested to determine its moisture content.

Smoke tube tests were conducted throughout the building to determine if the building was under positive pressure and to test the effectiveness of the bathroom vents. Smoke tube tests were also conducted in the cafeteria area to determine if the cafeteria was under negative or positive pressure in relation to the rest of the building.

Medical Evaluation

NIOSH physicians interviewed the three confidential requesters by telephone. One of the requesters provided a list of employees with asthma. During the site visit, 26 employees were interviewed. Of these 26, 9 were employees from the list provided by the requestor, 12 were randomly selected from a personnel phone list, and 5 responded to an email that was sent by management to all personnel notifying them of our availability if they had any concerns regarding air quality in the building and/or health complaints related to work. Medical records were reviewed for three employees who reported having been diagnosed with asthma since working in the building and who related their symptoms to work.

EVALUATION CRITERIA

NIOSH investigators have completed over 1,200 investigations of the occupational indoor environment in a wide variety of non-industrial settings. Almost all of these investigations have been conducted since 1979. Overall, the symptoms and health complaints reported by building occupants have been diverse and usually not suggestive of any particular medical diagnosis or readily associated with a causative agent. Symptoms frequently reported usually include headaches, unusual fatigue, itching or burning eyes, skin irritation, nasal congestion, dry or irritated throats, and other respiratory irritations. Typically, the workplace environment has been implicated because workers often report that their symptoms lessen or resolve when they leave the building.

A number of published studies have reported a high prevalence of symptoms among occupants of office buildings.[1,2,3,4,5] Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building-related occupant complaints.[6,7] Among these factors are imprecisely-defined characteristics of HVAC systems, cumulative effects of exposure to low concentrations of multiple chemical pollutants, odors, elevated concentrations of particulate matter, microbiological contamination, and physical factors such as thermal comfort, lighting, and noise.[8,9,10,11,12,13] 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 sources or indoor sources.

Other studies have shown that occupant perceptions of the indoor environment are more closely related to the occurrence of symptoms than any measured indoor contaminant or condition.[14,15,16] Some studies have shown relationships between psychological, social, and

organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[16,17,18,19]

Less often, an illness may be found to be specifically related to something in the building environment. Some examples of potentially building-related illnesses are allergic rhinitis, allergic asthma, hypersensitivity pneumonitis, Legionnaires' disease, Pontiac fever, and carbon monoxide (CO) poisoning.

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

Standards specific 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 to specific chemical and physical agents.[20,21,22] With few exceptions, pollutant concentrations observed in non-industrial indoor environments fall well below these published occupational standards or recommended exposure limits. The American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE) has published recommended building ventilation design criteria and thermal comfort guidelines.[23,24] The ACGIH has also developed a manual of guidelines for approaching investigations of building-related complaints that might be caused by airborne living organisms or their effluents.[25]

Measurements of indoor environmental contaminants have generally not proved to be helpful in determining the cause of symptoms and complaints, except where there are strong or unusual sources, or a proven relationship between contaminants and specific building-related illnesses. The low-level concentrations of particles and variable mixtures of organic materials usually found are difficult to interpret and usually impossible to causally link to observed and reported health symptoms. However, measuring ventilation and comfort indicators such as CO_2, temperature, and RH, has proven useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems.

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

Carbon Dioxide (CO_2)

CO_2 is a normal constituent of exhaled breath, and if monitored at equilibrium concentrations in a building, may be useful as a screening technique to evaluate whether adequate quantities of fresh air are being introduced into an occupied space. The American National Standards Institute (ANSI)/ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality, recommends outdoor air supply rates of 20 cubic feet per

minute per person (cfm/person) for office spaces and conference rooms, 15 cfm/person for reception areas, classrooms, libraries, auditoriums, and corridors, and 60 cfm/person for smoking lounges. 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 IAQ.

CO_2 is not considered a building air pollutant, but CO_2 concentration is used as an indicator of the adequacy of outside air supplied to occupied areas. Indoor CO_2 concentrations are normally higher than the generally constant ambient CO_2 concentration (range 300-350 ppm). ASHRAE Standard 62-1989 recommends 1,000 ppm as the upper limit for comfort (odor) reasons.[23] When indoor CO_2 concentrations exceed 800 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected.[27] 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 when the measurements are made.

Temperature and Relative Humidity

Temperature and RH measurements are often collected as part of an IEQ investigation 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 temperatures.[28] Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. The ASHRAE Standard 55-1992, specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable.[24]

Work-Related Asthma

Asthma is a chronic inflammatory disease of the airways characterized by symptoms of breathlessness, wheezing, chest tightness, and coughing, that is at least partially reversible with pharmacologic agents or time. Genetics play a large role in the development of asthma, accounting for 30-80% of the asthma risk, with the rest apparently related to environmental exposures.[29] Asthma is a common diagnosis in both adults and children, with an estimated 17.3 million individuals in the United States having asthma in 1998.[30]

Work-related asthma (WRA) is asthma attributable to, or made worse by, exposures in the workplace. There are two categories of WRA, occupational asthma (OA) and work-aggravated asthma (WAA).[31] WAA is symptomatic asthma that is worsened by workplace exposures. OA is new-onset asthma caused by exposures at work. OA, which affects only a portion of an exposed population, develops after a latent period ranging from months to years. The symptoms of OA usually occur within minutes of exposure but may also occur several hours after exposure. Symptoms of OA usually get worse as the workweek continues, but improve on weekends and vacations. As OA progresses, recovery may take days to weeks.[32]

RESULTS

Industrial Hygiene

Evidence of water damage was observed on one ceiling tile located on the west side of the building. (Building maintenance was informed of the tile location so that they could determine the source of the moisture and replace the tile.) Other areas where moisture incursion would likely occur (along exterior walls and around windows and entrances) were checked for moisture content. Moisture measurements did not indicate any chronic water incursion. Visible active fungal growth was not observed on any building

materials. Visual inspection indicated that general housekeeping was appropriate.

The HVAC units were recently switched from a manual adjustment system to a computer-controlled system. During our evaluation, the computer-controlled system had the outside air intakes (for the units on the roof) adjusted to 10%. However, the units were actually closed. The computer-controlled system was fairly new and had not been accurately calibrated. Maintenance personnel were working on the system during the evaluation to fix the disparity.

Inspection of the HVAC units did not reveal any visible microbial contamination. However, some of the HVAC units (# 1, 2, 5, 7, and 8) had standing water in the condensate drip pans with some visible rust. The outside air intakes for HVAC units #4 and #5 were located in close proximity to bathroom exhaust vents on the roof (see Figure 1). Depending upon the wind directions, there may be opportunities for the bathroom exhaust odors to be entrained into the outside air intakes of units #4 and #5 .

The smoke tube tests indicated that the building was under positive pressure. Positive pressure inside the building reduces the possibility of unfiltered/unconditioned air and outside water vapor from penetrating the building. The cafeteria was under negative pressure, which helps keep odors from this area from being disseminated into work spaces. The smoke test also identified a bathroom vent (near the main entrance of the building) that was not operating.

Tables 1 and 2 present the CO_2 measurements inside and outside the building on July 12, 2000. CO_2 measurements were made in 24 locations in the morning and afternoon. During the morning, the CO_2 concentrations inside the building ranged from 435 ppm to 769 ppm with a mean of 570 ppm. CO_2 measurements obtained from the same locations in the afternoon ranged from 780 ppm to 1,006 ppm, with a mean of 880 ppm. All CO_2 concentrations inside the building in the morning were below the NIOSH recommeded criteria of 800 ppm. In the afternoon, 20 of the 24 measurements inside the building had CO_2 concentrations that exceeded the NIOSH recommended criteria of 800 ppm. CO_2 concentrations outside the building ranged from 293 to 353 ppm in the morning, and from 270 to 360 ppm in the afternoon, with means of 320 ppm and 310 ppm, respectively.

Comfort Parameters

Tables 1 and 2 present the temperature and RH measurements inside the building. There were some deviations outside the recommended temperature range, however the majority of temperature and RH measurements were within a range in which 80% or more of the occupants would be expected to find the environment thermally comfortable (ASHRAE Standard 55–1992.)

Figures 2-5 graphically illustrate the temperature variations over a 24–hour period (measured with the HOBO Pro Series loggers) at different locations. These figures illustrate variation in temperature from data loggers placed in areas that are serviced by different AHUs during occupied and unoccupied hours. The area of the building serviced by AHU #2 (see Figure 2) had temperatures ranging between 71.8 - 76.6°F during occupied hours. In the area serviced by AHU #3 (see Figure 3), the temperatures ranged from 68.3 to 74°F, and in the area serviced by AHU #5 (see Figure 4) the temperatures ranged from 71.7 to 75.9°F. The area of the building that is serviced by AHU # 7 (see Figure 5) had temperatures ranging from 69 to 75.2°F during occupied hours.

Medical

Thirteen of the 29 persons interviewed reported a physician diagnosis of asthma. Seven reported being diagnosed with asthma prior to working at RSC; of these, two reported no change in symptoms related to presence in the workplace, two reported an occasional increase in symptoms related to odors or dust in the building, and three reported a consistent increase in symptoms related to presence in the workplace. Of the six

diagnosed since beginning work at RSC, two reported no change in symptoms related to presence in the workplace, one noted an occasional increase in symptoms if the copiers were being used extensively, and three reported a consistent increase in symptoms related to presence in the workplace.

In addition to asthma, 10 of the 29 employees interviewed reported upper respiratory symptoms or mucous membrane irritation temporally related to the work environment. Ten of the 29 reported having positive allergy tests for dust mites. Four employees reported no symptoms related to work.

Medical records were obtained for the three individuals who reported both being diagnosed with asthma since beginning work at the RSC and having a consistent increase in symptoms related to being at work. One of the three had information in the medical record possibly consistent with a diagnosis of asthma, but no evidence of a decrement in lung function at work; two did not have documented evidence of asthma.

Among the 29 persons interviewed, the most frequently reported observation was that the work environment was dusty and the cloth-covered cubicles were dirty. Several persons complained of odors from the kitchen. In addition, several persons reported the use of ozone generating air cleaners at their desks.

DISCUSSION AND CONCLUSIONS

This evaluation did not reveal the existence of microbial reservoirs or suggest a chronic water incursion problem in the building. A water-damaged ceiling tile was found.

Smoke tube tests revealed that the building was maintained under a positive pressure with respect to the outdoor environment. Thus, contaminants and moisture from outdoors should not enter the RSC building through open doors or penetrations in the building envelope.

Smoke tests indicated that the cafeteria was under negative pressure relative to the rest of the building. Keeping the cafeteria under negative pressure will help prevent odors from entering the rest of the building. Smoke tests conducted in the women's bathroom near the main entrance of the building indicated that this room was under positive pressure, and that the exhaust fan was not operating.

CO_2 measurements above the NIOSH recommended criteria of 800 ppm indicate that the HVAC system is not providing enough outdoor air to the occupied areas. The HVAC system should be capable of maintaining outdoor air supply rates of at least 20 cfm/person for office spaces.[23] The current AHUs utilize computer– controlled, variable-air-volume boxes to control temperature and the amount of outdoor air brought into the building. During our evaluation, the computer-controlled system needed to be adjusted so that the setting for the outside air intakes on the computer matched the actual outside air damper adjustments on the HVAC units. Previously, CO_2 concentrations were measured in the building by consultants. These data indicated that CO_2 concentrations were below 800 ppm inside the building when the outside air intakes were set higher than 15%. Based on that previous survey, a minimum damper setting (>15%) should be established to ensure that an adequate amount of outdoor air is supplied to the building at all times.

Two of the HVAC units (unit #4 and #5) had outside air intakes near bathroom exhaust fans. This allows odors from the exhaust fans to be entrained into the HVAC units. The HVAC units appeared to be clean and have good air filtration systems. Some of the condensate pans had evidence of standing water and rust. Condensate pans should allow for good drainage to prevent standing water and rust inside the HVAC systems.

Asthma was reported by several persons, and some of these felt that symptoms were related to the work environment. Two of three medical records reviewed from employees who reported a physician diagnosis of asthma did not support a diagnosis of asthma. Ten persons reported upper

respiratory symptoms or mucous membrane irritation temporally related to the work environment.

Based on medical interviews, a commonly reported concern was the dust in the work environment. Several employees had allergy testing that indicated allergies to dust mites. Dust mites of the genus *Dermatophagoides* are the most important source of allergens in house dust, and there is sufficient evidence in the medical literature to show a causal relationship between dust mite allergen exposure and asthma exacerbations in sensitized individuals. Dust mites require four things to thrive: sites for nesting, such as carpet, upholstered furniture, mattresses, and bedding; the presence of humans whose skin scales provide a food source; temperature optimal for growth; and humidity. Dust mite levels can be reduced by removing carpets or treating them with benzyl benzoate, eliminating or reducing upholstered furnishings or replacing them with leather, plastic, or other smooth-surfaced materials, reducing or eliminating unnecessary fabrics such as draperies, and lowering humidity.[33]

Several employees reported the use of personal air cleaners (i.e., portable ion-generating and electrostatic precipitator devices). There is limited evidence that particle air cleaners are associated with a reduction in asthma symptoms.[33] In addition, ion-generating air cleaners and electrostatic precipitators can produce ozone in significant quantities.[34] Ozone is a mucous membrane and lung irritant. Exposure to ozone is associated with measurable decreases in lung function. Such exposure also results in increased responsiveness of the airways to nonspecific stimuli. Symptoms include cough, chest pain, shortness of breath, throat irritation, and wheezing. These effects are self–limited.[35]

RECOMMENDATIONS

1. The predetermined computer setting should periodically be compared with the actual adjustment of the outside air damper on the HVAC units during preventive maintenance inspections. A minimum damper setting of 15% should be established to ensure that an adequate amount of outdoor air is supplied.

2. The AHU condensate pans should be cleaned and adjusted to allow for good drainage.

3. The outside air intakes of HVAC units #4 and #5 should be relocated to avoid entraining bathroom exhaust fan emissions.

4. All bathroom exhaust fans should be checked periodically. If not operating properly, they should be fixed to meet original design specifications.

5. The water–damaged ceiling tile noted during our evaluation should be discarded. As a general rule, all porous water- or mold-damaged material that cannot be dried within 24 to 48 hours should be discarded. Attempts to clean or disinfect mold–contaminated porous materials are generally unsuccessful. Any identified sources of excessive moisture or leaks that may cause water damage to the building's interior or furnishings should be promptly eliminated. Any episodes of water incursion should be dealt with promptly. Water should be removed immediately from porous, water–damaged furnishings, carpets, and construction materials. Heat fans should be used within 24 hours to dry carpets and other applicable surfaces. Steam or other water-based cleaning methods which add moisture to the environment must be used with extreme care. A written program for dealing with water incursion and IAQ incidents should be implemented.

6. References regarding a written program to deal with IAQ issues include the "Building Air Quality Action Plan,"[36] and the "Building Air Quality – A Guide for Building Owners and Facility Managers."[37] The "Building Air Quality Action Plan" is particularly useful for the implementation of an effective IEQ management program. These documents contain some of the best practical advice available regarding the prevention, evaluation, and correction of IEQ problems.

7. Ozone-generating air cleaners should not be used.

8. Dust in the work environment should be minimized by frequent vacuuming of carpets and cubicle upholstery with a high–efficiency particulate air (HEPA)-filtered vacuum.

9. Periodic assessments of the building pressure (related to outside pressure) and the cafeteria pressure (related to the pressure inside the building) should be conducted.

10. Communication between management and employees should be improved in order to facilitate the exchange of concerns about environmental conditions in the building. Employees should be made aware of the problems with the building and decisions made by building managers to address those problems. Employees with work-related health concerns should be encouraged to report these concerns to the appropriate management personnel, and should consult their health care provider to determine the cause and proper treatment.

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Table 1
Carbon Dioxide, Temperature, and Relative Humidity Levels
Rehabilitation Services Commission building
Columbus, Ohio
HETA 2000-0283-2823
July 12, 2000

Measurements Taken in AHU Area	CO_2 (ppm)	Temperature (ºF)	Relative Humidity (%)
Morning			
AHU#1	530	72	42.8
	470	72	42.7
	475	72.3	42.6
	585	72.3	44.3
AHU#2	459	72.3	41.2
	490	73.2	41.2
	496	72.6	41.5
AHU#3	658	71.5	38.2
	650	72.6	42.7
	724	72.8	38.9
	728	72.8	38.5
AHU#4	575	71.1	43.8
	664	71.5	39
AHU#5	435	72	39.4
	456	72.1	39.6
	465	72.3	40.3
AHU#6	435	73.5	38.3
	457	73.4	38.3
AHU #7	656	73.7	40.3
	620	73.2	41.5
	625	73	42.4
AHU#8	769	73.6	39
	653	73.9	39.7
	565	74.7	40.1
Outside Building	353	73.5	42.5
	353	74.5	40.2
	297	69.2	45.1
	293	70.5	45.5

Table *2*
Carbon Dioxide, Temperature, and Relative Humidity Levels
Rehabilitation Services Commission building
Columbus, Ohio
HETA 2000-0283-2823
July 12, 2000

Measurements Taken in AHU Area	CO_2 (ppm)	Temperature (^oF)	Relative Humidity (%)
Afternoon			
AHU#1	863	71.5	40.5
	878	71.7	41.1
	988	72.3	45.3
	890	72.4	43.7
AHU#2	859	72.6	39.5
	935	74.4	40.4
	875	74.7	38.1
AHU#3	920	72.1	42.8
	1006	73.2	41.5
	965	73.3	41
	975	73.8	41.4
AHU#4	975	72.1	44
	915	72	43
AHU#5	812	74.8	35
	780	74.7	34
	853	74.3	36.6
AHU#6	837	74.8	36.4
	829	74.7	36.3
AHU #7	798	74.1	37.5
	784	73.5	38.2
	831	73.4	40.4
AHU#8	915	74.4	41.1
	860	74.9	40.5
	780	73.5	41.1
Outside Building	344	81	43.3
	360	84.9	38.1
	278	82.2	33.7
	270	80.2	42.8

Figure 1. Bathroom exhaust near outside air intake.

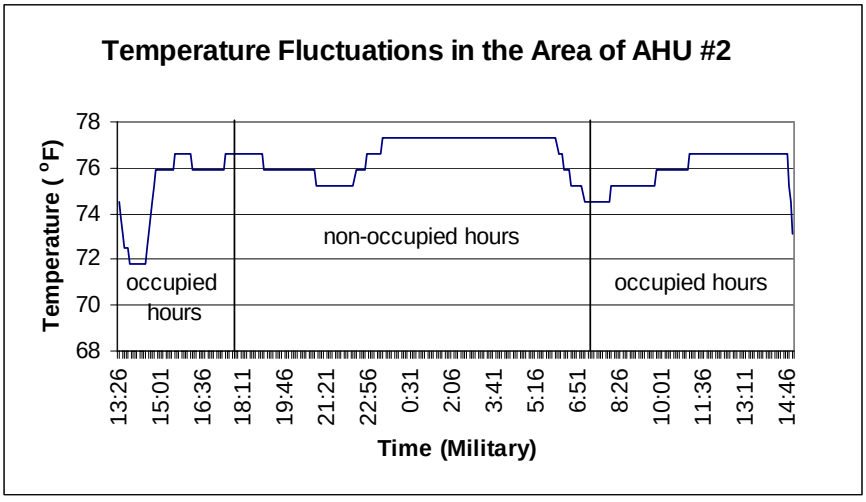

Figure 2. Temperature fluctuations in the area within the building serviced by AHU #2.

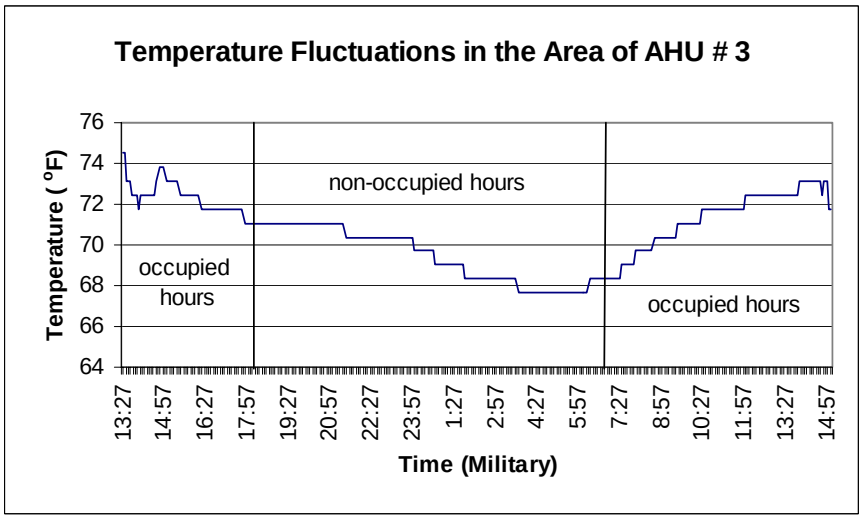

Figure 3. Temperature fluctuations in the area within the building serviced by AHU #3.

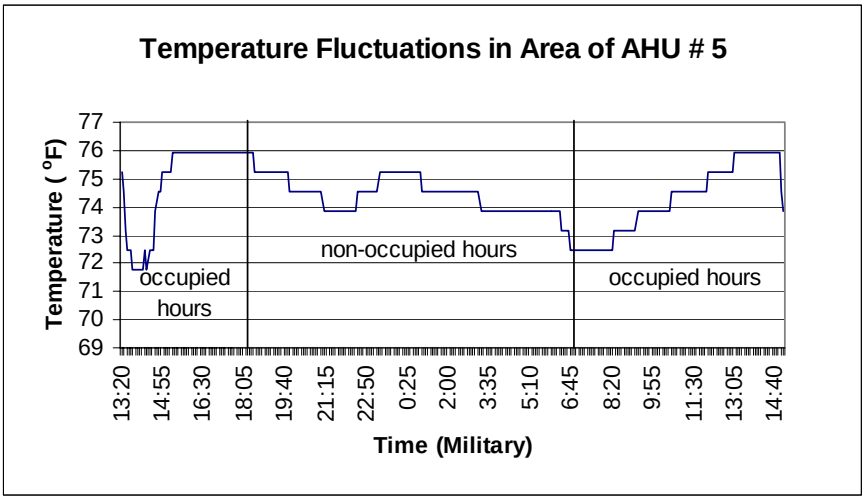

Figure 4. Temperature fluctuations in the area within the building serviced by AHU #5.

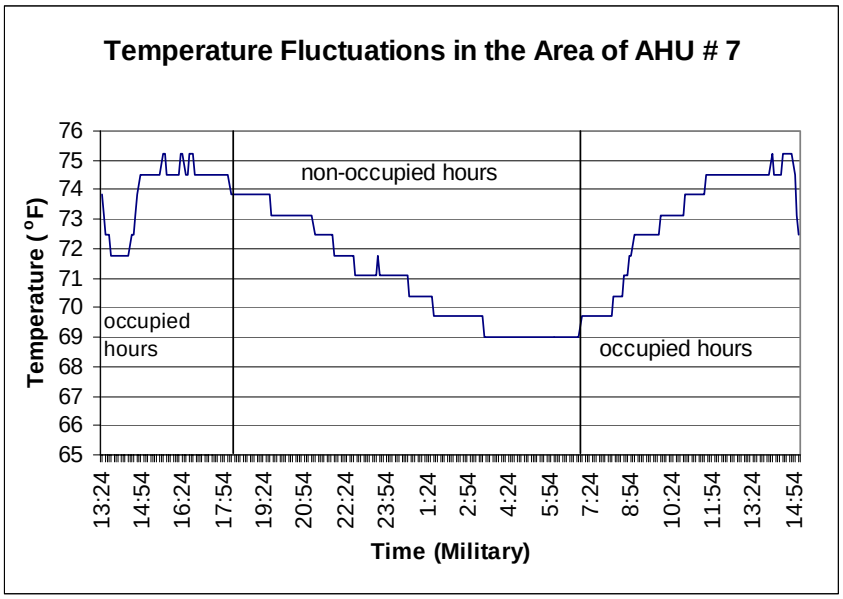

Figure 5. Temperature fluctuations in the area within the building serviced by AHU #7.

For Information on Other
Occupational Safety and Health Concerns

Call NIOSH at:
1–800–35–NIOSH (356–4674)
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