HEALTH HAZARD EVALUATION REPORT

HETA 92-0374-2402
SOCIAL SECURITY ADMINISTRATION
RICHMOND, VIRGINIA

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 2, 1992, the National Institute for Occupational Safety and Health **(NIOSH)** received a request from the American Federation of Governmental Employees **(AFGE)** Area 6 Coordinator to conduct a Health Hazard Evaluation **(HHE)** at the Social Security Administration **(SSA)** Office in Petersburg, Virginia. The requestor stated that over the past 2 years employees and the public have complained of high relative humidity and breathing problems, burning eyes, and lack of air-conditioning.

On January 13 to 14, 1993, NIOSH investigators conducted a site visit at the Petersburg, Virginia, SSA Office. This visit included an environmental evaluation and physical inspection of the heating, ventilating, and air-conditioning **(HVAC)** system; measurement of carbon dioxide **(CO_2)**, temperature, and relative humidity **(RH)**; airflow measurements of the air supply and return to the HVAC system; and analysis of bulk samples from the HVAC air handling unit **(AHU)** for microbial contamination.

Based on visual inspection, of the HVAC unit servicing the SSA offices, there is a need to improve the preventive maintenance program. The interior of the AHU mixed air plenum had an abundance of visible microbiological growth, and the pneumatic linkage for the return air damper was disconnected. Subsequent, analysis of bulk material samples collected from the AHU mixed air plenum confirmed the presence of an abundance of fungi and bacteria. The present filter system is a fiberglass roll filter, which is less than 20% efficient based, on the American Society of Heating, Refrigerating, and Air-Conditioning Engineers **(ASHRAE)** dust spot criteria.

Airflow measurements collected at 113 of 121 slot diffusers in the light fixtures ranged from 18 cubic feet per minute **(cfm)** to 89 cfm, in some cases the measured airflow volume was less that 50% (e.g., 81 cfm vs. 27 cfm) of the adjacent slot diffusers. These differences suggest that the HVAC may not properly balanced. This can result in poor air distribution and may contribute to thermal comfort complaints. All temperature measurements exceeded the ASHRAE thermal comfort range for winter months (64°F to 74°F). During the midday sample period all CO_2 measurements exceeded 800 parts per million **(ppm)** and some exceeded the ASHRAE ceiling recommendation of 1,000 ppm.

Environmental sampling revealed temperature and CO_2 concentrations in excess of the ASHRAE recommendations. Also, bulk material samples collected within the AHU mixed air plenum revealed the existence of an abundance of fungi and bacterial colonies. The recommendations included in this report focus on the implementation of an aggressive and effective HVAC system maintenance program, and further evaluation of the current ventilation system for possible improvements in the building's temperature and humidity control and the provision of outside air.

KEYWORDS: SIC 9441 (Government Offices), indoor environmental quality **(IEQ)**, carbon dioxide, fungi, bacteria, ventilation.

II. INTRODUCTION

On September 2, 1992, the National Institute for Occupational Safety and Health (**NIOSH**) received a request from the American Federation of Governmental Employees (**AFGE**) Area 6 Coordinator to conduct a Health Hazard Evaluation (**HHE**) at the Social Security Administration (**SSA**) Office in Petersburg, Virginia. The requestor stated that over the past 2 years employees and the public have complained of high relative humidity and breathing problems, burning eyes, and lack of air-conditioning.

On January 13 to 14, 1993, NIOSH investigators conducted an environmental site visit at the Petersburg, Virginia, SSA Office and on February 2, 1993, an interim report with preliminary recommendations was sent to the Petersburg SSA management, Post Office personnel, and the AFGE Area 6 Coordinator.

The SSA Offices are located within the Petersburg Post Office building. The Post Office leases space to the General Services Administration, which sublets the space to the SSA. The Post Office was built in 1932, and is constructed of brick. The southern half of the building is three stories and the northern half is two stories. The SSA offices are located in the basement (or ground floor level) in the northern half of the building. The SSA has occupied this space since about 1970. The SSA Office, arranged primarily as an open space layout, provides space for 27 workers and occupies approximately 6,000 square feet. Smoking is not allowed in the SSA work areas.

The main entrance to the SSA offices is located on the east side of the building and leads into a basement corridor. The corridor runs the entire width of the building from east to west and separates the SSA offices from the ground floor Post Office spaces. The second floor (above the SSA offices) is occupied by the Post Office operations including the Post Office loading dock on the north end of the building.

The heating, ventilation, and air-conditioning (**HVAC**) system serving the SSA offices is a direct digital control (**DDC**) system and is designated as HVAC #5. The HVAC #5 is dedicated to the space occupied by the SSA offices, with the exception of one space occupied by the post office maintenance and supply area, which has one air supply duct and no air return grill or ducting.

Supply air is provided to the SSA office through slot diffusers in the light fixtures (troffer units). Two air return grills, 2 feet by 2 feet, are located on the north wall. The system has only one thermal sensor, located in the center of the north wall directly above a return air grill.

III. METHODS AND MATERIALS

An opening conference was conducted at 2:00 p.m. on Wednesday, January 13, 1993. The opening conference was attended by the NIOSH investigators, the SSA District Manager, and the AFGE Area 6 Coordinator for Social Security Employees. Following the opening conference a walk-through inspection of the SSA office areas was conducted. The Petersburg Postmaster and maintenance personnel accompanied the NIOSH investigators. A visual inspection of accessible parts of HVAC #5 was conducted, including the outside air intake, mixed air plenum, filters, heating coils, condenser coils, and condensate pans. Additionally, bulk samples from the mixed air plenum acoustical lining and debris from the condensate pan were collected and sent to a laboratory to be characterized for microbial content.

On Thursday, January 14, 1993, temperature, relative humidity, and carbon dioxide (**CO_2**) measurements were collected in the SSA office areas (please see Figure 1 for sample locations). Airborne CO_2 concentrations were measured using a Gastech direct reading portable CO_2 Monitor (Model RI411), set in the continuous reading mode. The Gastech CO_2 Monitor was calibrated using 800 ppm CO_2 in nitrogen. The air temperature and relative humidity were measured using a hand-held, direct-reading, electronic Vaisala HM34 Humidity and Temperature Meter.

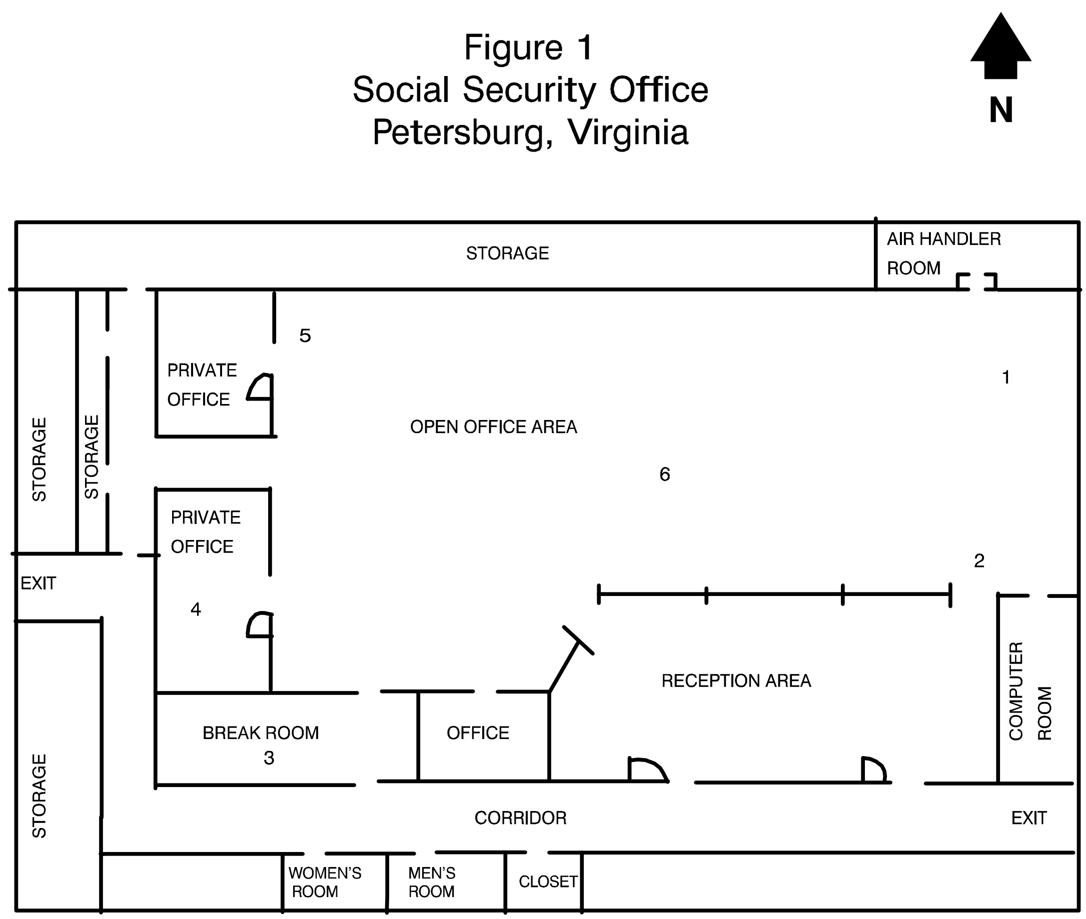
Additionally, airflow measurements were collected at all accessible supply air diffusers and exhausts using a Shortridge (MN 86BP) Flow Hood.

IV. EVALUATION CRITERIA

NIOSH investigators have completed over 1,100 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.

Figure 1
Social Security Office
Petersburg, Virginia



Numbers denote CO_2, temperature, and relative humidity sample locations.

A number of published studies have reported high prevalences of symptoms among occupants of office buildings.[1-5] Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building-related occupant complaints.[6,7] Among these factors are imprecisely defined characteristics of 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.[8-13] Indoor environmental pollutants can arise from either outdoor sources or indoor sources.

There are also reports describing results which show that occupant perceptions of the indoor environment are more closely related than any measured indoor contaminant or condition to the occurrence of symptoms.[14-16] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[16-19]

Less often, an illness may be found to be specifically related to something in the building environment. Some examples of potentially building-related illnesses are allergic rhinitis, allergic asthma, hypersensitivity pneumonitis, Legionnaires' disease, Pontiac fever, 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 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, 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.[20-22] With few exceptions, pollutant concentrations observed in non-industrial indoor environments fall well below these published occupational standards or recommended exposure limits. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (**ASHRAE**) has published recommended building ventilation design criteria and thermal comfort guidelines.[23,24] The ACGIH has also developed a manual of guidelines for approaching investigations of building-related complaints that might be caused by airborne living organisms or their effluents.[25]

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 carbon dioxide (CO_2), temperature and relative humidity, has proven useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems.

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

CARBON DIOXIDE

Carbon dioxide (**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.[23]

Indoor CO_2 concentrations are normally higher than the generally constant ambient CO_2 concentration (range 300 to 350 ppm). When indoor CO_2 concentrations exceed 1,000 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 thermal 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.[24]

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 adequate supply of a nutrient substrate. Under the appropriate conditions (optimum temperature, pH, and with sufficient moisture and available nutrients) saprophytic microorganism populations can be amplified.

Through various mechanisms, these organisms can then 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 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.(27,28)

Some individuals manifest increased immunologic responses to antigenic agents encountered in the environment. These responses and the subsequent expression of allergic disease is based, partly, on a genetic predisposition.(29) 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).(27) The first three (allergic rhinitis, allergic asthma, and ABPA) are considered antibody responses and are associated with the presentation of IgE antibodies. Extrinsic allergic alveolitis appears to be a cell mediated response and/or 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, biotechnology, office, and home environments.(30-37)

Symptomology vary with the disease: (1) allergic rhinitis is characterized by paroxysms of sneezing; itching of the nose, eyes, palate, or pharynx; nasal stuffiness with partial or total airflow obstruction; rhinorrhea with postnasal drainage; (2) allergic asthma is characterized by episodic or prolonged wheezing and shortness of breath in response to bronchial narrowing; (3) 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.(27,38) 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 (shortness of breath) 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.(39)

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.(40) 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 limited 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 symptomology may suggest that the contaminant may be responsible for the health effects.

V. RESULTS

Inspection of the AHU revealed many problems with preventive maintenance of the HVAC. Visual inspection of the acoustical lining of the mixed air plenum suggested the existence of biological growth, and an accumulation of dry scaly debris in the condensate pan. Subsequent laboratory analysis of bulk material samples collected from the condensate pan and acoustical liner confirmed amplification of biological material in the buildings AHU. Additionally, the mechanical linkage for the pneumatic return air damper was disconnected, which may have prevented the proper operation of the AHU.

The filtration system consisted of a fiberglass roll filter, a material which is less than 20% efficient based on the ASHRAE dust spot criteria. These filters are used to keep lint and dust from accumulating on the heating and cooling coils of the system. For general office spaces ASHRAE recommends filters with a dust spot rating of 35% to 60%.[41] Current installations are sometimes as high as 85% efficient.

Airflow measurements at all accessible air supply slots (113 of 121) were collected in the area occupied by the SSA. Airflow measurements in open office spaces, and private offices, ranged from 18 cubic feet per minute **(cfm)** to 89 cfm. In some cases the measured airflow rate, at locations with similar usage and occupant density (e.g., open office spaces), was less than 50 percent (e.g., 81 cfm vs. 27 cfm) of the adjacent slot diffusers. While a test and balance report was not available for comparing these measured airflow rates, the significant differences in side-by-side diffusers suggest an unbalanced system. This condition can result in poor air distribution and a lack of temperature control, and may be responsible for the complaints of thermal comfort. An unbalanced HVAC system can affect the perceived comfort of individuals in the occupied space (i.e., occupants complained of too much airflow while others complained of too little airflow). Adjustment of airflow from the diffusers can improve the system imbalance, but should be done **only** by trained HVAC professionals.

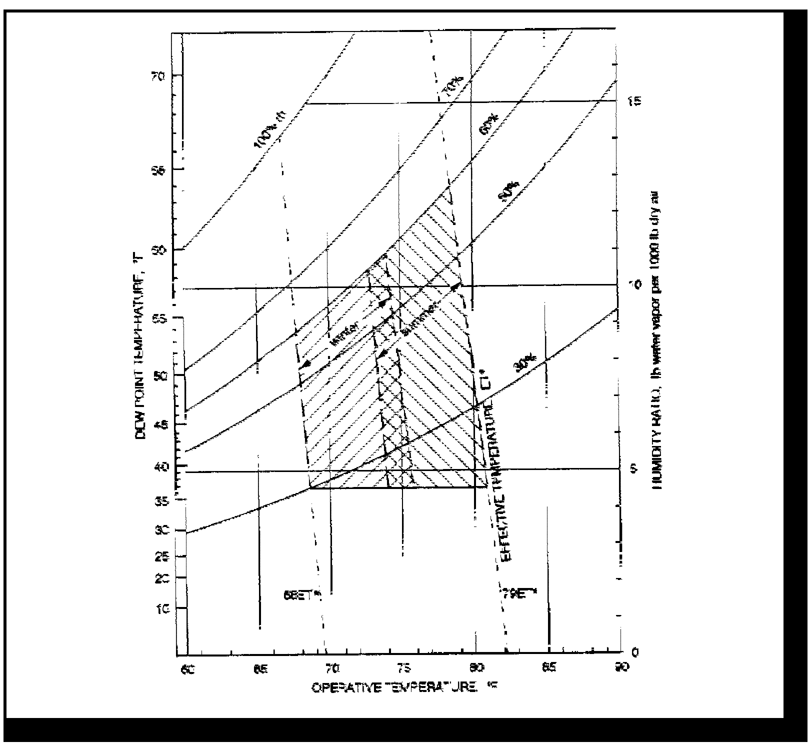


Figure 2. ASHRAE Thermal Comfort Chart.

The results of CO_2, temperature and relative humidity **(RH)** measurements collected at six locations within the SSA offices on Thursday, January 14, 1993, are presented in the table at the right. These data show that temperatures exceed the ASHRAE thermal comfort range for winter months (64°F-74°F), and CO_2 concentrations exceeded the ASHRAE recommendation of 1,000 ppm during the midday sample period at location #2 and the reception area. The outdoor CO_2 concentration was 350 ppm (within the normal range for outdoors).

Table I

January 14, 1993
CO_2 Temperature and Relative Humidity Measurements

Time Period	Ranges		
	CO_2*	Temperature	RH**
7:30 a.m.	575 - 650	76°F-77°F	35%-38%
11:25 a.m.	825 -1125	76°F-78°F	28%-30%
2:35 p.m.	625 - 750	77°F-78°F	26%-30%

The indoor temperatures and RH recommended by the ASHRAE are shown in Figure 2 (thermal comfort chart). This chart specifies the acceptable (at least 90% would be expected to feel thermally comfortable) ranges of operative temperature and humidity for persons clothed in typical summer and winter clothing, performing mainly sedentary activity.[24]

The analytical results of bulk samples collected from the acoustical lining of the AHU mixed air plenum and the condensate pan are presented in Table 2. All of the fungal taxa identified are normal constituents of the environment. The concentrations observed (ranging from 520,000 to 3,400,000 CFU/gm) indicate the presence of flourishing fungal cultures. The predominance of yeast colonies is characteristic of the presence of moisture. While yeasts have not been

Table 2

Microbiological Results of Bulk Samples

Sample Location	Fungi		Bacteria	
	(CFU/gm)	**Taxa Rank**	**(CFU/gm)**	**Taxa Rank**
Mixed air plenum acoustical lining	3,400,000	Pen>Clad	ND	Alc>Cor
Condensate pan	520,000	Yea>>Pen	9,300,000	Xan>Ps>TA

NOTE: Yea = *Yeast*
Pen = *Penicillium*
Cla = *Cladosporium*
Alc = *Alcaligines faecalis*
Cor = *Corynebacterium pdeudodiphtheriticum*
Xan = *Xanthomonas campestris (Gram -)*
Ps = *Pseudomonas avenae (Gram -)*
TA = *Thermoactinomyces*
ND = non-detectable

documented to cause immunologic problems, their existence and the quantity present in this case indicates an environment favorable for the growth of microorganisms. Gram negative **(Gram -)** bacteria were also found in the bulk material sample collected from the condensate pan, which again indicates the presence of stagnant water at some point in time. Gram negative bacteria can produce endotoxins, which have been documented to produce hypersensitivity pneumonitis in some exposed individuals. Although, there are no established criteria regarding "acceptable" concentrations of fungi and/or bacteria in ventilation system interiors, the concentrations observed indicate that there was a microbial reservoir, and amplification in that reservoir was occurring.

Employees were questioned about their perceptions of various environmental conditions on their floor. Informal discussions with employees revealed that environmental concerns about the building included a lack of air movement, detecting cigarette smoke, thermal discomfort, and odors. Reports of employees being too hot or too cold did not appear to be related to one specific work area. This may be due to individual locations in the work area having markedly different conditions than others, possibly due to proximity to the thermal sensor or ventilation ducts (supply or return), or because of improper balance of the HVAC system. The ASHRAE thermal comfort guideline is designed to maintain comfort for 90% of employees.[24]

VI. CONCLUSION

Significant deficiencies in the indoor environment were noted at the Petersburg Social Security Administration (SSA) offices that may be related to both symptoms and comfort complaints. Carbon dioxide levels in excess of the ASHRAE recommendation were observed at some locations in the building, indicating an insufficient amount of fresh air supply (dilution ventilation) to the building at certain times. Visual inspection of the HVAC unit servicing the SSA offices revealed inadequate maintenance of the HVAC unit as evidenced by the disconnected mechanical linkage for the pneumatic return air damper. Additionally, visual inspection of the interior of the AHU mixed air plenum revealed the presence of microbiological growth, subsequent analysis of the bulk material samples collected from the AHU mixed air plenum confirmed the presence of fungi and bacteria (which are of course ubiquitous, but amplified in this AHU).

The air filtration system is a low efficiency fiberglass roll filter. Airflow measurements suggest an unbalanced HVAC system. An unbalanced system can result in poor air distribution and can affect the perceived comfort of certain individuals in the occupied spaces.

VII. RECOMMENDATIONS

The following recommendations were discussed at the closing conference and included in the interim report of February 2, 1993. Subsequent analysis of the bulk material samples support these recommendations.

1. A qualified HVAC firm should be contracted to conduct a mechanical system audit of the HVAC system serving the SSA offices to verify that the system is adequately sized and designed for the current application. The amount of outside air delivered to the

space should be determined and the system adjusted to deliver a minimum of 20 cfm per person of outside air during periods of normal occupancy as specified in ASHRAE 62-1989, Ventilation for Acceptable Indoor Air Quality. If the system is not capable of delivering an adequate amount of outside air the system may be undersized and may need to be reconfigured. The entire HVAC system should also be tested and balanced. A properly balanced system should result in the even distribution of supply air in the occupied space to alleviate thermal comfort problems.

2. The SSA space should be placed under slight positive pressure relative to the outdoor environment and the adjacent Post Office spaces to minimize air from the adjacent spaces from entering into the SSA spaces. The SSA AHU should provide an outside air intake volume which is at least 10% greater than the exhaust air volumes from the area served to achieve this pressure balance.

3. The thermal sensor configuration should be evaluated to determine if additional sensors or temperature averaging sensors would result in increased thermal comfort.

4. Preventive maintenance is a critical component in controlling biological growth in indoor environments. A preventive maintenance plan should address the regular inspection of facilities so that equipment can be maintained such that it does not promote the growth of microbial contamination.

5. The AHU serving the SSA offices and all other AHUs within the building should be inspected and cleaned on a monthly basis. A record of all cleaning performed should be kept and any potential problems corrected.

6. The condenser coil condensate pan should be cleaned and disinfected with a biocide. Based on the results of the microbial analysis, the AHU mixed air plenum acoustical lining (interior) should be removed and replaced, ideally with a new exterior lining. The acoustical lining material is too porous to be effectively cleaned and disinfected. When choosing a biocide to clean and disinfect the interior of the AHU, it is important to consider that biocides are used to kill living cells and can pose health effects if used incorrectly or in improper dilutions. The existence of spores are possible when dealing with molds, therefore, a biocide which also contains a sporicide should be considered (e.g., hypochlorite containing compounds). Sodium hypochlorite is generally supplied as a 1% - 5% water-based solution and has a wide spectrum of biocidal activity. The hypochlorites, when combined with water, form hypochlorous acid and are the most effective at a neutral pH (**pH=7**). Because the potential exists for bioaerosol exposure to individuals involved in the clean-up process, the use of respirators with high efficiency particulate air (**HEPA**) filters is recommended and a respiratory protection program conforming to the guidelines set forth in 29 CFR 1910.134 should be implemented. Additionally, ample ventilation should be provided in all areas when clean-up is underway, and clean-up activities should be performed on the weekend when the building is not occupied and the AHU is inactivated.

7. The disconnected mechanical pneumatic linkage for the return air damper should be repaired and tested to determine that it is in proper working order.

8. The fiberglass roll filter system (<20% efficiency) should be upgraded to the maximum efficiency possible without affecting the HVAC system performance. Some current designs employ filtration systems of 85% efficiency according to the ASHRAE dust spot test.

9. A comprehensive inspection of all AHUs serving the building should be conducted.

10. Communication between management and employees should be increased to facilitate the exchange of concerns about environmental conditions at the building. Employees should be made aware of the problems with the building and decisions made by management to address those problems.

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