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HETA 2000–0091–2803
Horry County Assessor's Office
Conway, South Carolina

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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 Gregory A. Burr and Kenneth F. Martinez of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Desktop publishing was performed by Ellen Blythe and Robin Smith. Review and preparation for printing were performed by Penny Arthur.

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

Highlights of the NIOSH Health Hazard Evaluation

Indoor Environmental Quality Survey at the Horry County Assessor's Office (801 Main Street Building)

Horry County employees working at 801 Main Street, Conway, South Carolina, submitted a Health Hazard Evaluation request concerning prior exposures to carbon monoxide (CO), as well as ongoing concerns with mold. The employees believed that their symptoms, which included headache, sinus problems, and upper respiratory problems, were work related

What NIOSH Did

- We walked through the entire building, including the crawl space.
- We took samples for carbon monoxide (CO) in office areas and the boiler room.
- We checked the carbon dioxide (CO_2), temperature, and relative humidity levels in the building. These tell us how well the building is ventilated.
- We took samples of visible mold.
- We looked inside some of the ventilation systems and where outside air is brought into the building.
- We checked for moisture in the walls and carpeting.

What NIOSH Found

- The CO levels were very low and should not be a problem.
- High CO_2 levels were measured in the Auditor's Office, Building Inspection, and Code Enforcement. This suggests that these areas, with their public access, may not always get enough outside air.
- The ventilation system was improved to bring in more outside air, but the use of movable office dividers in some areas causes poor air circulation.
- We saw wet areas around some windows, water stains on ceiling tiles and down walls, patches of peeling paint, rust–stains, and some patches of mold.
- The vacuum samples we took from the floor did not find high fungal (mold) levels. However, bacterial levels were high.
- We saw microbial contamination in the crawl space and smelled an odor that was probably from microbiological growth. However, it was not clear if there was as way for this contamination to enter the occupied office areas of the building.
- Most of the symptoms mentioned by the employees we spoke with were similar to those found by us in other surveys. It is difficult to link these symptoms to any specific environmental problem.

What Horry County Can Do

- Clean up any localized patches of mold (see the Appendix in the final report for details on how to do this safely).
- Make sure that employees are aware of the problems with the building and any decisions made to fix those problems.
- Fix any acute water damaged areas as quickly as possible. Heat fans should be used to dry surfaces within 24 hours.
- Evaluate replacing or cleaning the carpets (see the final report for more details).
- Add exhaust ventilation for the crawl space to reduce the chance that contaminants in this area could enter the building.
- Run the heat pump fans more often in the offices with the highest CO_2 levels (Auditor, Building Inspection, and Code Enforcement). This should help bring in more outside air.
- Re-check the temperature and humidity levels in the offices during hotter and more humid weather conditions.
- Look for ways to improve air circulation, perhaps by relocating office cubicles.
- Name an Environmental Quality Manager who can work with the management, employees, and any contractor(s) to discuss ongoing and/or future maintenance work.

What the Horry County Employees Can Do

- Quickly report any water leaks or water damage so repairs can be made.

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We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513/841-4252 and ask for HETA Report # 2000–0091–2803

National Institute for Occupational Safety and Health
NIOSH

Health Hazard Evaluation Report 2000–0091–2803
Horry County Assessor's Office
Conway, South Carolina
July 2000

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SUMMARY

In December 1999, the National Institute for Occupational Safety and Health (NIOSH) received health hazard evaluation (HHE) requests from employees working in a Horry County Administrative Building, Conway, South Carolina. These workers described a prior incident in 1999, which involved carbon monoxide (CO) exposures, as well as ongoing concerns with mold in the building. The employees believed that their symptoms, which included headache, sinus problems, and upper respiratory problems, were work related.

A walk–through of the entire building was conducted March 27, 2000. Measurements of carbon dioxide (CO_2), CO, temperature, and relative humidity (RH) were made and the ventilation systems were visually examined, including the condition of the air filters, coils, drain pan, and other interior components of two randomly selected heat pump units. Five bulk dust samples were collected by micro–vacuuming sections of carpet. Ten "sticky" tape samples were collected of suspect fungal colonies by using the adhesive side of the tape to pull spore structures and hyphae from the growth surface. Areas suspected of water damage (both exterior walls and carpeted floors near these walls) were probed with a moisture meter to qualitatively assess water content. Twelve of the approximately 115 employees volunteered for informal interviews.

The highest CO_2 concentrations ranged from 1030 to 1190 parts per million (ppm), suggesting that parts of the two story building may be receiving insufficient amounts of outside air. Temperature and RH levels ranged from 69 to 75°F, and 35 to 53%, respectively, which were within the thermal comfort parameters recommended by the American Society of Heating, Refrigerating, and Air–Conditioning Engineers. CO concentrations were very low, ranging from none–detected to 2 ppm. A new exhaust ventilation system in the boiler room, along with repairing cracks in the walls of the boiler room, were made to prevent CO from re–entering the building.

Of the 12 employees interviewed, most reported respiratory problems (sinus problems or allergies), congestion, fatigue, and headache while working in the building. Several of the interviewed employees were also concerned with hair loss, high blood pressure, digestive problems, and joint pain which they believed were work–related. Many of those interviewed had been experiencing these symptoms since they first began working in this building.

NIOSH investigators conclude that various indoor environmental quality deficiencies exist in this building, including inadequate amounts of outside air (OA) to some offices, localized microbial reservoirs, and numerous ongoing moisture incursion or moist conditions. It is unclear, however, how these conditions relate to the health complaints described by the interviewed employees. Recommendations are provided to further improve ventilation and eliminate the wet conditions conducive to microbial growth.

Keywords: SIC 9199 (General Government, Not Elsewhere Classified), indoor environmental quality, indoor air quality, IEQ, IAQ, microbial, ventilation, carbon dioxide, carbon monoxide, fungi, bacteria.

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INTRODUCTION

In December 1999, the National Institute for Occupational Safety and Health (NIOSH) received multiple requests from employees working in various Horry County administrative offices (including Auditors, Assessors, Planning, and Zoning offices) located at 801 Main Street, Conway, South Carolina. All of these requests described a prior incident in 1999 which involved carbon monoxide (CO) exposures to the office workers, as well as ongoing concerns with mold in the building. The employees believed that their symptoms, which included headache, sinus problems, and upper respiratory problems, were related to working in this building. On March 27 and 28, 2000, NIOSH investigators conducted an initial survey of the 801 Main Street building. An interim report dated April 12, 2000, was provided to management and employees.

BACKGROUND

Formerly a school, the approximately 110 year old, two–story brick building was renovated in the late 1980s. It is currently occupied by the following Horry County administrative departments: Assessor, Auditor, Treasurer, Planning, Code Enforcement, Addressing, and Management Information Systems. Approximately 115 people worked in the building at the time of this NIOSH survey. A crawl space (partially finished) extends under most of the first floor, and this area was included in this survey due to ongoing concerns about accumulated water beneath the building. A large, two–story auditorium is connected to the building that is normally unoccupied.

Heating and air–conditioning for the building is provided by 43 water–source heat pumps which are located in the plenum above the offices (the space above the suspended ceiling panels). A gas–fired boiler, located in a small room connected to the exterior of the building, provides hot water to the heat pumps, while a cooling tower situated adjacent to the building provides chilled water. Outside air (OA) is ducted to each individual heat pump. Inducer fans (booster fans) were at the OA intakes in February 2000, to bring more OA into the building. Low efficiency fiberglass panel filters (20" x 20" x 1") were installed in the return air vents on each heat pump system. These vents were located in the ceiling.

METHODS

The evaluation consisted of: (1) an opening and closing conference attended by management representatives and employees who were members of the safety and health committee; (2) a walk–through inspection of the office space; (3) confidential interviews with Horry County employees; (4) measurement of ventilation and comfort indicators such as carbon dioxide (CO_2), temperature, and Relative humidity (RH); (5) monitoring for CO; (6) limited inspection of the heating, ventilation and air conditioning (HVAC) systems; (7) collection of bulk samples using surface vacuum and "sticky tape" techniques to confirm suspensions of localized microbiological contamination in the building, and (8) a review of an earlier consultant's report of this building prepared by the South Carolina Department of Labor, Licensing and Regulation (DOL).

Employee Interviews

The purpose of the interviews was to determine the type of symptoms or illnesses and whether they could be related to an exposure at work. All employees were invited to be interviewed.

Environmental

Carbon Dioxide, Temperature, and Relative Humidity

A walk–through of the entire building was conducted March 27, 2000. Throughout the following day measurements of CO_2, temperature, and RH were made at 13 randomly selected locations on the first and second floors of the building.

CO_2 measurements were made using a Q–Trak™ Model 8550/8551 IAQ Monitor. This portable, battery–operated instrument monitors CO_2 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. Locations were sampled four times during the work day (twice in the morning, twice in the afternoon).

The Q–Trak™ Model 8550/8551 IAQ Monitor was also used to make real–time temperature and RH measurements in E–Wing. In addition to measuring CO_2, this meter is capable of directly evaluating dry bulb temperature (range 32 to 122°F) and RH (range 5 to 95%).

Carbon Monoxide

Toxilog® diffusion monitors were used to sample for CO. Measurements were made during the work day at the following four locations in the building: Planning Office; Code Enforcement Office; the Auditorium Balcony; and the Boiler Room. These sampling locations were selected based on the areas where the highest CO concentrations had been previously measured by investigators from the South Carolina DOL.

Ventilation System

The ventilation blueprints of the first and second floor were reviewed, the six OA intakes were visually examined, the condition of the air filters, coils, drain pan, and other interior components of two randomly selected heat pump units were checked, and the duct connecting the roof–mounted OA intakes to the heat pumps located in the attic of the building was visually examined.

Microbial Assessment

The microbial assessment consisted of collecting bulk samples by vacuuming carpeted floor areas and "sticky tape" samples of visually contaminated surfaces. The five bulk samples were analyzed for either total fungal or total bacterial count. Ten "sticky tape" samples were submitted for dust characterization.

Five bulk dust samples were collected by micro–vacuuming 2 or 4 square foot sections of carpet in the following locations: Auditor's Office (beneath exterior window in employee break room); Code Enforcement (beneath work desk and near an exterior window); Assessor's Drafting Office (near exterior window); Assessor's Administrative Office (by exterior wall in a conference room); and Information Technology Area (beneath desk and near exterior window).

Ten "sticky" tape samples were collected of suspect fungal colonies by using the adhesive side of the tape to pull spore structures and hyphae from the growth surface. The tape sample was mounted (in the field) to a glass slide and subsequently sent to a laboratory to be microscopically analyzed. These "sticky" tape bulk surface samples were collected in the following locations: Mapping Room (on return duct insulation on a heat pump); Code Enforcement (on return diffuser, interior surface of return duct, insulation on a heat pump access panel, and old window frame); Assessor's Office (black mold from old window frame); and Planning Office (black mold from new window frame).

In addition to the surface vacuum and tape samples, areas suspected of water damage (both exterior walls and carpeted floors near these walls) were probed with a moisture meter to qualitatively assess residual amounts of water. These measurements were collected using a Delmhorst Instrument Company Moisture Tester, Model BD–9, battery–operated detector. This meter provides direct readings for moisture content in the range of 8 to 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.

EVALUATION CRITERIA

NIOSH investigators have completed over 1,500 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.[1,2,3,4,5] Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building–related occupant complaints.[6,7] Among these factors are imprecisely–defined characteristics of HVAC systems, cumulative effects of exposure to low concentrations of multiple chemical pollutants, odors, elevated concentrations of particulate matter, microbiological contamination, and physical factors such as thermal comfort, lighting, and noise.[8,9,10,11,12,13] 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.[14,15,16] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[16,17,18,19]

Less often, an illness may be found to be specifically related to something in the building environment. Some examples of potentially building–related illnesses are allergic rhinitis, allergic asthma, hypersensitivity pneumonitis, Legionnaires' disease, Pontiac fever, 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 the following: 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 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 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.[20,21,22] 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.[23,24] The ACGIH has also developed a manual of guidelines for approaching investigations of building–related complaints that might be caused by airborne living organisms or their effluents.[25]

Measurement of indoor environmental contaminants has rarely proved to be helpful in determining the cause of symptoms and complaints except where there are strong or unusual sources, or a proven relationship between contaminants and specific building–related illnesses. The low–level concentrations of particles and variable mixtures of organic materials usually found are difficult to interpret and usually impossible to causally link to observed and reported health symptoms. However, measuring ventilation and comfort indicators such as 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.

NIOSH and the Environmental Protection Agency (EPA) jointly published a manual on building air quality, written to help prevent environmental problems in buildings and solve problems when they occur.[26] This manual suggests that indoor environmental quality (IEQ) is a constantly changing interaction of a complex set of factors. Four of the most important elements involved in the development of IEQ problems are: (1) a source of odors or contaminants; (2) a problem with the design or operation of the HVAC system; (3) a pathway between the contaminant source and the location of the complaint; 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 CO_2, 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

CO_2 is a normal constituent of exhaled breath and, if monitored, may be useful as a screening technique to evaluate whether adequate quantities of outside air are being introduced into an occupied space. 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.[23] 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 800 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected.[27] 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. American National Standards Institute (ANSI)/ASHRAE Standard 55–1992 specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable.[24] 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%.[23] 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.

Carbon Monoxide

CO is a colorless, odorless, tasteless gas produced by incomplete burning of carbon–containing materials; e.g., natural gas. The initial symptoms of CO poisoning may include headache, dizziness, drowsiness, and nausea. These initial symptoms may advance to vomiting, loss of consciousness, and collapse if prolonged or high exposures are encountered. These symptoms may continue to occur for several days to several weeks after the exposure stops and the poisoned person has apparently recovered.[22,28] While there are not any regulatory standards for CO in office environments, the National Research Council (NRC) has developed a CO exposure standard of 15 ppm that may be applicable to an office work environment because it is based on a 24 hours per day, 90–day time weighted average exposure.[29]

Microorganisms

Microorganisms (including fungi and bacteria) are normal inhabitants of the environment. The saprophytic varieties (those utilizing nonliving 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).[30,31]

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.[32] 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).[30] Allergic respiratory diseases resulting from exposures to microbial agents have been documented in agricultural, biotechnology, office, and home environments.[33,34,35,36,37,38,39,40]

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.[25] 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.

RESULTS

Employee Interviews

Twelve of the approximately 115 employees were informally interviewed — 10 females and 2 males. Most reported respiratory problems (sinus problems or allergies), congestion, fatigue, and headache while working in the building. Several employees were also concerned with hair loss, high blood pressure, digestive problems, and joint pain which they believed were work–related. Many of those interviewed indicated that they had been experiencing these symptoms since they first began working in this building.

Environmental

Carbon Dioxide, Temperature, and RH

As shown in Figure 1, the highest CO_2 concentrations were measured in the Auditors, Building Inspection, and Code Enforcement offices (ranging from 1030 to 1190 ppm). For the remaining locations, the CO_2 concentrations ranged from approximately 600 to 800 ppm.

Temperature and RH on the first floor ranged from 70 to 75°F, and 39 to 53%, respectively. Temperature and RH were similar on the second floor, ranging from 69 to 74°F, and 35 to 48%, respectively. The temperature and RH levels measured outside the building on March 28, 2000, ranged from 68 to 76°F, and 23 to 38%, respectively.

Carbon Monoxide

Toxilog® diffusion monitors were used to sample for CO. The highest peak CO concentrations recorded over the approximately 6 hour sampling period was 1–2 ppm (measured in the area samples collected in the Boiler Room and the Auditorium Balcony). Both of these areas are typically unoccupied. No CO was detected in the other two sampling locations.

Ventilation System

The following is based on a visual examination of the ventilation systems.

- Powered OA inducer units located on both the roof and the side walls had been installed in February 2000, to increase the amount of OA brought into the building. These fans are controlled by a timer and operate from approximately 7:00 a.m. to midnight. (Note: based on requests from several employees who were concerned that the OA ducts were improperly installed, one of the flexible ducts connecting one of the roof–mounted OA units to a heat pump was visually examined on March 28, 2000. This flexible duct was located in the attic of the building and was securely connected to the roof–mounted OA inducer fan. The other end of this duct which would be connected to the heat pump system, however, was not visible due to an intervening wall.)

- Heating and air–conditioning for the building is provided by 43 water–source heat pumps which are located in the plenum above the offices (the space above the suspended ceiling panels). At the time of this evaluation, the heat pumps were operating 24 hours/day.

- Two panel filters installed at the return air vents of two different heat pump systems were randomly inspected. These low efficiency filters appeared to be in good condition and installed correctly (i.e. a tight fit that assures no leakage).

- The interior of a randomly selected ceiling mounted heat pump unit on the first floor was examined. No problems were observed (coils were clean, no standing water in the condensate pan, no deterioration of the interior fiberglass lining of the heat pump).

Microbial Assessment

Fungal concentrations from the bulk material samples ranged from $1x10^3$ to $1x10^5$ colony forming units per gram of material (CFU/gm) and the predominant species identified were *Cladosporium*, *Epicoccum*, and *Penicillium* (see Table 1). Bacterial concentrations from the bulk samples ranged from $2x10^5$ to $7x10^6$ CFU/gm and the predominant species were *Bacillus*, Gram negative bacteria, and *Shewanella* (see Table 2).

Results of the microscopic analysis of the "sticky tape" samples are summarized in Table 3. Concentrations of fungal structures are presented semi–quantitatively, i.e., ranking order from "trace," "few," "many," "numerous," to "massive." Identification was facilitated by the observation of spores, hyphae, and conidiophores. (Please note that sample site selection was based on observed fungal surface contamination.) The predominant fungi identified included *Cladosporium* and *Ulocladium*, and the results were relatively consistent throughout the first and second floor sampling locations. In one sticky tape sample, a trace of spores, conidiophores, and hyphae of *Stachybotrys chartarum* was identified.

Moisture Measurements

Spot measurements of exterior walls and carpeted floor areas near the exterior walls were collected to qualitatively indicate residual water which would be suggestive of past water incursion problems. Most of the higher moisture readings were obtained on the interior wall space below exterior windows, suggesting past and present water incursion in these areas. The carpeted areas that were checked were predominately dry, although low amounts of residual moisture was measured in a few areas of carpeting on the first floor. It should be noted that during the collection of many of these moisture measurements, visual evidence of water damage, such as bubbled plaster, rusted window frames, and condensation on the windows, was observed. This visible evidence, along with the residual moisture readings, indicated a chronic history of water infiltration and damage to walls and flooring.

Review of the South Carolina DOL Report

The findings contained in the South Carolina DOL report highlight moisture and ventilation–related problems which directly relate to occupant comfort and a perception of poor IEQ in office areas. The September 1999 report identified water incursion in the crawl space, CO_2 concentrations which exceed 1,000 ppm (suggesting an inadequate amount of OA being introduced into the building), and ozone produced from office equipment such as laser copiers, printers, and fax machines. These could affect employee comfort and influence the perception that the work environment is not safe.

DISCUSSION

The growth and survival of microorganisms in environmental reservoirs requires: (a) a suitable nutrient source; (b) adequate available water; and (c) an appropriate temperature. These factors are all determined by the localized environment and when combined with high porosity materials, can provide optimum conditions for microorganisms to grow. In the crawl space under the building, these factors were all present; i.e., water intrusion from snow melt and rain storms, organic material in the dirt floor, and cool temperatures. Qualitative measurements of residual moisture in the wood support beams under the first floor revealed significant levels, often peaking the meter. Microbial contamination was visually apparent in various locations in the crawl space and an odor, attributable to microbiological growth, was strongly present. However, it was unclear whether a dissemination pathway existed between the crawl space and the occupied areas of the building.

Microbial growth conditions were also apparent in the second floor drop ceiling plenum space above the Assessor's Drafting Office, as evidenced by water stains in ceiling tiles and observed fungal growth on glued panels attached to a roof support beam. Ventilation systems located in this space could entrain disseminated fungal spores in the ceiling plenum which could be subsequently dispersed to occupied areas. Fungal contamination was visibly evident on the window frames of the Code

Enforcement Office. Additionally, on the morning of March 27, 1999, significant condensation was observed on the window panes. Tape samples of suspect fungal colonies revealed *Cladosporium*, *Ulocladium*, and trace levels of *Stachybotrys chartarum*.

Micro–vacuum samples of flooring materials did not reveal significant concentrations of fungal reservoirs; however, bacterial analysis did reveal significant levels (ranging up to 5.9×10^6 CFU/gm of collected dust) which were predominated by Gram negative species. The outer cell wall of Gram negative bacteria are partly composed of a compound commonly referred to as endotoxin. Endotoxins have a wide range of biological activities involving inflammatory, hemodynamic, and immunological responses. Clinically, little is known about the response to inhaled endotoxins and the effects of repeated exposure to aerosols of endotoxins in humans are not known. Exposure of previously unexposed persons to airborne endotoxin can result in acute fever, dyspnea (shortness of breath), and coughing.[40]

In addition to avoiding conditions which are conducive for microbiological growth, another important aspect of maintaining acceptable IEQ is good ventilation. Three of the approximately 42 heat pumps located in the building were visually inspected as part of this evaluation. All three had low efficiency air filters which were located at the supply air vent. Noteworthy changes to the ventilation of the building included increasing the amount of OA by the installation of inducer fans. These OA fans were also being operated for longer time periods (operation times extended to both before and after normal occupancy times). In additional, most of the heat pumps were being operated 24 hours/day, which further aided in air mixing and improving the overall ventilation for the building.

CONCLUSIONS

■ The use of electrically–powered induction fans to introduce more OA into the building appears to have succeeded in lowering the CO_2 concentrations in most areas of the building from the levels measured reported in the South Carolina DOL report. In most office areas, the CO_2 concentrations measured in this survey were near or below 800 ppm. This is indicative of adequate ventilation.

■ Localized microbial reservoirs in the building existed at the time of this NIOSH site visit. Although micro–vacuum samples of flooring materials did not reveal significant concentrations of fungal reservoirs, bacterial analysis did reveal significant levels ranging up to 5.9×10^6 CFU/gm of collected dust, predominated by Gram negative species. These high levels of Gram negative species indicate ongoing moist conditions.

■ Numerous ongoing moisture incursion or moist conditions were noted, for example, around some windows, on carpeted floors, and on plaster walls. These wet conditions, needed for ongoing growth of microbial contaminants, could have resulted from a variety of factors, including the presence of old, typically uninsulated windows in several office locations, defective caulking, and leaking window frames. In other areas there was evidence of past water incursion events, such as water stains on ceiling tiles and down walls, patches of peeling paint on wall surfaces, rust–stained materials, and the observation of visible microbial colonization. Finally, the wooden framing and supports commonly used in older buildings can absorb and retain water, thus helping to maintain moist conditions which are conducive for bacterial and mold growth.

■ The presence of *Stachybotrys* fungal species in the one location was probably a residual from a localized water incursion event (such as a water leak) and did not appear to suggest widespread *Stachybotrys* contamination.

■ The highest CO_2 concentrations (ranging from 1030 to 1150 ppm) were measured in the following three areas: Auditor's Office, Building Inspection, and Code Enforcement. It was observed that two of these areas were open to the general public. These

CO_2 concentrations suggest that these office areas may be inadequately ventilated during part of the work day, probably due to the presence of the public in these areas.

■ On the day of this survey, the temperature and RH levels were within the ANSI/ASHRAE specified conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable. However, NIOSH investigators observed conditions that could effect worker comfort and their perception of their work environment as unhealthy, such as poor air distribution due to the use of movable office dividers and employees being unaware of the problems with the building and decisions made by management to address those problems.

■ Most of the symptoms reported by the interviewed Horry County employees were similar to what has been found by NIOSH investigators in previous IEQ investigations. It is difficult to associate these symptoms to any specific environmental problem in the building.

■ The CO concentrations measured during this evaluation were very low (or not detected) and should not be a cause for concern. The new exhaust ventilation system provided for the boiler room, along with repairing cracks in the walls of boiler room, appeared to be effective measures to ventilate this area and prevent CO from entering the occupied areas of the building.

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.

2. An environmental committee should be formed to facilitate the flow of employee concerns to management. In addition, it has been our experience that an Environmental Quality Manager who can interact with the management, employees, and the various maintenance contractor(s) to discuss ongoing and/or future maintenance, renovation, or construction work is often beneficial. The designated Environmental Quality Manager could be responsible for collecting, reviewing, and maintaining the following information:

- ♦ written description of building systems;
- ♦ diagrams and drawings of the HVAC systems;
- ♦ daily HVAC operating schedules and design ventilation rates;
- ♦ written maintenance program;
- ♦ occupancy information (e.g., room layouts, number of occupants, and office equipment);
- ♦ employee complaint records;
- ♦ pesticide application schedule and chemicals used (if appropriate);
- ♦ construction and renovation activities (when necessary); and
- ♦ facilitating the meetings of an Environmental Quality Committee.

The following are additional recommendations which may help improve the work environment.

3. Any episodes of acute 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). More information on the New York City Department of Health recommended guidelines for evaluating and remediating fungi in indoor environments may be obtained at the following

internet address: http://www.ci.nyc.ny.us/html/doh/html/epi/moldrpt1.htm1.

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.

6. Carpet replacement or steam cleaning of the carpet is recommended to reduce the high levels of Gram negative bacteria measured in surface vacuum samples of carpeted areas on the first and second floors. Carpet replacement would be preferred over cleaning, but the cost of replacement would likely need to be compared to the following: (1) the future occupancy of the building (at the time of the NIOSH survey a new office complex for Horry County employees was expected to be completed within the next several years); and (2) residual moisture in the wooded underlayment and supports, along with moisture incursion problems, could result in contamination of the new replacement carpeting.

7. Exhaust ventilation should be considered for the crawlspace to reduce the chance that microbiological contaminants in this area could pass to the indoor occupied spaces. This would help maintain the crawlspace under negative pressure in relation to the occupied space of the building, thus reducing the opportunity for microbial contaminants to the office areas.

8. In the offices where with the highest CO_2 concentrations were measured (for example, the Auditor's Office, Building Inspection, and Code Enforcement areas) the heat pump fans should be set to run continuously. This would bring in more OA even during periods that heating or cooling is not required.

9. Review the overall layout of office cubicles in relation to the ceiling supply diffusers with the goal of improving air distribution.

10. Use higher efficiency pleated air filters in the heat pump systems in place of the low efficiency panel filters currently in use. This should only be attempted after determining if the heat pump system can accommodate a higher efficiency filter. Ideally, any filter should be located near the heat pump fan. At the time of the NIOSH evaluation, the low efficiency panel air filters were located in the ceiling supply diffuser.

11. Although the indoor temperature and RH levels measured in this survey were within ASHRAE comfort guidelines, it is unknown what impact 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 than in the recent past. The temperature and RH should be checked on a regular basis throughout the year to see if further modifications to the ventilation system are necessary during hotter and more humid weather conditions.

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Table 1
Fungal Content of Bulk Samples
Horry County Administrative Building, Conway, South Carolina
HETA 2000–0091–2803

(Samples collected on March 28, 2000, and cultured using malt extract agar [MEA] media)

Location	Predominate Fungal ID	Concentration (CFU/g)‡	Percentage†
Auditor's Office, beneath exterior window in employee break room	*Cladosporium* *Penicillium* *Epicoccum nigrum* *Rhodotorula glutinis*	116,667 116,667 33,333 33,333	29 29 8 8
Code Enforcement, beneath work desk and near an exterior window	*Cladosporium* *Epicoccum nigrum* *Penicillium* yeasts	90,370 78,519 23,704 5,926	41 36 11 3
Assessor's Office (Drafting), sample collected near an exterior window	*Cladosporium* *Epicoccum nigrum* *Penicillium* *Alternaria alternata*	132,727 78,182 38,182 10,909	45 26 13 4
Assessor's Office (Administration), by exterior wall in conference room	*Penicillium* *Cladosporium* *Rhodotorula glutinis* *Epicoccum nigrum*	89,231 58,462 49,231 48,205	31 20 17 17
Information Technology Area, beneath desk and near exterior window	*Epicoccum nigrum* *Cladosporium* *Rhodotorula glutinis* yeasts	24,390 976 7,805 27,317	31 1 10 35

Note: Only the top four fungal species per bulk sample are presented. Other species identified but which accounted for <5% of the total fungal population in each bulk sample included the following: *Acremonium, Aspergillus niger, Aspergillus sydowii, Aspergillus versicolor, Aureobasidium pullulans, Curvularia, Fusarium, Mucor, Phoma, Pithomyces chartarum, Rhizopus stolonifer*, and sterile fungi.

‡ = colony forming units per gram of material
† = percentage of each group of fungi in total population

Table 2
Bacterial Content of Bulk Samples
Horry County Administrative Building, Conway, South Carolina
HETA 2000–0091–2803

(Samples collected on March 28, 2000, and cultured using tryptic soy agar [TSA] media)

Location	Predominate Bacterial ID	Concentration (CFU/g)‡	Percentage†
Auditor's Office, beneath exterior window in employee break room	*Pseudomonas sp.* non *aeruginosa*	3,006,667	31
	Flavobacterium	2,186,667	23
	Shewanella putrefaciens	1,640,000	17
	Gram negative bacteria	1,093,333	11
Code Enforcement, beneath work desk and near an exterior window	Gram negative bacteria	728,889	39
	Bacillus	242,963	13
	Methylobacterium	242,963	13
	Staphylococcus	242,963	13
Assessor's Office (Drafting), sample collected near an exterior window	Gram negative bacteria	1,341,818	49
	Methylobacterium	596,364	22
	Pseudomonas sp. non aeruginosa	223,636	8
	Staphylococcus	223,636	8
Assessor's Office (Administration), by exterior wall in conference room	*Shewanella putrefaciens*	7,653,333	68
	Gram negative bacteria	2,481,026	22
	Pseudomonas sp. non *aeruginosa*	630,769	6
	Staphylococcus	378,462	3
Information Technology Area, beneath desk and near exterior window	*Bacillus*	555,484	30
	Staphylococcus	529,032	29
	Gram negative bacteria	317,419	17
	Flavobacterium	211,613	11

Note: Only the top four bacterial species per bulk sample are presented. Other species identified but which accounted for <6% of the total bacterial population in any one bulk sample included the following: Actinomycetes, Micrococcus luteus, and Rhodococcus.

‡ = colony forming units per gram of material
† = percentage of each group of fungi in total population

Table 3
Qualitative Characterization of “Sticky tape” Surface Samples
Horry County Administrative Building, Conway, South Carolina
HETA 2000–0091–2803

Location	Identification
Auditor’s Office, beneath exterior window in employee break room	Many dust particles, pollen grains, and paper fibers. A trace of loose fungal spores were detected, but no obvious sign of fungal growth was observed.
Code Enforcement, beneath work desk and near an exterior window	Many dust particles, pollen grains, and fiberglass were observed. A trace of loose fungal spores were detected, but no obvious sign of fungal growth was observed.
Assessor’s Office (Drafting), sample collected near an exterior window	Many dust particles, pollen, grains, and paper fibers. A few loose spores were detected, suggesting fungal contamination.
Assessor’s Office (Administration), by exterior wall in conference room	Many dust particles, pollen grains, and paper fibers. A few loose spores were detected, suggesting fungal contamination.
Surface of the insulation on a heat pump access panel	Many dust particles, fiberglass, and pollen grains. Many spores, conidiophores, and hyphae of *Cladosporium* observed (suggesting fungal growth).
Assessor’s Office, Black mold from old window frame in Assessor’s Office	Many spores, conidiophores, and hyphae of *Cladosporium* observed, suggesting fungal growth.
Code Enforcement Office, Black mold from old window frame	Many spores, conidiophores, and hyphae of *Cladosporium* observed, suggesting fungal growth.
Code Enforcement Office, Black mold from old window frame	Many spores, conidiophores, and hyphae of *Cladosporium* observed, suggesting fungal growth.
Code Enforcement Office, Black mold from old window frame in (above bleach area)	Many spores, conidiophores, and hyphae of *Ulocladium*; a few spores, conidiophores, and hyphae of *Cladosporium*; and a trace of spores, conidiophores, and hyphae of *Stachybotrys Chartarum* observed, suggesting fungal growth.
Planning Office, Black mold from new window frame	Many spores, conidiophores, and hyphae of *Cladosporium* observed, suggesting fungal growth.

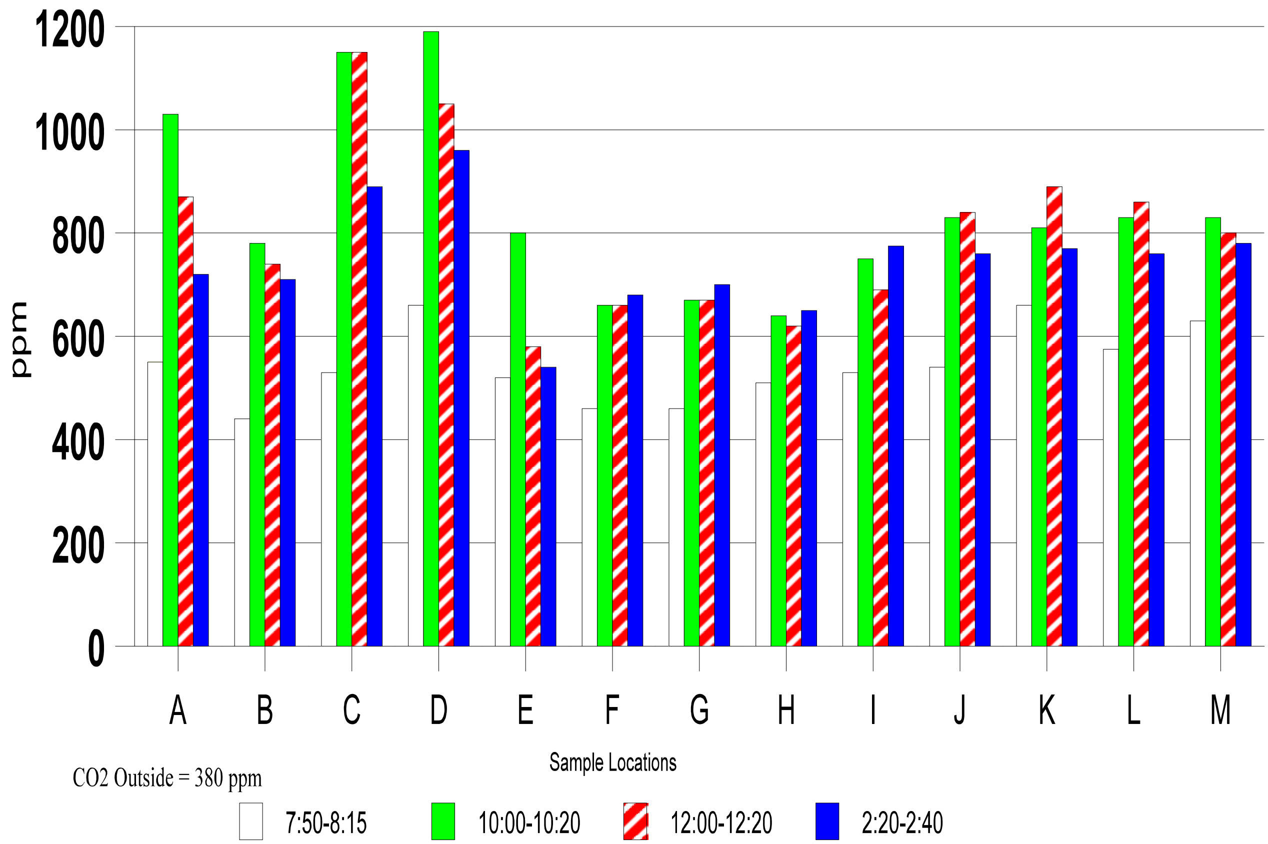
Reference Description: Massive > Numerous > Many > A Few > A Trace > No Growth

Figure 1

Carbon Dioxide Measurements

Horry County Administrative Building, Conway, South Carolina

HETA 2000–0091–2803



Note: NIOSH suspects inadequate ventilation in areas when indoor CO_2 concentrations exceed 800 ppm, 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.

Sampling Locations:

Location A: Auditor's Office
Location B: Planning
Location C: Building Inspection
Location D: Code Enforcement
Location E: Assessor's Office – Adm.
Location F: Assessor's Office – Drafting
Location G: Assessor's Office – GIS
Location H: Appraiser's Office – Room 231
Location I: Appraiser's Office – Switchboard
Location J: Appraiser's Office – Sales Analyst
Location K: Treasurer's Office – Tax Payment
Location L: Treasurer's Office – Break area
Location M: Treasurer's Office – Bookkeeping

Appendix
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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or visit the NIOSH Web site at:
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