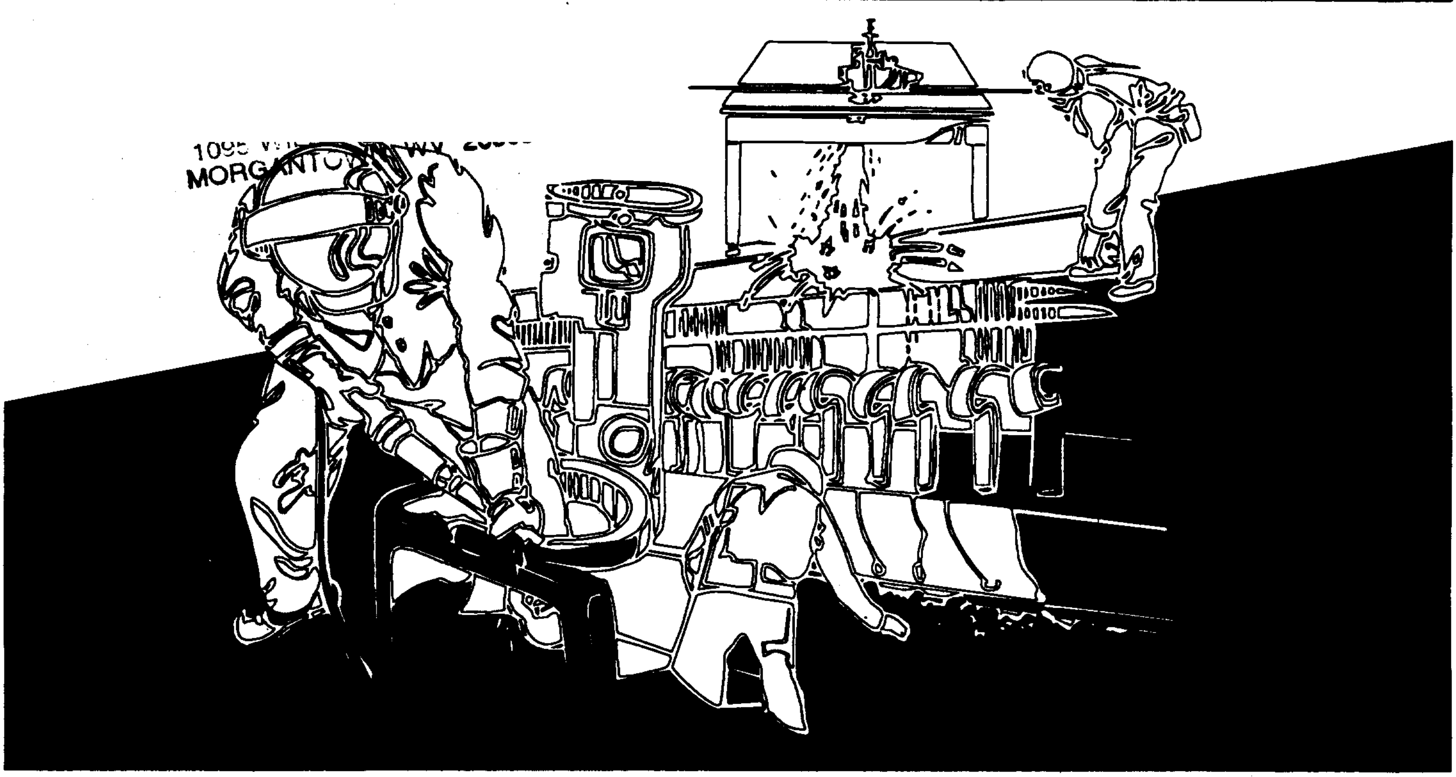
NIOSH

HEALTH HAZARD EVALUATION REPORT

HETA 92-066-2216
UNIVERSITY OF GEORGIA
INSTITUTE OF ECOLOGY
ATHENS, GEORGIA



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer and authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 92-066-2216
MARCH, 1992
UNIVERSITY OF GEORGIA
INSTITUTE OF ECOLOGY
ATHENS, GEORGIA

NIOSH INVESTIGATORS:
Max Kiefer, CIH
Stan Salisbury, CIH

SUMMARY

On November 21, 1991, The National Institute for Occupational Safety and Health (NIOSH), Atlanta Regional Office, received a request to conduct a health hazard evaluation (HHE) at the University of Georgia (UGA) Institute of Ecology. The request was initiated by UGA employees who work in this building. The requestors asked NIOSH to investigate health problems experienced by some building occupants that were possibly related to poor indoor air quality (IAQ). These health problems included headaches, sinus infections, arthritis-like symptoms, nausea, dizziness and disorientation. Additionally, the requestors were concerned that outdoor pollutants from a nearby power plant might be entering the building. Because previous efforts to identify and resolve the cause(s) of the IAQ problems were unsuccessful, NIOSH was requested to conduct an investigation.

In response to this request, NIOSH investigators reviewed the results of previous IAQ investigations concerning this building that were conducted by UGA, as well as the results of an engineering evaluation of the building heating, ventilating and air-conditioning (HVAC) systems. A site visit was conducted on January 22, 1992, to inspect the Institute of Ecology facility, interview building occupants, review the building's HVAC system, and conduct limited environmental monitoring if conditions warranted.

During the opening conference, NIOSH investigators reviewed historical information regarding IAQ at the facility, and discussed actions taken by UGA to resolve the problems. During this meeting, several of the occupants reported that episodic health complaints associated with the building were still occurring although UGA officials had taken many actions to identify and resolve the problems. Following the opening conference, NIOSH investigators inspected all the HVAC systems, interviewed the principal UGA IAQ investigators, and inspected the building and surrounding areas. Spot temperature, relative humidity (RH) and carbon dioxide (CO_2) readings were collected for comparison with consensus criteria associated with IAQ. In room 12, a bulk sample of filter material from a portable air cleaner was obtained and sent to the NIOSH laboratory for analysis.

The building is serviced by four constant-volume HVAC systems. The facility has been periodically renovated over the years to accommodate personnel and equipment, and is currently undergoing renovation/office relocation. The environmental parameters associated with IAQ that were measured by UGA all fell within ranges considered acceptable for employee comfort (temperature, relative humidity) as defined by the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE). The CO_2 measurements indicated that sufficient outside air

(exceeding ASHRAE criteria) was being provided to building occupants. Sulfur dioxide (SO_2) monitoring, conducted by UGA in November, 1991, indicated the presence of approximately 0.1 parts per million (ppm) of SO_2 in the mixing chambers of air handlers #3 and #6 over a sample time of about 150 minutes. The air cleaner filter analysis detected only normal soil constituents typically found in airborne dust. The complaint log (May - August, 1991) indicated that of the 98 total complaints noted, thirty-four (35%) of the respondents associated the problem with an odor. Thirty-six (73%) of the forty-nine questionnaires returned indicated the respondents had experienced either a health problem or a comfort problem associated with IAQ. The engineering firm identified a number of potential problems, including an extreme negative pressure situation occurring in the laboratories, and the potential for insufficient outside air to be provided to the building. UGA implemented the engineering recommendations and the HVAC systems were verified as operating properly. Insulation linings in the HVAC air handlers down-stream from the air filters showed signs of deterioration and mold growth. For the most part, however, the systems were functioning properly and in good condition. It is likely that the IAQ-related issues are multifactorial in nature, and may be associated with entrainment of pollutants from external sources. Suggestions for further actions are offered in the recommendation section of this report.

Health symptoms and complaints consistent with those commonly referred to as "sick building syndrome" have been experienced by some occupants of the UGA Ecology Institute. The problems appear to be episodic in nature and may possibly be more prevalent in the summer. The primary health complaints (headache, stuffiness, fatigue) are typically associated with ventilation deficiencies such as inadequate outside air; however, outside air in excess of recommended quantities is being provided to building occupants. Potential explanations include both internal and external sources, and are likely multifactorial in nature. Recommendations to address employee concerns include implementation of an IAQ management plan, conducting additional sulfur dioxide monitoring, relocating laser printers, and replacing HVAC duct lining that shows evidence of mold growth.

KEYWORDS: SIC 8221 (Educational Institution), indoor air quality, IAQ, carbon dioxide, relative humidity, sulfur dioxide, temperature, ozone, bioaerosols, headache, fatigue, irritation.

INTRODUCTION

NIOSH received a request from the University of Georgia (UGA) on November 17, 1991, to investigate ongoing health complaints associated with indoor air quality (IAQ) among employees who work in the University's Institute of Ecology building. The reported health complaints included headaches, sinus infections, arthritis-like symptoms, and fatigue. Previous university efforts to resolve these problems had been unsuccessful and NIOSH was asked to conduct an investigation.

NIOSH reviewed the results of previous IAQ investigations regarding this facility, as well as the results of an engineering evaluation of the facility's heating, ventilating and air-conditioning (HVAC) system. An initial site visit to evaluate the Institute of Ecology building was conducted on January 22, 1992. During the survey, NIOSH investigators met with university representatives, inspected the HVAC system, conducted limited environmental monitoring, and interviewed building occupants.

An initial response letter describing the actions taken by NIOSH, as well as preliminary findings and recommendations, was issued to university officials on March 17, 1991.

BACKGROUND

The UGA Institute of Ecology building (Figure 1) is a modern, single story structure that was constructed in the late 1960s, with a new addition (Marine Institute) in 1978. The building occupants (approximately 70) are primarily administrative and teaching staff, laboratory researchers, and graduate students. The building is serviced by four constant-volume HVAC systems. The office area is served by air handling unit AH-1, the computer area is served by AH-2, the laboratory and some corridors by AH-3 (and makeup air fan S-1), and the marine sciences section by AH-6. Outside air is directly ducted to the air handlers from wall louvers. Each unit is equipped with a minimum outside air damper. AH-1 and AH-2 obtain outside air from a louvre approximately 15 feet above grade on the west side, AH-3, a 100% outside air system, obtains outside air from the east side approximately 4 feet above grade, and AH-6 obtains outside air from the north side at ground level. The facility has been periodically renovated over the years to accommodate personnel and equipment, and is currently undergoing renovation/office relocation. Smoking is not permitted in the building. Employees have access to thermostats for temperature control.

Episodic IAQ problems that were thought to be the cause of adverse health symptoms experienced by some of the building occupants have been an ongoing issue in this building for more than 2 years. Prior to the NIOSH investigation, university officials conducted monitoring to assess standard IAQ parameters (temperature, carbon dioxide, relative humidity) and various other suspected contaminants (sulfur dioxide, volatile organic compounds [VOCs]). The university also contracted with an engineering consultant to review the HVAC systems and recommend improvements.

Many of the consultant's improvements were implemented and the HVAC systems were also tested and balanced.

EVALUATION PROCEDURES

The NIOSH evaluation consisted of the following: (1) a review of the actions taken by UGA investigators to identify and resolve the IAQ problems; (2) an assessment of employee questionnaire, and complaint log results from the Institute of Ecology; (3) a review of engineering assessments of the building HVAC systems, and; (4) a site visit to conduct a facility inspection, interview building occupants and collect environmental samples. Prior to the site visit university officials provided the following information to NIOSH for review:

Floor plans of the Ecology Building
Summary sheet of the UGA IAQ investigations
Ecology building IAQ complaint summary
Ecology building IAQ questionnaire summary
Consultant engineering evaluation of the HVAC systems
UGA physical plant test and balance report of the Marine Institute HVAC system

Monitoring Methods

Sampling and analytical methodology used during the survey was as follows:

A. **Carbon Dioxide (CO_2)**

Instantaneous measurements of CO_2 concentrations were obtained using a Gastech Model RI-411A Portable (direct reading) CO_2 monitor. The principle of detection is non-dispersive infrared absorption. The instrument was zeroed (zero CO_2 gas source) and calibrated prior to use with a known CO_2 source (span gas). The monitor provides CO_2 concentrations in 25 parts per million (ppm) increments with a range of 0 - 4975 ppm. Measurements were obtained at various intervals and locations throughout the building. Outdoor readings were taken to determine baseline CO_2 levels.

B. **Temperature and Relative Humidity (RH)**

Dry bulb temperature and RH levels were determined in various locations. Outdoor readings were obtained for comparison purposes. Instrumentation consisted of a Vaisala model HM 34 humidity and temperature meter with a digital readout. This unit is battery operated and has humidity and temperature sensors on an extendable probe. The temperature range of the meter is -4 to 140°F and the humidity range is 0 - 100%.

C. **Bulk Sample**

A small section of filter material from the inlet side of a floor-mounted portable air cleaner in room 12 was submitted to the NIOSH laboratory for analysis. The sample was analyzed for the presence of trace metals using inductively coupled plasma - atomic emission spectroscopy (ICP-AES).

In an effort to further characterize the scope of the IAQ issues in the Ecology building, UGA investigators initiated the use of a form for logging IAQ complaints, and encouraged building occupants to record any problems that occur. Additionally, UGA investigators provided questionnaires to all building occupants in August, 1991, to solicit additional information regarding the nature of the IAQ problems. The results of the questionnaires and complaint logs were reviewed. Information requested on the questionnaire included comfort and health concerns such as temperature, noise, dust, "stuffiness", and, symptoms experienced.

EVALUATION CRITERIA

A number of published studies have reported high prevalences of symptoms among occupants of office buildings.[1-5] NIOSH investigators have completed over 700 investigations of the indoor environment in a wide variety of settings. The majority of these investigations have been conducted since 1979.

The symptoms and health complaints reported by building occupants have been diverse and are usually not suggestive of any particular medical diagnosis or causative agent. A typical spectrum of symptoms has included headaches, unusual fatigue, varying degrees of itching or burning eyes, irritations of the skin, nasal congestion, dry or irritated throats and other respiratory irritations. Typically, the workplace environment has been implicated because employees report that their symptoms lessen or resolve when they leave the building.

Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building-related occupant complaints .[6,7] Among these factors are imprecisely defined characteristics of heating, ventilating, and air-conditioning (HVAC) systems, cumulative effects of exposure to low concentrations of multiple chemical pollutants, odors, elevated concentrations of particulate matter, microbiological contamination, and physical factors such as thermal comfort, lighting, and noise.[8-13] Reports are not conclusive as to whether increases of outdoor air above currently recommended amounts ($\geq$15 cubic feet per minute per person) are beneficial.[14,15] However, rates lower than these amounts appear to increase the rates of complaints and symptoms in some studies.[16,17] Design, maintenance, and operation of HVAC systems are critical to their proper functioning and provision of healthy and thermally comfortable indoor environments. Indoor environmental pollutants can arise from either outdoor sources or indoor sources.[18]

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 the measurement of any indoor contaminant or condition.[19-21] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[21-24]

Less often, an illness may be found to be specifically related to something in the building environment. Some examples of potentially building-related illnesses are allergic rhinitis, allergic asthma, hypersensitivity pneumonitis, Legionnaires' disease, Pontiac fever, carbon monoxide poisoning, and reaction to boiler corrosion inhibitors. The first three conditions can be caused by various microorganisms or other organic material. Legionnaires' disease and Pontiac fever are caused by Legionella bacteria. Sources of carbon monoxide include vehicle exhaust and inadequately ventilated kerosene heaters or other fuel-burning appliances. Exposure to boiler additives can occur if boiler steam is used for humidification or is released by accident.

Problems NIOSH investigators have found in the non-industrial indoor environment have included poor air quality due to ventilation system deficiencies, overcrowding, volatile organic chemicals from office furnishings, machines, structural components of the building and contents, tobacco smoke, microbiological contamination, and outside air pollutants; comfort problems due to improper temperature and relative humidity conditions, poor lighting, and unacceptable noise levels; adverse ergonomic conditions; and job-related psychosocial stressors. In most cases, however, no cause of the reported health effects could be determined.

Standards specifically for the non-industrial indoor environment do not exist. NIOSH, the Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH) have published regulatory standards or recommended limits for occupational exposures.[25-27] With few exceptions, pollutant concentrations observed in the office work environment fall well below these published occupational standards or recommended exposure limits. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published recommended building ventilation design criteria and thermal comfort guidelines.[28-29]

The ACGIH has developed a manual of guidelines for approaching investigations of building-related complaints that might be caused by airborne living organisms or their effluents.[30] Note that exposure standards for airborne microorganisms (bioaerosols) have not been established. Additionally, microbial organisms will be found throughout the environment (including buildings that are not experiencing IAQ problems) and their presence should not be construed as proof of the cause of health problems.[30] However, obvious signs of bioaerosol reservoirs, amplifiers and disemminators should be corrected to reduce the potential for these sources to cause health problems. These sources include the building HVAC system (stagnant water in condensate pans, filters that become moist, porous acoustical liner in ducts), and water damaged carpet, ceiling tile or other furnishings. Health outcomes associated with bioaerosols include hypersensitivity pneumonitis (a potentially severe disease) or allergic rhinitis, which can be caused by bacteria, fungi, protozoa or other bioaerosols.

The basis for monitoring carbon dioxide, temperature, and relative humidity are presented below:

A. Carbon Dioxide (CO_2)

CO_2 is a normal constituent of exhaled breath and, if monitored, can be used as a screening technique to evaluate whether adequate quantities of fresh 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 conference rooms, 15 cfm/person for reception areas, and 60 CFM/person for smoking lounges, and provides estimated maximum occupancy figures for each area.[28]

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

B. Temperature and Relative Humidity

The perception of comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperatures. Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. ANSI/ASHRAE Standard 55-1981 specifies conditions in which 80% or more of the occupants will find the environment thermally comfortable.[29] ASHRAE has developed a chart which includes a "comfort zone" considered to be both comfortable and healthful for the majority of the building occupants. This zone lies between 73° and 77° F and 20 to 60% relative humidity. Note, however, that some scientists feel that RH levels below 30% may produce discomfort from dryness.[31] The range is wide because the feeling of comfort is a subjective, individual perception that is related to metabolic heat production, body temperature, and clothing.

RESULTS AND DISCUSSION

1. UGA Investigations

UGA Safety representatives have investigated IAQ complaints in the Ecology building since September, 1990. Prior to June, 1991, the IAQ issues were considered to be isolated events. However, the number of complaints significantly increased in the summer of 1991, and a more detailed investigation was initiated. These investigations included implementing an employee complaint log to identify how widespread the problems were, and to obtain details regarding the types of health problems experienced. A questionnaire, based on the standard NIOSH IAQ questionnaire, was also administered to building occupants.[32] Environmental monitoring was conducted for a variety of IAQ parameters, including temperature, CO_2, and relative humidity. UGA officials also monitored for carbon monoxide, sulfur dioxide, heavy metals, and volatile organic compounds (VOCs). The UGA IAQ investigation protocol was reviewed with environmental consultants from the Georgia Tech Research Institute, and Emory University. The building was surveyed to assess chemical use practices in the laboratories. Various modifications to the ventilation system were made in response to recommendations from an HVAC consulting firm.

The measured environmental parameters associated with IAQ all fell within ranges considered acceptable for employee comfort (temperature, relative humidity) as defined by ASHRAE. The CO_2 measurements indicated that sufficient outside air (exceeding ASHRAE criteria) was being provided to building occupants. No appreciable amount of carbon monoxide was detected, and the VOC monitoring indicated all analytes were below the limit of detection. The VOC monitoring was conducted by using a passive dosimeter with subsequent analysis by gas chromatography/mass spectroscopy. Samples were collected for 8 hours in four locations in the building. No compounds were found on the samples at a detection limit of <0.45 milligrams per cubic meter (mg/m^3).

The sulfur dioxide (SO_2) monitoring, conducted in November, 1991, indicated the presence of approximately 0.1 parts per million (ppm) of SO_2 in the mixing chambers of air handlers #3 and #6 over a sample time of about 150 minutes. SO_2 sampling was initiated to determine if flue gas from a nearby (approximately 500 feet) power plant stack (coal and oil fired boiler) was entrained in the building ventilation system. The Environmental Protection Agency's National Ambient Air Quality Standard for SO_2 is an annual average of 0.03 ppm and a one-time 24-hour average of 0.14 ppm.[33]

Prior to the NIOSH visit, both building occupants and UGA investigators had samples analyzed from HVAC system filters which detected various amounts of metals, including lead and arsenic. Building occupants were concerned because blood tests conducted on a former laboratory worker had detected the presence of mercury, arsenic and lead. External sources, primarily fly ash from the nearby power plant, were suspected as the source of the metals. The potential for entrainment from outside sources was suspected as both building occupants and UGA investigators indicated that at various times, odors associated with activities at a Physical Plant electronic maintenance shop have been detected in the Ecology building. The maintenance shop is located at a slightly higher elevation (5-6 feet), approximately 50 feet from the south side of the Ecology building.

With the exception of mercury, air sampling conducted by UGA in October, 1990 did not detect the presence of any metals above the detection limit of the method. The mercury sample, collected above the ceiling in Room 152, detected approximately 2 micrograms of mercury per cubic meter of air ($\mu g/m^3$). The NIOSH recommended exposure limit (REL) and OSHA permissible exposure limit (PEL) for mercury vapor is $50 \mu g/m^3$ as a full-shift time-weighted average.[34,26] Room 152 is a laboratory, and this could be a possible source for the mercury. Ambient air concentrations have been reported to average 0.01-0.02 $\mu g/m^3$, with higher concentrations in industrialized areas.[35] Levels of 10-15 $\mu g/m^3$ have been detected near point emission sources such as mercury mines and refineries, and agricultural fields treated with mercury fungicides.[35]

2. UGA IAQ Complaint Log and Questionnaire

In an effort to further characterize the scope of the IAQ issues in the Ecology building, UGA investigators initiated the use of a form from May - August, 1991 for logging IAQ complaints, and encouraged building occupants to record any problems that occur. A total of 98 complaints were logged in this time frame. Additionally, UGA investigators provided questionnaires to all building occupants in August, 1991, to solicit additional information regarding the nature of the IAQ problems. A summary of these data collection efforts are as follows:

Complaint Log

Thirty-four (35%) of the respondents associated the complaint with an odor. The most common odor reported (14 [41%]) was a chemical odor, which included the description of "solvent", and lighter fluid. Pesticide odors accounted for nine (26%) of the total reported odors.

Complaints By Date:	May: 2 (2%)	June: 28 (26%)
	July: 58 (54%)	August: 12 (11%)

Complaints by Room

Room Number	Number of Complaints	Percent of Total
12	41	44
152	22	24
104	10	11
Systems	4	4
103	3	3
153	3	3
Seminar Room	2	2
105	2	2
Courtyard	1	1
194	1	1
RR	1	1
164	1	1
North Annex	1	1
Marine Sciences	1	1

Symptoms Reported on Complaint Log

Symptom Reported	Number Reported	Percent
Headache	70	71
Fatigue	46	47
Eye irritation	38	39
Muscle ache	37	38
Nasal Irritation	36	37
Dizziness	33	34
Skin rash	17	17
Chest pain	14	14
Sinus congestion	12	12
Nausea	12	12
Memory loss	11	11
Scratchy throat	11	11
Shortness of breath	11	11
Muscle spasm	10	10
Coughing	9	9
Respiratory infection	2	2

Questionnaire

Forty-nine (70%) of the IAQ questionnaires were returned to the UGA investigators. Thirty-six (73%) of the respondents indicated they had experienced either a health problem or a comfort problem associated with being in the building. Eleven (22%) of the 49 were concerned from a comfort standpoint only. Noticeable odors were the most common complaint with 26 (66%) reporting this parameter. Eighteen (37%) reported the presence of irritating fumes, and 15 (31%) indicated a lack of air circulation or stuffiness. Temperature extremes (too hot or too cold, or both) were reported by 9 (18%) of the respondents.

As with the complaint log, the most common health problem reported was headache (17 [36%]). This was followed by sinus congestion (16 [33%]), fatigue (13 [27%]), nasal irritation (12, [25%]) and eye irritation (10 [20%]).

3. HVAC System Evaluations

In March, a mechanical engineering firm evaluated the Ecology Building HVAC systems (except the Marine Institute) to help resolve the IAQ problems and recommend modifications to comply with ASHRAE guidelines. Systems AH-1 (office area), AH-2 (computer area), and AH-3 (laboratories) were inspected. Temperature, relative humidity and CO_2 measurements were collected. The firm identified a number of potential problems, including an extreme negative pressure situation occurring in the laboratories, and the potential for insufficient outside air to be provided to the building. The negative pressure was caused by both the extensive lab hood and kiln exhaust systems, and the unwillingness of building occupants to operate an auxiliary supply air fan (the auxiliary supply air fan provides unconditioned make-up air which caused discomfort). The engineering firm found that the negative pressure was drawing odors from adjacent locations, primarily the kiln and grinding areas. According to the engineering firm, there was minimal potential for reentrainment of laboratory hood exhaust stack emissions into the building's outside air intake vents. This was because the exhaust stacks had been raised to 17.5 feet above the roof and had tapered discharge outlets to increase velocity. The normal wind direction (from the west) is away from the air intakes. A report was issued recommending relocating or removing equipment (kiln hoods and room exhaust fan) in the laboratory to address the negative pressure issue, and re-sizing duct work to increase the minimum outside air quantities for AH-1 and AH-2. AH-3, servicing the laboratories and some corridors is a 100% outside air system (no return air).

UGA implemented these recommendations and the consulting firm returned on June 6, 1991 to review the effect of these changes. The consulting firm reported that the recommendations have been completed and the negative air situation, and potential for insufficient outside air, were alleviated. Additionally the grinding operation was relocated which eliminated this activity as a source of odors.

Because IAQ problems persisted after these modifications, UGA personnel focused on the new addition (Marine Institute, HVAC system AH-6). This system was not evaluated by the engineering firm, and the complaint log indicated that the most common complaint area (41 [44%]) was room 12, which is serviced by AH-6. Room 12 is a former conference room that has been converted to a work area for administrative staff.

AH-6 is a constant-air-volume system that operates 24-hours/day with the discharge air controlled to 50° F. There are 17 reheat boxes that are individually controlled by wall-mounted pneumatic thermostats located in various rooms. The system is designed to operate in two modes: when the outside air temperature is between 40° and 70° F, the system uses 100% outside air; at temperatures below 40° F and above 70° F the system simultaneously modulates the return air and the outside air dampers. In no case does the outside air damper close completely. HVAC systems AH-1 and AH-2 also operate under the same parameters.

A UGA technician tested and balanced AH-6 on December 2, 1991. According to UGA officials, one air vent was found blocked. Outside air quantities provided to the Marine Institute exceeded ASHRAE recommendations. Relative humidity and CO_2 readings were within ASHRAE guidelines.

4. <u>NIOSH Site Visit</u>

Building Ventilation

On the down-stream side of the air filters in AH-6, visible mold growth and liner deterioration were noted. Standing water or moisture in the air-handler (e.g. condensation pans) was not found, and the system otherwise appeared clean. The HVAC set points were checked. It was observed that with outside air temperature at 50° F, the outside air damper was closed to a minimum stop and the return air damper was fully open, indicating an improperly calibrated system (design calls for 100% outside air when outdoor temperatures fall between 40° and 70° F). UGA personnel then adjusted the set point and the outside air and return air dampers moved to their proper positions. The system has a ducted outside air and return system. The air-handler is equipped with bag filters rated at 60% efficiency. Some construction materials (floor coatings in sealed cans) were stored in the mechanical room. The AH-6 outside air intake vent was surrounded by a temporary enclosure that was open at the top about three feet below the level of the roof. This enclosure was installed to prevent dust generated from adjacent construction activities from drifting into the vent.

The outside air dampers for AH-3 were open and the system appeared to be clean and dry. The condensate pans were inaccessible and were not inspected.

Fan EF-3A (exhaust fan for room air in laboratories) was found shut-off at the roof disconnect. UGA personnel re-activated the fan when this was noted.

Humidification capability is not available on the building HVAC systems. As the systems are currently operated, extensive quantities of outside air are provided to occupied spaces. Heating the outside air to comfortable levels removes moisture, resulting in low relative humidity levels inside the building.

AH-1 and AH-2 are located in a roof mezzanine and receive ducted outside air from the front of the building. The lining in these air handlers also showed signs of deterioration, and possible mold growth. The systems otherwise appeared clean and dry. Supply duct linings were not inspected during this evaluation.

Building Inspection

The corridor adjacent to Laboratories 152-156 is equipped with dividers to create office cubicles for graduate students. This may affect proper air distribution or ventilation in this area. In some areas (e.g. room 12), the walls have been completely covered with cork, which could possibly result in the adsorption, and later release of, contaminants. Porous material such as cork may also be a reservoir for mold, especially if water damage had occurred. In some areas (seminar room, exhibit room) there was evidence of water damaged ceiling tiles. In the main entrance, visible evidence of moisture leakage from air supply vents was noted.

One laser printer in room 12 is located very close to the breathing zone of one of the office workers. During periods of heavy use this printer can affect the surrounding environment due to heat build-up or possible contaminant generation such as ozone.

A fairly large floor-mounted portable air cleaner, which circulates room air through a high efficiency filter and charcoal bed, has operated in room 12 since January, 1990. A small section of the filter material (inlet side) was removed and submitted to the NIOSH laboratory for a metals analysis. The results of this analysis, depicted in Table 1, found trace levels of aluminum, barium, calcium, sodium, iron, titanium, zinc, strontium and magnesium. These elements are normally found in airborne dust samples because they are natural constituents of soil. For instance, aluminum, iron, barium and zinc are some of the most abundant metals in the earths crust, and calcium is a component of many common rocks (e.g. limestone).[36] The presence of these elements collected on the filter material is not indicative of a hazard. Furthermore, the results can not be extrapolated to an airborne concentration as neither the air volume pulled through the air cleaner nor the collection efficiency of the air filter is known. No arsenic or lead was detected in the sample.

At 3:00 PM spot temperature, relative humidity (RH) and CO_2 measurements were taken outdoors and in room 12 (serviced by AH-6), and an adjacent "systems room" (former computer room now used by administrative staff, serviced by AH-2). The results are as follows:

Location	Relative Humidity	Temperature	CO_2 (ppm)
Room 12	16%	79°F	450
Systems	19%	71°F	425
Outside	25%	63°F	325

The CO_2 levels indicate that sufficient outside air is being supplied to these rooms. The relatively high temperature in room 12 was due to occupant preference for a warmer air temperature. The RH levels are outside the ASHRAE comfort range. As mentioned, this may be due to the large quantities of outside air being brought into the building (influenced by outside RH levels and the amount of heating needed to bring this air up to the comfort range), and the lack of any HVAC humidification capability. Excessively dry air, even at comfortable temperatures, can lead to drying and irritation of mucus membranes of the eyes, nose and throat.[32]

Occupant interviews indicated that an odor described as "musty" or "moldy" periodically occurs. These types of odors are often associated with biological growth, such as mold. During the walk-through, a musty odor was detected in the room housing the drying oven. This may have been the source for some of these odors which were, as the engineering firm indicated, being drawn into other areas by the extreme negative pressure in the laboratories.

A walk-through survey of the labs on the south side of the building indicated that most chemical handling activities take place in the ventilated hoods. As mentioned, the laboratories are at a negative pressure with respect to the rest of the building, and air is not recirculated (100% make-up). Under these conditions, any odors originating in the laboratories would not be expected to migrate into other occupied areas. Housekeeping in these labs, however, could be improved. Glass chemical containers were stored on the floor (potential spill risk), access to the chemical spill kit was blocked in room 152, and open containers of incompatible chemicals were found in one hood (acetone and aqua-regia).

CONCLUSIONS

Ongoing health symptoms and complaints consistent with those commonly referred to as "sick building syndrome" have been experienced by some occupants of the UGA Ecology Institute. The problems appear to be episodic in nature and may possibly be more prevalent in the summer. The primary health complaints (headache, stuffiness, fatigue) are typically associated with ventilation deficiencies such as inadequate outside air. Outside air in excess of the quantity recommended by ASHRAE is being provided to building occupants.

Many recent changes have been made or planned for the building (ventilation, equipment relocation, office staff relocations). Many of these changes were made in an effort to improve air quality. The effectiveness of these changes has not been assessed.

No chemical explanation for the IAQ problems reported was found during this survey. This is typical of most IAQ investigations. Resolution of IAQ problems generally involves a cycle of hypothesis generation and testing. As questions or plausible causes are suggested, they should be considered and evaluated. This serves to narrow down the possibilities as potential explanations are ruled out, or improvements are implemented. This is the course of action recommended for the UGA Ecology Institute. As the problems are likely multifactorial in nature, it may be that some or all of the potential causes may have contributed to the problems, either singly or in combination with other events. Its likely that additional IAQ problems may decrease as each potential explanation is addressed.

Potential explanations noted at the UGA Ecology Institute included both internal and external sources. Under certain meteorological conditions, power-plant flue gas, or emissions from the physical plant maintenance shop may become entrained in the Ecology building air intake. The affect of having large surface areas of porous material (cork on walls) in the building is problematic. Studies have shown that porous surfaces will adsorb and later emit volatile organic materials; however this phenomena is poorly understood.[37] Evidence of biological growth was noted in some areas. There may be an IAQ impact associated with improperly calibrated, or non-functioning HVAC system components (e.g. a primary HVAC exhaust fan had been inadvertently shut down for an unknown period of time). For instance, the general laboratory air exhaust fan, if turned off, may create a relative positive pressure situation in these laboratories. Outward migration of odors or contaminants from these labs could occur. The proximity of the laser printers to the occupants (especially in room 12) may also have an influence.

RECOMMENDATIONS

1. Implement an IAQ Management Plan for the Ecology building. An IAQ manager or administrator with clearly defined responsibilities, authority, and resources should be selected. This individual should have a good understanding of the building's structure and function, and should be able to effectively communicate with occupants. The elements of a good plan include the following:

   -- Proper operation and maintenance of HVAC equipment.

   -- Overseeing the activities of occupants and contractors that affect IAQ (e.g., housekeeping, pest control, maintenance, food preparation).

   -- Maintaining and ensuring effective and timely communication with occupants regarding IAQ.

   -- Educating building occupants and contractors about their responsibilities in relation to IAQ.

   -- Pro-active identification and management of projects that may affect IAQ (e.g., redecoration, renovation, relocation of personnel, etc.).

   Reference #32 should be consulted for details on developing and implementing IAQ management plans.

2. Conduct additional monitoring for SO_2 to evaluate the potential for power plant flue gas to become entrained in the building HVAC system. The EPA Atmospheric Monitoring Laboratory in Athens, GA has agreed to assist with this endeavor. The results should be correlated with atmospheric conditions, power plant operations, and occupant complaints.

3. Improve chemical handling and housekeeping practices in the laboratories.

4. Consider moving laser printers further away from occupied workstations. A recently completed NIOSH study detected ozone emissions from a laser printer.[38] Ozone has a pungent odor at low concentrations and can cause irritation to the eyes and respiratory tract. Chronic exposure can result in headache, weakness, shortness of breath, fatigue and confusion.[39]

5. Internal HVAC duct and air handler linings showing signs of deterioration or mold growth should be replaced. The water damaged ceiling tiles should be replaced and the source of the moisture located and repaired. HVAC air supply duct linings should be inspected to determine if other areas are damaged or show signs of biological growth. Access to allow visual inspection of the condensate

pans on AHU #3 should be provided. Inspection and maintenance of these condensate pans to ensure proper drainage should be a routine preventive maintenance items.

6. Consider removing the cork wall lining. Although there is debate regarding the impact of porous surfaces on IAQ, removing this material will eliminate this item as a potential problem.

7. After the office relocations and renovations are completed, the IAQ questionnaire should again be administered to all building occupants to assess the impact of these changes on perceived air quality.

8. Ensure HVAC system setpoints are properly calibrated and routinely tested.

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AUTHORSHIP AND ACKNOWLEDGMENTS

Evaluation Conducted and Report Prepared By:	Max Kiefer, CIH Industrial Hygienist NIOSH Atlanta Regional Office Atlanta, GA
	Stan Salisbury, CIH Regional Program Consultant NIOSH Atlanta Regional Office Atlanta, GA
Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations, and Field Studies NIOSH Cincinnati, Ohio
Laboratory Support	Staff Measurements Research Support Branch, NIOSH Cincinnati, Ohio

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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.

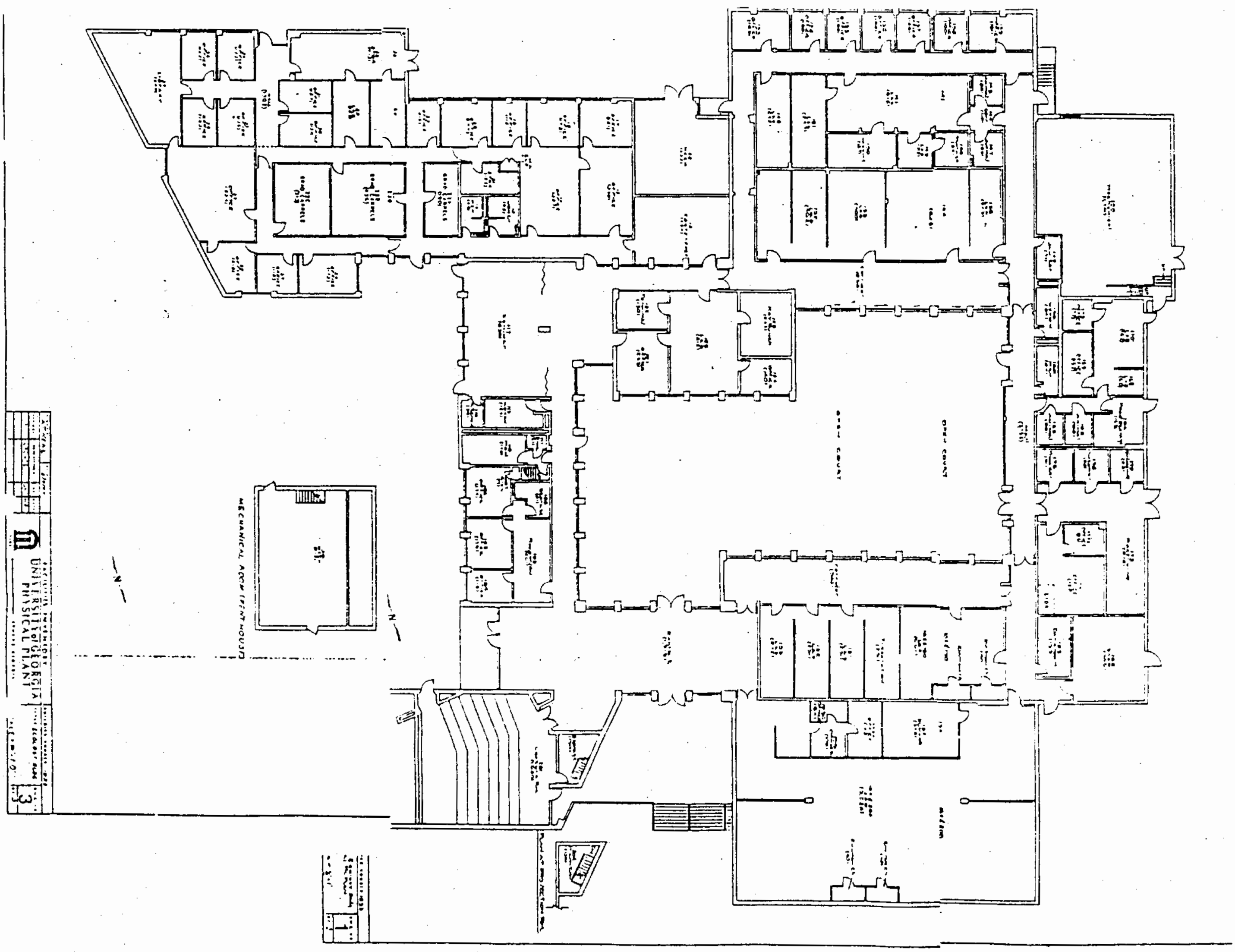
Table 1
University of Georgia Ecology Building
Athens, Georgia
HETA 92-066
January 22, 1992

Metals Analysis: Portable Air Filter - Room 12

Metal	Results (μg/filter)
Aluminum	278
Barium	32.2
Calcium	696
Iron	25.8
Magnesium	9.9
Sodium	152
Strontium	1.1
Titanium	2.7
Zinc	33.6
Silver, Arsenic, Beryllium, Cadmium, Cobalt, Chromium, Copper, Lanthanum, Lithium, Manganese, Molybdenum, Nickel, Phosphorous, Lead, Selenium, Tellurium, Vanadium, Yttrium, Zirconium	<1.0

NOTE:
μg/filter = micrograms of element detected on the filter
< = less than

Figure 1
University of Georgia
Institute of Ecology
HETA 92-066



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1992

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XXIIIrd PAN AMERICAN SANITARY CONFERENCE
September 1990