HETA 94-0051-2463
October 1994
Deerwood Place Office Building
San Ramon, California

NIOSH INVESTIGATORS:
Robert Malkin, D.D.S., Dr.P.H.
Angela M. Weber, M.S.

SUMMARY

On November 3, 1993, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the California State Department of Industrial Relations, Division of Occupational Safety and Health (CalOSHA), concerning overwhelming fatigue that had been reported among three previous occupants of the Executive Suites, located on the second floor of the Deerwood Place office building in San Ramon, California. The physicians of two of these individuals suggested that their symptoms may have developed as a result of exposures to airborne mold, particularly the genus *Aspergillis*. CalOSHA asked NIOSH investigators to conduct a Health Hazard Evaluation (HHE) to assess mold contamination in the building and to determine whether other occupants were being similarly affected. The NIOSH site evaluation was conducted on April 13-14, 1994.

Bulk samples taken from the sound liner in the fan room identified reservoirs of fungi (predominantly *Cladosporium* and unidentified yeasts) and bacteria (predominantly *Micrococcus* and lower levels of thermophilic actinomycetes). The presence of yeast colonies is characteristic of microbial proliferation due to extremely moist conditions. Water samples taken from condensate drain pans, sumps, and the decorative fountain in the atrium were also collected. Analysis for fungal organisms from the condensate drain pan, both within the AHU and the return air plenum, revealed contamination with *Cladosporium, Epicoccum, Alternaria,* and unidentified yeasts that are typically found in outdoor air. Water samples analyzed for bacteria, however, revealed contamination in both areas of the condensate drain pan consisting of various species of *Pseudomonas,* as well as thermophilic actinomycetes. Although no detectable concentrations of fungi were found in the decorative fountain water, elevated levels of bacteria (*Moraxella*) were present. Swarms of mosquitoes were present in the mixing plenum of the air handling unit (AHU). Since there was water in both of the sumps and the drain pan, the mosquitoes may have been breeding in or near the AHU.

Interviews with 14 current tenants of the building and 3 employees of the Executive Based Network did not reveal any symptoms that they felt were related to working in the building. No additional cases of severe fatigue or other symptoms typically associated with the indoor environment (such as nasal congestion, sore throat, irritated eyes, or headache) were identified.

Based on the results of the bulk and water samples, the potential exists for dissemination of bioaerosols from the AHU into the occupied spaces. Whether exposure in occupied areas is presently occurring or occurred in the past cannot be determined from this analysis of bulk and water samples. However, based on the locations of the sample sites, it is possible that dissemination of bioaerosols may occur since there was growth in the supply HVAC components. Recommendations include: 1) eliminating all sources of standing water in or near the AHU, 2) removing all contaminated porous material, and 3) improving preventative maintenance procedures.

SIC 6531 (Real estate managers): indoor environmental quality, fungi, bacteria, thermoactinomycetes, bioaerosols

INTRODUCTION

On November 3, 1993, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the California State Department of Industrial Relations, Division of Occupational Safety and Health (CalOSHA), concerning overwhelming fatigue that had been reported among three previous occupants of the Executive Suites. The Executive Suites are located on the second floor of the Deerwood Place office building in San Ramon, California. The physicians of two of these individuals suggested that their symptoms might have developed as a result of exposures to airborne mold, particularly the genus *Aspergillis*. CalOSHA asked NIOSH investigators to conduct a Health Hazard Evaluation (HHE) to assess mold contamination in the building and to determine whether present-day occupants were being similarly affected. The NIOSH site evaluation was conducted on April 13-14, 1994.

BACKGROUND

The Executive Suites are located on the second floor of the North tower of the Deerwood Place office building in San Ramon, California. Construction of the 74,000 square-foot building was completed in 1985. The three-story building is rectangular in shape and consists of two (north and south) towers connected by an atrium. The atrium was open at the top and was landscaped with trees, flowers, shrubbery, and a decorative fountain. There were drains located in the floor of the atrium to remove rain water. One elevator serviced both towers.

One air handling unit (AHU) serves the entire building. The AHU is a single duct, variable air volume (VAV) system. Unconditioned outside air (OA) enters the basement floor through a set of dampers located in a well approximately 20-feet deep on the north side of the building. The room located immediately after the dampers serves as a mixing plenum for the OA and return air from the occupied spaces. The entire basement serves as the return air plenum. The OA intake rate is controlled by the pressure in the mixed air plenum.

Mixed air flows into the AHU and passes through a bank of pleated fiberglass filters having a rated filtration efficiency of 30 percent. The air then passes through a cooling coil, a fan, supply air ductwork, and a VAV box. The cooled air is then delivered to the occupied spaces through four-way ceiling diffusers. The temperature of the supply air leaving the air handler is kept near 55°F; the supply air ductwork contains no internal lining. Air from the occupied areas enters the return plenum above the dropped ceiling through grilles and is returned to the air handler. Air is exhausted from the building through restroom exhaust systems which operate continuously during the occupied hours. The heating, ventilating, and air-conditioning (HVAC) system switches to an unoccupied cycle at 7:00 p.m., at which time the outside air dampers close and the system shuts down. The HVAC system switches back on at 7:00 a.m.

The evaluated area of the building, the Executive Suites, consists of approximately 40 enclosed offices around the perimeter of the building and approximately 20 enclosed offices in the interior space. There is a common waiting room, a receptionist, and a secretarial staff. At the time of the site visit, the Executive Suites had 51 tenants and three full time employees.

Eighteen sensor-controlled ventilation zones (induction units) serve the Executive Suites. The AHU supplies primary air through the ductwork to the fan-powered induction units located in the plenum above the ceiling. For each zone, the unit mixes the required amount of primary supply air with induced return air from the plenum. Low-efficiency filters are located in the induction units. Heat is supplied to the perimeters of the building by fan coil units located in the return air plenum.

Symptoms among occupants of the Executive Suites were first reported by one individual in 1987, by a second person in 1990, and a third in 1991. The symptoms consisted of debilitating fatigue, skin rash, memory problems, and cough. The individuals reporting debilitating fatigue remained in the building until 1992, when they were advised to leave the building by their physicians, who concluded that their symptoms were due to building-related exposures to mold. This conclusion was based on the finding that two symptomatic employees, who shared an office, had high levels of antibody to the same molds.

The building has a history of moisture problems dating back to its initial construction in 1985. NIOSH investigators were informed that the building was constructed over a natural underground spring that runs from the northwest corner of the building to the southeast corner (the deepest part of the stream is in the southeast corner of the building). A french drainage system was installed at the time of construction to prevent the groundwater from penetrating into the foundation of the building. The system consists of a perforated drainage pipe located at the perimeter of the foundation that is encased with crushed stones surrounded by a filter medium. The water is then carried away in the storm sewer. The system is designed to prevent the development of hydrostatic pressure which would force the water through cracks in the foundation into the basement.

There has consistently been a problem with water seeping in through the foundation in the basement in the southeast corner of the north tower where the fan room of the HVAC system is located. An attempt was made, in 1993, to divert the water out of this room by installing a two-inch trough on the south wall of the building to direct the incoming water to a sump located in the adjacent return air plenum. The potential sources or cause for the moisture incursion in these areas has not been determined.

Other incidents of water damage in the building included a flood of the basement and part of the first floor in the north tower, caused by a clogged toilet in the women's restroom on the first floor, and the flooding of the basement due to an overflowing sump located in the return air plenum. Both of these incidents, however, occurred after the onset of symptoms in two of the affected individuals.

EVALUATION CRITERIA

MICROBIOLOGICAL CONTAMINANTS

Acceptable levels of airborne microorganisms have not been established, primarily due to the varying immunogenic susceptibilities of individuals. Relationships between health effects and environmental microorganisms must be determined through the combined contributions of medical, epidemiologic, and environmental evaluation.[1] The current strategy for environmental evaluation involves a comprehensive inspection of the building to identify sources of microbial contamination and routes of dissemination. In those locations where contamination is visibly evident or suspected, bulk samples may be collected to identify the predominant species (fungi, bacteria, and thermophilic actinomycetes).

The committee on Bioaerosols of the American Conference of Governmental Industrial Hygienists (ACGIH) has developed guidelines for the assessment and sampling of saprophytic (organisms living on dead or dying organic matter) bioaerosols in the indoor environment.[1] These guidelines indicate that straightforward remedial action can resolve most problems associated with moisture incursion in HVAC systems. Remedial actions have focused on elimination or control of these moisture problems.

Microorganisms (including fungi and bacteria) are normal inhabitants of the environment. The saprophytic varieties inhabit soil, vegetation, water, or any reservoir that can provide an adequate supply of a nutrient substrate. Under the appropriate conditions (optimum temperature, pH, sufficient moisture, and available nutrients) saprophytic microorganism populations can be amplified. Through various mechanisms, these organisms can then be disseminated as individual cells or in association with soil or dust particles or water droplets. In the outdoor environment, 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 in the air 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 the filtration efficiency of the HVAC system), with consistently similar ranking among the microbial species.[2,3]

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.[4] Allergic diseases typically associated with exposures in indoor environments include allergic rhinitis (nasal allergy), allergic asthma, allergic bronchopulmonary aspergillosis (ABPA), and extrinsic allergic alveolitis (hypersensitivity pneumonitis).[2] Allergic respiratory diseases resulting from exposures to microbial agents have been documented in agricultural, biotechnology, office, and home environments.[5,6,7,8,9,10,11,12]

Symptoms vary with the type of allergic disease: (1) Allergic rhinitis is characterized by paroxysms of sneezing; itching of the nose, eyes, palate, or pharynx; nasal stuffiness with partial or total airflow obstruction; rhinorrhea with postnasal drainage: (2) Allergic asthma is characterized by episodic or prolonged wheezing and shortness of breath due to bronchial narrowing: (3) ABPA is characterized by symptoms of cough, lassitude, low grade fever, wheezing, and occasional expectoration of mucous[2,13]: (4) Heavy exposures to airborne microorganisms can result in an acute form of extrinsic allergic alveolitis which is characterized by chills, fever, malaise, cough, and dyspnea (shortness of breath) appearing 4 to 8 hours after exposure. Onset of the chronic form of extrinsic allergic alveolitis is thought to be induced by a continuous low-level exposure, and onset occurs without chills, fever, or malaise but is characterized by progressive shortness of breath with weight loss.[14]

Bacteria

Gram-positive bacteria (as identified through staining mechanisms) generally dominate the viable airborne bacterial flora in indoor air and are associated with the human body (shed from the human skin and respiratory secretions). Examples of such organisms include *Micrococcus*, *Bacillus*, and *Staphylococcus*; elevated airborne concentrations may indicate inadequate ventilation. Thermophilic actinomycetes (also a gram-positive bacterium), which can cause hypersensitivity pneumonitis, and have been found to amplify on wet, porous insulation in AHUs and in stagnant water in condensate drain pans.[15,16] The Bioaerosol Committee of the ACGIH considers the finding of thermophyllic actinomycetes unusual in non-agricultural, indoor environments, and that their presence indicates microbiologic contamination.[1]

In contrast, gram-negative leaf surface bacteria (e.g., *Pseudomonas*, *Flavobacterium*, *Moraxella*) are most abundant outdoors. Therefore, the presence of these organisms may indicate an unusual proliferation site within the building (e.g., stagnant water in the HVAC system). For example, the proliferation of such organisms as *Bacillus*, *Flavobacterium*, and *Pseudomonas* in stagnant water in cooling coil condensate drain pans and ventilation system liners has been identified in outbreaks of humidifier fever and hypersensitivity pneumonitis.[17,18] As a result of the information gathered in one particular study,[17] the authors proposed an upper limit of 10^5/ml of bacteria in stagnant water; however, there are no established criteria addressing "acceptable" concentrations of fungi or bacteria in ventilation systems.

Endotoxins are lipopolysaccharide-protein complexes that are integral parts of the outer membrane of gram negative bacteria.[19] Endotoxins have a wide range of biological activities involving inflammatory, hemodynamic, and immunological responses. The biological properties of endotoxin vary, depending upon the bacterial species from which they are derived, as well as upon the state of the growth cycle of the bacteria.[20] Gram-negative bacteria containing endotoxins can cause irritation and possibly modify an individuals's response to other biological agents.[21] The effects of endotoxin in the lung are of most importance from occupational exposures.[22]

Clinically, little is known about the response to inhaled endotoxins. Exposure of previously unexposed persons to airborne endotoxin can result in acute fever, dyspnea, coughing, and small reductions in one-second forced expiratory volume (FEV_1), although some investigators have not been able to demonstrate this.[22] The effects of repeated exposure to aerosols of endotoxins in humans are not known. Some animal studies have demonstrated a chronic inflammatory response characterized by goblet cell hyperplasia and increased mucous production. This suggests that repeated exposure may cause a syndrome similar, if not identical, to chronic bronchitis.[22]

METHODS

Medical Evaluation

The goal of the medical evaluation was to determine whether present-day occupants of the building had unusually severe fatigue or other symptoms commonly reported by occupants of office buildings (headache, sore throat, nasal congestion, and irritated eyes). Tenants of the Executive Suites, full-time employees of the Executive Based Network, and occupants of suites on the first and third floor who were present at work on April 14, 1994, were interviewed. Extensive efforts were made to interview all tenants of the Executive Suites present during the days of the NIOSH site visit.

Environmental Evaluation

Following the opening conference and walkthrough evaluation, a visual inspection of sections of the HVAC system serving the building was conducted by the NIOSH investigators. Because mold exposure was a suspected cause of illness in previous occupants, and water damage was a known factor, identification of biological contamination was the central focus of the walk-through evaluation.

The AHU was inspected to characterize the HVAC system design, determine position of make-up air intake dampers, and to evaluate filtration and overall system integrity and cleanliness. Based on visual evidence of microbial growth, bulk or water samples (analyzed for viable microbial content) were collected from the following locations: water from the sumps located in the air intake and in the return air plenum, water from the fountain in the atrium of the building, stagnant water from the condensate drain pans, a section of material from the atrium fountain filter, and a section of the fiberglass sound liner insulating the AHU. Debris from the surface of the outside air dampers was collected on a piece of tape and qualitatively evaluated for the presence of fungal spores. The water sample collected from the basement sump broke during shipment and could not be analyzed.

RESULTS AND DISCUSSION

Medical Results

Although the number of tenants in the Executive Suites was 51, the occupancy at any one time was, in fact, low. According to management of the Executive Suites, many of the offices were used by salespeople, who were regularly out of the office. A total of 14 current tenants and 3 current employees of the Executive Based Network were interviewed at the time of this evaluation. None reported severe fatigue, and none attributed any other symptoms commonly reported in office buildings such as nasal congestion, irritated eyes, sore throat or headache, to working in the building.

Environmental Results and Observations

HVAC Inspection

Inspection of the HVAC system and ancillary equipment revealed several deficiencies related to both maintenance and building construction. The combination of water seepage through the foundation, the presence of porous lining material in the fan room which is a humid environment (nearly 100% relative humidity), and organic debris inside the HVAC system provided an environment conducive to the proliferation of microorganisms.

The outdoor air intake was located below-grade in a 20-foot well. For below-grade air intakes, there is the potential for microbial-contaminated decaying leaf litter and debris to become entrained into the building's ventilation system. Another environmentally-related problem with the location of this intake regarded the installation of a sump to drain rain water from the well. Since the sump did not operate regularly, it contained stagnant water and debris which may serve as a reservoir for the amplification of microorganisms.

The filters for the AHU were found to be clean and installed correctly; however, their filtration efficiency was low (30%). This filtration efficiency may be adequate for stopping larger particles, however, smaller particles could pass through the filter and settle out on the interior surfaces of the AHU, thus affecting efficiency and increasing energy and maintenance costs, as well as potentially affecting the quality of the air supplied throughout the building. It has been suggested that a minimum filtration efficiency of 50 percent will remove most microbial particulate from the supply air stream.[23] The presence of debris such as bugs and dirt on the downstream side of the filter suggests that filter bypass has occurred or the debris may be entraining into the system when the maintenance covers are removed for servicing. A considerable amount of moist organic debris was present on the cooling coils which provided an ideal site for the amplification of microorganisms. Organic debris deposited in an HVAC system provides a nutrient source for microorganisms.

There was standing water or evidence of standing water at several locations within the AHU, including the area downstream of the OA intake dampers, the condensate drain pans, the fan room, and the return air plenum. The standing water located downstream of the OA dampers was probably due to the accumulation of rain water in the area. Condensate drain pans contained standing water and were coated on the bottom with rust, debris, and a microbiological "slime." A portion of the coils were located in the adjacent return air plenum. The portion of the pan serving this part of the coil also contained standing water. It appeared that the water was unable to drain due to insufficient sloping of the pan (based on observing the angle of tilt with a hand level). Water from the pans was designed to drain into the sump in the OA intake; therefore, any microorganisms present in the drain pan may be released at a point where air is brought into the building. Swarms of mosquitoes were present in the mixing plenum of the AHU. Due to the standing water in both of the sumps and the drain pan, and the other moist conditions in the mechanical room, the mosquitoes were most probably breeding in or near the AHU.

Visual evidence of microbial contamination was found on the wet, porous, man-made insulation (sound liner) in the fan room. The liner located on the south wall, which is where water seeps in through the foundation, was saturated and stained. Evidence of a prior flooding of the basement was identified in the fan room and the return air plenum due to staining of the fiberglass lining up to approximately two inches above the floor level. Additional evidence of flooding was the rust located on the supports of the supply air fan. Another significant source of moisture in the fan room is the air conditioner. The relative humidity immediately downstream of the cooling coils was almost 100 percent.

Fiberglass lining can collect dirt and moisture, serve as a site for microbial growth, and is difficult to clean. Such lining should not be used where it will be subjected to high relative humidity. In addition, the lining can support microbial growth long after it appears to be dry. Microorganisms can remain in these materials for years and may present a health hazard even after the organism are no longer viable.

Due to the large amounts of water seeping into the fan room, a trough was installed on the south wall of the building to direct the incoming water to a sump located in the return air plenum. This sump was observed to contain standing water and debris. Water from the decorative fountain in the atrium is also drained into this sump. Therefore, water containing elevated levels of microorganisms (as identified from sample analysis) was being drained into an area located in the return air stream where the contaminants could potentially be recirculated throughout the building.

A slime was present on the bottom of the decorative fountain in the atrium. The water in the fountain is not chlorinated. The filters and the pump for the fountain are located in the basement. NIOSH investigators were unable to determine how often the filters are cleaned or the methods used for cleaning the filters.

In one area of the building (the counseling center on the first floor, north tower), damaged fiberglass insulation was found in the return air plenum above the ceiling. The insulation appeared to have been left there during construction or renovation activities. Due to the location of the insulation, fibers may migrate into the occupied work space and/or become entrained in the ventilation system. Several studies of skin irritation in office employees due to contact with glass fiber have been published.[24,25,26,27] Glass fibers of diameters greater than 3.5 micrometers (µm) are known to cause dermatitis through skin irritation and can also cause eye and upper respiratory tract irritation.[28]

Bulk and Water Samples

Analytical results of bulk and water samples are presented in Table 1. All of the fungal taxa identified are normal constituents of the environment. The concentrations observed for the water samples (20 CFU/ml and 300 CFU/ml) indicate small reservoirs of fungi in the condensate drain pans, but their existence may be more indicative of sedimentation from "normal" outdoor/indoor sources as opposed to flourishing fungal cultures. A sample obtained from the soundliner of the AHU downstream of the cooling coils on the south wall indicated moderate concentrations of fungi (3×10^5 CFU/gm) with the predominant species consisting of *Cladosporium* and unidentified yeasts. Generally, the presence of yeast colonies is characteristic of microbial proliferation due to extremely moist conditions. A bacterial concentration of 4×10^5 CFU/gm in the sample of the soundliner consisted predominantly *of Micrococcus* (a soil organism also shed by humans) and lower levels of thermophilic actinomycetes. As mentioned previously, the ACGIH Bioaerosol committee considers a source to be contaminated if thermophilic actinomycetes are present.[1]

Water samples collected from the condensate drain pan, both within the AHU and the return air plenum revealed low levels of fungi. The molds found (*Cladosporium, Epicoccum, Alternaria*, and unidentified yeasts) are common saprophytic molds that are typically found in outdoor air. Water samples from both areas of the condensate drain pan, analyzed for bacteria, revealed contamination with various species of *Pseudomonas* as well as thermophilic actinomycetes. The species of *Pseudomonas* identified were primarily non-pathogenic; however, they could present a hazard to the occupants of the building due to the presence of endotoxins if they become airborne. Proliferation of these organisms in areas within the supply and return air streams dictates the need for remedial action.

No detectable levels of fungi were found in the water sample from the sump in the OA intake; but moderate levels (3×10^5 CFU/gm) of bacteria were found which consisted predominantly of *Staphylococcus* and *Pseudomonas fluorescens*. Although the cooling coil drain pan is designed to empty water into this sump, different organisms were identified in samples from each area, possibly due to varying environmental conditions (e.g., temperature, relative humidity). These findings may represent a possible hazard due to the location of the sump in the air intake and the potential for proliferation and dissemination to occur.

There were no detectable concentrations of fungi in the atrium fountain, and very low levels (500 CFU/gm) on the filter media from the fountain. The bacterial concentration in the water was 7×10^4 CFU/ml and consisted of an unidentified species of *Moraxella*. *Moraxella* is a gram negative bacterium; some species are potentially pathogenic. During the evaluation, NIOSH investigators were told by building management that the atrium fountain was not treated with a disinfectant, as is commonly done.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the bulk and water samples, the potential exists for dissemination of bioaerosols from the AHU into the occupied spaces. Whether this airborne dissemination is presently occurring or occurred in the past could not be determined from analysis of bulk samples. However, the lack of any symptoms among interviewed tenants or employees of the Executive Based Network may indicate that dissemination was not occurring at levels capable of eliciting symptoms at the present time. Since components of the HVAC system are functioning as amplification sites for microorganisms and future dissemination remains a possibility, the following recommendations are offered to remediate the microbial contaminated components of the HVAC system. Although no air sampling was done during this visit, our recommendations would remain the same if it had been done, regardless of the outcome. Corrective actions, in the order of importance, include: 1) eliminating all sources of standing water in or near the AHU, 2) removing all contaminated porous material, and 3) improving preventative maintenance procedures. These recommendations are discussed in further detail below.

1. All sources of moisture in or near the AHU, including the leaks in the foundation, standing water in the condensate drain pans of the cooling coils, and standing water in the sumps located in the ventilation system, should be identified and repaired. A firm specializing in building design and construction should be consulted to determine the reason for the water seepage through the foundation of the basement in the fan room (on the south wall). This should include the evaluation of the foundation drainage system, and the possibility of installing a vapor barrier as part of the foundation. The portion of the drip pans that are located in the return air plenum, a design problem, should be either removed or enclosed within the adjacent AHU. Additionally, the slope of the drain pan must be increased to prevent the accumulation of water in the pan. Another poor design feature identified in the HVAC system is the sump located in the return air plenum. This sump should be covered in order to minimize the potentially for aerosolization into the return air stream. Both the pan and the sumps provide a location for the growth, amplification and possible dissemination of microbiological contamination into the building ventilation system. If the removal of the sources of water does not abate the mosquitoes, a finer mesh screen should be installed at the air intake. If this is done, the screen should be inspected more frequently since it will tend to become clogged with debris more often.

2. The fiberglass sound liners downstream of the cooling coils and the liners located in the return air plenum should be discarded and replaced, preferably with a smooth-surfaced insulation to prevent the collection of microbial contaminants. Subsequent to the removal of the insulation, all surfaces (nonporous and porous) should be dried and cleaned with a high-efficiency particulate air (HEPA)-filtered vacuum to remove dirt, debris, and microorganisms before removal. The surface of the insulation should not be damaged by vacuuming. All remedial activities should be performed when the building is vacant and when the HVAC system is decommissioned. All materials should be discarded appropriately according to state and local regulations.

   During renovation, the spread of contaminants (e.g., bioaerosols, debris, and fiberglass fibers) through recirculation of air to occupied spaces needs to be controlled. This may be accomplished by: 1) isolating areas being renovated from the rest of the building (including negative pressurization to prevent exfiltration of contaminated air), 2) exhausting air contaminants from the area undergoing renovation directly to the outdoors, and 3) sealing off ductwork to prevent the redistribution of contaminated air and contamination of ductwork.

3. During the removal of any damaged materials, precautions should be taken to minimize exposures to the remediation workers performing the abatement. Remediation efforts should include provisions for the proper protection of the individuals conducting the remediation work. Workers should wear respiratory protection consisting of high efficiency particulate air (HEPA) filters and adequate skin and eye protection. A complete respirator program must be implemented that meets the requirements of the OSHA respiratory protection standard (29 Code of Federal Regulations 1910.134).[29] The minimum requirements for a respiratory protection program include a written standard operating procedure for the selection and use of respirators; the medical evaluation of employees to determine that they are physically able to wear the respirator selected for use; training and instructions on respirator usage; the cleaning, repair, and storage of respirators; the continued surveillance of work area conditions for worker exposure and stress; and a fir-test program.

4. Once the liner has been removed, all components of the AHU must be cleaned of debris including the following: OA intake, OA dampers, mixing plenum, drain pans upstream and downstream of the cooling coils, air supply plenum, the supply air fan, and the return air plenum in the basement. A firm familiar with performing indoor air quality investigations should be consulted to determine if visible growth is present in the supply air duct work, induction units, and fan coil units to determine whether these components should also be cleaned. If dirt and debris have accumulated in ductwork, microbial growth can occur when moisture levels are elevated. Components should be cleaned of debris in a manner which avoids creating dust (i.e., HEPA-filtered vacuuming, wet methods). During the cleaning, workers should wear the protective equipment mentioned previously.

5. After all the debris is removed, the components of the AHU should be sanitized using a dilute aqueous household bleach solution (10%) while the HVAC system is not operating.[19] A water rinse should follow cleaning. Bacterial endospores, produced by some thermophilic actinomyces, may be slightly resistant to disinfectants; therefore, surfaces should be kept moist for a sufficient contact time to allow for disinfection to occur. Hypochlorites have a relatively low order of toxicity and skin irritation potential. Due to the level of contamination, mechanical cleaning of the surfaces with steam or a high-pressure water sprayer may be useful prior to using the disinfectant if the treatment does not damage the heat exchanger.[19]

6. Due to the inherent problem of constructing the building over a spring, moisture incursion may remain a potential problem even after the leaks have been repaired. To minimize further moisture contamination, an enamel-based concrete sealer should be applied to further minimize moisture incursion into fan room. EPA has registered certain compounds which are available for use in AHUs.

7. Below-grade air intake wells serving basement mechanical rooms provides the potential for microbial contamination from standing water. The accumulation of decaying leaf litter, soil and other organic debris in these wells can allow for the growth of bacteria and fungi that can enter the air intake. Ideally, the location of the air intake should be moved to an area at least 25 feet away from external bioaerosol amplification sites.[22]

8. The low efficiency filters in the AHU should be replaced with a filter that is 50 to 70% efficient (according to the ASHRAE dust spot efficiency) in order to remove microbial particulates from the airstream. Observations of the induction units revealed that several of the filters were not appropriately fitted in their frames and some the fan blades were found to be very dusty, especially on the perimeter units which operate more frequently. Filters in the induction units should also be upgraded using the most efficient filters whose pressure drop the system can handle.

9. The water in the decorative fountain must be disinfected on a regular basis. The microbial "biomat" on the bottom of the fountain must be thoroughly cleaned for the disinfectants to work appropriately. The fountain was reportedly chlorinated in the past; however, due to occupant complaints of odor, the treatment was discontinued. Other methods available for disinfecting water which are odorless include bromination and ozonation.

10. The fiberglass insulation located in the return air plenum should be removed. Care should be taken to minimize aerosolization of the fibers.

11. A formal written preventative maintenance schedule for the AHU should be implemented in consultation with the manufacturers of the equipment. Preventative maintenance on the equipment should be documented and the documentation kept in a file to assure continuity

between mechanical personnel. The HVAC cooling coils and condensate drip pans should be kept free of standing water and visible microbial growth. Throughout the year, coils, condensate pans, and drains should be inspected monthly and, if necessary, cleaned. Pill packs should not be used to keep the drip pans free of debris or biological growth. These tablets are not effective unless a sufficient pool of water in the pan enables the tablet to dissolve evenly throughout the pan. The floor of the fan room should be kept free of debris which could become entrained into the supply air stream.

AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:	Angela M. Weber, MS Industrial Hygienist Industrial Hygiene Section Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations and Field Studies
	Robert Malkin, DDS, DrPH Supervisory Epidemiologist Medical Section Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations and Field Studies
Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations and Field Studies
Report Typed by:	Kathy Mitchell Secretary

DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report may be freely reproduced and are not copyrighted. Single copies of this report will be available for a period of 90 days from the date of this report from the NIOSH Publications office, 4676 Columbia Parkway, Cincinnati, Ohio 45226. To expedite your request, include a self-addressed mailing label along with your written request. After this time, copies may be purchased from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. Information regarding the NTIS stock number may be obtained from the NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Deerwood Corporation
2. California OSHA
3. OSHA Region IX

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.

REFERENCES

1. ACGIH [1989]. Guidelines for the assessment of bioaerosols in the indoor environment. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

2. Burge, HA [1988]. Environmental allergy: definition, causes, control. Engineering Solutions to Indoor Air Problems. Atlanta, GA: American Society of Heating, Refrigeration and Air-Conditioning Engineers pp. 3-9.

3. Morey, MR, Feeley, JC [1990]. The landlord, tenant, and investigator: their needs, concerns and viewpoints. Biological Contaminants in Indoor Environments. Baltimore, MD: American Society for Testing and Materials pp. 1-20.

4. Pickering, CA [1992]. Immune respiratory disease associated with the inadequate control of indoor air quality. Indoor Environment 1:157-161.

5. Vinken W, Roels P [1984]. Hypersensitivity pneumonitis to *Aspergillus fumigatus* in compost. Thorax 39:74-74.

6. Malmberg P, Rask-Andersen A, Palmgren U, Höglund S, Kolmodin-Hedman B, Stålenheim G [1985]. Exposure to microorganisms, febrile and airway-obstructive symptoms, immune status and lung function of Swedish farmers. Scandinavian Journal of Work and Environmental Health 11:287-293.

7. Topping MD, Scarsbrick DA, Luczynska CM, Clarke EC, Seaton A [1985]. Clinical and immunological reactions to *Aspergillus niger* among workers at a biotechnology plant. British Journal of Industrial Medicine. 42:312-318.

8. Edwards JH [1980]. Microbial and immunological investigations and remedial action after an outbreak of humidifier fever. British Journal of Industrial Medicine 37:55-62.

9. Weiss NS, Soleymani Y [1971]. Hypersensitivity lung disease caused by contamination of an air-conditioning system. Annals of Allergy. 29:154-156.

10. Hodgson MJ, Morey PR, Attfield M, Sorenson W, Fink JN, Rhodes WW, Visvesvara GS [1985]. Pulmonary disease associated with cafeteria flooding. Archives of Environmental Health 40(2):96-101.

11. Fink JN, Banazak EF, Thiede WH, Barboriak JJ [1971]. Interstitial pneumonitis due to hypersensitivity to an organism contaminating a heating system. Annals of Internal Medicine 74:80-83.

12. Banazak EF, Barboriak J, Fink J, Scanlon G, Schlueter EP, Sosman A, Thiede W, Unger G [1974]. Epidemiologic studies relating thermophilic fungi and hypersensitivity lung

syndrome. American Review of Respiratory Disease 110:585-591.

13. Kaliner M, Eggleston PA, Mathews KP [1987]. Rhinitis and asthma. Journal of the American Medical Association 258(20):2851-2873.

14. Jordan FN, deShazo R [1987]. Immunologic aspects of granulomatous and interstitial lung diseases. Jour of the Amer Med Assoc 258(20):2938-2944.

15. Fink JN [1983]. Hypersensitivity pneumonitis. In Allergy Principles and Practice, E Middleton, CE Reed, and EF Ellis, eds. St Louis: C.V. Mosby Co.

16. Morey PR and Feeley JC [1990]. The landlord, tenant, and investigator: their needs, concerns and viewpoints. In: Biological Contaminants in Indoor Environments, ASTM STP 1071, Morey PR, Feeley JC, and Otten JA, Eds. American Society for Testing and Materials, Philadelphia.

17. Morey PR, Hodgson MJ, Sorenson WG, Kullman GJ, Rhodes WW, and Visvesvara GS [1984]. Environmental studies in moldy office buildings: biological agents, sources and preventative measures. Annual Am Conf of Govern Ind Hyg, Vol. 10:21-35.

18. Hood MA [1990]. Gram negative bacteria as bioaerosols. In: Biological Contaminants in Indoor Environments, ASTM STP 1071. Morey PR, Feeley JC, and Otten JA, Eds. American Society for Testing and Materials, Philadelphia, PA.

19. Olenchock SA [1985]. Endotoxins in occupationally related airborne dusts. Govern Lab *1*:28-30.

20. Rylander R [1987]. The role of endotoxin for reactions after exposure to cotton dust. Am J Ind Med *12*:687-697.

21. Flannigan B [1992]. Approaches to assessment of the microbial flora of buildings. IAQ '92, Environments for people, San Francisco, CA.

22. Jacobs RR [1989]. Airborne endotoxins: an association with occupational lung disease. Appl Occup Environ Hyg *4*:50-56.

23. Morey PR [1988]. Microorganisms in buildings and HVAC systems: A summary of 21 environmental studies. Engineering solutions to indoor air problems. Proceedings of the ASHRAE Conference, IAQ 88, Atlanta, GA: pp. 10-24.

24. Verbeck SJA, Buise-van Unnik EMM, Malten KE [1981]. Itching in office workers from glass fibers. Cont Dermatol 7:354.

25. Farkas J [1983]. Fiberglass dermatitis in employees of a project-office in a new building. Cont Dermatol 9:79.

26. Lob M, Guillemin M, Madelaine P, Boillat MA, Baudraz F [1984]. Collective dermatitis in a modern office. In: Grandjean E, ed. Ergonomics and health in modern offices. London, UK: Taylor and Francis, pp. 52-58.

27. Anderson FE [1986]. The mystery of itching telephonists. Aust J Dermatol 27:64-66.

28. Adams RM [1990]. Dermatitis due to fibrous glass. In: Adams RM, ed. Occupational skin disease. 2nd ed. Philadelphia, PA: W.B. Saunders Company, pp. 16-17.

29. Code of Federal Regulations [1992]. OSHA respiratory protection standard. 29 CFR 1910.134. Washington, DC: U.S. Government Printing Office, Federal Register.

TABLE 1
Microbiological Results of Bulk and Water Samples
HETA 94-0051-2463
Deerwood Park Office Building
San Ramon, California
April 13-14, 1994

SAMPLE LOCATION	FUNGI		BACTERIA	
	Concentration	Taxa Rank	Concentration	Taxa Rank
Water from sump in OA intake	ND		$3X10^5$/ml	Staph>Ps fl>Flav>>TA
Water from sump in return plenum	NA		NA	
Water from fountain in atrium	ND		$7X10^4$/ml	Morax
Water from drain pan in AHU	$3X10^2$/ml	Unid>Clad>Epi	$3X10^6$/ml	Ps sp>Ps cep>>TA
Water from drain pan in return plenum	2X10/ml	Yea=Alt	$1X10^6$/ml	Ps cor>Ps meph>>TA
Surface of OA damper	NQ	Debris>Unid> Alt	NA	
Filter material from fountain	$5X10^2$/gm	Unid	$2.6X10^4$/gm	Bac>>TA
Soundliner in AHU	$3X10^5$/gm	Clad>Yea>Alt>A sp	$4X10^5$/gm	micro > TA

Note:Concentrations for water and bulk samples are given as colony forming units per milliliter (CFU/ml) and as colony forming units per gram (CFU/gm), respectively. NA=Not Analyzed, ND=Not Detected, NQ=Not Quantitative.

Abbreviations:

Alt = *Alternaria*
Asp=*Aspergillus*
Bac=*Bacillus insolitus*
Clad=*Cladosporium*
Debris=Non-biological material
Epi=*Epicoccum*
Flav=*Flavobacterium* species
Micro=*Micrococcus* species
Morax=*Moraxella* species

Ps cep=*Pseudomonas cepacia*
Ps cor=*Pseudomonas corrugata*
Ps fl=*Pseudomonas flourescens*
Ps meph=*Pseudomonas mephitica*
Ps sp=*Pseudomonas* species
Staph=*Staphylococcus*
TA=Thermophilic Actinomyces
Unid=Unidentified Fungi
Yea=Unidentified Yeast