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CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH HEALTH HAZARD EVALUATION REPORT

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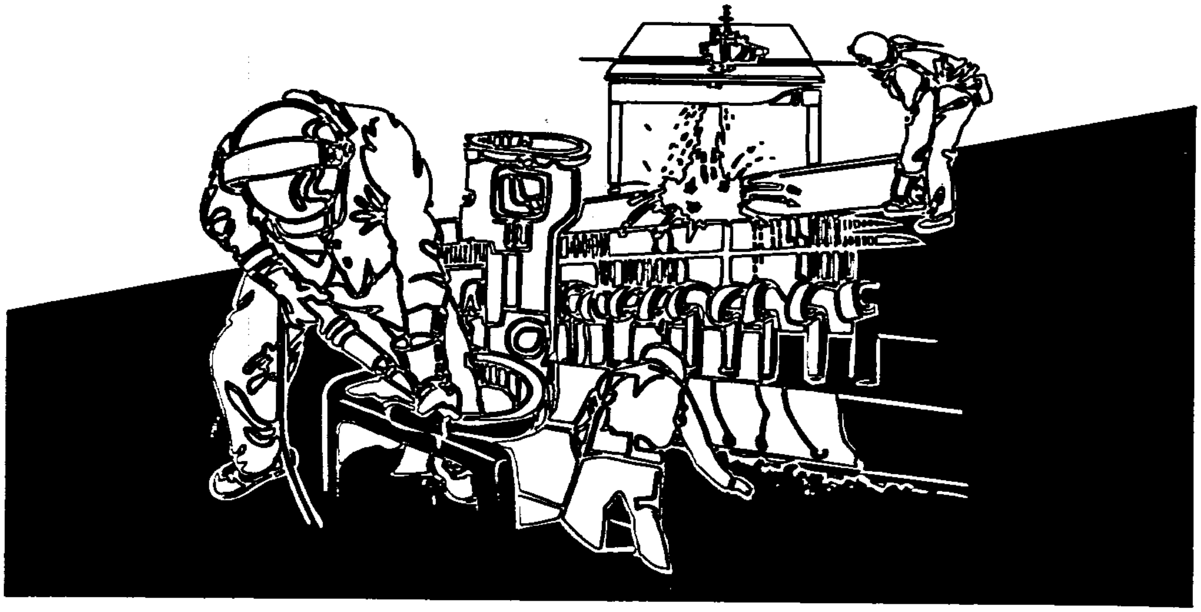
PATIO ENCLOSURES, INC.
MACEDONIA, OHIO



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.

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I. SUMMARY

On September 15, 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) from a management representative of Patio Enclosures, Inc., in Macedonia, Ohio. The management and workers were concerned about employee illnesses and about symptoms that occurred while they worked in the 700 and 720 office buildings of Patio Enclosures. Employees in the offices experienced varying degrees of eye irritation (burning, itching, redness, dryness), throat irritation, and sinus problems. NIOSH investigators conducted an environmental survey at this facility on November 5-7, 1991.

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

Average temperatures in the office ranged from 69.2 to 74.9°F during the morning, and from 69.1 to 75.3°F during the afternoon. Average relative humidity (RH) levels ranged from 15.0 to 21.2% during the morning, and from 18.0 to 23.3% during the afternoon. Average carbon dioxide (CO_2) concentrations ranged from 375 to 850 parts per million (ppm) in the morning, and from 500 to 850 ppm in the afternoon.

Inspection of the heating, ventilating, and air conditioning (HVAC) system revealed the presence of visible microbial growth in some of the air handling unit (AHU) drip pans. Microbial analysis of bulk samples collected from the AHUs and from some office locations showed the presence of several common outdoor microbial species, such as *Penicillium*, *Cladosporium*, *Aspergillus*, *Alternaria*, Yeasts, *Ulocladium*, and *Fusarium*.

Smoking was permitted in private offices and, since the air from these offices was returned to air handling units that also served other areas, this constituted a potential health hazard. NIOSH considers environmental tobacco smoke to be a potential human carcinogen.

A potential health hazard was identified due to the recirculation of environmental tobacco smoke throughout the offices from private offices where smoking was allowed. The presence of microbial growth within the HVAC system presents the possibility of aerosolization and distribution of this material into the occupied portions of the building. Recommendations for establishing a no smoking policy, reducing microbial growth, and for cleaning cooling coil condensate pans and drains are included in this report.

KEYWORDS: SIC 3442 (Metal Doors, Sash, Frames, Molding, and Trim) Indoor Environmental Quality (IEQ), Indoor Air Quality (IAQ), office air

II. INTRODUCTION

On September 15, 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) from a management representative of Patio Enclosures, Inc., Macedonia, Ohio. The requestor asked NIOSH to evaluate complaints among Patio Enclosures personnel of eye problems (burning, itching, redness, dryness), burning of the throat, and sinus problems. These symptoms were experienced by various office personnel and not by workers in the manufacturing area. NIOSH investigators conducted an environmental survey at this facility on November 5-7, 1991.

III. BACKGROUND AND DESCRIPTIVE INFORMATION

Patio Enclosures consisted of a large manufacturing area with two-story office areas at the east and west ends. The office area on the west side was called the 700 building and the east offices were called the 720 building. Solariums and patio enclosures were assembled in the manufacturing area. This process involved cutting metal window frames and attaching them to glass panes.

The heating, ventilating, and air conditioning (HVAC) system for the building consisted of 12 rooftop air handling units (AHUs), six for both the 700 and 720 buildings. Each floor was served by three separate AHUs. The AHUs provided conditioned air to the offices via duct work to ceiling air diffusers. Air from the occupied space then returned to the AHU through ceiling return air vents and duct work. There were five thermostats in each of the buildings. Five of the six AHUs had outside air dampers that allowed them to bring outside air into the office space.

The evaluated area included both floors of the 700 and 720 office areas. Each floor was about 4,000 ft^2. All areas were carpeted and most employees could see a window from their desk. The employees performed typical office activities and routinely moved about the office in the performance of their duties. Some of the thermostats had a lock so that they could be adjusted only by the building manager. Others had a sign which said that only the building manager may adjust the thermostat. The smoking policy at the time of the investigation allowed employees to smoke in their private offices. However, environmental tobacco smoke was then recirculated to other areas because several offices were served by a common air handler.

The carpeting in part of the ground floor of the 700 building had reportedly been flooded due to a drinking fountain overflow two times within four years prior to this investigation. This carpeting had not been replaced at the time of this investigation.

IV. EVALUATION METHODS

The environmental survey included evaluation of the relevant areas of the facility and the ventilation system serving those areas, and air sampling for possible airborne chemical contaminants. It also included collection of bulk samples, such as duct insulation from the ventilation system, and scrapings from under a carpet that had been flooded. Measurements of carbon dioxide (CO_2), temperature, and relative humidity (RH) were made at specified sites throughout the day. Airflow through supply and return vents was measured in all offices.

A total of nine general-area air samples were collected throughout the facility and were analyzed for volatile organic compounds (VOCs). Samples were collected in the manufacturing area and on each level of both office areas. Outdoor air samples were collected to provide background levels. Background samples are important when evaluating potentially "trace" concentrations of contaminants, because they may illustrate differences in trace contaminants between the areas being investigated and the ambient air. It also can demonstrate if outdoor contaminants are being introduced to the indoor environment.

Seven air samples were collected on solid sorbent tubes (150 milligrams [mg] of activated charcoal) connected via Tygon™ tubing to battery-powered vacuum pumps calibrated at a flow rate of 0.2 liters per minute (ℓpm). Three of these charcoal tubes were analyzed qualitatively for VOCs. Each of these charcoal tube samples was desorbed in one milliliter (mℓ) of carbon disulfide and screened by gas chromatography (GC) with a flame ionization detector (FID). The samples were then analyzed by GC/mass spectrometry detector (MSD) to identify the contaminants.

Based on the results of qualitative analysis of these three samples, the remaining four charcoal tubes were analyzed quantitatively for n-hexane, 1,1,1-trichloroethane, toluene, and p-dichlorobenzene. These four samples were desorbed using carbon disulfide and then analyzed using GC/FID according to NIOSH method 1500.[1]

Due to concern about the possibility of pollutants from a nearby industrial facility that uses acids in a manufacturing process, two air samples were collected to determine if acid gases were present. One sample was collected on the ground level of the 700 building and one was collected on the roof. These samples were collected on a solid sorbent tube and were analyzed according to NIOSH method 7903.[2]

Six locations on each office level (24 total) were selected for environmental measurements throughout the day. The CO_2 concentration, temperature, and RH were measured at each location four times during the following intervals throughout the workday: before workers arrived (7:05-7:55 a.m.), before lunch (10:35-11:25 a.m.), after lunch (1:10-2:05 p.m.), and at the end of the workday (3:25-4:20 p.m.).

Carbon Dioxide

Real-time CO_2 levels were determined with a Gastech Model RI-411 portable CO_2 indicator. This portable, battery-operated instrument monitors CO_2 (range 0-4975 parts per million [ppm]) via nondispersive infrared absorption with a sensitivity of 25 ppm. Instrument zeroing and calibration were performed prior to use with zero air and a known CO_2 span gas (800 ppm).

Temperature and Relative Humidity

Real-time temperature and RH measurements were taken by using a Vaisala HM 34 humidity and temperature meter. This portable, battery-powered meter is accurate to within $\pm 2\%$ RH and $\pm 0.5°F$.

V. EVALUATION CRITERIA

NIOSH investigators have completed over 1100 investigations of the occupational indoor environment in a wide variety of non-industrial settings. The majority of these investigations have been conducted since 1979.

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

A number of published studies have reported high prevalences of symptoms among occupants of office buildings.[3-7] Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building-related occupant complaints.[8,9] 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.[10-15] Indoor environmental pollutants can arise from either outdoor sources or indoor sources.

There are also reports which show that occupant perceptions of the indoor environment are more closely related to the occurrence of symptoms than any measured indoor contaminant or condition.[16-18] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[19-21]

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

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

Standards specifically for the non-industrial indoor environment do not exist. NIOSH, the Occupational Safety and Health Administration (OSHA), and the American Conference of Governmental Industrial

Hygienists (ACGIH) have published regulatory standards or recommended limits for occupational exposures.[22-24] With few exceptions, pollutant concentrations observed in non-industrial indoor environments fall well below these published occupational standards or recommended exposure limits.

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published recommended building ventilation design criteria and thermal comfort guidelines.[25,26] 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.[27]

Measurement of indoor environmental contaminants has rarely proved to be helpful in determining the cause of symptoms and complaints except where there are strong or unusual sources, or a proven relationship between contaminants and specific building-related illnesses. The low-level concentrations of particles and variable mixtures of 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.[28] This manual suggests that indoor environmental quality (IEQ) is a constantly changing interaction of a complex set of factors. Four of the most important elements involved in the development of IEQ problems are: (1) a source of odors or contaminants; (2) a problem with the design or operation of the HVAC system; (3) a pathway between the contaminant source and the location of the complaint; (4) and the building occupants. A basic understanding of these factors is critical to preventing, investigating, and resolving IEQ problems.

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

<u>CARBON DIOXIDE (CO_2)</u>

CO_2 is a normal constituent of exhaled breath and, if monitored, may be useful as a screening technique to evaluate whether adequate quantities of fresh air are being introduced into an occupied space.

The ANSI/ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality, recommends outdoor air supply rates of 20 cubic feet per minute per person (cfm/person) for office spaces and conference rooms, 15 cfm/person for reception areas, and 60 cfm/person for smoking lounges, and provides estimated maximum occupancy figures for each area.[25]

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

TEMPERATURE AND RELATIVE HUMIDITY

The perception of comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperatures. Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. ANSI/ASHRAE Standard 55-1981 specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable. The thermal comfort range, as specified by this standard, is 68°F to 74°F in winter months and 73°F to 79°F in summer months. The acceptable RH range for comfort and control of microbial growth is 30% to 60%, according to ASHRAE.[26]

MICROBIOLOGICAL CONTAMINANTS

Microorganisms (including fungi and bacteria) are normal inhabitants of the environment. The saprophytic varieties (those utilizing non-living organic matter as a food source) inhabit soil, vegetation, water, or any reservoir that can provide an ample supply of a nutrient substrate. Under the appropriate conditions (optimum temperature, pH, and with sufficient moisture and available nutrients) saprophytic microorganisms can then be disseminated as individual cells or in association with soil/dust or water particles. In the outdoor environment, the levels of microbial aerosols will vary according to the geographic location, climatic conditions, and surrounding activity. In a "normal" indoor environment, the level of microorganisms may vary somewhat as a function of the cleanliness of the HVAC system and the numbers and activity level of the occupants. Generally, the indoor levels are expected to be below the outdoor levels (depending on HVAC system filter efficiency) with consistently similar ranking among the microbial species.[29,30]

Acceptable levels of airborne microorganisms have not been established, primarily due to the lack of research addressing the dose-response relationship of allergen exposure; the varying immunogenic susceptibilities of individuals are difficult to resolve. As such, causal relationships of microbial origin must be determined through the combined contributions of medical, epidemiologic, and on-site evaluation.[31] The current strategy for on-site evaluation involves a comprehensive walk-through of the problem building to identify sources of microbial contamination and routes of dissemination. In those locations where contamination is visibly evident or suspected, bulk samples may be collected to identify the predominant species (fungi, bacteria, and thermoactinomycetes).

VOLATILE ORGANIC COMPOUNDS (VOC)

VOCs, including formaldehyde and other aldehydes, are emitted in varying concentrations from numerous indoor sources (e.g., carpeting, fabrics, adhesives, solvents, paints, cleaners, waxes, cigarettes, kerosene heaters, and other combustion heating products). New building materials, products, and furnishings are known to emit a large number of organic chemicals into indoor air.[32] The length of time over which each material strongly emits VOCs can be highly variable. A compound may have very high emissions but dry rather quickly. Another may have low total emissions and dry slowly. A critical factor in the rate of decrease of emissions is the ventilation rate. Health symptoms experienced by building occupants are often blamed on the presence of such chemicals in indoor air, although the health consequences of most VOCs emitted from building materials are not well understood. Some organic species (e.g., formaldehyde and benzene) have been determined to be carcinogenic in animal studies. NIOSH, OSHA, and the ACGIH have established compound-specific Recommended Exposure Limits (RELs), Permissible Exposure Limits (PELs), and Threshold Limit Values (TLVs) for many organic compounds.[22-24] Total indoor VOCs and aldehyde concentrations typically exceed corresponding outdoor levels except in locations immediately impacted by industrial or combustion source emissions. Laboratory studies evaluating human responses to controlled exposures to varying VOC mixtures reported test subject health symptoms similar to those reported by workers in large office buildings.[12]

VI. ENVIRONMENTAL RESULTS AND OBSERVATIONS

The office areas evaluated were in good physical condition and were well lighted. Fluorescent lighting was used throughout the evaluated area, with some natural lighting through the side windows.

There were six rooftop HVAC units on each side of the plant. The NIOSH investigators conducted a visual inspection of seven of these rooftop AHUs. On the 700 side, AHU #4 had a dirty acoustic liner and had debris in the mixed air plenum. The liner for AHU #5 was also dirty and appeared to have mold growing on it. The drip pan for this AHU had overflowed and there was debris in the mixed air plenum. AHU #2 did not have an outside air intake duct, and the liner inside AHU #3 was loose.

On the 720 side, AHU #5 had a dirty liner and had debris in the drip pan. For AHU #2, the fan filter gasket did not fully seal the filter, which allowed air to bypass the filter. The outside air damper for AHU #3 was closed and the drip pan was dirty. There was what appeared to be visible microbial growth in all three of these AHUs.

Indoor environmental CO_2 measurements are presented in Table 1. Measurements were made at six locations on each floor of the evaluated area at four times throughout the day. Table 1 presents the average CO_2 concentration for each floor during the four measurement periods. CO_2 concentrations in the evaluated area ranged from 375 to 850 ppm during the two morning measurement periods, and from 500 to 850 ppm during the afternoon measurement periods. The outdoor concentration was 350 ppm in the morning and 375 ppm in the afternoon. The highest measurements were 850 ppm, both measured on the second floor of the 700 building in the data processing department.

Temperatures (see Table 2) ranged from 69.2 to 74.9°F during the morning measurement periods, and from 69.1 to 75.3°F during the afternoon. Temperatures throughout the evaluated area were cooler than the comfort range recommended by ASHRAE for summer months (74 to 81°F), but were within the comfort range recommended by ASHRAE for winter months (69 to 76°F). It is most appropriate to use the winter range, because clothing worn by the occupants was most similar to the ASHRAE-typical clothing for winter.

RH (see Table 3) ranged from 15.0 to 21.2% during the morning, and from 18.0 to 23.3% during the afternoon measurement periods. Throughout the evaluated area, RH was lower than the %RH range recommended by ASHRAE. However, the outdoor RH during the day of the investigation was low, less than 25%.

Results of microbial analysis of bulk samples are presented in Table 4. The filter from the small desk fan (sample 1) was relatively clean microbiologically (5,300 colony-forming units per gram [CFU/g]), with a few different mold spores. Mold species detected were *Penicillium, Cladosporium, Aspergillus*, and *Alternaria*. The cheese cloth (sample 2) from the ceiling diffuser was likewise fairly clean, with a relatively small amount of yeasts. Compared to mold spores, yeasts are less able to become airborne in large numbers, and have not been reported to cause significant respiratory problems. Both *Penicillium* and *Ulocladium* are common saprophytic environmental molds, and are not uncommon in indoor environments. Because of the lack of environmental criteria for these types of samples, it is difficult to draw conclusions from the identification of these microbes in the ventilation system and from the offices. Although it is not uncommon to find microbial growth when drip pans do not drain properly, it is not desirable to have large reservoirs of microbial growth in the drip pans of AHUs.

Table 5 presents the results of VOC air sampling. Toluene was detected in low concentrations throughout the offices (0.01 ppm). A sample collected in the manufacturing area that was analyzed qualitatively showed toluene to be the VOC in the greatest abundance. Sample 3, which was collected on the second floor of the 700 building, had low levels of n-hexane (0.08 ppm) and 1,1,1-trichloroethane (0.07 ppm). These were the two compounds detected in the greatest abundance in a qualitative air sample from the Graphics Department, which was near the area in which sample 3 was collected. Indoor levels of these VOCs, although very low, were higher than the outdoor concentrations of the same compounds. While the presence of these VOCs at such low levels does not constitute a health hazard, they could be a source of irritation for some building occupants.

Table 6 contains the results of air sampling for acid gases. Hydrochloric acid (HCl), the only acid detected in either air sample, was present in very small amounts; however, since HCl was detected in the two field blanks in nearly the same amounts (these amounts were between the Limit of Detection (3 micrograms [μg]) and the Limit of Quantitation (10 μg) for this acid), the amount of HCl in the samples can be considered zero.

Air flow measurements for the supply diffusers and return vents for the HVAC system showed that both office buildings were under positive pressure.

VII. CONCLUSIONS AND RECOMMENDATIONS

Some problems with the HVAC system were identified during the NIOSH evaluation. Most of the rooftop AHUs that were inspected had dirt and other debris in the mixed air plenum and/or the condensate drip pan. Also the acoustical liners for most of these AHUs were dirty and/or loose-fitting. Dirty liners, drip pans, and poorly fitting filters may allow microbials to grow in the AHU and potentially be distributed throughout the ventilated area. Although the microbials detected in this investigation are saprophytic, when they are present in very high numbers they could be a potential source of irritation and illness. It is unclear from the results of microbial sampling in this investigation whether microbial concentrations were sufficiently large to cause health effects.

On the ground floor of the 700 building, carpeting near a drinking fountain had been flooded two times prior to this investigation due to water fountain overflow. Microbial analysis of bulk samples collected under this carpet showed a proliferation of yeast, probably because the carpet had been wet for some time after the water leaks.

Although the VOC concentrations measured were all very low, the results indicate that the adhesives and other materials used in the Graphics Department can be a source of indoor air pollutants throughout the offices. Another possible source is the manufacturing area. Toluene was detected in all of the air samples collected in both office buildings, and it was detected in the highest abundance in the sample collected in the manufacturing area. It is possible that air from the manufacturing area could be moving into the office area, causing low levels of airborne toluene.

Based on the results and observations of this evaluation, the following recommendations are offered to correct the identified deficiencies and optimize employee comfort.

1. The AHU coils and drip pans should be inspected regularly, especially during the more humid months. The return air plenum should be cleaned as needed. The drip pan should be kept cleared of debris so that it drains properly. The presence of dirt, debris, and pooled water within the HVAC system presents a potential for microbial growth.

2. The carpeting on the first floor of the 700 building, which was flooded, should be replaced. After carpeting has been flooded it is very difficult, if not impossible, to effectively clean or prevent microbial growth from recurring.

3. All of the rooftop AHUs should be able to draw in outside air. One of the AHUs inspected during this investigation did not have an outdoor air damper.

4. Acoustical liners in the AHUs should fit tightly. Filters should have a good seal with the filter framework to reduce or eliminate filter bypass.

5. A no smoking policy should be instituted throughout the building to prevent employee exposure to environmental tobacco smoke (i.e., "second-hand smoke"). Until this goal of a smoke-free environment is achieved, an alternative is to provide a smoking room that has a dedicated exhaust system so that tobacco smoke is exhausted directly outside the building and is not allowed to recirculate.

6. Because all of the AHUs should be equipped to bring outside air into the building, an outside air damper should be installed on the AHU on the 700 side of the building that lacked this capability.

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1. Assistant to the President, Patio Enclosures, Macedonia, Ohio
2. OSHA, Region V

For the purpose of informing affected employees, 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

Mean CO_2 Concentrations (parts per million) Throughout the Workday
Patio Enclosures, Inc.
Macedonia, Ohio
November 6, 1991
HETA 91-0394

	I	II	III	IV
700 1st floor*	421	729	642	713
700 2nd floor*	375	704	713	738
720 1st floor*	425	533	546	592
720 2nd floor*	404	525	571	546
700 building**	398	717	677	725
720 building**	415	529	558	569

* Each CO_2 concentration is the average of measurements taken from six different locations on each floor. Measurements were collected at four different times throughout the day. The times are given below.

I	7:05	-	7:55
II	10:35	-	11:25
III	13:10	-	14:05
IV	15:25	-	16:20

** These are average values for each office building throughout the day.

Table 2

Mean Temperatures Throughout the Workday (°F)
Patio Enclosures, Inc.
Macedonia, Ohio
November 6, 1991
HETA 91-0394

	I	II	III	IV
700 1st floor*	71.6	73.9	72.3	73.6
700 2nd floor*	70.6	72.1	72.6	72.7
720 1st floor*	71.2	72.9	73.4	73.3
720 2nd floor*	69.9	72.5	74.7	73.8
700 building**	71.1	73.0	72.5	73.2
720 building**	70.6	72.7	74.1	73.6

* Each temperature measurement is the average of measurements taken from six different locations on each floor. Measurements were collected at four different times throughout the day. The times are given below.

I	7:05	-	7:55
II	10:35	-	11:25
III	13:10	-	14:05
IV	15:25	-	16:20

** These are average values for each office building throughout the day.

Table 3

Mean Relative Humidities Throughout the Workday (%RH)
Patio Enclosures, Inc.
Macedonia, Ohio
November 6, 1991
HETA 91-0394

	I	II	III	IV
700 1st floor*	17.3	19.4	20.5	21.8
700 2nd floor*	16.2	19.4	20.4	21.9
720 1st floor*	16.1	18.1	19.1	20.9
720 2nd floor*	16.6	17.7	18.5	20.3
700 building**	16.7	19.4	20.5	21.9
720 building**	16.4	17.9	18.8	20.6

* Each relative humidity measurement is the average of measurements taken from six different locations on each floor. Measurements were collected at four different times throughout the day. The times are given below.

I	7:05	-	7:55
II	10:35	-	11:25
III	13:10	-	14:05
IV	15:25	-	16:20

** These are average values for each office building throughout the day.

Table 4

Microbial Analysis of Bulk Samples
Patio Enclosures, Inc.
Macedonia, Ohio
November 6, 1991
HETA 91-0394

Sample number and location	Fungi (CFU/g)	Identifications
1- fan filter (small fan used on ground level on 700 side)	5,300	Pen = Clad > Asp = Alt
2- carpet scrapings (ground level on 700 side)	300,000	Yea
3- cheese cloth (from ceiling diffuser on the 700 side)	1,800	Yea > Pen = Ulo = Fus
4- liner for AHU #5 (700 side)	20,000	Pen
5- liner for AHU #4 (700 side)	1,000,000	Ulo = Yea
6- AHU plenum debris (AHU #4 - 700 side)	2,000,000	Yea
7- drip pan debris (AHU #5 - 700 side)	1,000,000	Yea >> Pen > Clad

Abbreviations:

CFU/g = colony-forming units per gram
Pen = *Penicillium*
Clad = *Cladosporium*
Asp = *Aspergillus*
Alt = *Alternaria*
Yea = unidentified yeasts
Ulo = *Ulocladium*
Fus = *Fusarium*

Table 5

Airborne Exposure Concentrations for Volatile Organic Compounds
Patio Enclosures, Inc.
Macedonia, Ohio
November 6, 1991
HETA 91-0394

Sample No.	Location	Time (minutes)	Volume (liters)	n-Hexane (ppm)	1,1,1-TCE (ppm)	Toluene (ppm)	p-DB (ppm)
1	700 1st floor	503	100.6	ND	ND	0.01	0.01
3	700 2nd floor	499	99.8	0.08	0.07	0.01	0.02
4	720 1st floor	479	95.8	ND	ND	0.01	0.01
7	outside on roof	445	89.0	ND	ND	ND	ND
			MDC	0.003	0.02	0.003	0.003
			MQC	0.01	0.07	0.01	0.01

Abbreviations:

1,1,1-TCE = 1,1,1-trichloroethane
p-DB = p-dichlorobenzene
ppm = parts per million
MDC = minimum detectable concentration (for a 100 liter sample)
MQC = minimum quantifiable concentration (for a 100 liter sample)
TWA = time-weighted average
STEL = short-term exposure limit
Ca = potential human occupational carcinogen

Table 6

Airborne Exposure Concentrations for Inorganic Acids
Patio Enclosures, Inc.
Macedonia, Ohio
November 6, 1991
HETA 91-0394

Sample No.	Location	Time (minutes)	Volume (liters)	HF (μg)	HBr (μg)	HNO_3 (μg)	H_2SO_4 (μg)	H_3PO_4 (μg)	HCl (μg)	HCl ppm	HCl mg/m^3
101	Secretary's desk	503	100.6	nd	nd	nd	nd	nd	7	0.05	0.07
102	on the roof	445	89.0	nd	nd	nd	nd	nd	3	0.02	0.03
103	field blank	--	--	nd	nd	nd	nd	nd	7	--	--
104	field blank	--	--	nd	nd	nd	nd	nd	4	--	--

NIOSH/OSHA ceiling limit: 5.0 7.0

Abbreviations:

nd = not detected
HF = Hydrofluoric acid
HBr = Hydrobromic acid
HNO_3 = Nitric acid
H_2SO_4 = Sulfuric acid
H_3PO_4 = Phosphoric acid
ppm = parts per million
μg = micrograms
mg/m^3 = milligrams per cubic meter