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I. SUMMARY

On June 13 and 24, and September 25, 1991, the National Institute for Occupational Safety and Health (**NIOSH**) conducted a health hazard evaluation at the Ohio Civil Rights Commission (**OCRC**) office in the Goodall Complex, Cincinnati, Ohio. This health hazard evaluation was conducted in response to an employer request to investigate the cause of employee complaints of poor indoor air quality.

An investigation, conducted on June 13, 1991, included a physical inspection of the air handling units located above the ceiling in the second floor west, third floor east, and third floor west; a walkthrough of the second, third, and fourth floors; and a review of drawings and specifications for the air handling system. One bulk sample of insulative liner was collected from the inside of the air handling unit on third floor west for microbiological analysis. During that visit, five of the eight OCRC investigators present on the day of the visit, two management, and two clerical personnel were interviewed. Questionnaires inquiring about health and comfort symptoms experienced while in the building were distributed during the follow up visit on June 24, 1991.

During the June 24, 1991 investigation, carbon dioxide concentrations, temperature, and relative humidity were measured in six locations inside the building. Measurements of outdoor conditions were made as well. Six rounds of sampling were conducted. Carbon dioxide concentrations rose from a mean of 366 ppm prior to the employees' arrival to a mean of 638 ppm in the afternoon. Temperatures ranged from 69.9 °F to 75.3 °F, with a mean of 73.0 °F. Relative humidity measurements ranged from 51.5% to 75.5%. Mean relative humidity was 66.3%. Sterile gauze pads were used to collect surface wipe samples for analysis of fungi. Sampling for bioaerosols was conducted at various locations in the OCRC offices using an Andersen two-stage viable cascade impactor. On September 25, 1991, a second round of sampling for bioaerosols was conducted as described above.

The results of interviews and questionnaires revealed that over half the employees have experienced symptoms such as nasal congestion, headaches, or eye irritation while in the building. These symptoms were more frequent for employees on the third floor and on fourth floor west. These symptoms had improved since changes to the ventilation system increased the outside air flow, but were still considered a problem by some employees. A major concern of many employees was the high humidity chronically present in the building during the late spring, summer and early fall. Many workers reported that they would set the thermostat control at as low a temperature as possible in an attempt to decrease the humidity.

This evaluation found excessive humidity in the office space, water- damaged carpet, signs of water incursion through walls and around windows, and deficiencies in the ventilation system. The filters for the outside air supply fit poorly and could allow dust from the outside to go around the filters and thus permit entrance of organic material into the air handling system. Significant moisture blowby of the cooling coils was also observed. Evidence of prior flooding was noted in one of the air handling units. Thus the system had moisture and nutrients within it that could allow microbial growth on the porous insulation or other surfaces within the ventilation system. In

addition, signs of exuberant microbial growth (yeast, etc.) were found on portions of the airhandler insulation. Microbial air sampling did not detect large amounts of viable airborne organisms within the building at the time of sampling, but did detect occasional colonies of thermophylic actinomycetes, a type of organism well documented to be capable of producing allergic respiratory disease when present in sufficient concentrations. There was no clear evidence that the employees' respiratory symptoms were caused by building contaminants. However, the presence of the thermophilic actinomycetes within this building raise concern that these organisms could have been present in higher amounts at other times.

On the basis of the data obtained during this investigation, the NIOSH investigators did not find clear evidence that employee respiratory symptoms were caused by building contaminants. However, conditions in the air handling system and building interior which favor microbial growth, such as high humidity, should be corrected. Recommendations are contained in Section VIII.

Keywords: SIC 9441 (Administration of Social, Manpower, and Income Maintenance Programs), indoor air quality, bioaerosols, thermophilic actinomycetes

II. INTRODUCTION

On June 13 and 24, and September 25, 1991, the National Institute for Occupational Safety and Health (**NIOSH**) conducted a health hazard evaluation at the Ohio Civil Rights Commission (**OCRC**) office in the Goodall Complex, Cincinnati, Ohio. This health hazard evaluation was conducted in response to an employer request to investigate the cause of employee complaints of poor indoor air quality. An interim letter dated September 4, 1991, reported the results of the June 13 and 24 visits. The results of air, surface wipe, and bulk sampling for microorganisms, which were not available at that time, are presented in this report.

III. BACKGROUND

The OCRC moved to its present location in 1985. The Commission leases three floors of an office building which was newly renovated when occupied. The OCRC investigates complaints of civil rights violations. Conduct of these investigations requires investigators to spend a portion of their time out of the office. There are 25 employees, six male and 19 female. The heating, ventilating and air-conditioning (**HVAC**) system is maintained by the building management and serviced by a contractor. Smoking is not permitted in the Commission's office space pending the completion of a smoking lounge.

Complaints began following water leaks from condensate pans in the air handling units on third floor east and third floor west beginning in August, 1990. These leaks resulted in damp carpeting in these areas. The carpeting remained damp for about three weeks prior to being cleaned and treated. Prior to this investigation, indoor air quality surveys had been performed by a private consultant on February 21 and March 11, 1991, and on two occasions by the Ohio Industrial Commission, the most recent of which was on March 14, 1991. The private consultant found,"...a slightly elevated level of carbon dioxide (1000 ppm) in the building," and concluded that employee complaints were most likely the result of, "...the intake of kitchen grill and deep-frying fumes, vapors and gases" from the exhaust of a restaurant located on the ground floor of the building. On his second visit, the Ohio Industrial Commission industrial hygienist found that switching the operation of fans in the air handling units from thermostat-based cyclical operation to constant operation resulted in carbon dioxide concentrations from 300 to 800 parts per million, a reduction from the concentration of 1000 ppm found by the private consultant.

A physician with the Occupational Health Clinic at the University of Cincinnati Medical Center evaluated three employees after the leak. As a result of this evaluation, the physician stated that, "It is my opinion that there is no question but that there are problems with indoor air pollution in the facility." The physician recommended that, "...further air testing be done and also that cultures be done for total fungal counts, colony counts, and bacteria."

IV. MATERIALS AND METHODS

A. INDUSTRIAL HYGIENE EVALUATION

The environmental portion of the indoor air quality investigation conducted on June 13, 1991 included a physical inspection of the air handling units located above the ceiling on second floor west, third floor east, and third floor west, a walkthrough of the second, third, and fourth floors, and a review of drawings and specifications for the air handling system. In addition, one bulk sample of insulation discolored by a white powdery substance was collected from the insulation lining the inside of the air handling unit on third floor west.

On June 24, 1991, carbon dioxide concentrations, temperature, and relative humidity were measured in 6 locations inside the building. Measurements were made outside the building as well. Six rounds of sampling were conducted, the first beginning at 6:30 a.m., followed by subsequent sampling rounds beginning at 8:27 a.m., 9:38 a.m., 11:27 a.m., 1:33 p.m., and 2:42 p.m. Carbon dioxide was measured using a Gastech RI 411 carbon dioxide monitor (Gastech, Inc., Newark, CA) calibrated before and after the day's samples were collected using 800 parts per million (**ppm**) carbon dioxide in nitrogen (Alphagaz, Division of Liquid Air Corporation, Cambridge, MD) as a calibrant. Temperature and relative humidity were measured using a Vaisala HM 34 humidity and temperature meter (Vaisala Oy, Helsinki, Finland). Sterile gauze pads were used to collect surface wipe samples for analysis of surface fungi. Samples were collected from the following locations: return air grilles on third floor west, a return air grille on third floor east, and a supply diffuser on third floor east.

On June 24, 1991, sampling for bioaerosols was conducted at various locations in the OCRC offices using an Andersen two-stage viable cascade impactor at a flow rate of 28.3 liters per minute (**lpm**). The 50 percent effective cutoff diameter for the Andersen sampler is eight micrometers (**µm**); hence, larger, nonrespirable particles are collected on the top stage and smaller, respirable particles are collected on the bottom stage. Standard Plate Count and Malt Extract agars were used for the enumeration of bacteria and fungi, respectively. The sample plates for bacteria and fungi were incubated at 28 °C. A sampling time of ten minutes was used at each sample location. At one sample location, the office on third floor east with the water-stained carpeting, aggressive sampling was performed in an attempt to aerosolize and collect viable particles from water stained areas.[†] Sampling locations included:

Second floor east (on file cabinets by copier)
Third floor west (in office with water stained carpet)
Third floor east (in office with water stained carpet)
Fourth floor east (conference room center)
Fourth floor west (conference room center)
Third floor east (aggressive sampling in office with water stained carpet)
Second floor west (center of hall formed by partitions)
Outside (Fourth floor fire escape landing, as a control)

[†] Aggressive sampling means collecting samples while two NIOSH investigators stomped around on the water-stained carpeting attempting to aerosolize viable particulates.

At each location, two samples were collected for bacteria and two samples were collected for fungi with the exception of second floor east, where one sample was collected for bacteria, and one sample was collected for fungi. Outside, three samples were collected for each bioaerosol.* Temperature and relative humidity were also recorded for each sample collection period.

On September 25, 1991, a second round of sampling for bioaerosols was conducted as described above. The sample plates for bacteria were incubated at 55 °C to promote the growth of thermotolerant bacteria (specifically, thermophilic actinomycetes). The sample plates for fungi were incubated at 28 °C. A sample time of ten minutes was used at all sample locations. Sampling locations included the following:

Fourth floor west (conference table)
Fourth floor east (conference table)
Third floor west (center of round table in empty office)
Third floor east (on table in office with water stained carpet)
Outside (on the fourth floor fire escape landing, used as a control)
Second floor west (center of room)
Second floor east (on top of file cabinets by copier)

For each location, four samples were collected for thermophilic bacteria and two samples were collected for fungi with the exception of second floor east, where only two thermophilic bacteria samples, and no fungal samples were collected. No aggressive sampling was performed. Temperature and relative humidity were recorded for each sample collection period.

B. MEDICAL EVALUATION

At the time of the initial site visit on June 13, 1991, there were ten investigators, three supervisors, two managers, and seven clerical personnel employed in the office which occupied the second, third, and fourth floors of the building. During that visit, five of the eight investigators present on the day of the visit, two management and two clerical personnel were interviewed. Questionnaires inquiring about symptoms experienced while in the building were distributed during the follow up visit on June 24, 1991.

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed from eight to ten hours a day, forty hours a week, for a working lifetime without experiencing adverse health effects. However, it is important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience

* When referring to sampling for bioaerosols, the word sample denotes two plates, one top, and one bottom. Thus, one sample equals two plates, two samples equals four plates, and so on.

adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substance may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled to the level set by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, thus potentially increasing the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the work place are: 1) NIOSH Criteria Documents and Recommended Exposure Limits (**RELs**), 2) the American Conference of Governmental Industrial Hygienists' (**ACGIH**) Threshold Limit Values (**TLVs**), and 3) the US Department of Labor, Occupational Safety and Health Administration (**OSHA**) Permissible Exposure Limits (**PELs**).[1-3] The OSHA PELs may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; in contrast, the NIOSH-recommended exposure limits are primarily based upon the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing those levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA PEL.

A time-weighted average exposure level (**TWA**) refers to the average airborne concentration of a substance during a normal eight to ten hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from brief high exposures.

A. Indoor Air Quality

A number of published studies have reported high prevalences of symptoms among occupants of office buildings.[4-8] 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 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. 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.[9,10] Among these factors are imprecisely defined characteristics of heating, ventilating, and air-conditioning (HVAC) systems, cumulative effects of exposure to low concentrations of multiple chemical pollutants, odors, elevated concentrations of particulate matter, microbiological contamination, and physical factors such as thermal comfort, lighting, and noise.[11-16] 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.[17,18] However, rates lower than these amounts appear to increase the rates of complaints and symptoms in some studies.[19,20] 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.[21]

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.[22-24] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[24-27]

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 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.[1-3] 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.[28-29] 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.[30]

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), and temperature and relative humidity, is useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems. The basis for the measurements made in this investigation are presented below.

1. Carbon Dioxide (CO_2)

   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 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.[28]

   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.

2. 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.[29]

B. Microbial Aerosols

Neither NIOSH nor OSHA has developed recommendations or standards for airborne microbial contamination. NIOSH investigators have in the past, through work addressing airborne microbial contamination in office buildings, suggested that a level of viable microorganisms in excess of 1000 colony forming units per cubic meter of sampled air (**CFU/m^3**) indicates that the indoor environment may be in need of further investigation and possible improvement. This level does not differentiate between the different classes of microorganisms (i.e., bacteria or fungi). However, levels above this do not indicate that the air is unsafe or hazardous. The presence of work-related illness can only be determined by epidemiological or medical studies.[31]

Even though microbiological contamination is not thought to be a common cause of health complaints, it can result in a potentially severe health condition known as hypersensitivity pneumonitis. This respiratory problem can be caused by bacteria, fungi, protozoa, or microbial products that may originate in contaminated ventilation system components. A similar condition known as humidifier fever is also the result of microbiological contamination of ventilation systems.

The Committee on Bioaerosols of the ACGIH has developed guidelines for the assessment and sampling of saprophytic bioaerosols in the indoor environment.[30**] These guidelines indicate that straightforward remedial action can resolve most problems where visible microbial contamination is evident. Because most microbial contamination problems in office environments have been associated with moisture incursion problems in heating, ventilating, and air conditioning (**HVAC**) systems, remedial actions have focused on elimination or control of these moisture problems. In previous NIOSH investigations, microbiological contamination has been found to have resulted from water damage to carpets or furnishings, or from standing water in ventilation system components.

The question of significant risk is difficult to assess for any bioaerosol. Where infectious agents are involved (e.g. *Legionella*), some information is available on bacterial levels in reservoirs that have been associated with outbreaks of disease.[30] However, for the majority of organisms likely to be recovered during routine air and source sampling, very little is known about potential health effects. Usually it is possible only to establish whether or not an unusual exposure situation exists with respect to other environments.[30] Therefore, in cases where air sampling for microorganisms is warranted, NIOSH investigators typically utilize a sampling strategy based upon comparison of complaint to non-complaint and/or outdoor air environments.

VI. RESULTS

A. ENVIRONMENTAL

The heating, ventilating, and air-conditioning (**HVAC**) system for the second, third, and fourth floor of the Goodall Complex consisted of six constant air volume (**CAV**) air handlers, supply and return duct work, and thermostat controls (one thermostat per unit). The air handlers are made up of fan and condenser-coil units located above the suspended ceiling.

There are two air handlers per floor, one located above and serving the eastern half of the floor, the other located above and serving the western half of the floor. Design specifications noted on architectural drawings call for units in the eastern portion of the building to provide 200 cubic feet per minute (**cfm**) of outside air, and units in the western portion of the building to provide 150 cfm of outside air. Based on the CO_2 sampling results of a previous indoor air quality investigation, which indicated a need to increase the amount of outdoor air, fans in the units run constantly. Each of the air handlers is designed to have the outside air and return air filtered. Filters are scheduled to be changed every three months. Building management had recently installed charcoal-impregnated filters in the air handlers. These did not fit properly on the units inspected. The outside air intake

**Saprophytic organisms live on dead or decaying organic matter.

for the second floor, west, is ten feet from the exhaust outlet of a restaurant, resulting in a "greasy" odor in that portion of the building. This intake was relocated during the course of this investigation.

Physical inspections were performed on three units: second floor east, and third floor, east and west. A muddy sediment was present in the condensate trough in the unit on second floor east. A flashlight beam shone through the air down stream from the cooling coil showed that a fog of water droplets was being carried over from the coil. Patchy white and brown areas were present on the insulative liner of the fan box, possibly indicating the presence of microbial growth. The unit on third floor west had a water line on the outside of the fan housing, showing that the unit had flooded in the past, and a white, powdery substance on the insulation lining the fan box. The unit on the third floor east also showed some evidence of microbial growth in the form of discolored insulation.

During the walk through, areas where the sub-floor had buckled (perhaps due to moisture) were noted, as was evidence of water leaks around some of the windows and on the carpeting underneath both of the air handling units on the third floor.

The results of CO_2 monitoring performed on June 24, 1991, are presented in table 1. Carbon dioxide concentrations rose from a mean of 366 ppm prior to the employees' arrival to a mean of 638 ppm for the round of sampling beginning at 1:33 p.m. These results indicate that carbon dioxide levels remained below the ASHRAE recommended limit of 1000 ppm.[28] However, the number of occupants present during each round of sampling should be noted. If the HVAC system is performing to design specifications (200 cfm of outdoor air for the eastern portion of the building and 150 cfm of outdoor air for the western portion), compliance with ASHRAE guidelines of 20 cfm of outdoor air per person would limit the number of occupants in the eastern portion of each floor of the building to ten, and the western portion of each floor to seven.[28] These results also demonstrate that in situations where occupant density is low, the concentration of CO_2 may not be an accurate index of overall indoor air quality.

Temperature and relative humidity levels are presented in table 2. Temperatures ranged from 69.9 °F to 75.3 °F, with a mean of 73.0 °F. The low temperature on the fourth floor west in the late afternoon was the result of employees lowering the thermostat setting in order to decrease the relative humidity. Relative humidity measurements ranged from 51.5% to 75.5%. The mean relative humidity was 66.3%. Again, the low relative humidity on fourth floor west in the afternoon was the result of the employees' action. In the afternoon, the relative humidity outside of the building was as much as 37 percent lower than it was inside. The mean temperature and relative humidity measurements indicate that these values (which result in a dewpoint temperature, estimated from a psychrometric chart, of approximately 61 °F) are within the limits of the ASHRAE thermal comfort chart (figure 1).[29] However, relative humidity in excess of 70% is beyond the summer boundaries of the chart, as well as the boundaries recommended by ASHRAE 62-1989 of 30 - 60%.[28,29] Therefore relative humidity should be reduced.

The levels of fungi in the wipe samples were low or undetectable. Based upon these results, there is no evidence of any significant fungal colonization on these surfaces. The insulation sample from the lining of the air handler on third floor west, on the other hand, had a significant microbial load (1,000,000 CFU/gram). The predominant microbial species were yeasts rather than molds. These results suggest that a level of moisture sufficient to support microbial growth was present at this site. Whether there is any particular risk associated with this situation is difficult to determine from these results; although, compared to mold spores, the yeast would tend to be less able to become airborne in large numbers.[32]

The results of air sampling for microorganisms performed on June 24, 1991 showed no evidence of any significant indoor reservoirs of bacteria or fungi. No evidence of any microbes that might constitute a significant health risk were detected. Outdoor air samples, collected at three different times, resulted in a mean total fungal count of 273 CFU/m3. *Cladosporium* is generally the most common fungal species found in outdoor air, and was also the most prominent fungal species identified in these outdoor samples. Also common were *Alterneria* and *Epicoccum*, as well as smaller numbers of *Penicillium* and *Chrysosporium*. A significant concentration of yeasts were detected on the bacterial media at two of the sites. In general, the mold species identified were quite typical of outdoor air. The mean outdoor bacterial count was 77 CFU/m^3. The presence of Gram positive cocci (i.e. *Staphylococcus* and *Micrococcus* species) is typical of airborne bacteria. Gram- negative rods (i.e. *Pantoea agglomerans*), generally observed as water-borne organisms, were present as well.[33]

The indoor fungal counts were low when compared to the outdoor concentrations (less than one third of the outdoor levels). The highest fungal counts were observed for the aggressive samples taken in the third floor east office with the water stained carpet; however, the species were qualitatively similar to outdoor air. For the majority of the indoor sites, *Cladosporium* was the most common fungi found. However, *Chrysosporium*, *Epicoccum*, *Chaetomium*, and *Penicillium* were the prominent species on a select few of the sample plates. These select sample plates do not qualitatively conform to the results from the outdoor samples. Nevertheless, the numbers were still very low and not indicative of any significant indoor reservoirs.[33]

The indoor bacterial concentrations did not appear significantly different from the outdoor concentrations. In indoor environments, considerable intra-day and inter-day variation in concentrations of airborne bacteria is common and generally reflects the influence of human activity in the area that could contribute human source bacteria (usually Gram-positive cocci) from skin and other body sites, rather than a building-related reservoir. The prominence of Gram negative rods (i.e. *Pantoea*, *Enterobacter* and *Klebsiella*) in some of these samples is somewhat atypical, but not totally unexpected considering the presence of Gram negative rods in the outdoor air samples.[33]

The sample results for thermophilic bacteria from September 25, 1991, indicated low concentrations of *Thermoactinomyces* present in all of the sampled locations with the exception of the third floor east, second floor east, and outside. These low concentrations, ranging from 4 to 7 CFU/m^3 were the result of one or two colonies observed on a sampling plate. While *Thermoactinomyces* were found only on indoor samples, the appearance of only one colony on an agar plate are not typical of levels which have been implicated in cases of hypersensitivity pneumonitis. However, actinomycetes (both mesophilic and thermophilic) are unusual in a nonfarm, indoor environment, and their presence indicates the need for remedial action.[30] *Bacillus* species (normal soil-borne, spore-forming bacteria) were detected in very low amounts in most of the outdoor samples and a few of the indoor samples, probably as a result of airborne dust containing bacterial spores.[34]

Outdoor fungal samples showed relatively low total counts of only 136 and 114 CFU/m^3. *Cladosporium*, generally the most common fungal species found in outdoor air, was also the most prominent fungal species identified in these outdoor samples. Also detected were smaller numbers of *Penicillium*, *Chrysosporium*, *Aspergillus*, and a few unidentified fungi and yeasts. In general, the fungal species identified were typical of outdoor air.[34] Indoor fungal counts were qualitatively similar to the outdoor counts, with a predominance of *Cladosporium*. However, quantitatively, two of the sample sites (fourth floor east and third floor west) had concentrations higher than those found outdoors (189 and 193 CFU/m^3, respectively), while three samples collected on fourth floor west, and one sample collected on fourth floor east approximated outdoor concentrations. The results of sampling at the remaining sampling sites were less than one third of the outdoor concentrations. The significance of the elevated fungal levels is difficult to determine. While they were greater than one third of the outdoor concentrations, the numbers were low in absolute terms. Considering the temporal and spatial variations inherent in indoor air sampling, along with the absence of any additional data suggesting a contaminated source, these elevated concentrations may have resulted from inefficient filtering of outside air by the air handling units.[34]

B. <u>MEDICAL</u>

The interviews done during the first visit revealed that high humidity within the office space is a significant employee concern. The humidity was reported to be high during the cooling season, especially following a heavy rain or when the outside humidity is elevated. Several employees pointed out areas on the south walls of the west wings of the third and fourth floors that showed signs of chronic water leaks. Employees also described a three week period during August, 1990 in which water constantly dripped out of diffusers in the east and west wings of the third floor causing the carpets under the two diffusers to remain wet for the duration of the episode. The water leak was reportedly the result of problems with the condensate drain lines from the air handlers in both wings of the third floor.

Odors were reported to episodically appear in the west wing of the fourth floor. The odor is most commonly described as a "locker room smell" and seems to appear during times of high humidity. Employees reported that the carpeting near the door to the fire escape on the fourth floor west occasionally became wet during rainy weather due to water leaks under the door.

Three interviewed employees (and reportedly one other former employee) have experienced severe asthma-like symptoms associated with their presence in the building. An occupational physician who evaluated three of these employees felt that there were unidentified exposures within the building that exacerbated the symptoms of these employees and that they should be transferred to another office. This physician also recommended that the OCRC offices be evaluated for the presence of airborne fungi and bacteria. At the time of the survey, the symptoms of the three had improved after the provision of additional fresh air or a change in work station location had been implemented.

Ten OCRC investigators, two supervisors, two management, and two clerical employees participated during the initial visit interviews and/or completed the questionnaires distributed during the second visit. These 16 workers reported experiencing the following symptoms when in the building: Seven with nasal congestion or irritation, six with headaches, six with eye irritation, four with episodic shortness of breath, three with lightheadedness, three with throat irritation, two with severe fatigue, two with impaired ability to concentrate, and two with nausea. The symptoms were most severe and frequent for occupants of four west and both wings of the third floor.

VII. CONCLUSIONS

The request was prompted by chronic complaints of many workers regarding concerns about the indoor environmental quality and specific severe respiratory symptoms experienced by four employees. Over half the employees reported experiencing symptoms such as nasal congestion, headaches, or eye irritation. These symptoms were more frequent for employees on the third floor and on four west. These symptoms had improved since the outside air flow in the ventilation system was increased, but they were still considered a problem by some employees. A major concern of many employees was the high humidity chronically present in the building during the late spring, summer and early fall. Many workers reported that they would set the thermostat control at as low a temperature as possible to attempt to decrease the humidity.

The occupational physician treating three of the individuals with respiratory symptoms felt that their symptoms could be caused by contaminants within the Civil Rights Commission offices and advised a thorough environmental evaluation including an assessment of the possible presence of microorganisms. NIOSH interviewed three employees with a history of specific respiratory symptoms that were compatible with allergic reactions. All three reported their symptoms were exacerbated by presence within the Goodall building offices. A comprehensive environmental evaluation of the offices by NIOSH found excessive humidity in the office space, water damaged carpet, signs of water incursion through walls and around windows and significant deficiencies in the ventilation system. The filters for the outside air supply fit poorly and could allow organic dust from the outside to go around the filters and thus allow entrance of organic nutrients into the air handling system. Significant moisture blowby of the cooling coils was also observed. Thus the system had moisture and nutrients within it that could allow microbial growth on the porous insulation or other surfaces within the ventilation system. In addition, evidence of past flooding was found in one air handling unit and signs of exuberant microbial growth (yeast, etc.) were found on a portion of the insulation. Microbial air sampling did not detect large amounts of viable airborne organisms within the building at the time of sampling, but did detect occasional colonies of thermophylic actinomycetes, a type of organism well documented to be capable of producing allergic respiratory disease when present in sufficient concentrations. There was no clear evidence that the employee respiratory symptoms were caused by building contaminants. However, the presence of the thermophilic actinomycetes within this building, which had demonstrated conditions favorable for microbial growth in the air handling system and in the offices (high humidity and water damaged carpet), raise concern that these organisms could have been present in higher amounts at other times. It is not uncommon that organisms such as actinomycetes bloom only intermittently in an indoor environment and low airborne concentrations over only a two day period do not suggest that they are never present in harmful concentrations.

In situations where moisture incursions have occurred, it is generally advised that moisture-damaged furnishings be replaced and the conditions that allow moisture incursion be corrected. Therefore, it would be advisable for the water-damaged rugs on the third and fourth floors to be replaced and the leaks in the walls repaired. In addition, the deficiencies in the ventilation system that caused high office humidity and conditions favorable for microbial proliferation in the air handling system should be addressed.

VIII. RECOMMENDATIONS

The following recommendations may help to reduce complaints related to indoor environmental conditions:

1. Replace the charcoal-impregnated filters with the filters recommended by the air handling units' manufacturer. Change the filters according to the manufacturer's recommendations.

2. Replace porous insulation lining the fan boxes of the air handling units with non-porous insulation. Porous insulation, moisture, and a carbon source, such as organic dust from outside air, are good conditions for the proliferation of microbes. Consult the manufacturer for recommendations regarding selection of a non-porous insulating material.

3. Clean the coils and condensate troughs/pans on a regular basis, according to the manufacturer's recommendations. The cleaning should be conducted on a yearly basis at a minimum.

4. High relative humidity and water carryover from the coils may be the result of excess cooling capacity in the system. Although the fans run constantly, the compressor does not, and it may not cycle with enough frequency to dehumidify the air. Carryover of water from the coils may be the result of excessive fan speeds. Persistent high relative humidity contributes to the growth of microorganisms on damp surfaces. Consult the air handling units' manufacturer regarding the cause and solution of the high humidity.

5. Remove and replace water-damaged carpeting. This is generally recommended in situations where water damage has occurred. Water-damaged materials often support microbial growth long after they appear dry, and dead materials (antigens, spores, toxins, and irritants) may remain in such materials for years. Carpet

cleaning is rarely effective in removing microbial contamination. Overuse of disinfectants can cause additional problems for occupants.[30]

6. Determine the cause of water incursions around windows and make necessary repairs to prevent it from recurring.

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3. Building Services Manager
4. Department of Administrative Services, State of Ohio
5. OSHA, Region V
6. NIOSH

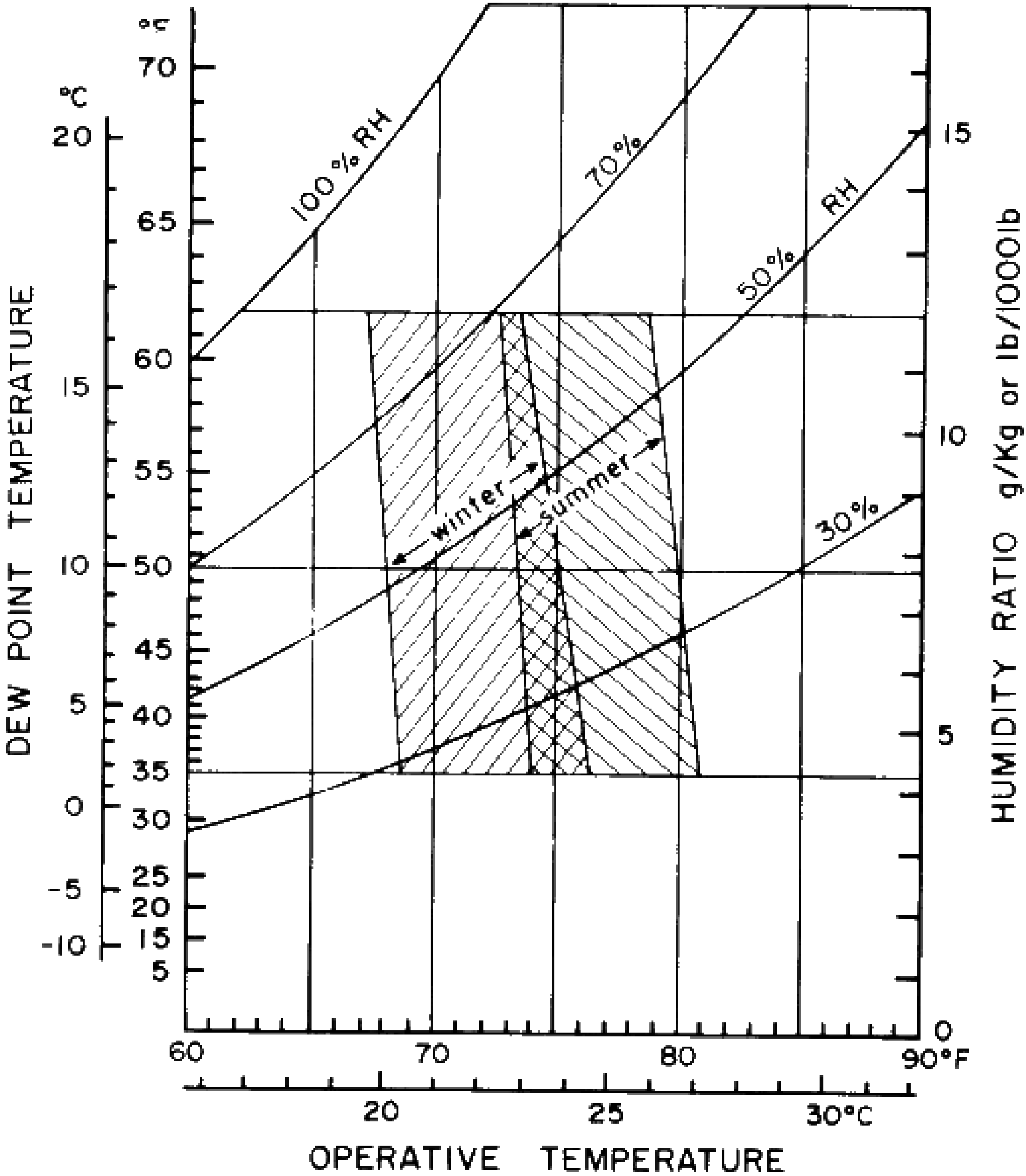
For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1
Carbon Dioxide Concentrations
Ohio Civil Rights Commission, Goodall Complex
Cincinnati, Ohio
June 24, 1991
HETA 91-257

Location	Carbon Dioxide Concentration (parts per million)						Occupants Present					
Round:	1	2	3	4	5	6	1	2	3	4	5	6
2E	400	575	650	725	800	775	0	5	6	4	5	5
2W	375	425	450	525	675	675	0	1	2	2	1	2
3E	375	425	500	550	625	625	0	2	2	0	2	3
3W	350	450	500	625	625	-	0	3	4	3	1	2
4E	350	375	475	525	525	-	0	1	1	3	2	1
4W	350	425	500	575	575	-	0	4	3	2	2	3
Outside	350	300	300	350	350	-	-	-	-	-	-	-

Table 2
Temperature and Relative Humidity
Ohio Civil Rights Commission, Goodall Complex
Cincinnati, Ohio
June 24, 1991
HETA 91-257

Location	Temperature (degrees Fahrenheit)						Relative Humidity (percent)					
Round:	1	2	3	4	5	6	1	2	3	4	5	6
2E	72.3	73.2	72.7	74.2	74.5	71.6	69.5	73.5	60.3	68.8	69.2	64.9
2W	72.6	----	72.2	73.9	75.1	73.3	62.9	----	63.2	61.0	63.0	65.8
3E	72.1	----	73.8	73.0	74.8	73.4	64.7	----	69.6	66.2	67.5	65.6
3W	72.0	----	74.1	73.3	75.3	74.1	66.5	----	60.0	63.0	59.4	61.9
4E	70.9	----	73.3	72.3	74.6	70.6	72.5	----	70.0	66.5	65.0	75.5
4W	71.0	----	73.6	73.2	73.3	69.9	72.4	----	69.4	72.9	74.5	51.5
Outside	71.4	----	77.7	81.4	85.7	----	76.4	----	62.6	51.5	46.9	----



°F
°C
DEW POINT TEMPERATURE
70
65
60
55
50
45
40
35
30
25
20
15
5
20
15
10
5
0
-5
-10
100% RH
70%
50% RH
30%
winter
summer
HUMIDITY RATIO g/Kg or lb/1000lb
15
10
5
0
60
70
80
90°F
20
25
30°C
OPERATIVE TEMPERATURE