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I. SUMMARY

On September 14-16, 1992, investigators from the National Institute for Occupational Safety and Health (NIOSH) conducted a Health Hazard Evaluation (HHE) at the National AIDS Program Office (NAPO) located in the Hubert H. Humphrey Federal Building, Washington D.C. The investigation was performed in response to a request from NAPO staff regarding concerns of health hazards relating to water damage from an uncapped sewage pipe above the NAPO area. The request stated that contractors had removed a section of sanitary drain pipe, which resulted in an overflow of water into the ceiling plenum and the collapse of the ceiling. According to the request, carpeting and building furnishings were contaminated with sewage and a health hazard was believed to exist. Repairs were initiated before the NIOSH investigation took place but water damaged building materials and furnishings were still in evidence.

A NIOSH physician conducted interviews with affected employees. A walkthrough survey of the NAPO and the adjoining Corridor G area was conducted, and the heating, ventilating, and air conditioning (HVAC) system was evaluated. Bulk samples for microbial analysis were collected from areas within the HVAC system. Anderson cascade impactors were used to sample for bioaerosols in occupied areas of the NAPO and in areas outside of the building.

Results of air sampling for bacteria revealed that there was no significant difference in samples from indoor versus outdoor locations. Bacterial culture plates showed a random distribution of gram positive organisms normally found in areas of human occupancy (*Staphylococcus* and *Micrococcus*), as well as a variety of ubiquitous soil/water gram negative bacteria (*Pseudomonas* and *Vibrio*). None of the organisms identified were associated with building-related illness.

Fungi collected indoors consisted predominantly of *Cladosporium*, with lesser numbers of *Penicillium*, *Alternaria*, *Aspergillus*, and yeasts. *Alternaria* was the predominant genus in outdoor samples, with lesser numbers of *Cladosporium*, *Aspergillus*, and *Epicoccum*. Outdoor sampling results were similar with those obtained indoors, with the exception of small numbers of yeast colonies appearing on selected plates.

At the time of the investigation, definitive cases of building-related illness were not identified in the Humphrey Building. The condition of certain components of the HVAC system (condensate drain pans in AHUs 7 & 8) and the presence of drip collection pans in the return air plenum suggest the need for increased maintenance to avoid conditions favorable for microbial growth and amplification. Recommendations are provided in this report for making the necessary repairs to the building, removing moisture sources from air handling plenums and cleaning and repairing certain components of the HVAC system.

KEYWORDS SIC 9431, 9199 (Administration of Public Health Programs, General Government, Not Elsewhere Classified), bioaerosols, bacteria and fungi, HVAC systems, indoor environmental quality, building-related illness.

II. INTRODUCTION

On September 14-16, 1992, investigators from the National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation (HHE) at the National AIDS Program Office (NAPO) to evaluate building occupant exposure to bioaerosols (airborne bacteria and fungi). The NAPO is located in the Hubert H. Humphrey Federal Building in Washington D.C. A request for an HHE was submitted to NIOSH by the NAPO on August 28, 1992.

The NAPO has a staff of 9 people and is one of many federal offices within the Humphrey Federal Building. The building is constructed of concrete and consists of eight floors with a parking garage located beneath the building. The building was partially completed in 1975 when the Department of Health and Human Services (DHHS [previously the Department of Health, Education and Welfare]) began occupancy. Initially, the building was configured in an open-space layout with corridors (A through H) arranged on each floor. The building is now configured with offices arranged throughout the eight corridors.

On September 14, 1992, an opening conference was conducted where NIOSH investigators presented an overview of the HHE program and discussed plans for an initial investigation of the NAPO (Room 738G). Immediately following the opening conference, a walkthrough familiarization was conducted in the NAPO, the general area of corridor G, and in sections of the heating, ventilating and air conditioning (HVAC) system which serve the NAPO. Because building sewage was reported as a possible contaminant, an evaluation was conducted for the presence of bioaerosols using Anderson cascade impactors, high flow sampling pumps and appropriate culture media. Bulk samples of water stained ceiling tiles, carpeting, peeling paint, water damaged wallboard and stagnant water from drip collection pans found in the ceiling plenum areas were also collected. The investigative team consisted of two NIOSH industrial hygienists, a NIOSH research microbiologist, and a NIOSH physician. The NIOSH industrial hygienists and microbiologist conducted the building investigation and performed air sampling while the NIOSH physician conducted personal interviews with NAPO staff to obtain information pertinent to possible health effects that were experienced by staff members.

III. BACKGROUND

The Hubert H. Humphrey Federal Building has a history of investigations related to complaints of poor indoor environmental quality (IEQ). NIOSH has conducted at least three prior HHEs in the building in the years 1980 (HHE 80-108-762) and 1981 (HHE 81-267); neither of these HHEs documented any building-related illness. However, NIOSH investigators conducting HHE 82-168-1302 (April, 1983) described a hypersensitivity pneumonitis-like syndrome believed to be associated with water leaks in the building. Investigators conducting HHE 82-168-1302 reported that the problem was not associated with the HVAC system, as was reported to be the case in previous investigations by NIOSH. The 1983 investigation outlined specific recommendations regarding corridor 7B and the need to remove and discard carpeting and ceiling tiles and clean wall partitions and furniture using a high efficiency particulate aerosol (HEPA) vacuum. The report also suggested that structural changes be made in corridor 7B, which at that time was directly below commercial dishwashers located in the cafeteria, which were reported to be a source of water contamination in the building.

According to an August 14, 1992, memorandum sent to NIOSH from the NAPO Assistant Director, the ceiling in Room 738G collapsed from water released from an uncapped sewage pipe recently serviced by building contractors. The correspondence mentioned that a four foot section of sewage pipe running through the ceiling plenum in the NAPO had been removed by building contractors who believed the pipe to be "dead," that is, that the pipe was not in use. The pipe had existed in that condition for a number of years. The memorandum stated that water would occasionally back up in the pipe but lacked sufficient pressure to overflow. When the four foot section of pipe was removed, the hydraulic pressure needed for an overflow was reduced and on the date of the reported incident, hot water and what was described by NAPO staff as sewage, "gushed from the ceiling...during the thirty minutes" that this event took place. Staff concerns regarding possible health effects associated with microbiological contamination in Room 738G prompted the request for an investigation by NIOSH.

The main building HVAC system for the Humphrey Federal Building is computer-controlled, and the system operates on the principal of constant air volume (CAV). Sensible heat provided by lights, office equipment and occupants permits the building to operated in a constant cooling mode. Cooling is accomplished by a centrifugal chiller located in the penthouse which supplies chilled water to central and peripheral cooling coils for each floor. According to building maintenance personnel, 22 air handlers provide ventilation to the building. Supply air is delivered to office spaces through slotted diffusers mounted on the sides of lighting. If heat is needed, reheat coils are located in main air supply ducts serving each floor. Slotted return air ducts are located around light fixtures in office areas and a common ceiling return air plenum is used.

Because this investigation was specific to the NAPO area and corridor G, the air handling units (AHUs) serving this space were inspected. Outdoor air intakes and HVAC equipment are located in a rooftop penthouse. Louvered grilles and pneumatically operated parallel vane dampers control the intake of make-up air. Air filtration is accomplished with a dual system of flat polyester filter panels and extended-media polyester bag filters. The filters were estimated to have an efficiency of approximately 40% based on American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE Standard 52.1) criteria.

IV. METHODS

Following the opening conference and walkthrough evaluation, a visual inspection of sections of the HVAC system serving the NAPO was conducted by the NIOSH investigators. Because previous investigations by NIOSH and private contractors indicted that possible microbiological contamination had occurred, and in this case water damage was a known factor, identification of biological contamination was the central focus of the building study.

Sampling for bioaerosols was performed at selected locations in the NAPO, other locations in the HHB and outside of the building. Airborne fungi and bacteria were sampled using an Andersen 2-stage viable cascade impactor calibrated to a flow rate of 28.3 liters per minute (lpm). The Andersen two-stage sampler has a 50% effective cutoff diameter for particles of 8 micrometers (µm) and smaller. Larger, non-respirable particles are collected on the top stage and the smaller, respirable fraction are collected on the bottom stage. An Andersen single-stage impactor also calibrated to a flow rate of 28.3 lpm was used for the collection of thermophilic actinomycetes (TA). The Andersen single-stage viable cascade impactor is designed to collect particles 0.65 µm and larger. A sample time of 10 minutes was used at all sample locations with three sample runs per location. A sample run included simultaneous sampling of airborne fungi, bacteria, and TA's.

Standard Plate Count and Malt Extract agars were used for the enumeration of bacteria (including TA's) and fungi, respectively. The sample plates for fungi and bacteria were incubated at 30°C, while those for TA were incubated at 55°C. Fungi and TA were examined visually and identified on the basis of morphology. Bacteria were subcultured and identified using the Microlog™ identification system (Biolog Inc., Hayward, CA.).

To characterize indoor environment comfort and ventilation parameters, temperature, relative humidity (RH) and airborne carbon dioxide (CO_2) levels were monitored in the NAPO and several adjoining offices in the G corridor. Temperature and RH measurements were made using a battery-operated, hand-held Vaisala™ HM 34 temperature and RH meter. A Gastech™ Model RI-411A portable CO_2 monitor was used to measure CO_2. Measurements were made on both days in NAPO office areas and the G corridor.

AHUs 7 & 8 were inspected to characterize the HVAC system design, determine position of make-up air intakes dampers, and to evaluate filtration and overall system integrity. Wherever possible, portions of supply ductwork serving the seventh floor were accessed via maintenance hatches in the penthouse and inspected for the presence of microbial contamination.

A NIOSH occupational medicine physician interviewed occupants on the first and the second days of the investigation. Interviews were conducted with nine employees currently working in the affected area of the building. Because not all staff were able to be contacted during the time of the investigation, follow-up interviews were conducted for six employees via telephone in the days following the investigation. Interviewed employees were selected by a supervisor, or self-selected as having a desire to talk with the medical officer. The physician obtained information regarding medical symptoms and diagnoses, health concerns, past medical history and workplace hygienic concerns from the employees.

V. EVALUATION CRITERIA

A number of published studies have reported high prevalences of symptoms among occupants of office buildings.[1-5] 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 .[6,7] Among these factors are imprecisely defined characteristics of HVAC systems, cumulative effects of exposure to low concentrations of multiple chemical pollutants, odors, elevated concentrations of particulate matter, microbiological contamination, and physical factors such as thermal comfort, lighting, and noise.[8-13] 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.[14,15] However, rates lower than these amounts appear to increase the rates of complaints and symptoms in some studies.[16,17] 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.[18]

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.[19-21] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[21-24]

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 specific cause of the reported health effects could be determined.

Chemical or biological 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.[25-27] With few exceptions, pollutant concentrations observed in the office work environment fall well below these published occupational standards or recommended exposure limits. The 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]

Generally speaking, 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 of contamination, or a proven relationship between a contaminant and a building-related illness. However, measuring ventilation and comfort indicators such as 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.

A. Carbon Dioxide (CO_2)

Measuring airborne concentrations of CO_2, a normal component of exhaled air, is a practice employed in indoor environmental investigations to characterize the degree of dilution ventilation supplied to a building. Dilution ventilation refers to the amount of fresh, outside air, which is being supplied to a building. CO_2 is a normal constituent of exhaled breath and, if monitored, can be used 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 outdoor CO_2 concentration of 300-350 parts per million (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.

B. Temperature and Relative Humidity

The perception of thermal comfort is related to an individual'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 will find the environment thermally comfortable.[29] The thermal comfort range specified by Standard 55-1981 is between 68°F and 74°F in winter months and between 73°F and 79°F in summer months. For RH, the comfort range according to ASHRAE is 30% to 60%.

C. Microbiological

Microorganisms (including fungi and bacteria) are ubiquitous in the ambient 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 adequate supply of water and nutrient substrate. Under the appropriate conditions (optimum temperature, pH, sufficient moisture and available nutrients) saprophytic microorganism populations can become amplified. Through various mechanisms, these organisms can be disseminated as individual cells or in association with soil/dust particles or water droplets. 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, where there is no unusual source of microorganisms, the level of microorganisms may vary somewhat as a function of the cleanliness of the HVAC system, amount of outdoor air supplied to the space, as well as 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.[31,32]

Some individuals manifest increased immunologic responses to antigenic agents encountered in the environment. These responses, and the subsequent expression of allergic disease are based partly on genetic predisposition.[33] Allergic diseases typically associated with exposures in indoor environments include allergic rhinitis (nasal allergy), allergic asthma, allergic bronchopulmonary aspergillosis (ABPA), and extrinsic allergic alveolitis (hypersensitivity pneumonitis).[31] The first three (allergic rhinitis, allergic asthma, and ABPA) are associated with the presentation of IgE antibodies. Extrinsic allergic alveolitis appears to be a cell mediated response and may involve other antibody-dependent mechanisms (other than the production of IgE antibodies). Allergic respiratory diseases resulting from exposures to microbial agents have been documented in agricultural, biotechnological, office, and home environments.[34,35,36,37,38,39,40,41]

Symptomology vary with the disease: (A) allergic rhinitis is characterized by paroxysms of sneezing, itching of the nose, eyes, palate, or pharynx; nasal stuffiness with partial or total airflow obstruction and rhinorrhea with postnasal drainage. (B) classic symptoms of allergic asthma are characterized by wheezing, cough, and dyspnea (shortness of breath). The underlying pathophysiology of asthma involves reversible airflow obstruction due to combinations of mucosal inflammation and edema, bronchial smooth muscle contraction, and thick, sticky mucous secretion. (C) ABPA is characterized by the production of IgE and IgG antibodies with symptoms of cough, lassitude, low grade fever, wheezing, and occasional expectoration of mucous containing fungal elements.[31,42] Heavy exposures to airborne microorganisms can develop into an acute form of extrinsic allergic alveolitis which is characterized by chills, fever, malaise, cough, and dyspnea appearing 4 to 8 hours after exposure. In the chronic form, thought to be induced by a continuous low-level exposure, onset occurs without chills, fever, or malaise and is characterized by progressive shortness of breath with weight loss.[43]

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, relationships between health effects and environmental microorganisms must be determined through the combined contributions of medical, epidemiologic, and environmental evaluation.[44] The current strategy for on-site evaluation involves a comprehensive inspection 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). In certain situations, air samples for microorganisms may be collected to document the airborne presence of a suspected microbial contaminant. Airborne dissemination (characterized by elevated levels in the complaint area, compared to outdoor and non-complaint areas, and anomalous ranking among the microbial species) correlated to occupant symptomatology, may suggest that microbial contaminants are responsible.

VI. RESULTS & DISCUSSION

A. Bacteria

A graphical summary of the results of bioaerosol sampling of bacteria and fungi is presented in Figure I. The mean bacterial count at various locations inside and outside of the building ranged from 8 to 35 colony forming units per cubic meter of air (cfu/m^3). An analysis of variance (ANOVA) was performed on the means of all inside and outside bacterial samples. No significant differences ($\alpha = 0.05$) were found among the mean values (p-value >0.05). Speciation of bacterial sample plates showed a random distribution consisting primarily of gram positive microorganisms (*Staphylococcus* and *Micrococcus*), which are normally found in association with human occupancy (i.e. desquamated skin). Also identified was a variety of ubiquitous soil/water gram negative bacteria (*Pseudomonas* and *Vibrio*). Although none of these bacterial species have been implicated as a causative agent of hypersensitivity pneumonitis or other building related illness, if amplified and disseminated as bioaerosols, some of them may pose a hazard to individuals whose specific and non-specific defenses are otherwise compromised. The mean percentages of bacteria in the respirable range were between 17 to 60%. Two colonies of TA were detected in a sample from Room 721G.

B. Fungi

The mean fungal count at various locations inside and outside of the building ranged from 23 to 623 cfu/m^3. Using ANOVA techniques, statistically significant differences ($\alpha = 0.05$) were observed between the samples collected outside (on the roof) and the indoor sample locations (p-value <.001). However, no significant differences ($\alpha = 0.05$) were found among the samples taken inside the building (p-value > 0.10).

The percentage of fungal particles in the respirable range was higher than that observed in the bacterial samples, with mean values ranging from 54 to 92%. The taxonomic rank (i.e. taxa ranking, refers to the relative abundance of each "taxa" or group of organisms) was similar among the samples collected outdoors and indoors, in the non-complaint and in the complaint areas. On the bottom stage of the sampler (respirable particles), the counts consisted predominantly of *Cladosporium* colonies with lesser numbers of colonies of *Penicillium*, *Alternaria*, *Aspergillus*, and yeasts. On the top stage of the sampler (non-respirable particles), *Alternaria* was the predominant genus in outdoor samples, with lesser numbers of *Cladosporium*, *Aspergillus*, and *Epicoccum*. These results were similar with those obtained indoors, with the exception of small numbers of yeast colonies appearing on selected plates. Observation of the taxonomic ranking does not indicate significant amplification of fungal species that have typically been associated with health effects (i.e., *Aspergillus*, *Penicillium*, *Sporobolomyces*, *Alternaria*, etc.).[44] In order to provoke immunologic responses in susceptible individuals, microorganisms must be present in sufficient quantities in the environment (reservoir), capable of growth (amplification), and then dispersed as an aerosol so that exposure occurs in the susceptible individual (dissemination).[45]

C. <u>Bulk Samples</u>

Analytical results of bulk samples collected in the HHB are also presented in Table 1. In samples collected from AHUs AC-7 and AC-8, the fungal content consisted predominantly of unidentified yeasts at concentrations ranging from 1×10^8 to 1×10^9 colony forming units per gram of material (CFU/gm). Bacteria (predominantly gram-negative *Pseudomonas* species) and fungi concentrations found in the AHUs were essentially similar in terms of absolute numbers. Bacterial concentrations in the bulk samples collected from the condensate pans were 2×10^7 (AC-7) and 1×10^6 (AC-8). The data indicate relatively high concentrations of yeast and gram-negative bacteria. Generally, this is characteristic of microbial proliferation due to extremely moist conditions. The condensate pans were dry when the samples were collected but a considerable buildup of dried material was found in the pans. The accumulated material suggests that during the cooling season, water was not draining adequately from the pans and the pans were not cleaned. The sample from the ceiling tile in Corridor B presented similar results as a result of water damage. Fungal concentrations of 2×10^8 CFU/gm (predominantly yeasts) and bacterial concentrations of 2.5×10^8 (predominantly *Pseudomonas*) were observed. Samples obtained on the outside of a fan coil window unit indicated high concentrations of fungi 6.6×10^7 (predominantly *Penicillium*) and 1×10^9 (*Cladosporium*). The remaining bulk samples contained small numbers of bacteria and unidentified yeast species. Levels of microbiological contamination in AHUs AC-7, AC-8 and the window fan coil unit indicate a reservoir for microbials. However, air sampling results do not suggest that dissemination of bioaerosols is a hazard to staff in the areas that were sampled.

D. <u>Temperature and Relative Humidity</u>

Temperature measurements made during the two days of investigation ranged from 75°F to 80°F, in the NAPO area and the corridor G area. Average temperature in the NAPO was 78°F. RH in the NAPO ranged between 45% and 52%. Average combined temperature and relative humidity (operative temperatures) measured in the NAPO area were within the ASHRAE 62-1989 guidelines for thermal comfort for summer conditions.

E. Carbon Dioxide Measurements

Instantaneous measurements of airborne CO_2 measured in the afternoon of the first day of the investigation ranged in concentration from 425 ppm to 525 ppm. Average concentrations measured 475 ppm. On the morning of the second day of the investigation average concentrations measured 550 ppm and were the same when measured in the early afternoon of the same day. The measurements suggest that adequate amounts of outdoor air are being provided to the NAPO space. However, on the days of the investigation the space did not appear to be fully occupied throughout the day. The ASHRAE guidelines for ventilation to maintain $CO_2 < 1000$ ppm are based on occupancy levels of seven people per 1000 square feet.

F. Medical Evaluation

The symptoms employees most commonly associated with working in the NAPO were: (1) Chronic sinus congestion or drainage; (2) dry, tired or strained eyes; (3) nonproductive cough; (4) headaches; (5) dry or sore throat; and (6) unusual fatigue or tiredness. Medical symptoms were generally worse in employees reporting a personal history of asthma or environmental allergies.

The most commonly reported employee concerns regarding their workplace were: (1) Mold or mildew collecting on air vents; (2) continued exposure to cigarette smoke; (3) temperature variations in the office such as, too hot or too cold; (4) perceptions of lack of air movement at certain times of the day, especially late afternoon and early morning; and (5) associating the building environment with symptom etiology (cause). The chronic passive exposure to workplace cigarette smoke is a source of concern for non-smoking employees. According to NAPO management, the Humphrey Building has been declared a smoke-free environment. However, during the investigation, NIOSH investigators observed smoking occurring in perimeter offices of the building which have windows, and in offices of the basement maintenance areas.

G. HVAC Inspection, AHUs 7 & 8

The outside air dampers for AHUs 7 & 8 were found to be partially open on the day of the investigation. The top row of damper vanes were open, all other rows were shut. Damper linkages for both air handling units were inspected and found to be intact. Pre-filters and bag filters on both units were found to be clean and installed correctly. Accumulations of pigeon feathers and debris were found trapped on the outside air intake screen. Evidence of filter bypass (dust streaking) was not immediately visible on the filter housing or on the upstream side of the coils. However, larger debris (including pigeon feathers) was found on the floor of the fan room in both AHU's 7 & 8 and in the condensate pan on AHU 8. The coils had visible signs of rust at their bases which is likely due to age and high summer humidity. The condensate pans were dry but all were found to contain considerable amounts of accumulated debris which appeared as a "biomat" or an agglomeration of biological growth that was desiccated. A dry white film was found in upper pans. These conditions indicate a lack of maintenance. A tear was found in the vibration isolation coupling connecting the AHU-7 supply fan motor to main supply air ducting. This condition could result in partial loss of duct pressure and diminished system capacity to provide supply ventilation. The fan motors had adequate machine guarding on fan belts and pulleys. Sections of duct work which were accessible via maintenance hatches were found to be free of microbial growth but rust was very noticeable on screws inside the ductwork. This suggests high moisture levels were present in the ducting at one time.

VII. CONCLUSIONS

There was obvious water damage in the NAPO. Stained ceiling tiles and peeling paint (unrepaired water damage) in corridor G confirmed a history of previous water leaks originating from the eighth floor. The presence of water collection drip pans (with fresh water irrigation and drain lines plumbed to some of these pans), and a Clorox® bottle wired in place in the ceiling plenum indicate that water leakage into occupied areas of the seventh floor has existed, apparently unabated, for some time.

While there are no published standards for increased risk of disease with indoor exposure to bacteria and fungi, air sampling results from this investigation do not indicate significant levels of airborne bacteria or fungi that would constitute an increased health risk for occupants of the NAPO. While individual hypersensitivities (allergies) predispose certain individuals to increased illness, this will vary unpredictably among individuals and may be seasonal, rather than a building-related problem.

As a general comparison, indoor concentrations of molds and bacteria should be one-third of outdoor levels when outdoor air is the only source of airborne flora.[46] In this investigation, indoor air concentrations of bacteria were essentially equal to outside air concentrations. Taxonomic ranking of fungi were found to be similar in indoor versus outdoor air (predominant species *Cladosporium*, *Penicillium* and *Alternaria*). Indoor bacteria were primarily *Pseudomonas*, which was found in outdoor air, and *Staphylococcus*, which are normal flora on human skin.

Bulk samples taken from material in the condensate pans and ceiling tile, suggest the presence of high numbers of microorganisms. Large numbers of yeasts ($>1 \times 10^9$ cfu /gram) were present in some of the bulk samples taken from the condensate pan downstream of the coils on AH-7 and AH-8, the AH-7 upper condensate pan, and a corridor B ceiling tile sample. It is important to note that while bulk sample results indicate the presence of microbiological contamination in building materials and a "reservoir effect," air sampling results do not indicate that bioaerosols are being dispersed into occupied spaces and creating a health hazard.

Building-related illness source causality is often ambiguous and difficult to characterize. Occupant perceptions of the quality of indoor environments are often more closely related to the occurrence of symptoms than any measurement of indoor contaminants. At the time of the investigation, definitive cases of building-related illness were not identified in the Humphrey Building, although the condition of certain components of the HVAC system (condensate drain pans in AHUs 7 & 8) and the presence of water collection pans in the return air plenum indicate the need for increased attention to maintenance to prevent conditions favorable for microbial growth, amplification, and dissemination.

VIII. RECOMMENDATIONS

1. The source of all water leaks into the NAPO and corridor G should be identified and repaired. All water damaged carpet, furnishings and building materials should be removed. The drip pans which were discovered in the ceiling return air plenums should all be removed. These pans represent a "contamination by design" situation. They are a potential source of standing water in the building return air plenum. Aside from the obvious problem of water overflow (which apparently already occurred when the Clorox® bottle became full and overflowed, shorting out a FAX machine) the pans provide a location for the growth, amplification and possible dissemination of microbiological contamination into the building ventilation system.

2. The screens installed at the penthouse make-up air intakes should be cleaned of debris (such as pigeon feathers) and inspected for cleanliness on a weekly basis or at the minimum, a monthly basis.

3. All condensate pans should be cleaned of accumulations of debris in AHUs-7 and 8. Cleaning should be done when the HVAC system is not in operation. Workers should avoid creating dust by using wet methods to clean the accumulated dry debris in the pans. Workers should wear respiratory protection consisting of high efficiency particulate aerosol (HEPA) filters and adequate skin and eye protection. After all debris is removed, the pans should be sanitized using a sodium hypochlorite 1-5% aqueous solution. A clear water rinse should follow cleaning. Hypochlorites are good disinfectants and have a relatively low order of toxicity and skin irritation potential. The angle of tilt on the condensate pans should be checked with the use of a hand level. If sufficient tilt (to allow drainage when clear water is poured in the pan) is not confirmed, the slope of the pans should modified to allow adequate condensate drainage. An operations and maintenance schedule should be developed and followed regarding HVAC maintenance. The fan room floor should be cleaned of any existing debris and keep free of dirt and debris which could become entrained into the building supply air stream.

4. The rubber isolation coupling on the AH-7 supply fan should be replaced.

5. Consideration should be given to having workers with chronic or worsening symptoms evaluated by a single physician with training in the diagnosis and treatment of occupational illnesses. This may be the DHHS employee health physician or another physician. This physician could evaluate the employees' medical conditions, discuss the work-relatedness of the symptoms, and assess the employees' ability to perform their duties. A workplace exposure is one of a number of possible explanations for symptoms reported during the medical interviews. In those employees with underlying asthma or allergies, it is important that environmental controls be used to eliminate sources of moisture and mold growth in their work areas.

6. NIOSH recommends that workers should not be involuntarily exposed to tobacco smoke. Workplace exposure to environmental tobacco smoke (ETS) is most efficiently and completely controlled by eliminating tobacco use from the workplace. The Surgeon General has concluded that tobacco smoke is a human carcinogen and an important risk factor for heart disease. Evidence is now clear that the health risk from inhaling tobacco

smoke is not limited to only the smoker, but also those who inhale ETS. Recent epidemiological studies of non-smokers exposed to ETS have shown an increased relative risk for lung cancer compared with nonsmokers. In addition, ETS exposure in nonsmokers may be associated with an increased risk of heart disease.[47]

The best methods for controlling worker exposure to ETS are to restrict smoking in the workplace, initiate a smoking cessation program, establish incentives to encourage workers to stop smoking and distribute information about health promotion and the harmful effects of smoking. The current DHHS non-smoking policy should be followed by all employees, contractors and visitors in the building. This smoke-free environment declaration should be carried out and enforced consistent with the current policy.

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