HETA 94-0370-2511
HILLSBOROUGH COUNTY SHERIFF'S OFFICE COMMUNICATION CENTER TAMPA, FLORIDA

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.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

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I. SUMMARY

On August 12, 1994, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a Health Hazard Evaluation (HHE) at the Hillsborough County Sheriff's Office in Tampa, Florida, from three employees working in the Communication Center. The employees were concerned that poor ventilation and possible exposure to mold and mildew were causing respiratory symptoms, headaches, and fatigue. NIOSH investigators conducted a site visit on January 4-6, 1995. During the site visit environmental measurements were taken, 26 employees (selected either by the requestors or randomly from employees at work on the day of the evaluation) were interviewed, and a questionnaire was administered to 77 employees of the Communication Center.

The most common symptoms reported on the questionnaire that were experienced more than once a week for the last four weeks that improved when the employees left the worksite (and the symptom prevalence rate) included: irritated eyes (35%); headache (25%); fatigue (25%); and stuffy nose/sinus congestion (25%). From the questionnaire, 56% of the employees reported having frequently experienced one or more such "building-related" symptoms during the four weeks preceding the administration of the questionnaire. These prevalence rates are not very different from what NIOSH has found in similar studies of the indoor, non-industrial environment. During the interviews, employees reported that there was insufficient fresh air at the Communication Center,

and 65% of the employees who completed the questionnaire said that there was frequently too little air movement in the work area.

The measured temperature and relative humidities were within the comfort ranges currently recommended by the American Society for Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE). The measured carbon dioxide (CO_2) concentrations ranged from 400 to 975 parts per million (ppm), below the ASHRAE guideline of 1,000 ppm, but could be further controlled by manipulating the exhaust system. Since the employees are moving into a new building by the end of the year, these changes should suffice until that time. The bulk samples collected from the heating, ventilating, and air-conditioning (HVAC) unit revealed microbial contamination with *Pseudomonas, Flavobacterium, and Moraxella.*species, specifically in and around the standing water found in the humidifier.

Microbial contamination of standing water in the ventilation system, poor housekeeping, and overcrowding were noted in the Communication Center. Microbial contamination in the HVAC system creates the potential for dissemination of bioaerosols from the HVAC system into the occupied spaces. Specific recommendations to improve environmental quality included: (1) increasing the frequency of exhaust cycles for the room, (2) removal of a humidifier from the HVAC system, (3) cleaning or replacing the HVAC system if the room is to be occupied in the future, and (4) improving HVAC maintenance and housekeeping.

SIC 9221 (police protection): indoor environmental quality, carbon dioxide, fungi, bacteria.

II. INTRODUCTION

On August 12, 1994, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a health hazard evaluation (HHE) at the Hillsborough County Sheriff's Office in Tampa, Florida, from three employees in the Communication Center. The employees were concerned that poor ventilation and possible exposure to mold and mildew were causing respiratory symptoms, headaches, and fatigue. A NIOSH industrial hygienist and a medical investigator conducted a site visit on January 4-6, 1995.

III. BACKGROUND AND DESCRIPTIVE INFORMATION

The present Hillsborough County Sheriff's Office building was constructed in 1979 in an urban/commercial area of Tampa, Florida. It is a two-story, brick building that houses all the departments of the county sheriff's office. There is no smoking allowed in the building. The Communication Center (the 911 response and police dispatch operations) occupies one room in the northwest corner of the second floor, which is its original location. It is essentially one 2,452 square foot (ft^2) room and contains one enclosed corner office, one enclosed break room, three enclosed storage and utility rooms, and approximately 29 open workstations. The separate rooms are accessible only through the main Communication Center room. Previously, another enclosed office for secretaries was present along the north wall of the room, but the wall has been removed and the area now houses 4 of the 29 workstations. The only windows are located in the break room, and the workers are free to open them. The room has a raised floor that consists of a metal grid filled with 1.5 ft^2 tiles; about 50% of the tiles are linoleum and about 50% are carpet. The walls are painted wallboard and there are suspended ceiling panels. Primary illumination is

from fluorescent lights in the ceiling and approximately five incandescent lamps used for task lighting. Most of the workstations are plastic veneer systems furniture, but a few are wood veneer conventional office furniture.

There is a central heating, ventilating, and air-conditioning (HVAC) system for this area, located in the southeast corner of the room. It is not enclosed, but there is a partition against the west side of the unit and a smaller one that covers the northwest corner. A smaller partition covers the front right half of the unit, and there is a set of enclosed shelves in front. This HVAC system supplies conditioned air through ten square ceiling diffusers. There are no return vents except on top of the unit itself. In 1991, an old ceiling exhaust fan that was originally intended for use during fire emergencies was converted into an outside air (OA) intake. The rooftop OA intake delivers unconditioned air into the workspace through a ceiling diffuser that is located above the HVAC unit. At about the same time in 1991, another ceiling exhaust, with two ducts into the ceiling, was converted into a daily-use exhaust system. This system was cycled on for three hours and off for five hours each shift. A few weeks before this site visit, the cycle was changed to four hours on and four hours off. During the site visit, the cycle was changed to two hours on and two hours off.

There are 118 employees in the Communication Center including dispatchers, community service officers (CSOs), secretaries, switchboard operators, and supervisors. There are a total of 93 dispatchers, divided into 10 squads of approximately 9 to a squad. On any given shift (day – 7 a.m. - 3 p.m.; evening – 3 p.m. - 11 p.m.; night – 11 p.m. - 7 a.m.) there were 20 dispatchers. On the first day of the NIOSH evaluation, there were 30 people working in the Communication Center on the day shift, 27 on the evening shift, and 21 on the night shift, for a total

of 78 workers. Since the job involved shift rotations that did not necessarily involve weekends, there were approximately 90 different workers who were present over the two days of the evaluation.

Dispatchers in the Communication Center receive all 911 calls for Hillsborough County, judge the severity of the emergency, and route the call for the appropriate response. Incoming calls are handled in three ways: 1) voice contact is made with a dispatcher for emergencies, 2) computer messages are sent for less urgent calls, or 3) a referral is made to the sheriff's office or other appropriate agency for non-emergencies.

IV. EVALUATION METHODS

Medical Evaluation

During the site visit on January 4-6, 1995, interviews were held with 26 employees. These employees were chosen because: 1) they reportedly had experienced symptoms while in the building and wished to talk to the NIOSH investigator or 2) they were randomly selected from employees present at work on the days of the survey. In addition, questionnaires were distributed to all employees present at work on the day of the evaluation. Questionnaires were handed directly to day and evening shift employees at their workstation. The night shift supervisor was given the questionnaires for night shift employees and was instructed on how to distribute the questionnaire. For the day and evening shifts, questionnaires were returned directly to NIOSH investigators; night shift employees were instructed to leave the questionnaire at the supervisor's desk.

The questionnaire asked if the employee had experienced, while at work on the day of the

survey, any of the symptoms (such as eye irritation, nasal congestion, headaches, etc.) commonly reported by occupants of "problem buildings"[1] and symptoms possibly indicative of more serious respiratory problems (such as chest tightness, wheezing, and shortness of breath). The questionnaire also asked about the frequency of occurrence of these symptoms while at work in the building during the four weeks preceding the survey, and whether these symptoms tended to get worse, stay the same, or get better when they were away from work. The final section of the questionnaire asked about environmental comfort (too hot, too cold, unusual odors, etc.) experienced while the employees were working in the building during the four weeks preceding the questionnaire administration.

To assess how severely employees were affected by symptoms, symptom groups were defined that consisted of possibly related symptoms. These groups required a participant to have more than one symptom, one day a week or more, that improved away from work. A category called "multiple atopic symptoms" was developed to assess the number of employees possibly having allergic symptoms, and required two of the following: sneezing, itchy eyes, and runny nose. A category called "multiple sick building syndrome symptoms" required at least three of the following five symptoms: headache, sore or dry throat, nasal congestion, unusual fatigue, or irritated eyes. These symptoms have been shown to have high prevalence rates in studies of the non-industrial indoor environment by NIOSH and other researchers.[1,2,3] Having multiple symptoms of this type can serve as a marker for the severity of health problems among occupants of a building. A final symptoms group, the "multiple respiratory group," required having at least three of the following symptoms: shortness of breath, cough, chest tightness, or wheezing. Because of the potential severity of these symptoms and the fact

that they are less likely to improve when leaving the worksite, employees were considered to meet the group criteria if they had the symptom frequently (one day a week or more), without necessarily improving when they left the office. Respondents in this group were subsequently interviewed by telephone.

Environmental Evaluation

During the environmental evaluation, information was collected using standardized checklists and inspection forms. These forms were used to address the whole building, the evaluation area, and the HVAC system. Descriptive information for the building (age, size, construction, location, etc.), the area to be evaluated (size, type of office space, cleaning policies, furnishings, pollutant sources, etc.), and the HVAC systems (type, specifications, maintenance schedules, etc.) were included. Inspections of the evaluated area and HVAC systems were conducted to determine current conditions. The purpose of the environmental investigation was to evaluate the work area's current indoor environmental status.

In addition to collecting the standardized information described above, indicators of occupant comfort were measured. These indicators were carbon dioxide (CO_2) concentration, temperature (T), and relative humidity (RH).

Real-time CO_2 concentrations were measured using a Gastech Model RI-411A, portable CO_2 indicator. This portable, battery-operated instrument uses a non-dispersive infrared absorption detector to measure CO_2 in the range of 0-4975 parts per million (ppm), with a sensitivity of ±25 ppm. Instrument zeroing and calibration were performed prior to use with zero air and a known concentration of CO_2 span gas (800 ppm).

Real-time temperature and humidity

measurements were made using a Vaisala, Model HM 34, battery-operated meter. This meter is capable of providing direct readings for dry-bulb temperature and RH, ranging from -4 to 140°F and 0 to 100%, respectively. Instrument calibration is performed monthly using primary standards.

Bulk samples from the HVAC unit were collected for microbial analysis. One sample was collected from each of the five following areas: the general residue of the drain pan, the inside of the humidifier just above the water level, the humidifier water, the drain pan residue under the humidifier, and the sound liner.

Electromagnetic fields

Because of the large amount of electronic equipment present in the Communication Center, measurements were made for extremely low frequency (ELF) electromagnetic fields (EMF). These measurements were made with the EMDEX II exposure system, developed by Enertech Consultants, under project sponsorship of the Electric Power Research Institute, Incorporated. The EMDEX II is a programmable data-acquisition meter which measures the orthogonal vector components of the magnetic field through internal sensors. Measurements can be made in the instantaneous read or storage mode. The system was designed to measure, record, and analyze power frequency magnetic fields in units of milliGauss (mG) in the frequency region from 40 to 800 Hertz (Hz). Measurements were made with this meter in the walk-around dosimetry mode at the location of the worker's hands on the equipment, at the worker's head, at floor level, along the wall,

on top of the 911 units, and adjacent to the voting comparators (machines that select available microwave channels for transmission).

V. EVALUATION CRITERIA

Indoor environmental quality (IEQ) is affected by the interaction of a complex set of factors which are constantly changing. Four elements involved in the development of IEQ problems are:

- sources of odors or contaminants,
- problems with the design or operation of the HVAC system,
- pathways between contaminant sources and the location of complaints,
- and the activities of building occupants.

A basic understanding of these factors is critical to preventing, investigating, and resolving IEQ problems.

The symptoms and health complaints reported to NIOSH by non-industrial 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. Usually, the workplace environment has been implicated because workers report that their symptoms lessen or resolve when they leave the building.

A number of published studies have reported high prevalences of symptoms among occupants of office buildings. Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building-related occupant complaints.[4,5] 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.[6,7,8,9,10,11]

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.[12,13,14] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[15,16,17]

Less often, an illness may be found to be specifically related to something in the building environment. Some examples of potential 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 or machines, structural components of the building and contents, tobacco smoke, microbiological contamination, and outside air pollutants; comfort problems due to improper temperature and RH conditions, poor lighting, and

unacceptable noise levels; adverse ergonomic conditions; and job-related psychosocial stressors. In most cases, however, these problems could not be directly linked to the reported health effects.

Standards specifically for the non-industrial indoor environment do not exist. NIOSH, the Occupational Safety and Health Administration (OSHA), and the American Conference of Governmental Industrial Hygienists (ACGIH) have published regulatory standards or recommended limits for occupational exposures.[18,19,20]

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.[21,22] 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.[23]

Measurement of indoor environmental contaminants has rarely been 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 mixtures of organic materials usually found are difficult to interpret and usually impossible to causally link to observed and reported health symptoms. However, measuring ventilation and comfort indicators such as CO_2, temperature, and RH has proven useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems. The basis for measurements made during this evaluation are listed below.

Carbon Dioxide

Carbon dioxide 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, and 15 cfm/person for reception areas, and provides estimated maximum occupancy figures for each area.[21]

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

Temperature and Relative Humidity

The perception of comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperatures. Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. ANSI/ASHRAE Standard 55-1981 specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable.[24]

Microbial Contaminants

Microorganisms (including fungi and bacteria) are normal inhabitants of the environment. The saprophytic varieties (those utilizing non-living organic matter as a food source) inhabit soil, vegetation, water, or any reservoir that can provide

an ample supply of a nutrient substrate. Under the appropriate conditions (optimum temperature, pH, and with sufficient moisture and available nutrients), saprophytic microorganism populations can be amplified. Through various mechanisms, these organisms can then be disseminated as individual cells or in association with soil/dust or water particles. Also, some species of fungi produce mycotoxins and volatile organic compounds (VOCs) and all gram-negative bacteria contain endotoxin. All three of these groups of substances include some compounds which can be harmful to humans. In the outdoor environment, the levels of microbial aerosols and vapors will vary according to the geographic location, climatic conditions, and surrounding activity. In a "normal" indoor environment, the level of microorganisms may vary somewhat as a function of the cleanliness of the HVAC system and the numbers and activity level of the occupants. Generally, the indoor levels are expected to be below the outdoor levels (depending on HVAC system filter efficiency) with consistently similar ranking among the microbial species.[25,26]

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.[27] 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).[23,26] Allergic respiratory diseases resulting from exposures to microbial agents have been documented in agricultural, biotechnology, office, and home environments.[28,29,30,31,32,33,34,35]

Individual symptomatology varies with the disease. 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 (runny nose) with postnasal drainage. Allergic asthma is characterized by episodic or prolonged wheezing and shortness of breath in response to bronchial (airways) narrowing. Allergic bronchopulmonary aspergillosis is characterized by cough, lassitude, low-grade fever, and wheezing.[36,37] Heavy exposures to airborne microorganisms can cause an acute form of extrinsic allergic alveolitis which is characterized by chills, fever, malaise, cough, and dyspnea (shortness of breath) appearing four to eight hours after exposure. In the chronic form, thought to be induced by continuous low-level exposure, onset occurs without chills, fever, or malaise and is characterized by progressive shortness of breath with weight loss.[38]

Acceptable levels of airborne microorganisms have not been established, primarily because allergic reactions can occur even with relatively low air concentrations of allergens, and individuals differ with respect to immunogenic susceptibilities. The current strategy for on-site evaluation of environmental microbial contamination involves an inspection to identify sources (reservoirs) of microbial growth and potential 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 may be collected to document the presence of a suspected microbial contaminant. Air sample results can be evaluated epidemiologically by comparing those from the "complaint areas" to those from non-complaint areas, or by relating exposure to immunologic findings.

Electromagnetic Fields

At present, there are limited occupational exposure

criteria for EMF field exposures for workers exposed to physical agents. Criteria for EMF not covered by OSHA come from either the ACGIH, NIOSH, or in some cases, from consensus standards promulgated by the American National Standards Institute (ANSI).

The ACGIH has published threshold limit values (TLVs) for sub-radio frequency electric and magnetic fields (30 kiloHertz and below).[39] The TLV for magnetic fields (B) states "routine occupational exposure should not exceed:

$$B_{TLV} \text{ in milliteslas} = 60/f$$

where f is the frequency in Hertz." In this evaluation, we were particularly interested in 60 Hz fields because of the large amount of electrical equipment present in the Communication Center. The current ACGIH occupational standard for 60Hz magnetic fields is 1 millitesla. One millitesla is equal to 10,000 milliGauss (10 Gauss).

Conversely, the electric field (E) TLV states "occupational exposures should not exceed a field strength of 25 kiloVolts per meter (kV/m) from 0 to 100 Hz. For frequencies in the range of 100 Hz to 4 kHz, the TLV is given by:

$$E_{TLV} \text{ in Volts per meter (V/m)} = (2.5 \times 10^6)/f$$

where f is the frequency in Hz. A value of 625 V/m is the exposure limit for frequencies from 4 kHz to 30 kHz." This means, for example, that at 60 Hz, which is classified as ELF, the electric field intensity TLV is 25,000 V/m.

VI. ENVIRONMENTAL RESULTS AND OBSERVATIONS

The whole Communication Center should be moved into a new building by the end of 1995, and therefore, one of the goals of the evaluation is to ensure that, should the Communication Center be reoccupied, future occupants of this room will have improved conditions.

The Communication Center was noticeably dirtier than the other areas of the building. The work areas and floors were very dusty, and the area below the raised floor was extremely dusty. Because the room is occupied 24 hours a day, thorough cleaning is difficult to perform. Since there is carpet, vacuuming is necessary, but it interferes with the workers who must communicate on the telephone. The room houses approximately 20 to 25 people per shift and the workstations are crowded together, which is another factor that prevents thorough cleaning. There is no visible water damage and no leaks have been reported in the past in this area. The break room contains a full refrigerator, a microwave oven, a coffee-maker, a kitchen sink, and a TV.

The HVAC system was installed in 1979 when the office building was completed, and an outside contractor is responsible for preventive and as-needed maintenance. Although the unit is not enclosed, access is restricted by the partition that covers the right, front half of the unit. There are two large panel doors that open to expose the coils, drain pan, and electrical components; the left door opens completely, but the right door is obstructed and can only open about ten inches. The overall condition of the HVAC unit was fair to poor and the sound liners had some slight damage. The drain pan was mostly dry with a few moist areas, but its surface was covered with residue of varying colors and consistencies. The coils had some debris on them, but no visible

evidence of microbial contamination. The most deficient part of the HVAC unit was the humidification system. This system consisted of an open pan (approximately 1 ft. x 1.5 ft.) of water suspended an inch above the drain pan. This pan had visible microbial growth around its edges, below it, on the components submersed in the water, and in the water itself. It was apparent during the survey that the drain pan, coils, and humidification system had not been cleaned in the recent past. A rectangular, frameless fiberglass filter was tacked to the top of the unit over the return vent for the system. The filter had less than 20% efficiency and, without a frame, air could bypass it quite easily.

The OA intake is located on the roof. In 1991, a fan was added to an old exhaust duct just above the suspended ceiling to draw outside air through the duct and into the room through a ceiling diffuser. A large piece of fiberglass filter material, similar to the kind used on the HVAC unit, had been shoved into the flexible duct under the rain cap to serve as a filter. When the filter was removed, we saw that the duct was covered with a mat of very fine dust.

A few of the ten supply diffusers had been tampered with by employees. One was completely obstructed by a piece of cardboard. In the area that used to be an enclosed office along the north wall of the room there was one air supply, but this area appeared to have little air movement. There was a strong negative air pressure in the room relative to the outside hallway – it was strong enough to hold the spring-loaded door slightly open if it was not pulled shut.

The bulk sample analysis for microbial contamination revealed varying amounts of fungi and bacteria. The bulk sample collected from the drain pan, under the humidifier, did not have any detectable amount of bacteria or fungi (less than 225 colony forming units per gram (CFU/g)), and

the sound liner had low to moderate amounts of *Bacillus* species of bacteria (3,125-12,500 CFU/g) and *Aspergillus* and *Penicillium* species of fungi (225-450 CFU/g). A different sample, collected from the middle of the drain pan, had 300,000 CFU/g of the bacteria species *Moraxella bovis* but less than 225 CFU/g of any fungi.

The humidifier bulk sample contained by far the highest amounts of bacteria and fungi. Levels of *Pseudomonas vesicularis*, *Pseudomonas stutzeri*, and *Flavobacterium* bacteria ranged from 450,000,000-500,000,000 CFU/g; there were also 20,000,000 CFU/g CDC Group II-I bacteria species; and 30,000 CFU/g *Acremonium* fungi species. The humidifier water also had *Pseudomonas vesicularis* (7,500,000 CFU/ml), *Comamonas testosteroni* (1,600 CFU/ml), and *Acremonium* species (140 CFU/ml).

Environmental CO_2 measurements were collected in nine locations in the evaluated area. Carbon dioxide concentrations ranged from 400 ppm to 975 ppm during the days of the site visit. From 3:30 to 4:00 p.m. on January 4, 1995, the concentrations ranged from 500 to 550 ppm; from 5:50 to 6:15 p.m. on January 4, 1995, the concentrations ranged from 400 to 500 ppm; from 9:30 to 10:00 a.m. on January 5, 1995, the concentrations ranged from 525 to 625 ppm; from 11:20 to 11:35 a.m. on January 5, 1995, the concentrations ranged from 950 to 975 ppm; and from 3:25 to 3:40 p.m. on January 5, 1995, the concentrations ranged from 550 to 650 ppm. The lower concentrations on January 4, 1995, could be due to the fact that the door to the room was propped open for most of that work shift – something that is rarely done. The outdoor CO_2 concentrations ranged from 350 ppm to 375 ppm on both days.

The sheriff's office had set up a real-time CO_2 monitor in the room a few weeks prior to the survey. This monitor had readings that were

similar to those taken by NIOSH. The real-time measurements showed that CO_2 concentrations were cycling from low (400 to 600 ppm) to high (sometimes greater than 1,000 ppm) every three to four hours. These cycles corresponded perfectly to the cycles of the exhaust fan operation. The fan cycles were then changed to two hours on and two hours off to try to reduce the build-up of CO_2 and any other potential contaminants. If the CO_2 concentrations were still cycling, the fan operation cycle could be modified again.

During the days of the survey, the temperatures ranged from 73 to 77°F in the Communication Center and they were in the high 60s outside. The RH ranged from 48 to 62% on January 4, 1995, when it was raining outside, and from 34 to 41% on January 5, 1995, when it was not raining outside.

Electromagnetic Field Measurement

Extremely low frequency (ELF) fields measurements made at operators' desks, near the location of their hands, ranged from 1.9 to 3.4 mG. Measurements made at operators' heads were lower than those at their hands which were closer to the electrical equipment. Measurements made along the floor and walls were similar to those made at the operators' hands. Higher levels were found on top of the 911 units (6.5-10.3 mG) and next to the microwave voting comparators (17.8 mG), which were located in an adjacent room. It was unlikely that workers would be present in either location for extended periods of time. The values at employee workstations are typical of levels found in other office settings where a computer is used.[40]

VII. MEDICAL RESULTS

Confidential medical Interviews were conducted with 26 employees. Commonly reported

symptoms (and the number of interviewed workers affected included): frequent headaches (4), burning or irritated eyes (7), runny nose or congestion (5), sinus problems and infections (8), and severe fatigue at work (6). Five of the employees reported frequently experiencing a feeling of insufficient ventilation while working in the building.

Several employees commented on the symptoms that had occurred during the renovation of an adjacent workspace, which had been completed several months prior to the visit, and occurred while the employees of the Communication Center were present. Workers reported that exposure to dust, noise, and chemical odors (paint, flooring cements, etc.) had been common during the renovation. They also reported having experienced exacerbations of sinus congestion and sinusitis during this exposure and frequently felt ill, especially when exposed to the odors of flooring cements. Workers also reported a Freon® leak in 1993 from the HVAC unit located in the Communication Center. This leak resulted in ill workers being sent home.

During the visit, questionnaires were distributed to the 90 Communication Center employees, working on the day of the site visit. Of the 77 employees that responded (85% response rate), 30 were male (39%), and 47 were female (61%). Twenty-four (31%) currently smoked cigarettes, 23 (30%) were former smokers, and 30 (39%) had never smoked. Respondents ranged in age from 20-72 (mean 41 years old), and had worked at the same location in the building for an average of six years.

The questionnaire results are shown in Table I at the end of this report. The first column of Table I shows the percentage of the 77 respondents who reported the occurrence of symptoms while at work on the day of the survey. Stuffy nose or sinus congestion, eye irritation, unusual fatigue,

and cough were the most commonly reported symptoms.

The second column shows the percentage of employees who reported experiencing the respective symptom once a week or more often while at work during the four weeks preceding the survey. With a few exceptions, these symptom prevalences are slightly greater than those for symptoms experienced on the day of the survey.

The third column shows the percentage of employees who reported experiencing the respective symptom once a week or more often while at work during the four weeks preceding the survey and also reported that the symptom tended to get better when they were away from work. This latter criterion has, in some studies of indoor air quality, been used to define a "work-related" symptom, but it is possible that a symptom which does not usually improve when away from the building could also be due to conditions at work.

The reported "work-related" frequent symptom prevalences, shown in the third column, are lower than the corresponding symptom prevalences over the last four weeks (shown in the second column), and are highest for eye irritation or strain, headache, fatigue, and stuffy nose or sinus nasal congestion. Symptoms prevalences were similar to what NIOSH has found in other buildings, with the exception of cough, which had a prevalence rate of 17% in this study, as compared with approximately 9% in other NIOSH studies.[41,42] Overall, 43 (56%) respondents reported having one or more symptoms that had occurred at work one or more days a week during the preceding four weeks and tended to get better when away from work and 29 (38%) reported three or more symptoms once a week or more that improved when away from work.

Multiple respiratory symptoms (frequently experiencing at least three of the following four symptoms: wheezing, chest tightness, shortness

of breath, or cough) were reported by seven workers (9%) of the respondents. A previous NIOSH study of 80 office buildings found a mean prevalence rate of 5% for this symptom group.[43] Although this represents an almost two–fold increased mean prevalence rate, it fell within the range for all buildings (0-40%). Multiple atopic symptoms (at least two of the following symptoms: sneezing, itchy eyes, or runny nose) were reported by 27% of the respondents with 14% reporting that the symptoms improved when the employee left work. The latter may indicate an allergic reaction in some persons that is related to working in the Communication Center.

Multiple sick building syndrome symptoms (frequently experiencing at least three of the following: headache, sore or dry throat, nasal congestion, unusual fatigue, or irritated eyes that improved when the employee left the worksite) were reported by 18% of the respondents.

Table II shows results of employee reports regarding environmental conditions at their workstations on the day of the survey and during the four weeks preceding the survey. Column one shows the results for the day of the survey; it shows that 48% of the respondents perceived that the ventilation system was not providing sufficient air movement, 36% thought it was too hot, and 22% felt that it was too cold during at least part of their workday.

The second column shows the responses to the questions about environmental comfort conditions experienced in the facility during the four weeks preceding the survey. Adverse environmental conditions (too hot, too cold, odors, etc.) were considered "frequent" if they were reported to occur at work once a week or more often. The results are generally somewhat higher than those shown in the first column for workstation environmental conditions experienced during the day of the

survey. Sixty-five percent of respondents perceived insufficient air movement, 16% reported too much air movement, 57% frequently were too hot, 36% were frequently too cold, 21% perceived frequent chemical odors in the workplace, and 33% frequently sensed other unpleasant odors.

Seven employees who reported either multiple respiratory symptoms or shortness of breath on the questionnaire were contacted by the telephone to determine, by interview, the severity of their symptoms. Five reported that they were aware of shortness of breath after exercise that they previously had been able to do, such as climbing stairs. In all cases, this symptom began after the employee started to work in the building. Of those five, one employee had been diagnosed with a usual interstitial pneumonitis and one other was under medical treatment for his shortness of breath. One other respondent who reported shortness of breath had an underlying medical condition (unrelated to the building) that may explain the symptom.

VIII. DISCUSSION

Pseudomonas bacteria, other bacteria, and fungi were identified in the samples collected from the humidifier. These organisms, endotoxin, or mycotoxin could potentially become entrained in the air supplied by the Communication Center HVAC system. Endotoxins are lipopolysaccharide compounds from the outer cell wall of gram-negative bacteria (such as *Pseudomonas*), which are ubiquitous in nature.[23,44,45] Since endotoxins are part of the cell wall of the bacteria, endotoxins can usually be assumed to be present wherever gram-negative bacteria are present.[46] High concentrations have been reported in a variety of environments where gram-negative bacteria flourish, such as vegetable fiber processing operations, agriculture or wastewater

treatment operations, industrial washwater mists, and contaminated room humidifiers.[44] Airborne endotoxin has also been reported in offices and laboratories.[23]

Clinically, much is not known about the response to inhaled aerosols of gram-negative bacteria and endotoxins.[47] Workers exposed to endotoxin at sewage treatment plants have reported shortness of breath, nausea, fever and wheezing.[48] One study of office workers found a six-fold increase in airborne endotoxin levels in "sick buildings" when compared to "healthy buildings" and concluded that contamination with gram-negative rods or endotoxin may be related to sick building syndrome.[49] The presence of gram-negative bacteria in the HVAC or humidification systems has been linked, by some researchers, to respiratory infection and chronic bronchitis.[50]

Although no air measurements for either bacteria or endotoxin were made in the workers' location during our site visit, the findings of bacteria within the humidifier may represent a possible hazard due to the location of the humidifier in the air stream and the potential for dissemination to occur. Specifically, the presence of *Pseudomonas* could represent a hazard to the occupants of the building due to the presence of endotoxins if they were to become airborne.

Exposure to mycotoxins is another consideration, based on the finding of fungal growth in the HVAC system. Mycotoxins are one group of secondary metabolites formed by hyphae of common molds when growing under a variety of conditions;[44] they are produced as side effects of the fungal digestion process.[23] No toxigenic fungus produces only a single toxin, and the type and amount of toxin produced will vary based on the surrounding conditions. However, most studies of the toxicology of mycotoxins concern them as contaminants in feed for farm animals, and almost

all cases of human mycotoxicosis have appeared in rural or agricultural settings, most resulting from the ingestion of contaminated food and/or skin contact. There is one isolated case of a severe *Stachybotrys atra* colonization in a house that resulted in symptoms of headaches, sore throats, hair loss, flu symptoms, diarrhea, fatigue, dermatitis, and generalized malaise. *S. atra,* however, is not commonly found in office buildings,[23] and was not found in this one. The effects of mycotoxins in the office environment are usually minimal but may be a factor in some cases.[51]

Allergic disorders associated with microorganisms are discussed in the Evaluation Criteria section of this report.

IX. CONCLUSIONS AND RECOMMENDATIONS

The potential exists for dissemination of bioaerosols from the HVAC system into the occupied spaces. Whether this airborne dissemination is presently occurring or occurred in the past could not be determined from our analyses. Since components of the HVAC system are functioning as amplification sites for microorganisms and future dissemination is a possibility, the microbial contaminated components of the HVAC system should be removed. Although no air sampling was done during this visit, our recommendations would remain the same if it had been done, regardless of the outcome. Additional recommendations are offered to correct environmental deficiencies that were found in the Communication Center during this evaluation such as overcrowding, poor housekeeping, and poor design of the air filter system.

1. The present HVAC humidification system should be eliminated because it serves as a reservoir for microbial amplification. In a climate such as Florida's, humidification

systems may well be unnecessary.

2. The room used for the Communication Center was too small to house 20 to 25 workers per shift, and the HVAC system was not designed to properly ventilate the room with that many people in it. The addition of an OA intake and exhaust system and increasing the frequency of the exhaust cycles has allowed for an adequate temporary solution pending the move to the new building. If necessary, the number of exhaust cycles could be increased, if needed, to keep CO_2 levels from rising within the room. Also, the HVAC maintenance has been poor. If this room is to be used as workspace in the future, NIOSH investigators recommend the following:

   a) This room should not again be used to house a large number of people. ASHRAE has recommended occupancy levels for office workers of seven employees per 1,000 square feet (ft^2) of usable space. The federal government (General Services Administration) sets guidelines for workspace area based on the pay grade (GS-level) of employees using the space. These workstation space allowances are 60 ft^2 for clerical personnel (GS 1-6), 75 ft^2 for technical personnel (GS 7-11), and 100 ft^2 and up for professional staff (GS-13 and higher). The federal Internal Revenue Service has a guideline of 125 ft^2 of primary office space per employee as an average occupancy level. This guideline does not include storage, lavatory, or cafeteria space as part of that 125 ft^2 total.

   b) To improve employee comfort, NIOSH investigators suggest that the room be thoroughly cleaned before re-occupation. This cleaning should occur when the area is not occupied and the exhaust system should

be kept operating during the cleaning procedures. Also, the routine housekeeping in this area should be improved to avoid future problems.

c) The present HVAC system should either be redesigned and replaced or at least thoroughly cleaned. Since it was 15 years old, and may be approaching the end of its intended lifespan, redesign and replacement may be the more economically sound choice. If not replaced, it should be thoroughly cleaned while the room is not occupied.

d) The HVAC filter system was inadequate for two reasons. The first was that there is no frame to place the filter in, which allows for air to easily by-pass the filter. The second was that the filter was a very low efficiency filter. Efficiency is the measure used to determine whether fine particles are removed from the air stream. Consideration should be given to using filters with 30 to 40% efficiency. Pleated filters have efficiencies around 40% and would help to reduce the dust in the work area. The OA should also be filtered through a higher efficiency filter. Since the OA, in this case, was not introduced into the HVAC unit directly, the OA intake should have its own higher efficiency filter. A lower efficiency filter could be used upstream so that the high efficiency filter only has to filter

out the smaller particles and the larger ones will be stopped by the first pre-filter.

e) If a raised floor is necessary for the new occupants, the present one should either be replaced with one consisting of vinyl tiles as opposed to carpeting (for easier cleaning), or at least thoroughly cleaned. There should be routine cleaning both above and below the

raised floor.

f) Employees in either the old or new building must not be allowed to adjust any components of the HVAC system, specifically the supply diffusers. Workers should be instructed that any alterations will affect the entire system.

3. The workspace in the new building is clearly larger and appeared to be better designed for a telecommunication center. To avoid any air quality problems in the future, preventive maintenance is necessary. The HVAC system, including the drain pan, filters, OA intake, supplies, and returns, must be maintained on a routine basis, preferably monthly or bimonthly. NIOSH investigators recommend a thorough cleaning of the HVAC unit semi-annually or annually, and as–needed, in between. Also, filters with a 30 to 40% efficiency are recommended.

4. Since this new work area will also be occupied 24 hours a day, 7 days a week, housekeeping may still be a problem. Supervisors and employees should devise a way to allow adequate housekeeping practices with the least amount of distraction to the workers.

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TABLE 1
Symptoms Experienced At Work
Hillsborough County Sheriff's Department
Tampa, Florida
HETA 94-0370-2511

Symptoms Of 77 Workers	Experienced On Days of Survey While At Work	Frequently Experienced Last Four Weeks While at Work	Have Frequent Symptoms that Improve When Away from Work
Dry, or irritated eyes	39%	51%	35%
Wheezing	5%	13%	7%
Stuffy nose, or sinus congestion	43%	46%	25%
Sneezing	23%	25%	16%
Sore or dry throat	29%	30%	21%
Dry or itchy skin	23%	22%	8%
Unusual fatigue or drowsiness	31%	39%	25%
Headache	22%	36%	25%
Muscle or joint pains	22%	16%	4%
Difficulty with memory or concentration	10%	14%	5%
Itchy eyes	29%	36%	22%
Runny nose	29%	33%	16%
Cough	30%	30%	17%

Chest tightness	4%	10%	8%
Shortness of breath	13%	14%	7%

TABLE 2
Description Of Workplace Conditions
Hillsborough County Sheriff's Department
Tampa, Florida
HETA 94-0370-2511

Conditions	Experienced At Work During Days of the Survey 77 Workers	Frequently Experienced While at Work During Previous Four Weeks 77 workers
Too much air movement	10%	16%
Too little air movement	48%	65%
Temperature too hot	36%	57%
Temperature too cold	22%	36%
Air too humid	6%	13%
Air too dry	37%	46%
Tobacco smoke odors	5%	8%
Chemical odors (e.g., paint, cleaning fluids, etc.	8%	21%
Other unpleasant odors (e.g., body odor, food odor, perfume)	27%	33%