



NIOSH HEALTH HAZARD EVALUATION REPORT:

HETA #2000-0092-2832

**Charles Harwood Complex
Saint Croix, United States Virgin Islands**

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

The NIOSH logo, consisting of the word "NIOSH" in a bold, italicized, sans-serif font. The "N" is significantly larger and more prominent than the other letters.

PREFACE

The Hazard Evaluations and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (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 (OSHA) 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 or 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.

HETAB also provides, upon request, technical and consultative assistance 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 NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Robert E. McCleery, Gregory A. Burr, and Kenneth F. Martinez of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Analytical support was provided by P & K Microbiology Services, Incorporated; Mike Whitmer of the Division of Respiratory Disease Studies (DRDS); and Data Chem Laboratories, Salt Lake City, Utah. Desktop publishing was performed by Robin Smith. Review and preparation for printing were performed by Penny Arthur.

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Highlights of the NIOSH Health Hazard Evaluation

NIOSH Indoor Air Quality Evaluation of the Charles Harwood Complex, Saint Croix, USVI

On December 15, 1999, NIOSH received a request from employees of the United States Virgin Islands Department of Health, Saint Croix. Employees working in offices at the Charles Harwood Complex (CHC) believed that their symptoms, which included headaches, coughing, rash, itching, infections, respiratory problems, and eye irritations, were related to working in this building.

What NIOSH Did

- We walked through the entire CHC, including the Maternal and Child Health building.
- We took air samples for fungi, fungal spores, and endotoxin.
- We took bulk samples of materials that had visible mold.
- We took carbon dioxide, relative humidity, and temperature measurements.
- We visually inspected the window air-conditioning (A/C) units and ducted, central A/C units in the various buildings.
- We checked for moisture in the walls.
- We talked to employees about the building and about health problems they felt may be associated with the building's air quality.

What NIOSH Found

- The building has areas with hurricane damage.
- Visual mold on the 2nd and 3rd floors.
- Evidence of water coming into the building.
- Carbon dioxide levels were low.
- Some temperature and relative humidity levels were above

what is considered to be comfortable by most people in offices.

- Indoor airborne fungi concentrations were lower than outside concentrations. However, some indoor samples indicated a larger percentage of *Aspergillus* and/or *Penicillium* species than outside samples. This suggests that there are fungal reservoirs in the building.

What CHC Managers Can Do

- Repair and renovate the structurally damaged portions and closed interior wings of the CHC.
- Fix leaks in the building. Water should be removed immediately from porous, water-damaged furnishings, carpets, and construction materials.
- Remove materials from areas where there is obvious visible mold growing (ceiling tiles for example).
- Improve temperature and humidity in the offices. Make sure central air systems and window A/C units are balanced and maintained as the manufacturer says.

What the Employees Can Do

- Report any new water damage or leaks as soon as you can so repairs can be made.
- Report any visible mold in office areas so it can be removed or cleaned.



What To Do For More Information:
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Health Hazard Evaluation Report HETA 2000-0092-2832
Charles Harwood Complex
Saint Croix, United States Virgin Islands
March 2001

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SUMMARY

On December 15, 1999, the National Institute for Occupational Safety and Health (NIOSH) received a request from employees of the United States Virgin Islands Department of Health, Saint Croix. Employees working at the Charles Harwood Complex (CHC) believed that their headaches, coughing, rash, itching, infections, respiratory problems, and eye irritations, were related to working in this building. On May 16 and 17, 2000, NIOSH investigators conducted a site visit at the CHC.

On May 16, 2000, NIOSH investigators conducted a walk-through inspection of the entire CHC. On May 16 and 17, 2000, air sampling was conducted for culturable fungi using an Anderson single-stage cascade impactor with malt extract agar and cornmeal agar, fungal spores using Air-O-Cell™ media and mixed cellulose ester filters, and endotoxin using poly-vinyl chloride filters. Bulk samples were collected of materials with suspect fungal colonies from various areas of the CHC. Carbon dioxide (CO₂), temperature, and relative humidity (RH) measurements were collected, and the condition of the air-conditioning systems was determined. Areas suspected of water damage (exterior walls, floors, and near windows) were probed with a moisture meter to qualitatively assess residual amounts of water.

Total fungal concentrations were higher outdoors than indoors for a majority of the air samples collected. However, some indoor air samples revealed a larger percentage of *Aspergillus* and/or *Penicillium* species than outdoor air samples, suggesting the presence of fungal reservoirs. *Stachybotrys chartarum*, *Cladosporium*, and *A. sydowii* were the predominant fungal species identified in the ceiling tile bulk samples collected in the unoccupied 3rd floor, executive wing, which indicates past or present microbial contamination.

All CO₂ concentrations were below 800 parts per million (ppm), suggesting that the two story building was receiving sufficient amounts of outside air. Temperature and RH levels ranged from 72°F to 84°F, and 33% to 74%, respectively. Some temperatures were beyond the thermal comfort parameters recommended by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE).

NIOSH investigators conclude that there was a potential for airborne fungal exposures in this complex resulting from moisture incursion. The building revealed evidence of localized patches of microbiological contamination and water-damaged materials. Air sampling in some indoor areas indicated a larger percentage of *Aspergillus* and/or *Penicillium* species than outdoor air samples, which suggests the presence of fungal reservoirs. Additionally, bulk samples of ceiling tiles revealed the presence of *Stachybotrys chartarum*. Continued delays in roof reconstruction and renovation of structurally damaged portions and closed interior wings could result in a progressive increase of fungal colonization. Recommendations are provided to assist in eliminating the wet conditions conducive to microbial growth and to generally improve the indoor environment.

Keywords: SIC 8011 (Offices and Clinics of Doctors of Medicine); indoor environmental quality, IEQ, indoor air quality, IAQ, medical clinic, doctor, microbial, ventilation, mold, fungi, bacteria, carbon dioxide.

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INTRODUCTION

On December 15, 1999, the National Institute for Occupational Safety and Health (NIOSH) received a request from employees of the United States Virgin Islands Department of Health, Saint Croix. Employees working at the Charles Harwood Complex (CHC) believed their headaches, coughing, rash, itching, infections, respiratory problems, and eye irritations, were related to working in this building.

In response to this request, NIOSH investigators conducted a site visit of the CHC on May 16 and 17, 2000. On the morning of May 16, NIOSH representatives conducted an opening conference with management and various departmental employee representatives. Following this meeting, a walk-through inspection of the facility was conducted to identify specific work areas and job tasks of employees, leading to selection of potential air sampling sites. NIOSH investigators looked for evidence of water damage, pathways for moisture vapor, and fungal reservoirs that may result from water intrusion into the building. On the afternoon of May 16 and throughout the day of May 17, area air samples were collected for culturable fungi, fungal spore counts/identification, and endotoxins; bulk samples of visible fungal and water stained materials were collected for fungal analysis; and carbon dioxide (CO₂), relative humidity (RH), and temperature readings were collected. This HHE report presents the results of the completed NIOSH evaluation and provides recommendations to assist in the elimination of wet conditions conducive to microbial growth and generally improve the building's indoor environment.

BACKGROUND

The two-story masonry buildings of the CHC are approximately 50-years old, and currently have programs which include, but are not limited to: Mental Health and Substance Abuse; Maternal

and Child Health (MCH); Family Planning; Women/Infant/Children (WIC); Vital Statistics; Immunization; Medical Assistance; and Primary Care. The MCH offices and patient rooms are located in their own building adjacent to the main building and other program areas. Approximately 170 people were employed at CHC at the time of this NIOSH survey.

Three wings in the main building of the CHC were closed at the time of the NIOSH site visit. The wing closures were due to hurricane damage over the last ten years. Hurricanes Hugo, Marilyn, and Lenny caused the most damage to the complex. The 3rd floor, Executive Wing (West, relative to the CHC entrance as South) had been closed since November 1999. This wing was beneath a damaged portion of the roof. At the time of the site visit, the remnants of the existing roof were covered with large tarps. Adjacent to this unoccupied wing was the Bureau of Health Education (South). Across the hall from the unoccupied area was the wing housing the temporary location of the Mental Health offices. The 2nd floor (ground level) consisted of four main wings. The original 2nd floor, Mental Health and Commissioner's offices (North) had been closed since Hurricane Hugo struck the island. The 2nd floor, Executive Wing (West) was also unoccupied. The East wing housed the Substance Abuse offices and WIC. Portions of the basement (1st floor) of the CHC were closed but were in the process of being renovated.

Conditioned air for the majority of the CHC complex was provided by window units (approximately 95 units were operating at the time of this survey). A few areas (Family Planning, WIC, 3rd Floor Executive Wing, and parts of the MCH building) were supplied by ducted, package air-conditioning (A/C) units (manufacturers included Rheem®, Carrier®, and International Comfort Products®). Most of the interior hallways of the building were not air-conditioned, and some were open to the outdoors. There was not a formal system for supplying outside air (OA) to most of the building

except through the window A/C units and building doors open to the outside. Low efficiency fiberglass panel filters (20 inches ["] x 20" x 1") were used in the package units.

METHODS

Environmental

Carbon Dioxide (CO₂), Temperature, and Relative Humidity (RH)

CO₂, temperature, and RH measurements were made at randomly selected locations on the first through third floors of the CHC complex, including the adjoining MCH building. Carbon dioxide measurements were made using a Q-Trak™ Model 8550/8551 IAQ Monitor (TSI Incorporated, Saint Paul, Minnesota). This portable, battery-operated instrument monitors CO₂ via non-dispersive infrared absorption with a range of 0–5000 parts per million (ppm) with a sensitivity of ±50 ppm. Instrument calibration was done prior to use. In addition to measuring CO₂, this meter is capable of directly evaluating dry bulb temperature (range 32°F to 122°F) and RH (range 5% to 95%).

Real-time Temperature and Relative Humidity

Temperature and RH measurements were also collected and logged for a continuous 24-hour period using HOBO H8 Pro Series loggers (Onset Computer Corporation, Bourne, Massachusetts). These battery-operated loggers use an internal temperature sensor and external RH sensor. The operating range is -22°F to 122°F and 0% to 100% RH.

Ventilation System Assessment

There were no ventilation blueprints available for review during this survey. However, a visual inspection was made of numerous window A/C units as well as an examination of the few newer package A/C systems to check the condition of the air filters, coils, and drain pan, as well as other interior components. NIOSH investigators also toured the hurricane-damaged portions of the CHC clinic. The damaged areas included the roof and sections of the basement, second, and third floors.

Microbial Assessment

Bulk Samples

Five bulk samples were collected in the CHC. Four of these samples were collected in the 3rd floor area and one sample was collected in the Vital Statistics area. All samples collected on the 3rd floor were of ceiling tile with residue resembling water stains and microbial growth. The sample collected in the Vital Statistics area was of fiberglass insulation around duct work in the back room. This sample had a white residue on the aluminum foil outer wrapping of the duct insulation.

Culturable Fungal Sampling

Air samples for culturable fungi were collected by using an Anderson single-stage cascade impactor in accordance with NIOSH Method 0800.¹ Corn-meal agar (CMA) and malt-extract agar (MEA) were used to collect airborne fungal spores at a calibrated flow rate of 28.3 liters per minute (lpm). Samples were collected at an approximate height of 3 feet using aseptic techniques (e.g., the cleaning and sanitization of working surfaces, the wiping of Anderson sampler collection surfaces with alcohol between samples, and the inversion of sample plates before and after sampling). All sample plates were incubated at room temperature (approximately 25°C). The

taxa and rank of the collected microorganisms were determined by morphological characteristics.

On May 16 and 17, 2000, air samples were collected for culturable fungi in 13 different areas. Sample locations included Rooms 376, 353, 350, 252, 238; MCH Rooms 5, 14, and Medical Records; Immunization; Family Planning; Vital Statistics; WIC; and outside. Two sets of air samples were collected outdoors, one on May 16 and one on May 17. Three replicate samples of each nutrient media were collected in each area with a sample time of 5 minutes (min). Temperature and RH were recorded at each sample location.

Spore Sampling

Air-O-Cell™ Sampler

Air samples were collected for fungal spore counts using an Air-O-Cell sampler (Zefon Analytical Accessories, St. Petersburg, Florida) which collects airborne particles through impaction onto a coated glass slide housed in a 37-millimeter (mm) plastic cassette. The cassette is connected via Tygon™ tubing to high-flow sampling pumps operating at a calibrated flow rate of 15 lpm. Samples were analyzed for fungal spore counts by optical microscopy. Slides were mounted in cotton blue/lactic acid, and scanned at 400x magnification with bright field or phase contrast illumination. Two hundred fields were counted for each sample. Only particles greater than 2 micrometers (µm) in diameter were considered to be possible fungal spores.

On May 16 and 17, 2000, air samples were collected for concentration of total fungal spores in 13 different areas. Sample locations included Rooms 376, 353, 350, 252, 238; MCH Rooms 5, 14, and Medical Records; Immunization; Family Planning; Vital Statistics; WIC; and outside. Two sets of air samples were collected outdoors, one on May 16 and one on May 17. Three replicate samples were taken at each location; two with a

sample time of 5 min. and one with a sample time of 10 min.

Mixed-Cellulose Ester (MCE) Filter

Air samples were collected for airborne concentrations of total fungal spores, using mixed cellulose ester (MCE) filters with a pore size of 0.8 µm and a diameter of 25 mm. The filters were placed on cellulose support pads and sealed in plastic filter cassettes. The filter holders were connected via Tygon tubing to high-flow sampling pumps operating at a calibrated flow rate of 2 lpm over an 8-hour time period. Samples were analyzed for fungal structure counts by optical microscopy. Filters were cleared with acetone vapor, mounted in cotton blue/lactic acid, and scanned at 400x magnification with bright field or phase contrast illumination. Two hundred fields were counted for each sample. Only particles greater than 2 µm in diameter were considered to be possible fungal spores.

On May 16 and 17, 2000, air samples were collected for concentration of total fungal structures in 26 different areas. Sample locations included Rooms 376, 353, 350, area by Room 313, area by Room 271/273, 238, 222, 214; MCH Rooms 17, 5, Nurses' Station; Outside Immunization; Mental Health Clinic; 3rd floor unoccupied area; Vital Statistics; WIC; Urine Analysis Laboratory; 1st floor Mechanical Room; and outside (2nd and 3rd floors).

Endotoxin Sampling

Samples for endotoxin (a cell wall constituent of Gram-negative bacteria) were collected on a 37-mm polyvinyl chloride (PVC) filter at a calibrated flow rate of 2 lpm. Each filter sample was analyzed gravimetrically (NIOSH Method 0500¹) and subsequently placed into 50 milliliter (ml) conical centrifuge tubes. Ten milliliters of sterile, pyrogen-free water (LAL Reagent Water, BioWhittaker Inc., Walkerville, Maryland) was added to each tube. The filter samples were gently rocked at room temperature for

approximately 60 min. Each supernate was then decanted in a 15 ml centrifuge tube and centrifuged for 10 min at 2200 revolutions per minute (rpm) at 4°C. From each tube, 3 ml of the supernatant fluid was recovered, placed in a sterile vial, and stored at -85°C until analyzed. The samples were assayed for endotoxin content using the Kinetic-QCL Assay Kit (BioWhittaker, Walkerville, Maryland) according to the manufacturer's recommended procedure.

On May 16 and 17, 2000, air samples were collected for endotoxin in 15 different areas. Sample locations included Rooms 376, 350, 313, 238, 222; MCH Room 17; Immunization; Nurses Station and Pre-natal; Urine Analysis Laboratory; Vital Statistics; Mental Health Clinic; WIC; and outside (2nd and 3rd floor).

Other Activities

In addition to the air sampling, areas suspected of water damage (exterior walls) were probed with a moisture meter to qualitatively assess residual amounts of water. A Delmhorst Instrument Company (Towaco, New Jersey) Moisture Tester, Model BD-9, battery-operated detector was used for this qualitative assessment. This meter provides direct readings for moisture content in the range of 8-50% on wood. A reference scale is used for comparative readings on other non-wood materials. This portable instrument uses the amount of electrical conductivity in the material being tested to determine its moisture content.

Informal discussions with employees were conducted during the evaluation. Discussions included topics such as: condition of the CHC, past hurricane damage to the CHC, improvements made to the building, and health problems they felt may be attributable to the building's air quality.

EVALUATION CRITERIA

NIOSH investigators have completed over 1,200 investigations of the occupational indoor environment in a wide variety of non-industrial settings. Almost all 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 suspected as a cause of the problem because workers report that their symptoms lessen or resolve when they leave the building.

A number of published studies have reported a high prevalence of symptoms among occupants of office buildings.^{2,3,4,5,6} Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building-related occupant complaints.^{7,8} 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.^{9,10,11,12,13,14} Indoor environmental pollutants can arise from either outdoor or indoor sources.

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 any measured indoor contaminant or condition.^{15,16,17} Some studies have shown relationships between psychological, social, and organizational factors

in the workplace and the occurrence of symptoms and comfort complaints.^{17,18,19,20}

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 (CO) 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 CO include vehicle exhaust and inadequately ventilated fuel-burning appliances. Exposure to boiler additives can occur if boiler steam is used for humidification or is released by accident.

Problems that NIOSH investigators have found in the non-industrial indoor environment have included, (1) poor air quality due to ventilation system deficiencies, overcrowding, volatile organic chemicals from furnishings, emissions from office machines, structural components of the building and contents, tobacco smoke, microbiological contamination, and OA pollutants; and (2) 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 specific 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.^{21,22,23} With few exceptions, pollutant concentrations observed in non-industrial indoor environments fall well below these published occupational standards or recommended exposure

limits. American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) has published recommended building ventilation design criteria and thermal comfort guidelines.^{24,25} 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.²⁶

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 CO₂, temperature, and RH, has proven useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems.

NIOSH and the Environmental Protection Agency (EPA) jointly published a manual on building air quality, written to help prevent environmental problems in buildings and solve problems when they occur.²⁷ 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; and (4) the building occupants. A basic understanding of these factors is critical to preventing, investigating, and resolving IEQ problems.

Ventilation and Comfort Indicators

Measurement of ventilation and comfort indicators such as CO₂, temperature, and RH, are often useful in an IEQ investigation in providing information relative to the proper functioning and control of HVAC systems. The basis for these measurements are listed below.

Carbon Dioxide (CO₂)

CO₂ is a normal constituent of exhaled breath, and if monitored, may be useful as a screening technique to evaluate whether adequate quantities of outside 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 provides estimated maximum occupancy figures for each area.²⁴ Indoor CO₂ concentrations are normally higher than the generally constant ambient CO₂ concentration (range 300-350 ppm). When indoor CO₂ concentrations exceed 800 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected.²⁸ Elevated CO₂ 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. The American National Standards Institute (ANSI)/ASHRAE Standard 55-1992, *Thermal Environmental Conditions for Human Occupancy*, specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable.²⁵

Assuming low air movement, 60% RH and sedentary job tasks, the temperatures recommended by ASHRAE range from 68-74°F in the winter, and from 73-79°F in the summer. ASHRAE also recommends that RH be maintained between 30% and 60%.²⁴ Excessive humidity can support the growth of microorganisms, while low RH could possibly cause the eyes and upper respiratory tract to dry which may result in irritation.

Microorganisms

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 with soil or 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).^{29,30}

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.³¹ Allergic diseases which have been reported to be associated with exposures in indoor environments include allergic rhinitis (nasal allergy), allergic asthma, allergic bronchopulmonary aspergillosis (ABPA), and

extrinsic allergic alveolitis (hypersensitivity pneumonitis).²⁹ Allergic respiratory diseases resulting from exposures to microbial agents have been documented in agricultural, biotechnology, office, and home environments.^{32,33,34,35,36,37,38,39,40,41}

Acceptable levels of airborne microorganisms have not been established. Relationships between health effects and environmental microorganisms must be determined through the combined contributions of medical, epidemiologic, and environmental evaluation.²⁶ The current strategy for on-site evaluation involves a comprehensive inspection of problem areas 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. However, associating health effects with airborne microbial contaminants can be difficult.

Aspergillus species

Airborne *Aspergillus* species (*Aspergillus* spp.) such as *A. fumigatus*, *A. flavus*, *A. niger*, and *A. versicolor* are commonly found in indoor environments. Water damaged materials in indoor environments can frequent this fungal species. Spores from several *Aspergillus* spp. may cause allergic reactions in humans. Certain species have the ability to produce mycotoxins. Exposure to these mycotoxins may cause disease in humans such as infection of living tissues and toxicosis occurring from the ingestion of fungal toxin containing foods. Various species have the ability to produce volatile organic compounds (VOCs).⁴² However, the role in human health of these fungal VOCs is unclear.

Cladosporium species

Airborne *Cladosporium* spp. are very common in outdoor and indoor environments. This species has been isolated from a large variety of substrates. *Cladosporium* spp. may cause an allergic reaction in humans.

Penicillium species

Penicillium spp. have been well studied primarily due to their antibiotic producing capabilities. This fungal species is commonly found in soil, on various building materials, and in indoor air environments. *Penicillium* has the ability to grow and flourish on many types of substrates especially those that are undergoing deterioration or spoilage. There is a large number of *Penicillium* species with the ability to produce harmful human mycotoxins. Some species also have the ability to produce VOCs.

Stachybotrys species

Stachybotrys spp. can be found in indoor environments in water damaged materials, particularly those that are cellulose based. Spores of this fungal species are not readily released into the air. Therefore, *Stachybotrys* spp. identified in air samples is an indication of an area that warrants further investigation. *S. chartarum* is a mycotoxin producer and a potential culprit of health problems in indoor environments. Exposure to *S. chartarum* may generate symptoms of sore throats, headaches, dermatitis, fatigue, and others.

Endotoxin

Endotoxins, the principle surface antigens in Gram-negative bacteria, are contained in the outer cell wall of Gram-negative bacteria. Aerosolized endotoxins are suspect causative agents in the development of chronic bronchitis, abnormal cross-shift declines in pulmonary function, and asthma.⁴³ Occupational exposure limits for endotoxins have not been established by NIOSH or OSHA.

RESULTS

Microbial Assessment

Bulk Samples

Collected bulk samples were analyzed for total culturable fungal count. Fungal concentrations from the bulk material samples, cultured on MEA, ranged from less than 641 colony forming units per gram of material (CFU/g) to 3,622,086 CFU/g; the predominant species identified were *S. chartarum*, *Cladosporium*, and *A. sydowii* (see Table 1). Fungal concentrations from the bulk material samples, cultured on CMA, ranged from less than 641 CFU/g to 3,370,552 CFU/g; the predominant species identified were *S. chartarum*, *Cladosporium*, and *A. sydowii* (see Table 1).

Air Samples

Culturable Fungi Sampling

Individual air sample results for MEA and CMA media are presented in Tables 2 and 3, respectively. Graphical summaries of the culturable air sampling results are presented in Figures 1–3. The total concentration of fungi is presented in Figure 1. Figures 2 and 3 present the percent of total for *Cladosporium*, *Aspergillus*, *Penicillium* species, and *Stachybotrys chartarum* on MEA and CMA. Geometric mean concentrations indoors ranged from 24–155 colony forming units per cubic meter (CFU/m³) for samples collected on MEA and from 44–188 CFU/m³ for samples collected on CMA. All indoor fungal concentrations were below geometric mean concentrations outdoors which were 286 CFU/m³ for both samples collected on MEA and 321 CFU/m³ and 289 CFU/m³ for samples collected on CMA. However, Figures 2 and 3 show a trend of increased *Aspergillus* and *Penicillium* species in indoor samples when

contrasted to outdoor samples. For all air samples collected on MEA and CMA the predominant genus was *Cladosporium*.

Spore Sampling

Individual air sample results for Air–O–Cell and MCE media are presented in Table 4 and 5, respectively. Graphical summaries of the spore air sampling results (identification includes spores and hyphal fragments) are presented in Figures 4–7. The total concentration of fungi is presented in Figures 4 and 6 on Air–O–Cell and MCE media, respectively. Figures 5 and 7 present the percent of total for *Cladosporium* and *Aspergillus/Penicillium* on Air–O–Cell and MCE media, respectively. All of the indoor fungal concentrations collected on Air–O–Cell media were below the geometric mean fungal concentration outdoors on their respective days, which were 310 fungal spores per cubic meter (FS/m³) and 628 FS/m³. Fungal concentrations were slightly higher on May 17 than the previous day. Outdoors (May 16), the predominant fungal structure identified was *Cladosporium*, which accounted for approximately 30% of the total. Outdoors (May 17), the predominant fungal structures identified were basidiospores; *Cladosporium*, accounted for approximately 27% of the total. Neither outdoor sample found *Aspergillus/Penicillium*. All other sampling areas varied in the amount of *Cladosporium* and/or *Aspergillus/Penicillium*. The highest fungal concentration of *Cladosporium* was in WIC on May 17, and accounted for approximately 44% of the total. The highest fungal concentration of *Aspergillus/Penicillium* was in MCH Medical Records on May 17, and accounted for approximately 22% of the total. MCH Room 14 did not have any *Cladosporium* or *Aspergillus/Penicillium* spores. Only basidiospores were found.

All of the indoor MCE filter fungal concentrations collected on May 16 were at or above the fungal concentration outdoors, which was <1157 FS/m³. The outdoor fungal concentration was below the

limit of detection of 1157 FS/m³. All of the indoor MCE filter fungal concentrations collected on May 17 (except for WIC and the Mental Health Clinic) were below the highest fungal concentration outdoors, which was 3470 FS/m³. Outdoors (May 17), the predominant fungal structures identified were basidiospores; ascospores; and *Cladosporium*, which accounted for approximately 33% of the total. Both outdoor samples did not result in any *Aspergillus/Penicillium* found. All other sampling areas varied in the amount of *Cladosporium* and/or *Aspergillus/Penicillium* detected. The highest fungal concentration of *Cladosporium* was in WIC on May 17, and accounted for approximately 75% of the total. The highest fungal concentration of *Aspergillus/Penicillium* (13880 FS/m³) was in the Mental Health Clinic on May 17, and accounted for approximately 100% of the total.

Endotoxin Sampling

Individual air sample results are presented in Table 6. The endotoxin air sample results were very low.

Environmental

Carbon Dioxide

CO₂ was measured three times during the work day (once in the morning and twice in the afternoon) in locations previously discussed (Figure 8). CO₂ levels ranged from 380 ppm to 780 ppm. The CO₂ levels measured outside the building on May 17, 2000, were 380, 380, and 390 ppm for the three time periods of collection. All of the CO₂ concentrations were below 800 ppm. CO₂ sampling was also conducted during the microbial air sampling.

Temperature and Relative Humidity

Temperature and RH was measured three times during the work day (once in the morning and twice in the afternoon) in locations previously discussed. Temperature (Figure 9) and RH (Figure 10) levels ranged from 72°F to 82°F, and 33% to 74%, respectively. These are beyond the thermal comfort parameters recommended by ASHRAE. The temperature and RH levels measured outside the building on May 17, 2000, ranged from 86°F to 88°F, and 68% to 74%, respectively.

Hobo Instrument Sampling

Temperature and RH results are displayed in Figures 11–22. The instruments were started on May 16, ran overnight, and through the next day. A majority of the figures indicated that the %RH tended to elevate during the evening hours, while temperature remained constant or dipped slightly. This is an expected outcome during evening hours. A substantial drop in %RH, as in Figure 11 and 12, may be attributed to the window units being turned on in the morning when employees are at work. Figure 14 indicates temperature and %RH cycling during the time period sampled which may indicate a problem with the A/C unit located in that room. Movement of %RH during the working hours is most likely due to doors to other office environments opening/closing and/or due to window A/C being used.

Ventilation System

The following comments are based on a visual examination of the ventilation systems made as part of this evaluation.

- A/C for the building is primarily provided by 95 window air conditioners located throughout the CHC complex.

- Ventilation for the MCH building consists of a combination of window A/C units and ducted, package, central air from other units in the building.
- There was evidence of damaged central air ventilation duct-work in various areas of the building.
- The Carrier package unit supplying the Family Planning area was not properly drained (water running out on the ground in front of the unit).

Moisture Measurements

Spot measurements of exterior walls and floor areas near the exterior walls were probed with a moisture meter to qualitatively assess residual amounts of water suggestive of past water incursion problems. Most of the higher moisture readings were obtained on the interior wall space below windows, suggesting past and present water incursion in these areas. It should be noted that during the collection of these moisture readings, visual evidence of water damage, such as bubbled plaster and rusted window frames were observed.

DISCUSSION

Visual evidence of localized patches of microbiological contamination was observed by NIOSH investigators on both the 2nd and 3rd floors of this office building. Some of the mold-impacted areas were closed which resulted in the elimination of common dissemination pathways to occupied areas of the building. However, mold reservoirs were observed in occupied areas as well. Bulk samples of ceiling tile from the third floor revealed *S. chartarum*, which is an indicator of current or past water intrusion from possible leaking pipes, damaged roof, etc. One air sample collected in Room 252 revealed *S. chartarum*. However, replicate air samples collected in this area did not produce this fungal species. The spore air sampling with MCE

filters indicated two samples with concentrations much higher than the other samples. One was in the 1st floor (basement) area mechanical room. Upon entrance into this area, NIOSH investigators noticed a "mold" smell. This area was cool, dark, and relatively damp with no mechanical ventilation. The second sample was in the Mental Health Clinic. This area had a roof above. The side door was kept open to the outside. This area exhibited evidence of water damage and leaks and was, in general, in poor condition.

Total concentrations (CFU/m³ and FS/m³) were higher outdoors than indoors for a majority of the air samples collected (Figures 1 and 4). However, the taxonomic ranking of a number of indoor air samples indicated a larger percentage of *Aspergillus* and/or *Penicillium* species than the outdoor air samples (Figures 2, 3, and 5). Even though these percentages were relatively small, they nevertheless suggest the dissemination of identified (and possible un-identified) fungal reservoirs within the building.

In contrast to areas with window A/C units, the Family Planning area, which was recently renovated and had its own HVAC unit, was among the lowest in total concentration. The WIC area, on an older central HVAC unit, also had a low total concentration. The Family Planning and WIC areas showed some signs of *Aspergillus* and/or *Penicillium* on air sampling media, however, both were among the lowest in percentage of *Aspergillus* and/or *Penicillium*.

Fungi are present in most indoor and outdoor environments and can cause a variety of allergic reactions, such as runny nose, eye irritation, cough, congestion, and aggravation of asthma. Immunologic responses are activated by an individual's reaction to particular antigenic constituents of a given microbial species. These responses and the subsequent expression of allergic disease are based on the type and extent of the exposures and, in part, on a genetic predisposition. The long term history of water incursion through hurricane damaged portions of

the building envelope and inefficient conditioning of the indoor air by small, package window units provides appropriate conditions indoors for the proliferation of fungal species. Furthermore, the observed evidence of localized reservoirs of mold within the building and air sampling results which indicated a larger percentage of *Aspergillus* and/or *Penicillium* species in indoor air samples compared with the outdoor air samples, suggest that exposure to disseminated fungal spores via inhalation is plausible.

CO₂ levels were not elevated (>800 ppm) during the three time periods of collection. Very few areas indicated a progressive elevation of CO₂ levels during the day. The ample amount of OA coming into the building (from the open doors and wall A/C units) is likely the reason for the low CO₂ levels. The temperature of many areas were not within the ANSI/ASHRAE specified conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable. A number of the areas indicated temperatures in the upper 70's or low 80's and steady or slight increase in temperature throughout the day. This may be due to the lack of A/C or the individual A/C window units set to receive a larger amount of OA and less recirculation of indoor air. The RH in a majority of the areas was within the 30%–60% range recommended by ASHRAE. However, Room 238 and the outdoor measurements revealed levels at approximately 70%. Room 238 had a window A/C unit, but it was broken at the time. Zoned units areas, such as Family Planning, offers a good comparison of temperature, CO₂, and %RH to those areas with just window A/C units.

CONCLUSIONS

Warm, moist environments, as was noted in this building, are needed for ongoing growth of microbial contaminants. Many areas of the building exhibited evidence of present and/or past water incursion events, such as water stains on ceiling tiles and walls, patches of peeling paint on

wall surfaces, rust-stained materials, and visible microbial colonization in occupied and unoccupied areas. The presence of *Stachybotrys* species in four of the five bulk samples is also an indicator of current or past contamination. Although outdoor fungal air concentrations were higher than indoor concentrations, observation of the taxonomic ranking of the indoor air results indicate a trend of increased *Aspergillus*/*Penicillium* percentages compared to outdoors. These facts suggest appropriate conditions indoors for the proliferation of fungal species and the possibility of exposure to disseminated fungal spores. It is not clear what impact these possible exposures may have had on the workers present in the clinic. Clinical study in combination with knowledge of their occupational exposures is necessary before definitive associations can be suggested.

The potential for building related problems is apparent. The building showed signs of considerable structural damage, water leaks, and indicators of past microbial growth. Continued delays in roof reconstruction and renovation of structurally damaged portions and closed interior wings could result in continued water incursion and indoor environmental conditions favorable to increased fungal growth. Furthermore, NIOSH investigators observed conditions that could affect worker comfort and their perception of their work environment as unhealthy, such as poor air distribution and employees being unaware of the problems with the building and decisions made by management to address those problems.

RECOMMENDATIONS

1. Communication between management and employees should be increased. Employees should be made aware of the problems with the building and decisions made by management to address those problems. An environmental committee should be formed to facilitate the flow of employee concerns to management. Formally identifying a person(s) that occupants can use as

a point of contact for their concerns or problems is often useful.

2. Renovate and repair damaged and condemned building areas as soon as possible. This work should begin with the roof and progress downward to each subsequent floor.
3. Any episodes of water incursion should be dealt with promptly. Water should be removed immediately from porous, water-damaged furnishings, carpets, and construction materials. Heat fans should be used to dry carpets and other applicable surfaces within 24 hours. Steam or other water-based cleaning method which adds moisture to the environment must be used with extreme care. Any soft materials that become wet with sewage contaminated water should be promptly discarded. Finally, a written program, which includes employee training in resolving water incursion problems, should be developed.
4. Remediate identified localized patches of mold (see Appendix A). More information on the evaluation and remediation of fungi in the indoor environment can be obtained from the New York City Department of Health web site, <http://www.ci.nyc.ny.us/html/doh/html/epi/moldrpt1.html> and a book published by ACGIH called, *Bioaerosols: Assessment and Control*.⁴⁴
5. Porous materials which readily absorb moisture and can collect organic debris (such as carpeting) should not be used in areas with a history of water damage. Any current porous materials with evidence of water stains (ex. ceiling tiles) should be removed.
6. Better control of the indoor temperature and RH levels must be implemented to bring the occupied office areas within ASHRAE comfort guidelines. It is unknown what influence the warmer and more humid summer weather may have on the ability of the building's ventilation system to maintain a comfortable work environment for most of the employees,

considering that more unconditioned OA is now being brought into the building. These thermal parameters should be checked on a regular basis to see if further modifications to the ventilation system are necessary during hotter and more humid weather conditions.

7. The window A/C and central air units should be regularly maintained according to manufacturer's directions. Furthermore, use higher efficiency air filters in place of the low efficiency filters currently in use. This should only be attempted after determining if the central air units can accommodate a higher efficiency filter.

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APPENDIX A

Building Cleaning – Visible or Suspected Microbial Contamination

Visible or suspected microbial contamination requires remediation efforts, including the removal of the contaminated material and/or clean-up with a high efficiency particulate air filter (HEPA) vacuum and decontamination with an effective chemical agent (i.e., 5% to 10% solution of chlorine bleach). Remediation will result in the disruption of microbiological reservoirs. The airborne dissemination of these bioaerosols can pose a significant exposure concern for the remediation workers. Additionally, these aerosols can be spread to uncontaminated areas of a building, increasing the hazard for the remaining occupants and adding to the difficulty of clean-up. Thus, it is important that all remediation activities be conducted with an awareness of the potential bioaerosol exposures and with minimal disturbance of contaminated materials. Specifically, controls must be instituted that protect both the *worker* and the *adjacent environment*.

Remediation workers should use personal protective equipment (PPE) appropriate for the hazards to which they may be exposed. Such decisions require *a priori* awareness of potentially hazardous agents, significant exposure routes (e.g., inhalation, dermal contact, or ingestion), and possible concentrations of the biological materials. Remediation work on small, localized patches of mold growth on ceilings or walls should be conducted with appropriate respirators (i.e., a disposable N-95, NIOSH-approved respirator with a facepiece that fits tightly, ensuring that contaminants do not enter through leaks between the respirator and a wearer's face), eye protection, and gloves. Situations involving gross contamination with microorganisms that pose potentially significant health outcomes (e.g., infectious or toxigenic fungi), may require a higher level of PPE (e.g., full-face, powered air-purifying respirators, disposable protective clothing with hoods, gloves, and disposable shoe coverings). For respirator use, OSHA requires a respiratory protection program that includes the following components: written standard operating procedures, user instruction and training, cleaning and disinfection, storage, inspection, surveillance of work area conditions, evaluation of respirator protection program, medical review, and use of certified respirators.¹

Given the level of disruption that may occur during microbiological remediation work, engineering controls applied at the source should be the primary control measure. Activities should be conducted in a manner that minimizes the disturbance of microbiological reservoirs. However, as the extent of the microbial contamination becomes larger, reservoir dissemination becomes unavoidable due to the activities of surrounding building material removal. Under these conditions, isolation barriers are required to contain airborne spores and other biological matter. Barriers alone disrupt the pathways between remediation zones and adjacent environments, but disseminated aerosols almost invariably find breaks in any barrier system. Therefore, negative pressure relative to adjacent areas is recommended to ensure containment. It is critical that the exhausted air streams be appropriately filtered (i.e., HEPA filters) to guard against the re-entry of microbially contaminated air back into the zone of remediation and/or to other areas that are considered uncontaminated. Specific control guidelines have been recommended for the remediation of toxigenic fungi from contaminated materials.²

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Table 1. Fungal Content of Bulk Samples

(May 17, 2000, samples collected and cultured on corn-meal agar [CMA] and malt-extract agar [MEA] media)

Location	Medium Used	Predominate Fungal ID	Colony Counts	Concentration (CFU/g)‡	Percentage †
Hallway – condemned area – close to Room 376 – ceiling tile	CMA	<i>Aspergillus sydowii</i>	4	100,613	2
		<i>Aspergillus versicolor</i>	1	25,153	< 1
		<i>Cladosporium</i>	84	2,112,884	38
		<i>Penicillium</i>	1	25,153	< 1
		<i>Stachybotrys chartarum</i>	134	3,370,552	60
	MEA	<i>Aspergillus sydowii</i>	12	301,841	5
		<i>Aspergillus ustus</i>	1	25,153	< 1
		<i>Aspergillus versicolor</i>	9	226,380	4
		<i>Cladosporium</i>	71	1,785,890	30
		<i>Emericella (Aspergillus) nidulans</i>	1	25,153	< 1
		<i>Penicillium</i>	1	25,153	< 1
		<i>Stachybotrys chartarum</i>	144	3,622,086	60
Hallway – outside of Room 384 – ceiling tile	CMA	<i>Aspergillus sydowii</i>	26	646,061	32
		<i>Aspergillus ustus</i>	6	149,091	7
		<i>Aspergillus versicolor</i>	2	49,697	2
		<i>Chaetomium globosum</i>	1	24,848	1
		<i>Stachybotrys chartarum</i>	47	1,167,879	57
	MEA	<i>Aspergillus sydowii</i>	38	944,242	48
		<i>Aspergillus ustus</i>	6	149,091	8
		<i>Chaetomium globosum</i>	1	24,848	1
		<i>Stachybotrys chartarum</i>	35	869,697	44
Hallway – outside of Room 351 – ceiling tile	CMA	<i>Aspergillus ustus</i>	2	39,614	3
		<i>Cladosporium</i>	3	59,420	4
		<i>Stachybotrys chartarum</i>	65	1,287,440	93
	MEA	<i>Aspergillus ustus</i>	1	19,807	2
		<i>Cladosporium</i>	1	19,807	2
		<i>Stachybotrys chartarum</i>	52	1,029,952	96
Vital Statistics – back office – outer layer of duct work	CMA	No Growth	NA	< 641	NA
	MEA	No Growth	NA	< 641	NA
Hallway – above Room 372 – ceiling tile	CMA	<i>Stachybotrys chartarum</i>	25	560,109	100
	MEA	<i>Aspergillus ustus</i>	1	22,404	5
		<i>Stachybotrys chartarum</i>	18	403,279	95
‡ = colony forming units per gram of material					
† = percentage of each group of fungi in total population					

Table 2. Air Samples for Culturable Fungi Using Malt-extract Agar

Sample Location	Date	GM	GSD	% Clado	% Asp	% Pen	% Stachy
Room 376	5/16/00	55	1.29	65	6	6	0
Room 350	5/16/00	80	1.31	69	2	7	0
Room 353	5/16/00	101	1.61	55	13	11	0
Room 252	5/16/00	87	1.09	66	3	14	0
Outside (N Center)	5/16/00	286	1.11	71	6	3	0
MCH Room 5	5/17/00	151	1.20	66	3	3	0
MCH Room 14	5/17/00	45	1.97	61	0	0	0
MCH Medical Records	5/17/00	110	1.33	42	0	2	0
Outside (N Center)	5/17/00	286	1.13	68	4	9	0
Room 238	5/17/00	155	1.24	60	12	14	0
Immunization	5/17/00	98	1.16	59	18	5	0
Family Planning	5/17/00	41	1.32	53	12	0	0
Vital Statistics	5/17/00	107	1.22	46	15	13	0
WIC	5/17/00	24	14.84	24	0	2	0

- GM = Geometric mean of fungal concentration (colony forming units per cubic meter [CFU/m³])
 GSD = Geometric standard deviation
 Clado = *Cladosporium* species
 Asp = *Aspergillus* species
 Pen = *Penicillium* species
 Stachy = *Stachybotrys* species

Table 3. Air Samples for Culturable Fungi Using Corn-meal Agar

Sample Location	Date	GM	GSD	% Clado	% Asp	% Pen	% Stachy
Room 376	5/16/00	70	1.77	78	0	0	0
Room 350	5/16/00	69	1.31	63	0	12	0
Room 353	5/16/00	122	1.06	48	4	8	0
Room 252	5/16/00	82	1.14	53	3	9	4
Outside (N Center)	5/16/00	321	1.14	74	6	3	0
MCH Room 5	5/17/00	122	1.06	77	2	13	0
MCH Room 14	5/17/00	44	1.18	72	6	0	0
MCH Medical Records	5/17/00	79	1.18	52	16	0	0
Outside (N Center)	5/17/00	289	1.20	71	7	6	0
Room 238	5/17/00	188	1.09	79	3	6	0
Immunization	5/17/00	98	1.47	50	24	6	0
Family Planning	5/17/00	44	1.49	74	4	0	0
Vital Statistics	5/17/00	88	1.19	67	14	0	0
WIC	5/17/00	100	1.22	41	4	6	0

- GM = Geometric mean of fungal concentration (colony forming units per cubic meter [CFU/m³])
- GSD = Geometric standard deviation
- Clado = *Cladosporium* species
- Asp = *Aspergillus* species
- Pen = *Penicillium* species
- Stachy = *Stachybotrys* species

Table 4. Air Samples for Fungal Structure Count and Identification Using Air-O-Cell Cassettes

Sample Location	Date	GM	GSD	% Clado	% Asp/Pen
Room 376	5/16/00	177	1.74	28	17
Room 350	5/16/00	28	18.4	0	16
Room 353	5/16/00	145	1.67	40	13
Room 252	5/16/00	86	2.21	33	0
Outside (N Center)	5/16/00	310	3.12	30	0
MCH Room 5	5/17/00	91	2.44	13	0
MCH Room 14	5/17/00	22	14.8	0	0
MCH Medical Records	5/17/00	111	1.85	23	22
Outside (N Center)	5/17/00	628	1.81	27	0
Room 238	5/17/00	427	2.38	22	15
Immunization	5/17/00	317	1.40	7	11
Family Planning	5/17/00	115	2.20	24	0
Vital Statistics	5/17/00	420	1.49	13	19
WIC	5/17/00	33	21.5	44	11

- GM = Geometric mean of fungal concentration (colony forming units per cubic meter [CFU/m³])
 GSD = Geometric standard deviation
 Clado = *Cladosporium* species
 Asp = *Aspergillus* species
 Pen = *Penicillium* species

Table 5. Air Samples for Fungal Structure Count and Identification Using MCE filters

Sample Location	Date	Sample Time (military)	Sample Volume (m ³)	Total Count (FS/m ³)	Clado Count (FS/m ³)	Asp/Pen Count (FS/m ³)	Stachy Count (FS/m ³)
Room 353	5/16/00	1245 – 1628	0.56	1157	0	0	0
Room 376	5/16/00	1255 – 0430	2.34	0	0	0	0
Area by 271/273	5/16/00	1307 – 1618	0.47	0	0	0	0
WIC	5/16/00	1310 – 1618	0.47	0	0	0	0
Room 214	5/16/00	1320 – 1640	0.56	0	0	0	0
3 rd floor, unoccupied area	5/16/00	1322 – 1617	0.43	0	0	0	0
Mental Health Clinic	5/16/00	1322 – 1622	0.45	1157	0	0	0
Room 222	5/16/00	1333 – 1645	0.48	1157	0	0	0
1 st floor mechanical room	5/16/00	1338 – 1632	0.43	8097	1157	6940	0
Outside of Immunization	5/16/00	1343 – 1630	0.41	1157	0	1157	0
Outside – 3 rd floor	5/16/00	1352 – 1628	0.38	0	0	0	0
Area by Room 313	5/16/00	1348 – 1628	0.40	0	0	0	0
MCH Nurses station	5/17/00	0844 – 1506	0.95	1157	0	0	0
Outside – 2 nd floor	5/17/00	0817 – 1533	1.09	3470	1157	0	0
Room 376	5/17/00	0835 – 1511	0.98	2313	1157	0	0
Room 350	5/17/00	0822 – 1511	1.03	1157	1157	0	0
Vital Statistics	5/17/00	0817 – 1506	1.01	3470	1157	1157	0
WIC	5/17/00	0828 – 1514	1.02	4627	3470	1157	0
MCH Room 17	5/17/00	0852 – 1504	0.93	2313	1157	1157	0
Outside – 3 rd floor	5/17/00	0837 – 1523	1.24	1157	0	0	0
Urine Analysis Laboratory	5/17/00	0840 – 1517	0.99	1157	1157	0	0
Area by Room 313	5/17/00	0831 – 1523	1.00	0	0	0	0
Room 238	5/17/00	0822 – 1459	0.76	2313	0	2313	0
MCH Pre-natal #5	5/17/00	0846 – 1505	0.94	1157	1157	0	0
Mental Health Clinic	5/17/00	0810 – 1503	1.03	13880	0	13880	0
Immunization	5/17/00	0857 – 1530	0.98	2313	1157	0	0

Clado = *Cladosporium* Asp = *Aspergillus* Pen = *Penicillium* Stachy = *Stachybotrys*
 FS = fungal structures m³ = cubic meter

Table 6. Air Samples for Endotoxin

Sample Location	Sample Time (military)	Sample Volume (m ³)	Filter Weight (milligrams)	EU/m ³
MCH Immunization	0857 – 1534	0.80	ND	0.38
MCH Pre-natal	0846 – 1505	0.77	ND	ND
Room 376	0835 – 1511	0.80	ND	ND
WIC	0828 – 1514	0.80	ND	ND
MCH Nurses Station	0844 – 1506	0.78	ND	ND
Room 222	0931 – 1459	0.78	ND	ND
Urine Analysis Laboratory	0840 – 1517	0.80	ND	ND
Mental Health Clinic	0810 – 1503	0.84	ND	1.08
MCH Room 17	0852 – 1504	0.76	ND	ND
Vital Statistics	0817 – 1506	0.82	ND	0.85
Outside – 2 nd floor	0817 – 1533	0.87	ND	ND
Room 238	0822 – 1459	0.80	ND	ND
Room 350	0822 – 1511	0.82	ND	ND
Outside – 3 rd floor	0837 – 1523	0.82	0.03	0.73
Room 313 area	0831 – 1523	0.83	ND	0.73

ND = non-detectable
 EU = endotoxin units
 m³ = cubic meter

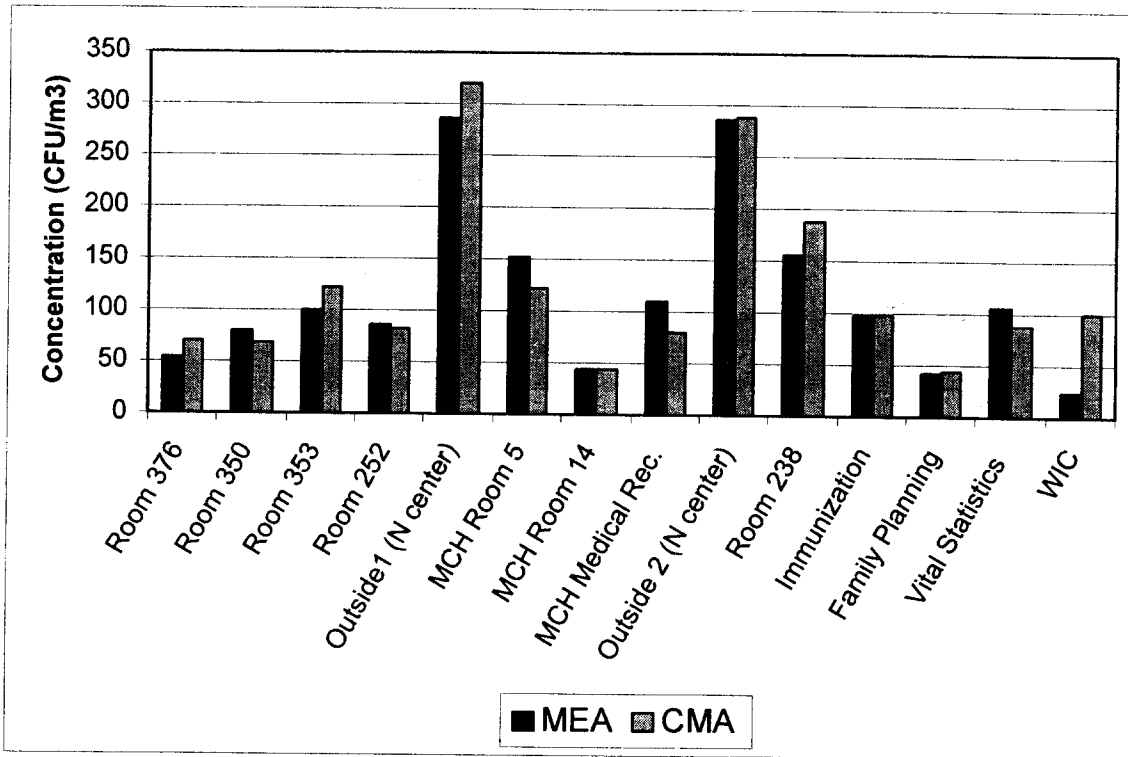


Figure 1. Culturable Air Sampling Measurement Results

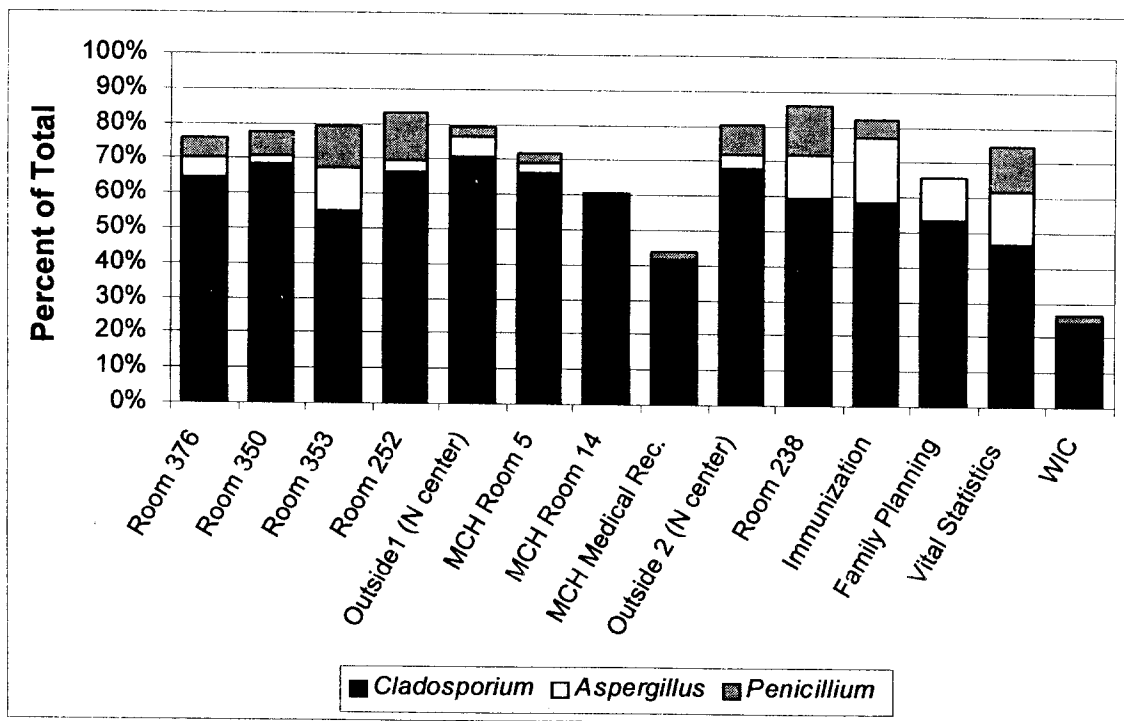


Figure 2. Culturable Air Sample Taxonomic Ranking on MEA

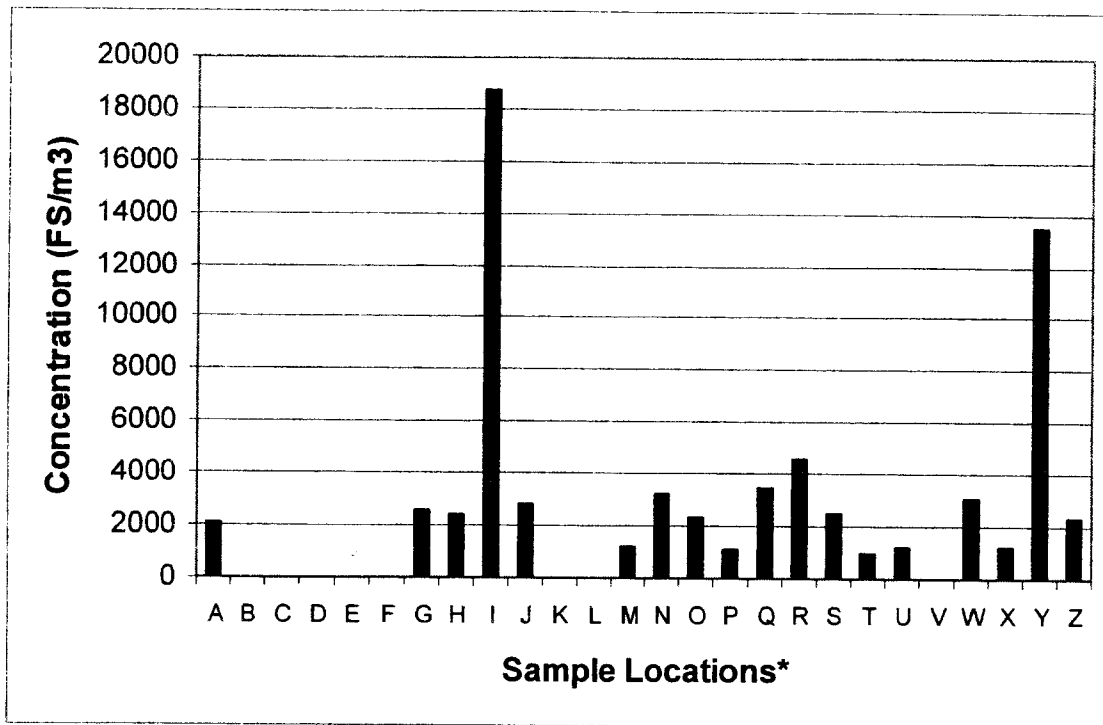


Figure 6. Total Fungal Structure Air Sampling Measurement Results (MCE)

***Sample Locations:**

5/16/00	Location A:	Room 353
	Location B:	Room 376
	Location C:	Area by Room 271/273
	Location D:	WIC – Outside Offices
	Location E:	Room 214
	Location F:	Unoccupied area – 2 nd floor – Hallway Area
	Location G:	Mental Health Clinic
	Location H:	Room 222
	Location I:	1 st floor – Mechanical Room
	Location J:	Outside of Immunization Area
	Location K:	Outside of 3 rd Floor Condemned Area
	Location L:	By Room 313
	5/17/00	Location M:
Location N:		Outside – 2 nd Floor Patio
Location O:		Room 376
Location P:		Room 350
Location Q:		Vital Statistics
Location R:		WIC – Outside Offices
Location S:		MCH – Room 17
Location T:		Outside of 3 rd Floor Condemned Area
Location U:		Urine Testing Laboratory
Location V:		By Room 313
Location W:		Room 238
Location X:		MCH – Room 5
Location Y:		Mental Health Clinic
Location Z:	Immunization	

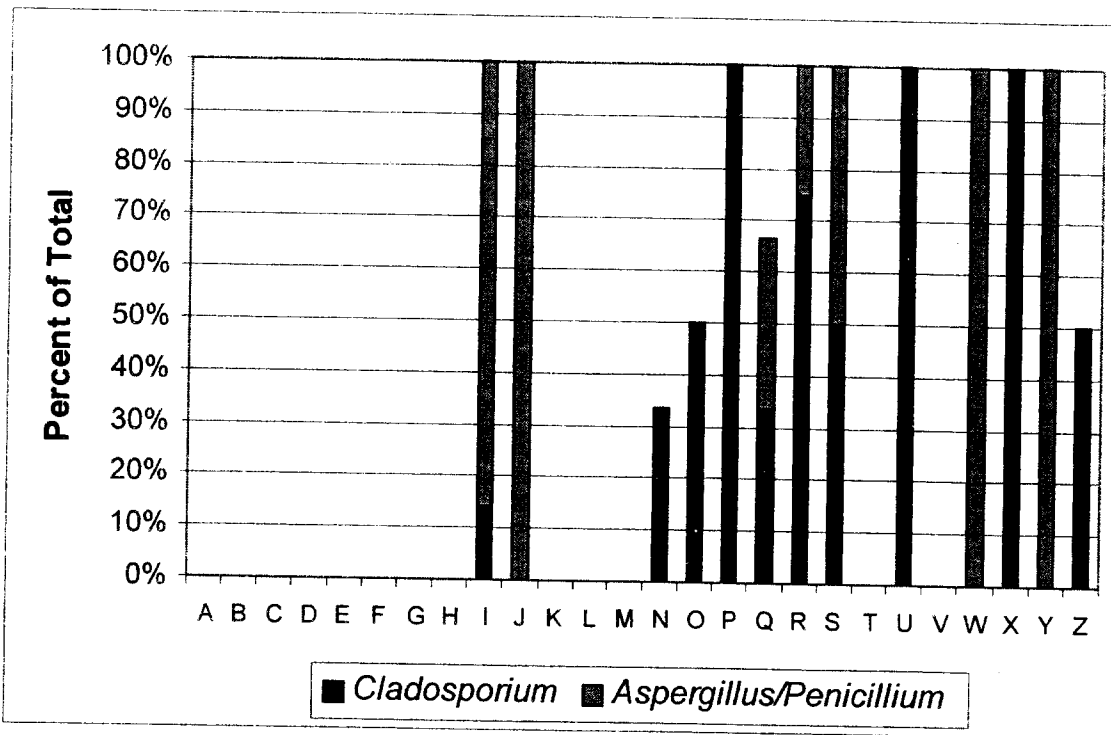


Figure 7. Fungal Structure Air Sampling Taxonomic Ranking (MCE)

Sampling Locations:

5/16/00	Location A:	Room 353	
	Location B:	Room 376	
	Location C:	Area by Room 271/273	
	Location D:	WIC – Outside Offices	
	Location E:	Room 214	
	Location F:	Unoccupied area – 2 nd floor – Hallway Area	
	Location G:	Mental Health Clinic	
	Location H:	Room 222	
	Location I:	1 st floor – Mechanical Room	
	Location J:	Outside of Immunization Area	
	Location K:	Outside of 3 rd Floor Condemned Area	
	Location L:	By Room 313	
	5/17/00	Location M:	MCH – Nurses’ Station
		Location N:	Outside – 2 nd Floor Patio
Location O:		Room 376	
Location P:		Room 350	
Location Q:		Vital Statistics	
Location R:		WIC – Outside Offices	
Location S:		MCH – Room 17	
Location T:		Outside of 3 rd Floor Condemned Area	
Location U:		Urine Testing Laboratory	
Location V:		By Room 313	
Location W:		Room 238	
Location X:		MCH – Room 5	
Location Y:		Mental Health Clinic	
Location Z:		Immunization	

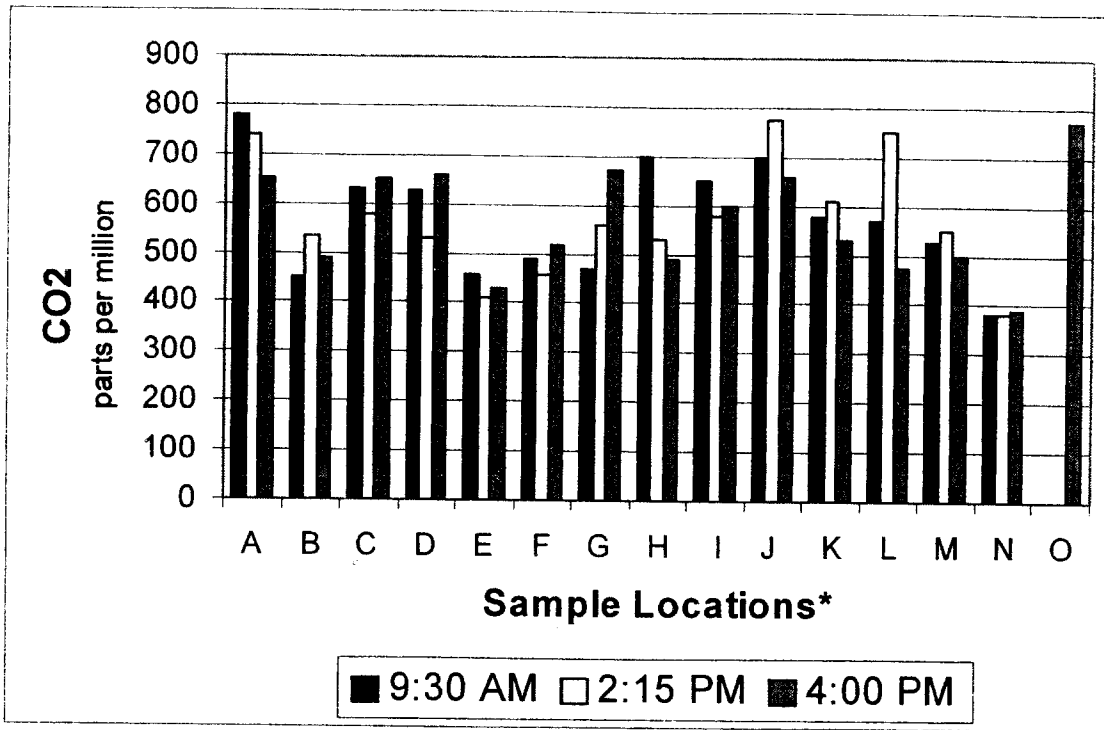


Figure 8. CHC Carbon Dioxide Measurements

Note: NIOSH suspects inadequate ventilation in areas when indoor CO₂ concentrations exceed 800 ppm, where the only known source is exhaled breath, inadequate ventilation is suspected. Elevated CO₂ concentrations suggest that other indoor contaminants may also be increased.

***Sample Locations:**

- 5/17/00
- Location A: Conference Room (adjacent to Room 376)
 - Location B: Room 376
 - Location C: Room 353
 - Location D: Room 238
 - Location E: Substance Abuse Lab
 - Location F: MCH Room 14
 - Location G: Vital Statistics
 - Location H: MCH Main Waiting Area
 - Location I: MCH Room 13
 - Location J: MCH Nurses' Station
 - Location K: Immunization Clinic
 - Location L: Family Planning – Clinic
 - Location M: Family Planning – Administration
 - Location N: Outside
 - Location O: Speech and Hearing Room

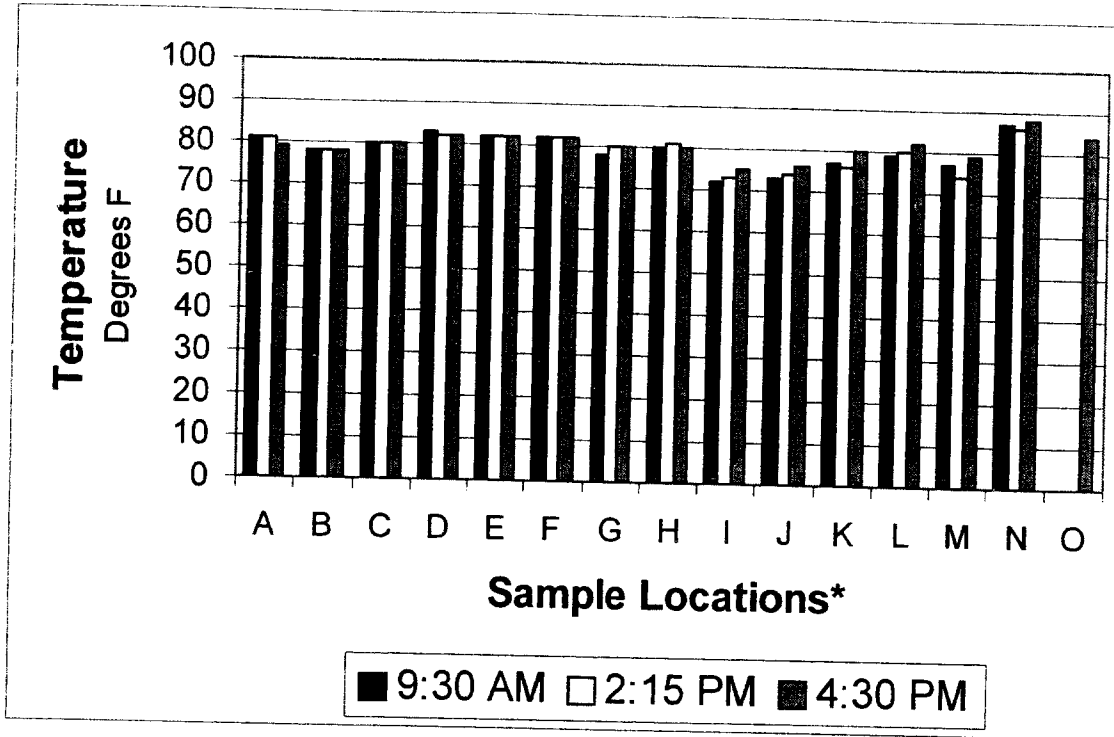


Figure 9. CHC Temperature Measurements

Note: Assuming low air movement, 60% RH, and sedentary job tasks, the temperatures recommended by ASHRAE range from 68–74°F in the winter, and from 73–79°F in the summer.

***Sample Locations:**

5/17/00	Location A:	Conference Room (adjacent to Room 376)
	Location B:	Room 376
	Location C:	Room 353
	Location D:	Room 238
	Location E:	Substance Abuse Lab
	Location F:	MCH Room 14
	Location G:	Vital Statistics
	Location H:	MCH Main Waiting Area
	Location I:	MCH Room 13
	Location J:	MCH Nurses' Station
	Location K:	Immunization Clinic
	Location L:	Family Planning – Clinic
	Location M:	Family Planning – Administration
	Location N:	Outside
	Location O:	Speech and Hearing Room

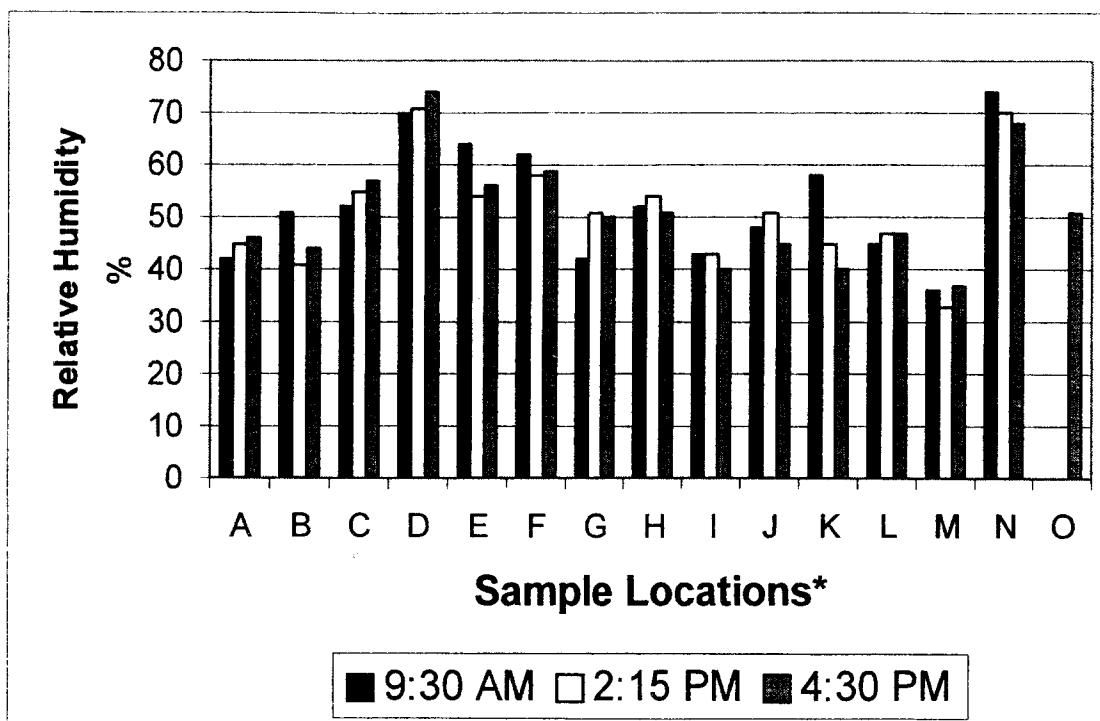


Figure 10. CHC Percent Relative Humidity Measurements

Note: ASHRAE recommends that RH be maintained between 30% and 60%.

***Sample Locations:**

- 5/17/00
- Location A: Conference Room (adjacent to Room 376)
 - Location B: Room 376
 - Location C: Room 353
 - Location D: Room 238
 - Location E: Substance Abuse Lab
 - Location F: MCH Room 14
 - Location G: Vital Statistics
 - Location H: MCH Main Waiting Area
 - Location I: MCH Room 13
 - Location J: MCH Nurses' Station
 - Location K: Immunization Clinic
 - Location L: Family Planning - Clinic
 - Location M: Family Planning - Administration
 - Location N: Outside
 - Location O: Speech and Hearing Room

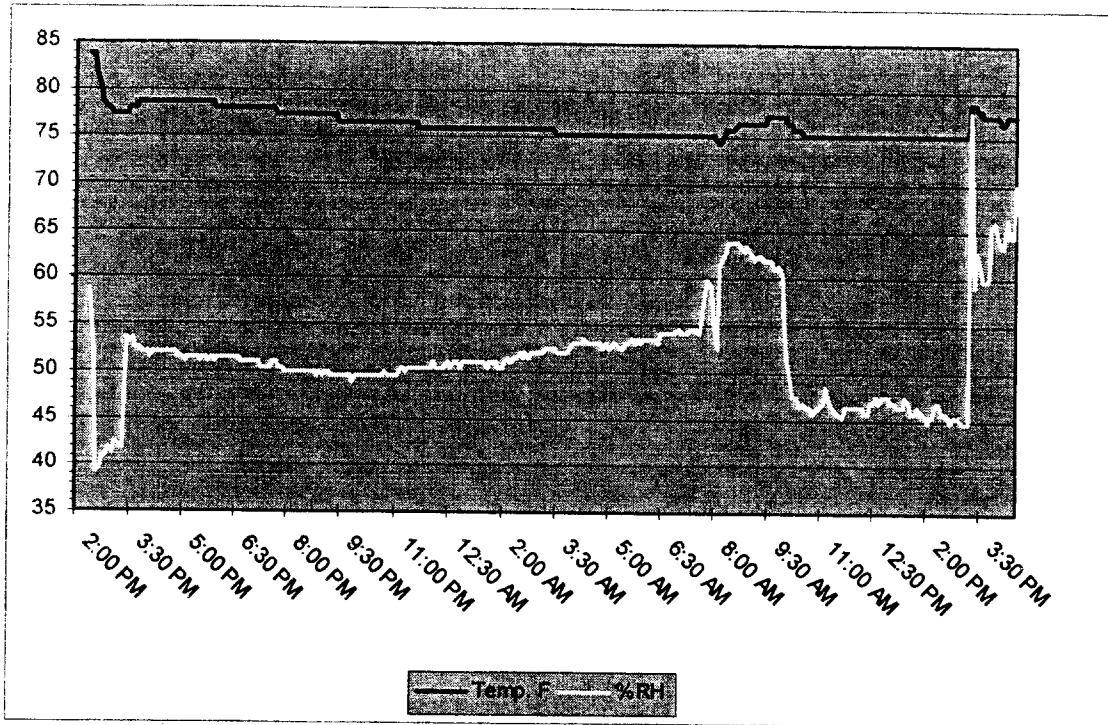


Figure 11. The Hobo Instrument's Temp. and %RH Measurements in Room 376

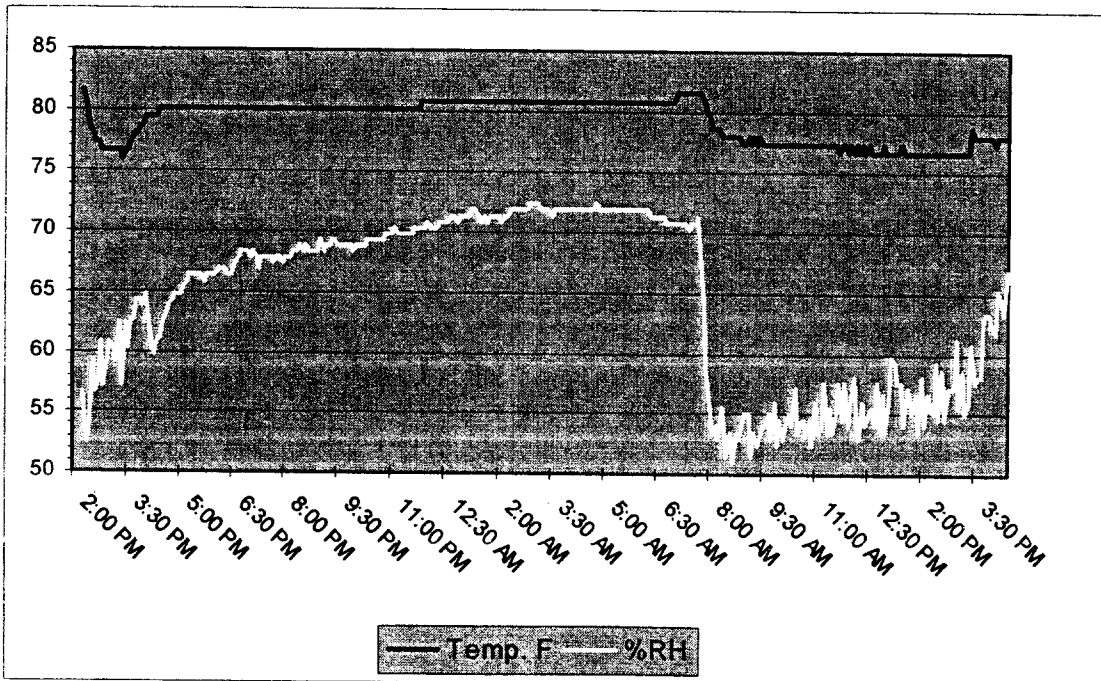


Figure 12. Hobo Instrument's Temp. and %RH Measurements in Room 353

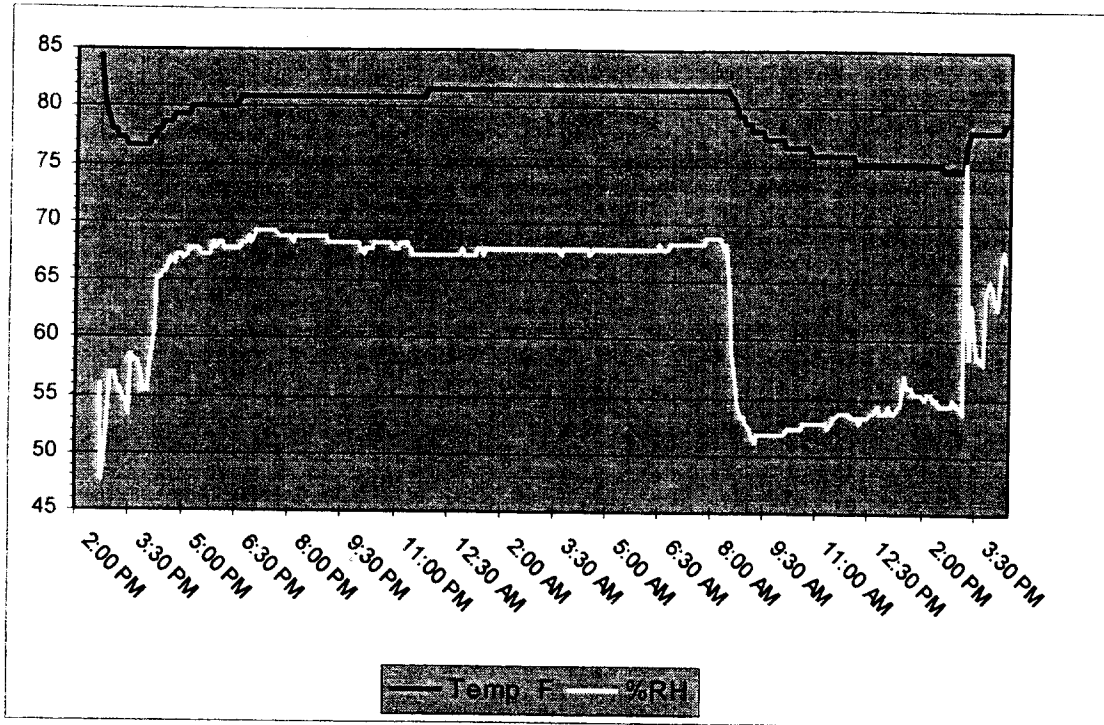


Figure 13. Hobo Instrument's Temp. and %RH Measurements in Room 350

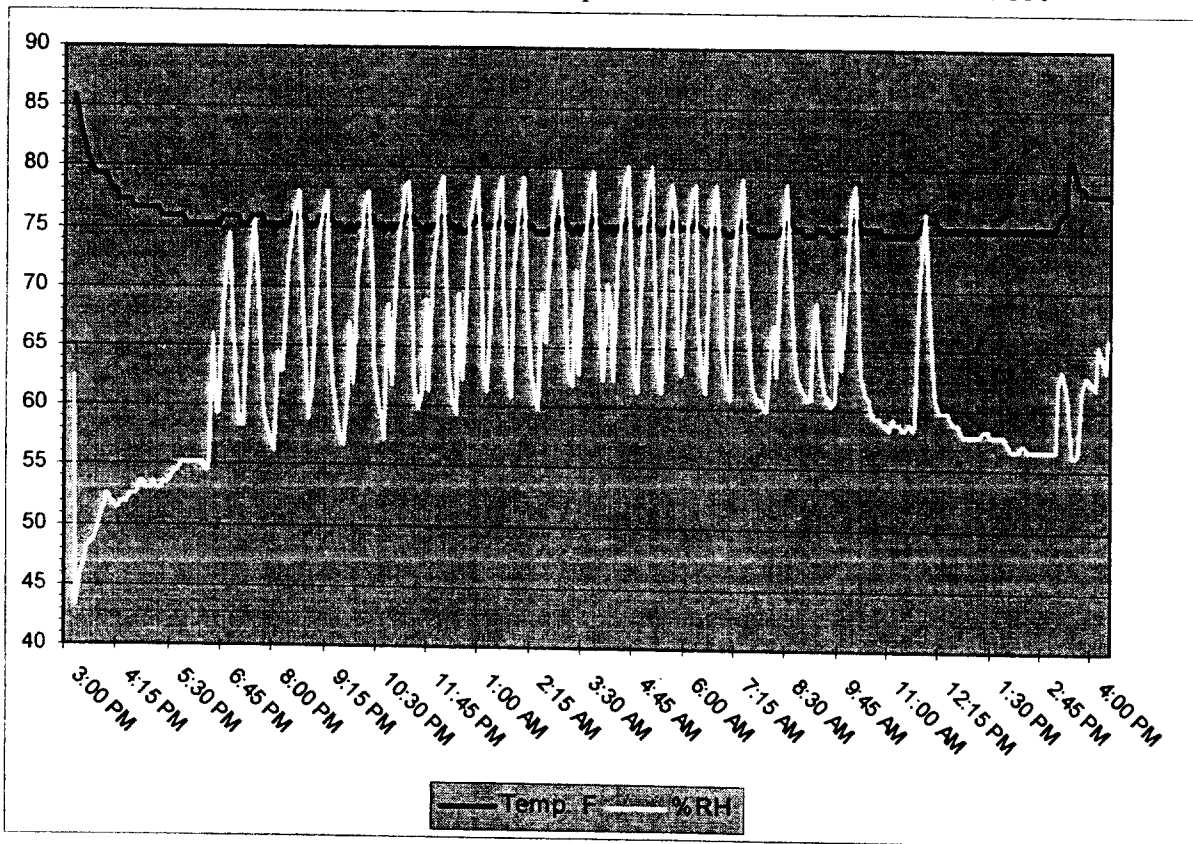


Figure 14. Hobo Instrument's Temp. and %RH Measurements in Room 252

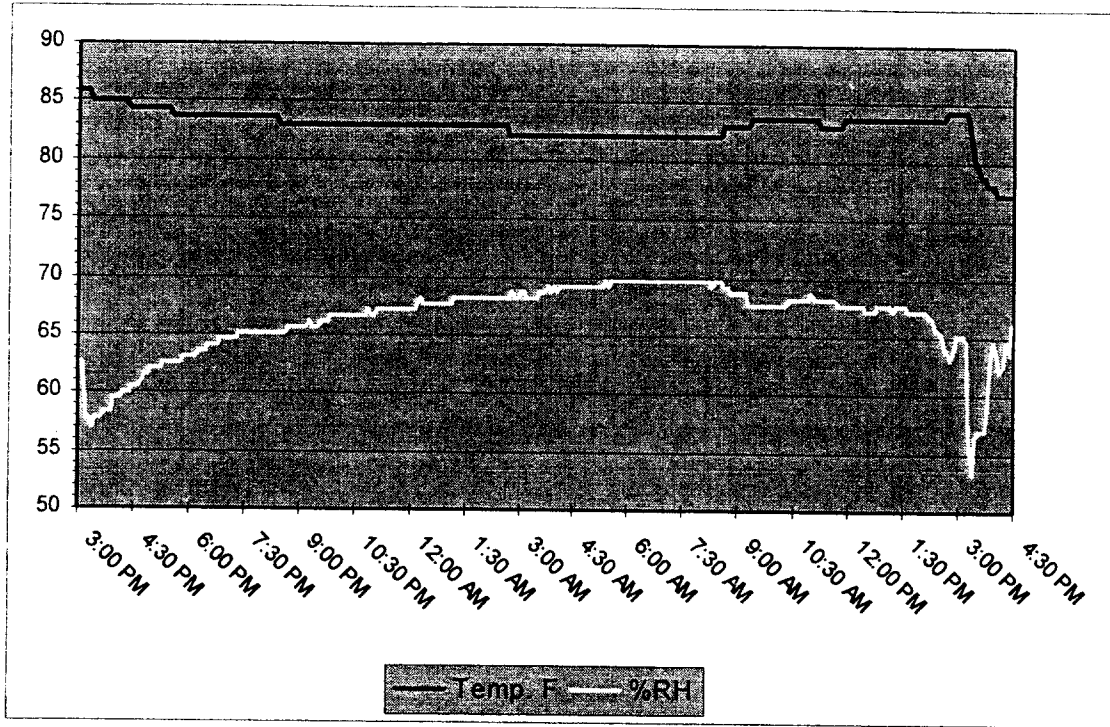


Figure 15. Hobo Instrument's Temp. and %RH Measurements in Room 238

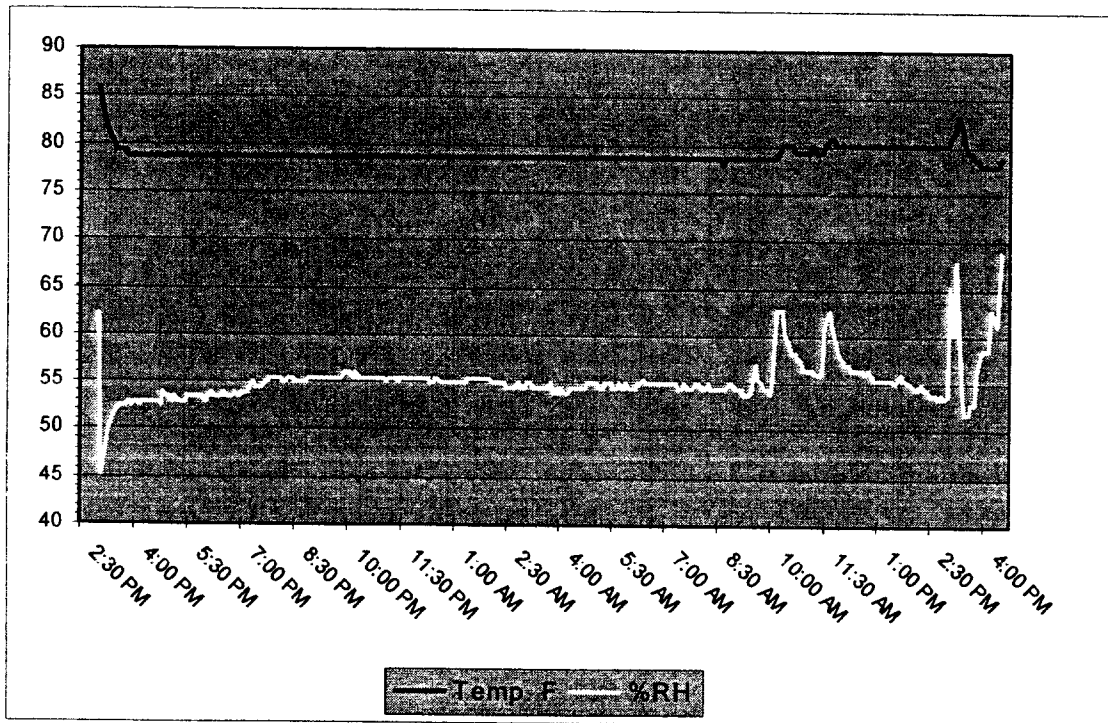


Figure 16. Hobo Instrument's Temp. and %RH Measurements in Medical Records Room

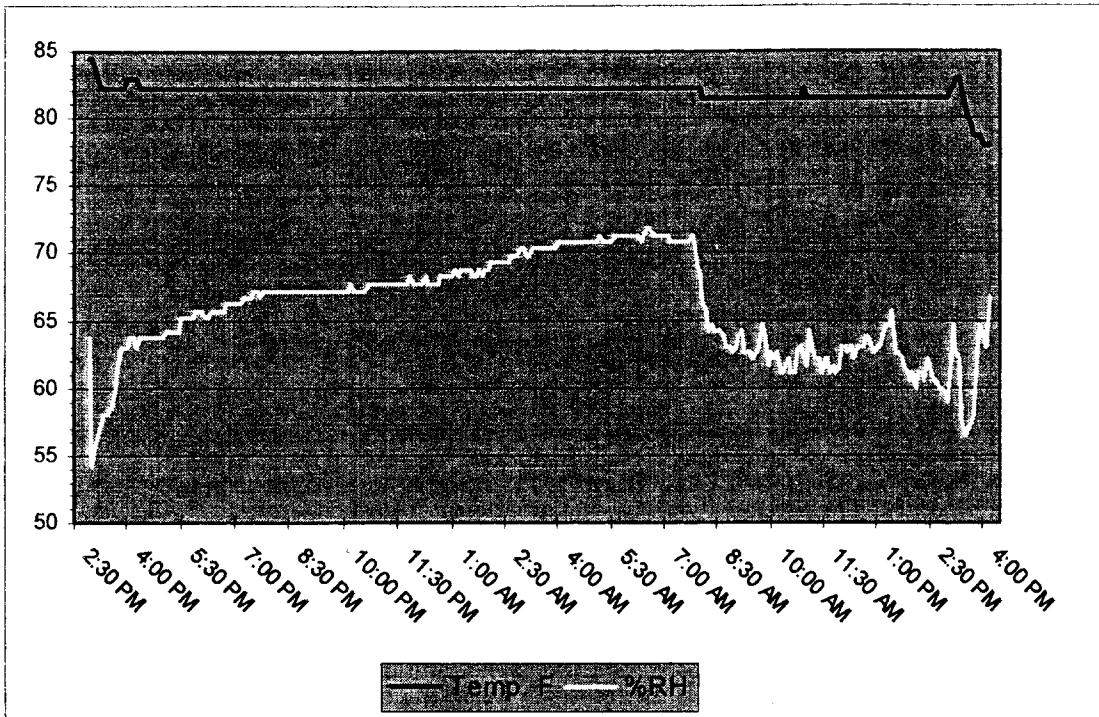


Figure 17. Hobo Instrument's Temp. and %RH Measurements in Mental Health Services

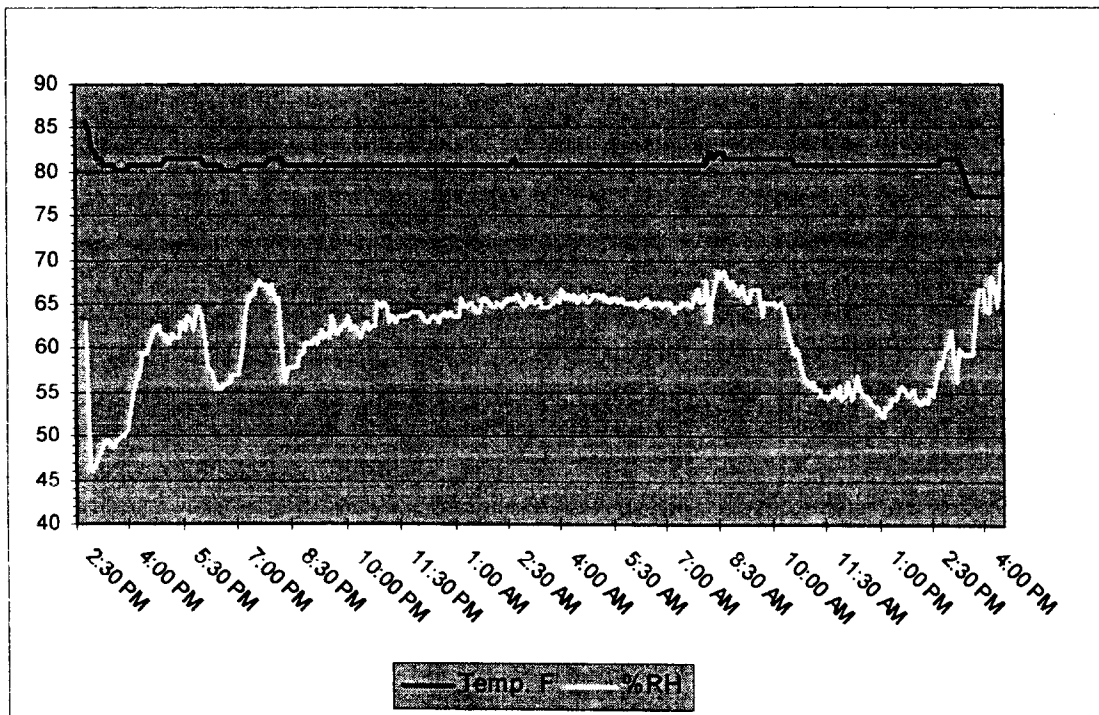


Figure 18. Hobo Instrument's Temp. and %RH Measurements in Substance Abuse Lab

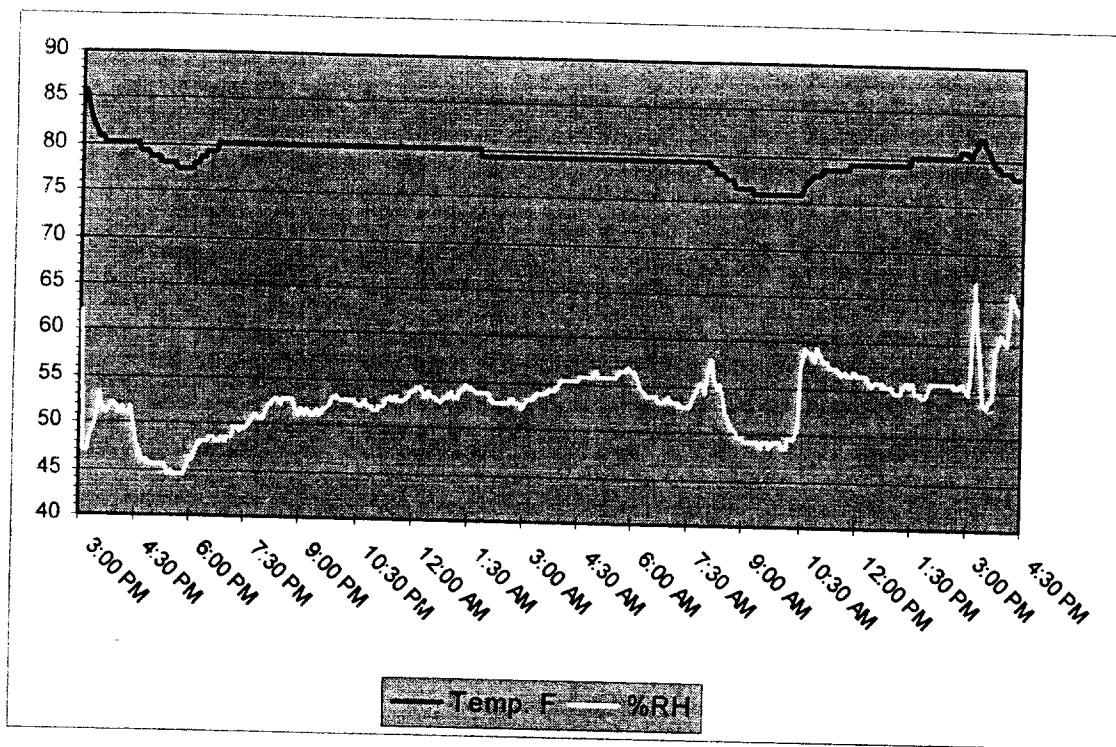


Figure 19. Hobo Instrument's Temp. and %RH Measurements in Vital Statistics

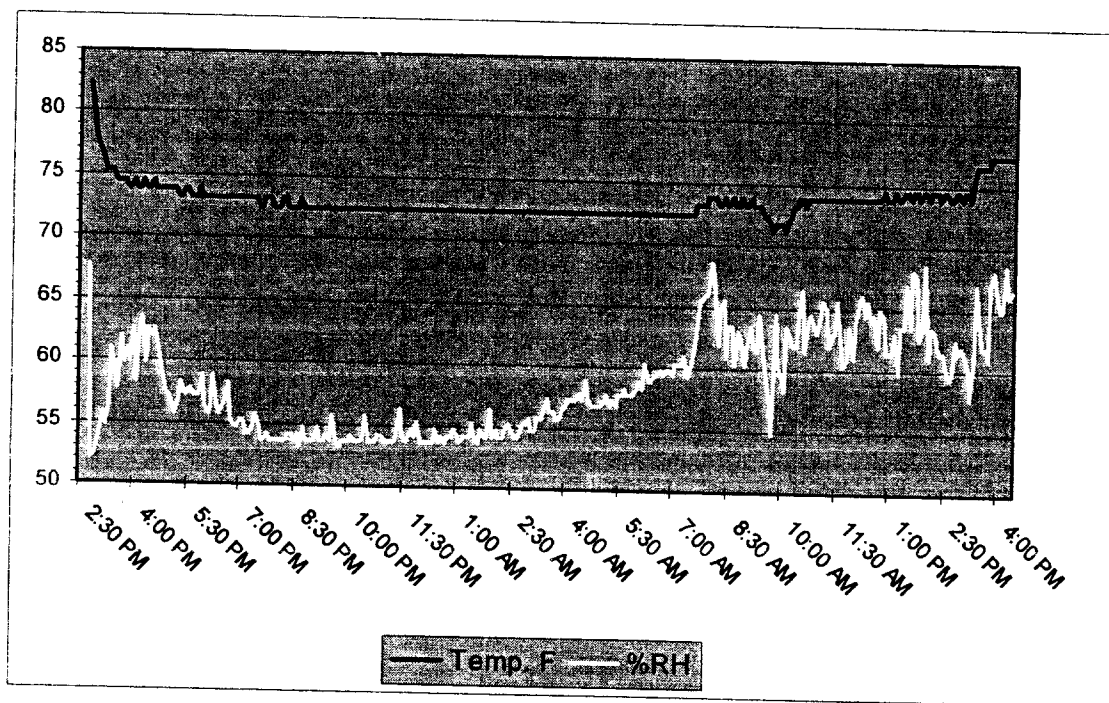


Figure 20. Hobo Instrument's Temp. and %RH Measurements in WIC

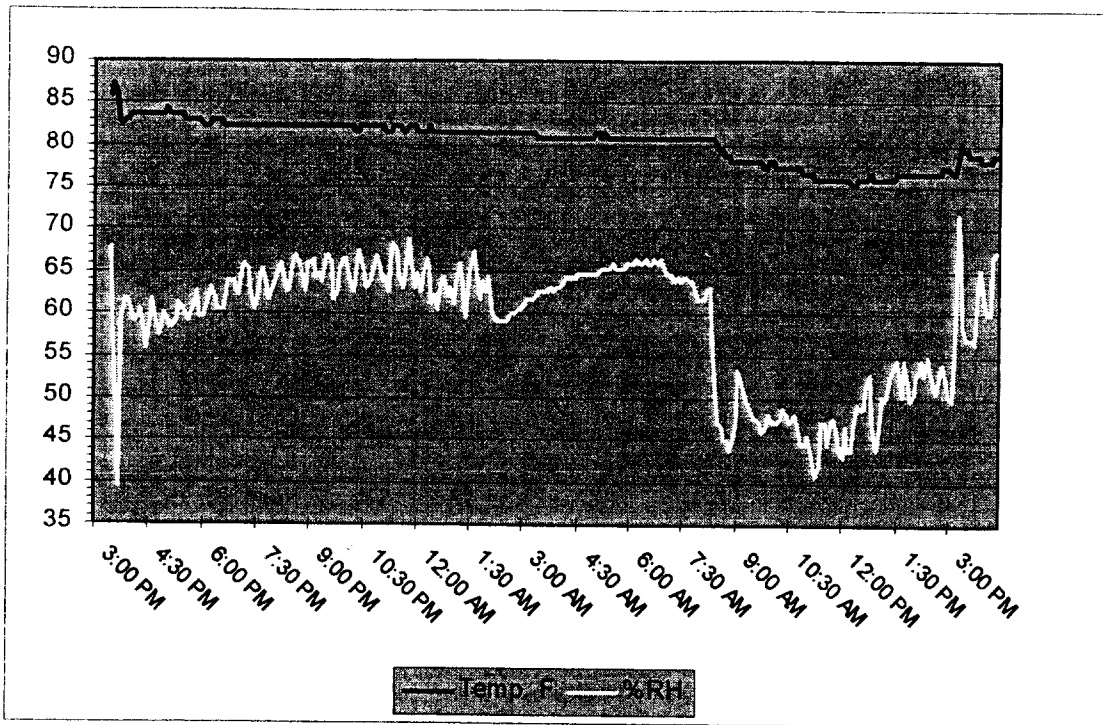


Figure 21. Hobo Instrument's Temp. and %RH Measurements in MCH Room 5

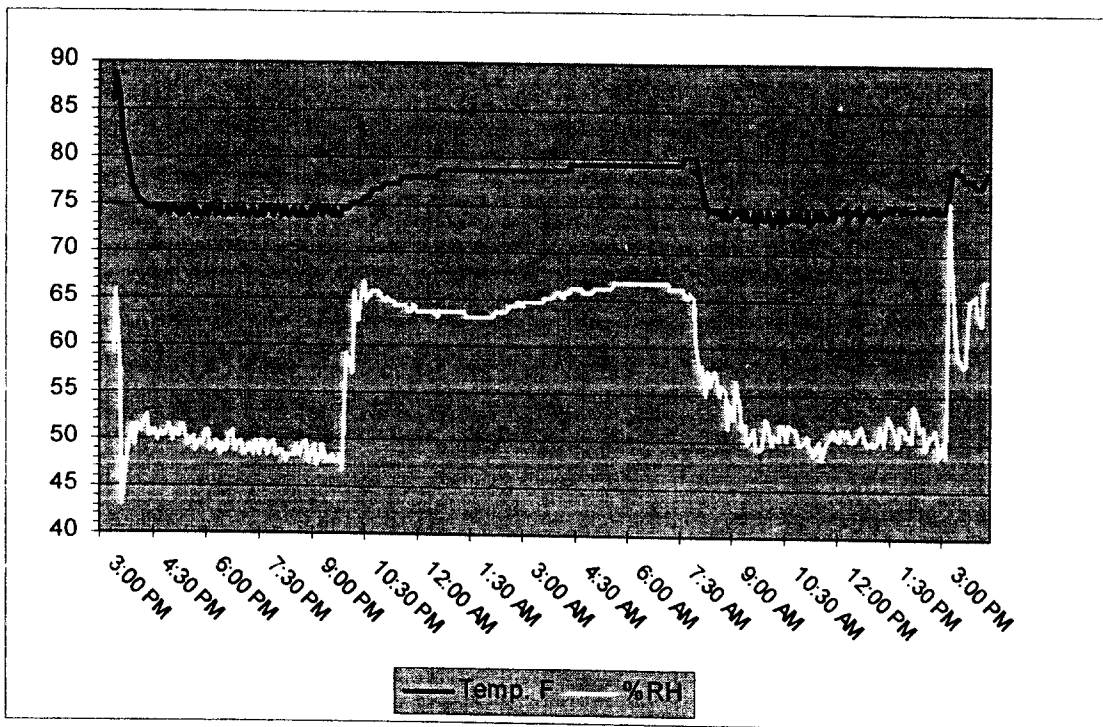


Figure 22. Hobo Instrument's Temp. and %RH Measurements in MCH Room 14

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