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I. SUMMARY

On May 17, 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request to conduct a health hazard evaluation (HHE) at the University of South Florida (USF) Administration Building. The university's Department of Environmental Health and Safety initiated the request as a result of employee health concerns regarding indoor air quality (IAQ). Specifically, because previous efforts to identify and resolve the cause(s) of the problems had been unsuccessful, USF requested NIOSH to conduct a complete investigation.

On July 23-26, 1991, NIOSH investigators conducted an evaluation of the USF Administration Building. During the opening conference, NIOSH investigators reviewed historical information regarding IAQ at the facility, and discussed actions taken by USF to resolve the problems. Self-administered questionnaires previously issued to employees were reviewed (193 questionnaires/239 employees), as well as 77 workers compensation claims that were filed associating health problems with IAQ in the building. The building's heating, ventilation and air conditioning (HVAC) system was inspected and the quantity of outside air provided to occupants determined. Environmental measurements were obtained to characterize carbon dioxide (CO_2) levels throughout the building. Additionally, temperature and relative humidity (RH) monitoring was conducted for comparison with comfort charts defined by the American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE). Instantaneous measurements to assess relative levels of volatile organic compounds (VOC) were obtained to identify potential sources of solvent emissions. Integrated air samples were collected to identify and quantitate compounds associated with recent renovation and maintenance projects in the building. The samples were also used to assess the effectiveness of a building treatment project in which low levels of ozone were generated to potentially reduce both microbial and chemical contaminants. A thorough visual inspection of the building was conducted. During the NIOSH investigation, a Florida Department of Labor and Employment Security (DOLES) Industrial Hygienist conducted monitoring for bioaerosols in various areas of the building to compare indoor vs. outdoor bioaerosol levels, and assess the building ozonation project.

The building has one variable air volume (VAV) HVAC system serving all areas. At the time of the inspection, the system was functioning as designed. The system was also clean, appeared well maintained, and provided outside air to occupied areas in quantities exceeding ASHRAE recommendations. Indoor levels of CO_2 ranged from 525 to 725 parts per million (ppm) and outdoor levels ranged from 350 to 425 ppm. No measurements reached or exceeded 1000 ppm (concentrations exceeding 1000 ppm suggests insufficient outside air supply). Temperature and RH levels, in general, were within ASHRAE's comfort guidelines of 73°F to 77°F and 20 to 60% RH. Temperatures throughout the building ranged from 72°F to 80°F. Inside RH levels ranged from 38% to 58%. Instantaneous measurements to assess relative VOC levels (indoor vs. outdoor, area vs. area) did not indicate any sources of solvent emissions.

The majority (76/77) of the IAQ related worker compensation (WC) claims filed originated from the Finance and Accounting Department on the first floor (East Wing). Both the WC claims and the questionnaires indicate that problems experienced by employees coincided with an asbestos abatement project on the second floor (East Wing). The use of a floor tile mastic remover during this project was specifically implicated. Seventy percent (135/193) of the questionnaire respondents indicated a health complaint related to IAQ.

The air samples collected did not identify any volatile compounds at levels that would contribute to the IAQ problems. Although a number of compounds were detected, the concentrations were below the level of quantification. These trace levels of compounds are typical of what is found in many office environments. As the concentrations of contaminants were below quantification limits, both before and after the ozone treatment project, the suggestion that ozone can reduce indoor VOC levels could not be confirmed.

The results of the bioaerosol monitoring indicated that the concentration of microbial aerosols were slightly higher in the areas where the majority of IAQ complaints occurred, when compared with the levels present in the other areas of the building and, in one case, outside levels. As with the other air samples, the impact of the ozone treatment could not be ascertained from the bioaerosol monitoring. The DOLES investigator concluded that elevated levels of bioaerosols were present in the areas where the majority of the IAQ complaints occurred. According to the DOLES investigator, the number of data points were insufficient to allow for statistical analysis.

A visual inspection of the building identified several areas with previously water damaged carpet and ceiling tile, with an associated musty odor. Most of this carpet is in the Finance and Accounting area.

Health symptoms and complaints consistent with those commonly referred to as "sick building syndrome" were experienced by the majority of employees in the USF administration building. Environmental monitoring failed to identify a causative contaminant. All ventilation system parameters measured indicated that the system was supplying sufficient quantities of outside air. The presence of water-damaged carpet and ceiling tile throughout the Finance and Administration office was the most obvious potential source of microbial contamination which could create indoor air quality problems. Recommendations made to address employee complaints include removal of the water damaged carpet, providing maximum amounts of fresh air during building renovation projects and improving housekeeping in office areas.

KEYWORDS: SIC 8221 (Educational Institution), indoor air quality, carbon dioxide, volatile organic compounds, relative humidity, temperature, headache, eye/throat irritation, fatigue, ozone treatment, bioaerosols.

II. INTRODUCTION

NIOSH received a request from the University of South Florida (USF) on May 17, 1991, to investigate numerous health complaints associated with indoor air quality (IAQ) among employees who work in the University's Administration building. The reported health complaints included headache, eye and throat irritation, and fatigue; symptoms commonly associated with poor indoor air quality. Previous University efforts to identify and resolve this issue had been unsuccessful and NIOSH was requested to conduct a complete investigation.

An initial site visit to evaluate the University's Administration building was conducted on July 23-26, 1991. During the survey, NIOSH investigators met with university representatives, inspected the facility heating, ventilation and air conditioning (HVAC) system, and conducted environmental monitoring to assess ventilation effectiveness and air quality. A thorough building inspection was conducted.

An initial response letter describing NIOSH's actions, preliminary findings and recommendations, and future actions was issued to university officials on August 7, 1991.

III. BACKGROUND

The university administration building was constructed in 1959. The building has two floors and comprises about 75,000 square feet. Figures 1A and 1B are schematics of the USF administration building. There are 239 occupants (140 first floor, 99 second floor). The Finance and Accounting department (F/A), where the majority of the complaints originated, is on the east wing of the first floor. There are 119 employees in the F/A department. Other occupants consist of Media Relations and Publications, Admissions, Purchasing, Student Affairs, and university executives (University President, Vice Presidents). The facility is rectangular in shape with an open air atrium and fountain in the center. There are few windows in the building, none of which can be opened. Most of the offices have doors that open outside. Smoking is not allowed inside the building. Some areas (primarily the second floor) have been recently renovated, or are undergoing renovation. Prior to the NIOSH site visit, the university industrial hygienist coordinated the completion of employee questionnaires regarding IAQ in this building.

University Officials provided historical information regarding suspected causes of the IAQ problems, actions taken, and the HVAC system. The following is a summary of 1991 events:

1. Employees had periodically voiced concerns about IAQ in the building in the past.
2. An HVAC system (including ductwork) cleaning and sealing project was completed for the administration building on March 23.

3. USF Physical Plant Engineers began cycling the HVAC system in January, 1991, for energy conservation purposes (system was shut down when the building was empty, e.g., nights, weekends).

4. On March 31, a roof drain collapsed over the east wing of the administration building. Immediate action was taken to seal and contain the area and an asbestos abatement/renovation project was initiated (asbestos is present in the ceiling of many parts of the building). The second floor was the only area affected.
5. The asbestos abatement project was completed on April 18. A floor tile mastic remover was utilized on April 13-14, an encapsulant was used on April 17 (3:30 - 5:30 AM).
6. During the week of April 15, numerous employees, primarily in the F/A offices on the first floor (under the area undergoing renovation) complained about odors associated with the asbestos abatement project. Some employees left work on certain days and/or visited physicians.
7. On April 18, employees in Rooms 105-106 (southeast wing, 1st. floor) were relocated because of their concern with IAQ.
8. In response to approximately 20 workers compensation claims attributing health problems to IAQ (apparently triggered by the renovation project), a risk management insurance investigator visited the site the first week of May.
9. USF Physical Plant Engineers ceased cycling the HVAC system during the second week of May, because of the IAQ concerns.
10. On May 8, a state Department of Labor and Employment Security investigator inspected the facility and reviewed the work practices of the asbestos abatement contractor. The investigator made several recommendations to address the IAQ problems.
11. Throughout May, the USF Industrial Hygienist collected air samples for volatile organic compounds (VOC's), bioaerosols, and fiberglass fibers. The results of the sampling were inconclusive.

A. **Ventilation**

The entire building is serviced by one dual-duct, variable air volume (VAV), HVAC system located on the south west side of the first floor. The system was converted from constant volume to VAV in 1983. As such, the quantity of air provided will vary depending on outside temperature. The maximum HVAC design capacity is 39150 cubic feet per minute (CFM) at 820 revolutions per minute (RPM), when the system is calling for full cooling. There is a minimum stop (20% of maximum) of 7830 CFM (this is the minimum air flow setting). The system is designed to maintain the building under positive pressure at all times. Each supply duct has static pressure sensors located near the farthest point of the duct. An automatic feedback system links the static pressure sensors with the fan speed controller (Eddy Current Clutch System) to maintain 0.9" static pressure (SP) at the end of the duct with the lowest SP. The main air handler will increase, or throttle back, based on duct SP.

Outside air is provided via a large (6' x 6') grille on the west side of the mechanical room. Twenty-five percent of the grille is always fully open, the other 75% will open depending on the outside air temperature.

There is one "hot" deck and one "cold" deck air handler unit. Each air handler supplies four duct branches supporting various quadrants of the building. The hot and cold ductwork is in tandem and air is mixed via Metco VAV control systems at the point of use. These mixing units consist of pneumatic controlled dampers on each hot and cold supply branch leading to the mixed air supply ducts. The dampers are controlled by room thermostats. Insulated flexible ducts distribute the mixed air to the ceiling diffusers. An auxiliary cooling coil was added to the "hot" deck side to increase cooling capacity (when the heating coils are shut off, the normally "hot" deck side can provide additional cool air capacity by activation of this auxiliary cooling coil). Cool air is provided by a traditional cooling coil system using plant chilled water.

Return air is provided through 5 ducted returns (4 on the first floor and one for the entire second floor). The return air is delivered into a common mechanical space, where it mixes with the outside air prior to being circulated through the HVAC system for subsequent delivery to building occupants. There is one fan supporting the system. This fan is upstream of the two air handling units. Supply air is obtained, through filters, from the common mechanical space.

Air filters for the supply air are Tri-Deck® 3 filter systems (coarse, medium, fine) and are reported to be 85% efficient to 2 micrometers (µm). These filters are reportedly changed about every five weeks by the building maintenance staff. The decision to change the filter is based on visual observation. Pressure probes, used to detect differential pressure for determining the need for a filter change, proved unsatisfactory for this application.

The only exhaust ventilation systems in the building are for bathrooms and the snack bar kitchen.

The HVAC system is controlled by a computerized Energy Management System (EMS). The EMS system is used to monitor HVAC performance and define or adjust control setpoints. The current setpoints for the administration building HVAC system are shown in the following table:

PARAMETER	SETPOINT	COMMENT
Hot water valves to hot deck close	OA >65°F	Hot deck heating unit shuts down
Hot deck duct damper closes	OA >65°F	Close to minimum stop setting
Cold ducts maintain 0.9" SP	OA >65°F	Will vary fan speed as necessary
Cold deck Temperature	>50.3°F	Will call for maximum chilled water
Hot duct temperature	OA <65°F	Will increase proportionately
Hot ducts maintain 0.9" SP	OA <65°F	Will vary fan speed as necessary
Outside air damper (economizer)	OA <70°F	Opens fully, no modulation

OA = Outside Air

B. Description of HVAC Cleaning Project

In an attempt to address employee IAQ concerns, a university-wide project to clean HVAC systems was initiated. A description of the process used at the USF Administration Building is as follows:

1) The HVAC system is shut down and the main ducts disconnected. One end of a duct is attached to a large vacuum with high efficiency particulate (HEPA) filtration to achieve an overall negative pressure of approximately 0.8" SP.
2) If the duct is large enough, workers will crawl the system and hand clean with brushes. No solvents are used. On smaller ducts, long handled brushes are utilized. The air handler units and condensation pans are also cleaned.
3) A device termed a "skipper line" is then used to mechanically clean the ducts. This system consists of a small aluminum or plastic ball connected to an air compressor via a long length of tubing. Air is forced into the ball at approximately 200 pounds per square inch (psi). Small holes on the back of the ball (where it connects to the tubing) allow high pressure air to escape. This causes the ball to agitate violently through the duct, dislodging any built-up contamination. The dislodged material is vacuumed out.
4) Latex based paint containing about 5% biocide (Intersept®) is used to seal the duct work and air handler shrouds, frames, and insulation. The material is applied to interior ductwork via a "robot" 360° spray head on wheels that moves down the duct. Alternatively, the duct may be disconnected, removed, sealed, and replaced.

C. Description of Floor Tile Mastic Removal Project and Encapsulant

A renovation project, undertaken to repair a partial roof collapse caused by a damaged or blocked roof drain at the USF administration building, involved abatement of asbestos-containing material, including floor tile and the mastic adhesive. The process used by the abatement contractor to remove the floor tile mastic involved the use of an orange-rind based solvent ("Orange Blossom" from Theochem Laboratories, Tampa, Florida). "Orange Blossom" is a complex terpene ("natural" hydrocarbon) mixture composed primarily of d-limonene, with some surfactant. No petroleum distillates are used in the mixture. D-limonene has a very low odor threshold; the odor has been reported as being detectable in water at 10 parts per billion.[1] No exposure limits (regulatory or recommended) have been established for this material. Inhalation of d-limonene vapor may cause nose or throat irritation.[2]

After removal of the tile, the solvent is applied by pouring approximately 1 gallon/100 square feet out of a container directly onto the mastic. The solvent is allowed to stay in contact with the mastic for 3-10 minutes, depending on the thickness of the mastic. The mastic is then scraped or brushed off the concrete floor. Absorbent material (e.g., clay, saw dust) is applied and the material is bagged. Spot cleaning is conducted and the abated area is then water rinsed with a mop. Segments of 100 square feet are completed before applying solvent to the next section.

During the project at the administration building, releases from the work area were contained using standard asbestos abatement techniques (all supply/return air ducts sealed, entire area enclosed, HEPA filter negative air machines used to maintain 4-8 air changes per hour). The exhaust from the negative air machine discharged outside to the stairwell of the building's south-east corner.

The asbestos contractor used an encapsulant for two hours (3:30 AM to 5:30 AM) on April 17. Encapsulants are used to seal, or "lock down" asbestos containing material, or abated areas, to reduce the potential for asbestos fiber release. The encapsulant used at USF was Guardian® Post Removal Encapsulant, manufactured by Control Resource System Inc. This encapsulant is primarily polyvinyl acetate polymer (similar to water-based household glue), with some acrylic polymer, clay and approximately 0.001% biocide (ICI America Proxel GXL). According to the manufacturer, no urethane or epoxy resin compounds are present in the encapsulant. The Material Safety Data Sheet and product literature indicates that there is very little odor, or vapor generation, associated with the use of this product. The material is applied with a conventional airless sprayer.

D. **Description of Ozonation Project**

In an effort to improve air quality in the administration building, university officials contracted with Worldwide Technology, Inc. (WTI), to treat the building with low levels of ozone. WTI manufactures equipment that utilizes ambient air and electrical current to generate relatively low levels of ozone. The ozone is intended to "decontaminate" the treated environment via oxidation of hydrocarbons and a biocidal action on fungus, bacteria, and viruses. WTI representatives indicated that treatment of this type had proved effective for removing odors from automobiles and residential homes. A large building project had not, however, previously been attempted by WTI. The university agreed to try this technique on the administration building.

Initially, WTI wanted to use high capacity ozone generators (20 ppm ozone) to obtain an equilibrium concentration of approximately 1 ppm throughout the building. Ozone generators would be placed in various areas after the building was vacated, and allowed to operate at night. The units would be shut down and the building cleared prior to allowing occupants to enter.

Because of safety concerns, WTI and university officials agreed to use equipment incapable of generating ozone levels greater than 0.05 ppm at the source. The Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for ozone is 0.1 ppm for an 8-hour, time-weighted average. OSHA has also established a short-term exposure limit of 0.3 ppm averaged over 15 minutes. The American Conference of Governmental Industrial hygienists has recommended a Threshold Limit Value of 0.1 ppm as a ceiling level which should not be exceeded, even instantaneously.

The ozone generators were operated as follows:

LOCATION	GENERATOR MODEL	MAXIMUM OUTPUT
Room 133 (occupied area)	Model P-600	0.025 ppm ozone, 105 CFM
Room 133 (vacant area)	Model P-4	0.05 ppm ozone, 105 CFM
Room 133 (above false ceiling)	Model P-4	0.05 ppm ozone, 105 CFM
Room 147	Model P-600	0.025 ppm ozone, 105 CFM
Room 136	Model P-400	0.025 ppm ozone, 56 CFM

On July 24, 1991, after the building was vacated (5:30 PM), the HVAC system was shut-down and the generators activated. The units were shut off at 6:00 AM on July 25, 1991, and the HVAC system turned on.

IV. EVALUATION PROCEDURES

The NIOSH investigation consisted of the following: (1) a comprehensive review of the facility HVAC system; (2) an assessment of employee questionnaire results and workers compensation claims from the areas of concern; (3) interviews with building employees, plant engineers and managers; (4) a visual inspection of the facility to identify areas that could be considered sources or causes of indoor air problems, and; (5) environmental monitoring to assess parameters associated with IAQ and identify contaminants that may contribute to IAQ problems. The sampling and analytical methodology used during this survey is 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 throughout the building were determined at various intervals. 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%. Readings were compared with simultaneous measurements taken with a Bendix Psychron Model 566 electrically aspirated psychrometer. Temperature and RH as determined via standard dry bulb, wet bulb and psychrometric chart correlated well with levels determined via the Vaisala meter.

C. Ventilation Monitoring

A Kurz model 491 Mini-Anemometer was used to measure air velocity at the outside air intake vent for subsequent determination of outside air volume. This is an electronic meter with a two-scale analog readout. Velocity is measured by the cooling effect of air as it passes over a heated (hot-wire) sensor at the end of the probe. The unit has a range of 0 - 6000 feet per minute (fpm). Relative room pressures were determined for each area with an outside door using an Alnor Jr. Velometer. The outside door was opened about 1 inch and the velometer was placed between the door and the door frame. Needle deflection on the analog meter was used to determine air flow direction, an indicator of relative pressure. The Alnor Jr. Velometer is a mechanical, swinging vane air velocity meter with two range settings (0-200 fpm, 0-800 fpm).

D. Integrated Air Sampling

Thermal Desorption Tubes

Six area air samples were obtained utilizing reusable Carbotrap® 300 multi-bed thermal desorption (TD) tubes as collection media. These tubes are designed to trap a wide range of organic compounds for subsequent qualitative analysis via thermal desorption and gas chromatography/mass spectrometry (GC/MS).

Constant-flow air sampling pumps (Gilian LFS 113) were used to collect the air samples. Flow rates of 20 cubic centimeters per minute (cc/min) and sample times of 100 minutes resulted in total sample volumes of 2 liters of air. The pumps were calibrated with a Gilian Bubble Generator prior to and after collecting the samples and the flow rates averaged. The difference between the pre and post calibration flow rates was less than 5% in all cases. Pre-sampling calibrations for two samples (S-3, S-1) were not obtained due to equipment problems. For these two samples the post-calibration flow rate was used to calculate the total volume.

Bulk samples of the floor tile mastic remover and HVAC duct sealer were obtained and submitted to the NIOSH analytical laboratory to compare compounds detected in the air samples with the composition of these materials.

The sampling strategy consisted of sampling before and after the building ozonation project. Samples were collected in the area where the majority of IAQ complaints originated, as well as on the opposite side of the building. Additionally, a sample was collected outside for use as a control. All samples were analyzed by the NIOSH Analytical Laboratory.

Charcoal Tube Samples

Thirteen integrated air samples were obtained using standard charcoal tubes (100 milligrams front section/50 milligrams backup) as the collection medium. The samples were collected using constant-volume SKC model 223 low-flow sampling pumps. Flow rates of 100 cc/min were used to collect the samples. Sampling times ranged from 3 to 5 hours. Pump calibration was checked prior to sampling using the soap bubble/buret technique. The pumps are equipped with a pump stroke counter and the number of strokes necessary to pull a known volume of air was determined. This information was used to calculate the air per pump stroke "K" factor. The pump stroke count was recorded before and after sampling and the difference used to calculate the total volume of air sampled.

Six of these samples were collected in conjunction with the TD tubes to allow for quantification, if possible, of any compounds detected on the Carbotrap. Seven charcoal tube samples were collected in various other areas of the building and analyzed via GC/MS to identify major compounds. Blanks were submitted with the samples. All samples were analyzed by the NIOSH Analytical Laboratory using NIOSH standard methods.[3]

E. Non-specific VOC Monitoring

Instantaneous measurements to assess relative levels of VOCs were obtained in various indoor and outdoor locations. This monitoring was done with an hnu Systems Model PL 101 analyzer. This portable, non-specific, direct-reading instrument uses the principle of photoionization for detection. The sensor consists of a sealed ultraviolet light source that emits photons which are energetic enough to ionize many compounds. These ions are driven to a collector electrode where the current (proportional to concentration) is measured. A 10.2 electron volt lamp was utilized. This lamp will ionize a wide variety of organic compounds, yet exclude normal constituents of air such as nitrogen, oxygen, carbon dioxide, etc. Measurements were obtained with the instrument set on maximum sensitivity. This sampling was conducted to identify potential sources of solvent emissions or material that may be emitting VOCs.

F. Questionnaires

Self-administered one-page questionnaires that had previously been provided to all USF administration building employees by the university Industrial Hygienist were reviewed. Information requested on the questionnaire included comfort and health concerns such as temperature, noise, dust, "stuffiness"; symptoms experienced, and; work task descriptions.

V. EVALUATION CRITERIA

Although regulatory and recommended occupational exposure standards exist for many chemical and physical agents, standards for indoor air quality in office environments have not been established. Contaminant concentrations detected in office environments are typically, with few exceptions, well below the standards and recommendations published by NIOSH, OSHA and the American Conference of Governmental Industrial Hygienists (ACGIH). The criteria developed by NIOSH, OSHA and ACGIH usually apply to exposure levels to which it is believed most workers may be exposed up to 10 hours per day, 40 hours per week, for a working lifetime, without adverse effect.[(4-6)] Historically, these criteria have been applied to industrial work settings. A small percentage of workers exposed at these concentrations may, however, experience adverse health effects due to individual susceptibility, hypersensitivity (allergy), or a preexisting medical condition.

Often, the symptoms and health complaints reported by office workers do not point to a specific medical diagnosis or causative agent. These symptoms include headaches, eye/skin irritation, sore throat, sinus and other respiratory problems. The building environment is often implicated because worker symptoms reportedly dissipate when they leave the office. It is possible that these symptoms and complaints are attributable to exposure to low concentrations of multiple contaminants, and not any one individual pollutant.

For office environments, NIOSH investigators often utilize recommended building design guidelines established by ASHRAE. These guidelines include ventilation performance criteria and thermal comfort recommendations. These criteria are specified to maintain acceptable indoor air quality for the majority (at least 80%) of the building's occupants.

Substances and parameters evaluated, and the relevant guidelines, are as follows:

A. Carbon Dioxide

Carbon dioxide is a normal constituent of exhaled breath, and, if monitored in indoor air, can often be used as a screening technique regarding the adequacy of outdoor air quantities provided to an occupied building or work area. Typically, ambient outdoor concentrations of CO_2 are about 350 ppm. Concentrations are usually higher inside than outside (even in buildings with few complaints about indoor air quality). In general, if CO_2 levels exceed 1000 ppm (3-4 times the outside level) in areas where the only known source is exhaled breath, inadequate supply or distribution of outside air is suspected. Elevated CO_2 levels suggest that the concentrations of other indoor contaminants also may be increased, which could be responsible for symptoms among building occupants.[7]

B. **Temperature and Relative Humidity**

ASHRAE has developed a "comfort" chart which includes a comfort zone considered to be both comfortable and healthful for the majority (80%) of building occupants. This zone lies between 73° and 77°F, and 30 to 60% relative humidity.[8] 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.

C. **Ventilation**

Office ventilation criteria has not been established by NIOSH or OSHA. Design engineers often use guidelines published by ASHRAE. Current ASHRAE guidelines (62-1989) specify a minimum rate of outside air of 15 CFM/person for general office areas.[9] As with the comfort chart, the target outcome of these outside air supply rates is to maintain an indoor air quality considered acceptable by at least 80% of the building occupants. Building owners are not, unless specified by local building codes, legally required to comply with these ASHRAE standards. Most building codes refer to earlier versions of the ASHRAE standard. Buildings constructed prior to this current standard often used the previous ASHRAE guidelines that call for as little as 5 CFM outside air/person in order to conserve energy.

D. **Bioaerosols**

Bioaerosols are airborne particles, that are living or were released from a living organism.[10] Exposure limits have not been established for bioaerosols. In more than 500 IAQ investigations, only 5% of NIOSHs indoor air investigations involved microbiological contamination.[7] However, in some cases, this type of contamination can cause or contribute to adverse health outcomes. These outcomes include hypersensitivity pneumonitis (a potentially severe disease) or allergic rhinitis, which can be caused by bacteria, fungi, protozoa and other bioaerosols. Note that microbial organisms will be found throughout the environment (including buildings that are not experiencing indoor air quality problems) and their presence should not be construed as proof of the cause of worker health problems. However, obvious signs of bioaerosol reservoirs, amplifiers and disseminators should be corrected to reduce the potential for these sources to create health problems. Potential 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 and other furnishings. Odor can be another indicator of microbial contamination. If the work area smells moldy, fungi are probably present, and their reservoirs should be identified and removed.[10]

Air sampling is generally considered to be a last resort as their is very little criteria available to interpret the data, dose-response relationship information is scant, and the presence of organisms does not prove a causal relationship with complaints.[10] Air sampling can be used, however, to compare bioaerosols in complaint, non-complaint and outdoor environments.

VI. RESULTS AND DISCUSSION

A. HVAC System

A schematic of the USF Administration Building HVAC system is shown in Figure 2. The NIOSH inspection of the HVAC system found no sources of contaminants near the outside air intake vent. The outside air vent was open per system design (25% of the supply grille open, 75% closed). The volume of outside air supplied to the HVAC mechanical space was measured at 3:05 PM on July 24 and found to be 9296 cubic feet per minute (CFM). This number was derived by averaging 15 velocity measurements taken at the face of the outside air intake louvre, utilizing the Kurz mini-anemometer, as follows:

Area of grille = 8.51 square feet (35" X 35")
Corrected area of grille = 8.51 X 0.78 = 6.64, where 0.78 = area correction for a Bar Grille
Average velocity = 1400 feet per minute
CFM = 1400 X 6.64 = 9296

Grille velocities were measured as follows:

Outside air intake velocity in feet per minute		
1800	1600	1800
1600	2000	2000
900	1500	1600
1000	1800	1600
1000	600	200

Based on 239 total building occupants, 9296 CFM equates to approximately 39 CFM of outside air per occupant. This exceeds the ASHRAE recommendation of 20 CFM per occupant. Note that this figure is a "point-in-time" measurement and will vary depending on outside air temperature, system design and occupant controlled thermostats. This figure also represents only the volume of outside air delivered to the common mechanical space, and not the volume delivered to specific occupied areas. Nevertheless, this measurement suggests that sufficient outside air is being provided to the HVAC system.

Carbon dioxide measurements were obtained to determine the CO_2 concentration in the return, supply and outside air sources. These measurements were used to calculate the percent outside air (%OA) being delivered to each HVAC zone. The calculation used was based on the formula developed for determining %OA based on temperature[11]:

$$\%OA = \frac{CO_2r - CO_2s}{CO_2r - CO_2o}$$

Where: CO_2r = concentration (ppm) in the return air
CO_2s = concentration (ppm) in the supply air
CO_2o = concentration (ppm) in the outside air

Using this formula, the percent OA being provided each HVAC zone was as follows:

Percent Outside Air (%OA) Delivered by Area	
Location	**%OA**
First Floor SW (Outside duct)	33
First Floor West, North (Inside duct)	43
First Floor East, (Inside duct)	27
First Floor Southeast (Outside duct)	18
Second Floor	33
First floor (average of all air returns)	32

It should be noted that the percentage of outside air provided to each area, as determined by this calculation, will vary depending on occupant load, system demand and outside temperature. Additionally the CO_2 application of this formula was originally intended for single zone systems[12]. Therefore, this formula must be used with caution and the results interpreted carefully. As the volumes of air delivered to each individual area, and the number of occupants per each area serviced at the time of the measurement were not determined, the percentage of outside air could not be used to calculate a specific quantity. How- ever, the overall percentages (first floor = 32%, second floor = 33%) correlate well with the percentages determined by comparing the measured quantity of outside air to the total CFM delivered by the HVAC system (approximately 33000 CFM). 9296 CFM of outside air equates to about 28%.

The total CFM was determined from the EMS system at 9:30 AM on 7/24/91. The EMS system showed operating conditions as follows:

Outside air temperature = 89.8°F
Cold deck temperature = 51.7°F
Chill water supply = 48°F (flow = 200 gallons per minute)
Chill water return = 54°F
Hot deck temperature = 70.6°F
Return air - second floor temperature = 74.6°F
Return air - fist floor west (inside duct) temperature = 74°F
Fan RPM = 696

As CFM varies directly with RPM, (39150 at 820 CFM), 696 RPM equates to 33230 CFM of total delivered air. Again, this is just a "point-in-time" measurement as this system is designed to change volumes based on outside temperature and the thermostat controls.

A visual inspection of the HVAC system indicated that the condensate collection pans were clean and were properly draining. Standing water, which can serve as a source of microbial contaminants such as fungus or bacteria was not observed. The ductwork also appeared to be clean and free of biological growth.

Pressure checks of each room exiting outside indicated that all second floor rooms were positive with respect to outside. Three rooms on the first floor (105-106, 120C, 185) were negative.

B. Questionnaire Results and Workers Compensation Claims

Prior to NIOSHs site visit, self-administered questionnaires were provided to all administration building employees by the University's industrial hygienist. The questionnaires provided were those contained in the NIOSH Guidance for Indoor Air Quality Investigations.[7] Of the 239 questionnaires issued, 193 (81%) were completed and returned. Of the 193 questionnaires completed, 135 (70%) respondents reported a health complaint commonly associated with poor indoor air quality. Forty-four respondents (23%) indicated concerns from a comfort standpoint only. A summary of the questionnaire results is as follows:

ITEM	# RESPONDING	PERCENT RESPONDING
Employees completing questionnaires	193	81%
Comfort complaints only	44	23%
No complaints	13	7%
Health problems or symptoms	135	70%
Respondents from the first floor	138	99%
Respondents from the second floor	55	56%

Note:

There are 239 employees in the administration building.
There are 99 employees on the second floor.
There are 140 employees on the first floor.

Table 1 contains information regarding the questionnaire results from respondents indicating health problems or symptoms associated with IAQ. The majority (70%) of the health problems were reported by occupants of the first floor. The predominant health problem reported (67%) was headache, followed by burning, irritated eyes (52%) and sore throat (45%). Most responders commented that the problems seemed related to the asbestos abatement project. Additionally, respondents were concerned about the carpet (considered to be a source of contaminants and rarely cleaned), and felt that their work areas were too crowded and cluttered. Many respondents (73%) indicated that the health problems and symptoms occurred daily and 61% indicated that their symptoms were alleviated after leaving the building. Most of these employees (85%) indicated a lack of circulation was the primary complaint about air quality, followed by noticeable odors (65%).

Table 2 shows the questionnaire results from respondents reporting comfort complaints. Most respondents (68%), as did those with health complaints, indicated a lack of circulation as the primary issue regarding the workplace air. Twenty-six (59%) of these employees considered the temperature to be too hot, versus twenty (45%) who were concerned about the temperature being too cold (some respondents were concerned about the temperature being too cold and too hot). Employees commented that the temperature was often inconsistent, and that control improved after USF ceased cycling the HVAC system. Cycling the HVAC system would result in occupants adjusting the thermostat to excess in the morning in an attempt to quickly improve the climate after the system had been shut down all evening. The temperature would then reach these excess levels (either too hot or too cold), and workers would have to adjust the thermostat again.

Of the 78 workers compensation (WC) claims attributed to indoor air quality, 77 were filed by employees in the F/A department located in the North and East quadrants of the first floor. F/A employees account for 50% of the total workers in the building. Most of the WC claims were filed in late April and early May (Figure 3). Many of the claims appear to coincide with the use of an asbestos floor tile mastic remover (April 12, 13) and encapsulant (used for two hours on the morning of April 17). Many WC claims, however, indicated a range of days that the problems began. Additionally, it appears that many filers put the date the claim was filed, not the date and time of the incident.

Many of the claims were filed at the suggestion of a University insurance/risk management investigator who visited the building during the first week of May. The investigator recommended building occupants file claims based on an evaluation of the number of complaints and existing claims (20).

Twenty-one employees visited private physicians in April with health complaints they attributed to indoor air quality. Nine employees visited workers compensation physicians. Irritation of the eyes, headache, sore throat, raspy voice and dizziness were common complaints on the WC claims. Physician diagnoses included allergic rhinitis, bronchitis and sinusitis. Most of the diagnoses indicated that air contaminants at the work place were responsible for the health problems. However, there were no clinical tests or lab results (e.g. positive response to mold allergy tests) on file to support the diagnoses.

C. **Visual Inspection**

A review of the facility carpeting indicated several areas where the carpet had a musty odor and appeared to have been water damaged. Water damaged carpet can serve as a host for, and amplifier of, microbial growth such as mold, fungus, and bacteria. These organisms can create indoor air quality problems from both a nuisance (odor, appearance) and health (allergic reactions such as asthma) standpoint. Areas identified where carpeting showed signs of damage were: first floor, north and east quadrant (room 147-110); Rooms 172 and 274, and; the hallway serving rooms 272-274. Additionally, ceiling tile in rooms 116, 117, and adjacent to the fixture above the occupied area in room 133 had been damaged by excess moisture. Water damaged ceiling tile can also serve as a host for biological growth.

Inspection of the building supply and return vents showed that, in some areas, access to some return air vents could be blocked if doors were left closed (e.g., room 147). Additionally, it was noted that some building occupants kept the outside doors open. This could affect air flows and maintenance of the building's positive pressure.

Storage space is an issue at the administration building. In many areas, boxes of files, paper, and equipment are stored in work areas. In an attempt to address space constraints, some F/A employees had been relocated to another facility.

The facility has not installed any new equipment or furnishings that coincides with the IAQ complaints. The health complaints occurred prior to carpeting or furnishing the renovated areas. According to university representatives, there had been no change in custodial practices, such as the use of new floor or carpet cleaners.

D. **Environmental Monitoring**

Temperature, Relative Humidity and Carbon Dioxide

Tables 3 and 4 depict the temperature, RH and CO_2 monitoring results for the USF administration building on July 24 and July 25, respectively.

Temperature and RH measurements were obtained throughout all areas of the building, at various intervals, on both days. Except for a few outliers, levels were within the parameters of the "comfort" chart as defined by ASHRAE[8]. Temperatures throughout the building ranged from 73° to 79°F on July 24, and 72° to 77°F on July 25. Outside temperatures (taken within the Atrium) ranged from 76°F in the morning to 85°F in the afternoon. The highest temperature measured inside the building was 80°F in room 295 (4:40 PM, July 24 1991). However, a door from this room opening outside was blocked open. This may have had some effect on the measurement.

Relative humidity levels ranged from a low of 38% (room 295, 4:40 PM, July 24 1991) to a high of 58% (room 106, 8:50 AM, July 24 1991) throughout the building. These values also fall within the parameters defined in the ASHRAE "comfort" chart.[8] Outside RH levels ranged from 60% to 83%.

The temperature and RH levels are consistent with the measurements obtained by the USF industrial hygienist (continuous monitoring in Room 140 from May 29 - July 19). The USF measurements indicated temperatures were consistently between 70° and 76°F during the workday, with some short duration excursions to 78°F. Relative humidity levels were between 50% and 58%, with short duration excursions to 60%.

The CO_2 levels ranged from 525 to 725 ppm throughout all areas of the building at various intervals on both days monitored (July 24, July 25). Outside levels ranged from 350 to 425 ppm throughout the day on both days. One reading of 950 ppm was obtained in room 139 at 11:45 AM on July 24. However, this reading may be attributed to the number of people (4) present in the office at the time the sample was collected, as it is not consistent with previous or subsequent samples collected in this room. The levels of CO_2 detected do not indicate a problem with insufficient outside air.

Non-Specific Volatile Organic Carbon Monitoring

Instantaneous measurements to assess relative levels of VOCs were obtained in the following areas: Outside - Atrium; Room 139; Room 133; Room 133 air space above false ceiling, and; the Copy room. Readings were obtained at various times on 7/24 and 7/25. These measurements did not indicate any sources of solvent emissions or material that may be emitting VOCs. All measurements were obtained with the hnu meter at maximum sensitivity (attenuation = 1, 0-20 scale). Relative needle deflection was compared and there were no appreciable differences between outside and inside levels, or the various areas inside the buildings.

Air/Bulk Sampling Results

Qualitative analysis of the Carbotrap® 300 sorbent tubes indicated trace levels of xylenes, limonene, perchloroethylene, trichlorofluoromethane and ethyl hexanol. The substances, however, were present in amounts too small to quantify. Major components found on the samples were 1,1,1-trichloroethane, trichloroethylene, and toluene. Four of the tubes showed similar compounds. Data from the sample collected outside was lost due to excessive moisture on the tube, which interfered with the analysis. One tube showed a different chromatographic peak pattern than the other samples. In addition to the above listed compounds, this sample also contained other hydrocarbons, including aromatic compounds such as trimethyl- and tetramethylbenzenes. This sample was collected in room 139. It was noted at the time of the sampling, however, that there was a noticeable odor present from both perfume worn by occupants and a "potpourri" scent generator in this office. It is possible that the additional compounds detected originated from these sources.

Eight of the charcoal tube samples collected, including two blanks, were analyzed (quantitatively) for trichloroethylene and 1,1,1-

trichloroethane. This decision was based on a GC/MS analysis of one charcoal tube which identified these two components as the major compounds present. The results, depicted in Table 5, indicated that the concentrations of trichloroethylene and 1,1,1-trichloroethane were below the limits of quantitation (30 micrograms/tube) for both compounds during the sampling period.

Overexposure to the substances identified on the air samples could result in irritation of the eyes, respiratory system and skin. Additionally, VOCs are generally considered to be central nervous system depressants. As such, overexposure could result in fatigue, dizziness, headache and confusion. In all cases, however, the levels present were below the limit of quantification and would not be expected to cause adverse health effects in healthy workers.

Analysis of a bulk sample of the mastic remover ("Orange Blossom") used in the asbestos abatement project indicated the primary component to be limonene. Traces of other terpenes ($C_{10}H_{16}$) and terpene derivatives were also detected. Analysis of the latex emulsion used to seal the interior of the ventilation ducts after the duct cleaning project indicated 2-ethyl-1-hexanol as the major extracted component. Small amounts of butanols, ethyl- and butyl acetates, and butyl ether were also present.

Bioaerosol Monitoring Results

Monitoring for airborne microbial contamination was conducted by the DOLES investigator on July 24 and 25, 1991. The samples were collected with an Anderson Single-Stage microbial air sampler. A Sabourand-Dextrose Agar with a growth inhibitor (chloramphenicol) was utilized. Sample duration was 5 minutes with a flow rate of 1 CFM. The results of the samples, reported as colony forming units per cubic meter (CFU/m^3), are depicted in Table 6.

Outdoor concentrations differed widely between day 1 (July 24) and day 2 (July 25). This may have been due to climatic conditions as the samples collected on July 24 were obtained during a rain storm. Aspergillus species and other common organisms were detected. However, no attempt was made to determine the various percentages of each species present. The split samples collected indicated a wide range of concentrations, making data interpretation difficult. The sampling indicates that the overall levels of microorganisms were slightly higher in the areas where the majority of the IAQ complaints occurred, when compared with the levels present in the Air Handler room. However, due to the limited number of samples collected, and the wide range in the data, the results are considered to be hypothesis generating only. Further investigation would be necessary to reach a determination from bioaerosol monitoring alone.

VII. CONCLUSIONS

1. Health symptoms and complaints consistent with those commonly referred to as "sick building syndrome" were experienced by the majority of the employees at the USF administration building. Most of these problems are associated with the Finance and Accounting Department, on the west wing of the first floor. Many of the primary health complaints reported (headache, stuffiness, fatigue) are associated with ventilation deficiencies such as inadequate fresh air. Other reported symptoms (chest tightness, short of breath, cough, fatigue) can be suggestive of microbial induced building-related illnesses such as hypersensitivity pneumonitis.

2. All ventilation system parameters measured indicated that the system was supplying sufficient quantities of conditioned air, including outside air, to the various building offices on the days monitored.

   The CO_2, temperature and RH measurements taken in the various office areas all fell within appropriate indoor air quality guidelines.[8-9] The outside air volume measurements correlated well with the outside air percentage as determined via CO_2 concentrations. That most of the health complaints originated from one area of the building (first floor east) is also suggestive of a cause other than the HVAC system. This is because the entire building is served by one HVAC system with a common air return and outside air supply. It would be expected that, if the HVAC system was the primary culprit, the health complaints would be prevalent throughout the building.

   Note that a variable air volume HVAC system is designed to "throttle back" when outside conditions are optimum. This results in little or no air being delivered to occupied areas, with a subsequent decrease in air exchange.

3. Based on discussions with employees and a review of questionnaires, it is likely that conditions contributing to poor indoor air quality had been present for some time, and were "triggered" by the asbestos abatement project. It is possible that the odor associated with the mastic remover became an obvious identifier for the problems that employees had been experiencing. Although the timing of the encapsulant application suggests a cause-effect relationship, the length of time the material was used, and the components of the encapsulant, are such that this is not considered a likely contributor to the problem.

4. The location of the asbestos abatement negative air machine exhaust (first floor stairwell, southwest corner) could have contributed to the complaints and subsequent relocation of occupants in rooms 105-

106. These rooms were found to be negative in pressure. Odors coming from the negative air machine exhaust (The filter is designed to capture particulate contaminants, not gases or vapors) could have infiltrated into these rooms.

5. The presence of water damaged carpet and ceiling tile, throughout the F/A department is the single most obvious potential source of microbiological contaminants that could create indoor air quality problems. The musty odor detected where this carpet is located also indicates the carpet is a source of contaminants.

6. It is possible that the practice of cycling the HVAC system heightened the awareness of employees already uncomfortable with the air quality in their work environment. The noticeable temperature swings, and possible stagnant conditions created (especially in areas where access to return air vents was hindered), probably served to exacerbate the problems.

7. Air sampling failed to identify any chemical contaminants in concentrations sufficient to explain the adverse health effects noted by many employees. It should be noted, however, that the sampling reflects the concentrations present during the sampling period only. The sampling may not be representative of conditions during the asbestos abatement project (e.g. mastic remover application)

8. The bioaerosol monitoring results indicated relatively higher concentrations of airborne microbes in the area where the majority of the IAQ complaints occurred and where the water-damaged carpet was present. However, although the data is suggestive, the small sample size and wide range of concentrations detected make drawing valid conclusions regarding cause and effect questionable.

VIII. **RECOMMENDATIONS**

1. The water-damaged carpet in the identified locations should be removed as soon as possible. The damaged carpet is the most obvious potential source of biological growth which could cause the types of indoor air quality problems the building has been experiencing.

2. The water-damaged ceiling tile should be replaced as soon as possible to eliminate this as a potential source for biological growth.

3. Ensure return-air paths are not blocked. It may be necessary to install additional louvers over, or in, doors to ensure the path of air is not restricted as it is common practice to close doors at the end of the workday.

4. The building air handling system should be balanced to ensure the building is uniformly positive, as per system design.

5. During periods when outside air conditions are optimum, from a comfort standpoint, the system airflows should be reviewed (e.g. hot duct damper throttled back, etc.) to ensure sufficient air exchange in the occupied areas. Twenty CFM of outside air per building occupant should be utilized as a parameter for ensuring sufficient air exchange.

6. During periods of renovation, provide the maximum amount of outside air, unless the area can be isolated. As the entire building is serviced by the same air handling system, and all return air ducts mix in the mechanical room, any contaminants generated during renovation would be distributed throughout the building.

7. Ensure outside doors are kept closed. Open doors do not provide additional fresh air to the room (the building is positive with respect to outside); however, building pressure maintenance and air flows are adversely affected. Building occupants should be educated regarding the need to keep outside doors closed.

8. Efforts should be made to reduce the amount of clutter (boxes of files, paper, etc.) and improve housekeeping in the work areas. Although the effect of these materials on occupant complaints cannot be quantified, visual stimuli (cleanliness, lighting, etc.) are often associated with a feeling of comfort.

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5. State of Florida Department of Labor and Employment Security, Division of Safety.

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
RESULTS OF SELF ADMINISTERED INDOOR AIR QUALITY QUESTIONNAIRE
UNIVERSITY OF SOUTH FLORIDA: ADMINISTRATION BUILDING
TAMPA, FLORIDA
MAY 1991

RESPONDENTS INDICATING HEALTH PROBLEMS OR SYMPTOMS

ITEM	NUMBER (N=135)	PERCENTAGE
COMPLAINT		
Lack of Air Circulation	115	85
Noticeable Odors	88	65
Temperature Too Hot	80	59
Dust in the Air	79	58
Temperature Too Cold	45	33
Disturbing Noise	31	23
HEALTH PROBLEMS OR SYMPTOMS		
Headache	90	67
Burning, Irritated, Watery Eyes	70	52
Sore Throat	61	45
Stuffy, Runny Nose/Congestion	60	44
Fatigue	30	22
Nausea/Upset Stomach	26	19
Cough	22	16
Dizziness/Lightheaded	21	16
Excessive Sneezing	19	14
Short of Breath/Difficulty Breathing	19	14
Rash/Itchy Skin	13	10
Sinus Infection	11	8
Nose Bleed	5	4
Raspy Throat/Loss of Voice	3	2
Symptoms clear up after work	83	61

TABLE 1 (Continued)
RESULTS OF SELF ADMINISTERED INDOOR AIR QUALITY QUESTIONNAIRE
UNIVERSITY OF SOUTH FLORIDA: ADMINISTRATION BUILDING
TAMPA, FLORIDA
MAY 1991

RESPONDENTS INDICATING HEALTH PROBLEMS OR SYMPTOMS

ITEM	NUMBER (N=135)	PERCENTAGE
FACTORS		
Work on the First Floor	94	70
Work on the Second Floor	35	26
VDT users	75	56
Copy Machine Use > 10% work shift	20	15
Smokers	15	11
Wear Contact Lens	23	17
OCCURRENCE		
Daily/All Day	98	73
No Trend	19	14
Afternoon	10	7
Morning	9	23

NOTES:

1. **Some respondents did not indicate what floor they worked on.**
2. **Common complaints and comments included: Asbestos abatement project created the problem; Carpet is a source of dust and is rarely cleaned; Work areas are crowded and cluttered.**

TABLE 2
RESULTS OF SELF ADMINISTERED INDOOR AIR QUALITY QUESTIONNAIRE
UNIVERSITY OF SOUTH FLORIDA: ADMINISTRATION BUILDING
TAMPA, FLORIDA
MAY 1991

RESPONDENTS INDICATING COMFORT COMPLAINTS ONLY

ITEM	NUMBER (N=44)	PERCENTAGE
COMPLAINT		
Temperature too Cold	20	45
Temperature too Hot	26	59
Lack of Air Circulation	30	68
Noticeable Odor	9	20
Dust in the Air	10	23
Disturbing Noise	5	11
TIME OF COMPLAINT/SYMPTOM		
All Day/Daily	24	55
No Trend	13	30
Afternoon	4	9
Morning	4	9
FACTORS		
Smokers	8	18
Contact Wearers	11	25
VDT Users	26	59
Copy Machine Use > 10% work shift	7	16
Work on First Floor	16	36
Work on Second Floor	20	45

NOTES:

1. **The building is designated no-smoking**
2. **Significant comments included: inconsistent temperatures; dissipation of odors after asbestos removal; improved temperature control after cessation of HVAC cycling.**

TABLE 3
RESULTS OF CARBON DIOXIDE (CO_2), RELATIVE HUMIDITY (RH%) AND TEMPERATURE (°F) MEASUREMENTS
UNIVERSITY OF SOUTH FLORIDA: ADMINISTRATION BUILDING
TAMPA, FLORIDA
MAY 24, 1991

LOCATION	TIME	%RH	°F[1]	CO_2[2](ppm)
Outside (Atrium)	0817	83	81	425
	1533	75	80	375
Room 106	0850	58	74	525
Room 139	0853	47	76	650
	1145	43	78	950
	1543	44	78	700
Room 133	1151	48	78	750
Vacant area	1539	50	79	625
Room 133 (occupied)	1155	58	73	675
Room 136	1559	54	75	525
Room 181	1620	48	77	725
Adjacent Room 189	1621	49	75	725
Room 172	1623	48	76	725
Room 181D	1627	42	79	775
Room 295	1642	38	80	775
Copy Room	1634	42	79	525

1) °F = Temperature in degrees Fahrenheit
2) ppm = parts of gas or vapor per million parts air

NOTE:

Supply air diffusers were checked for instantaneous CO_2 levels in rooms 133, 139 and 145. CO_2 concentrations ranged from 525 to 550 ppm.

TABLE 4
RESULTS OF CARBON DIOXIDE (CO_2), RELATIVE HUMIDITY (RH%) AND TEMPERATURE (°F) MEASUREMENTS
UNIVERSITY OF SOUTH FLORIDA: ADMINISTRATION BUILDING
TAMPA, FLORIDA
MAY 25, 1991

LOCATION	TIME	%RH	°F[1]	CO_2[2] (ppm)
Outside - Atrium	0840	84	77	425
	1124	60	77	350
	1440	67	85	350
	1622	67	83	350
Room 133 Vacant area	0848	56	73	575
	1138	57	73	575
	1455	52	75	575
	1624	52	75	575
Room 133-134 Accounting/Finance	0850	53	73	675
	1145	52	73	725
	1500	49	75	675
	1628	52	75	575
Room 139	0852	50	73	550
	1132	49	73	625
	1502	52	72	575
	1631	50	73	650
Room 176	0856	52	73	650
	1150	48	75	725
	1539	49	75	675
	1649	49	75	625
Outside Room 262	0901	52	74	625
	1154	50	74	625
	1515	52	74	625
	1640	49	76	675
Hallway Rm 220-221	0909	51	75	600
	1200	48	76	650
	1510	48	77	650
	1636	49	76	675

TABLE 4 (Continued)
RESULTS OF CARBON DIOXIDE (CO_2), RELATIVE HUMIDITY (RH%)
AND TEMPERATURE (°F) MEASUREMENTS
UNIVERSITY OF SOUTH FLORIDA: ADMINISTRATION BUILDING
TAMPA, FLORIDA
MAY 25, 1991

LOCATION	TIME	%RH	°F[1]	CO_2[2] (ppm)
Room 186-187 Hallway	1152	51	75	650
	1530	51	75	650
	1646	50	76	700

1) °F = Temperature in degrees Fahrenheit
2) ppm = parts of gas or vapor per million parts air

TABLE 5
RESULTS OF AREA AIR MONITORING
UNIVERSITY OF SOUTH FLORIDA: ADMINISTRATION BUILDING
TAMPA, FLORIDA
MAY 25 - 26, 1991

Sample Number	Sample Location	Sample Date & Time (min)	Sample Volume (Liters of air)	Concentration (ppm)
C2	Room 133 - above the false ceiling In the vacated area	7/24 14:15 - 17:07 (172)	17.93	TCA = < 0.01 TCE = < 0.01
C4	Open office area adjacent Room 186	7/24 14:33 - 17:17 (164)	16.5	TCA = < 0.1 TCE = < 0.1
C9	Open office area adjacent Room 186	7/25 13:27 - 16:59 (212)	21.64	TCA = < 0.09 TCE = < 0.09
C11	Room 133 - above the false ceiling in the vacated area	7/25 13:12 - 17:04 (232)	25.56	TCA = < 0.07 TCE = < 0.07
C10	Room 136 - Above the administrators work desk.	7/25 13:15 - 17:01 (226)	23.13	TCA = < 0.08 TCE = < 0.08
C13	Room 133 - vacant area adjacent occupied area. Under diffuser	7/25 13:11 - 17:03 (232)	23.85	TCA = < 0.08 TCE = < 0.08

1) ppm = parts of gas or vapor per million parts of air
2) TCA = 1,1,1-trichloroethane
TCE = trichloroethylene

The NIOSH recommended exposure limit for 1,1,1-trichloroethane is 350 ppm for up to 10 hours/day, 40-hour work week

The NIOSH recommended exposure limit for trichloroethylene is 25 ppm for up to 10 hours/day, 40-hour work week. Trichloroethylene is considered by NIOSH to be a potential occupational carcinogen.

TABLE 6
BIOAEROSOL MONITORING RESULTS
UNIVERSITY OF SOUTH FLORIDA: ADMINISTRATION BUILDING
TAMPA, FLORIDA
MAY 25 - 26, 1991

SAMPLING LOCATION	CONCENTRATION (CFU/M^3) 7/24/91	CONCENTRATION (CFU/M^3) 7/25/91
Outside Building	509	92
Building HVAC Mechanical Room	Sample 1: 381 Sample 2: 367	Sample 1: 42 Sample 2: 100
Room 133	Sample 1: 500 Sample 2: 21	Sample 1: 134 Sample 2: 50
Room 139	Sample 1: 400 Sample 2: 403	Not Available, samples lost during analysis
Second Floor	Sample 1: 184 Sample 2: 35	Sample 1: 100 Sample 2: 49

1) CFU/M^3 = Colony Forming Units of microorganisms per cubic meter of air
2) Sample time = 5 minutes
3) Sample 1 and Sample 2 indicate concurrent samples collected in the same location

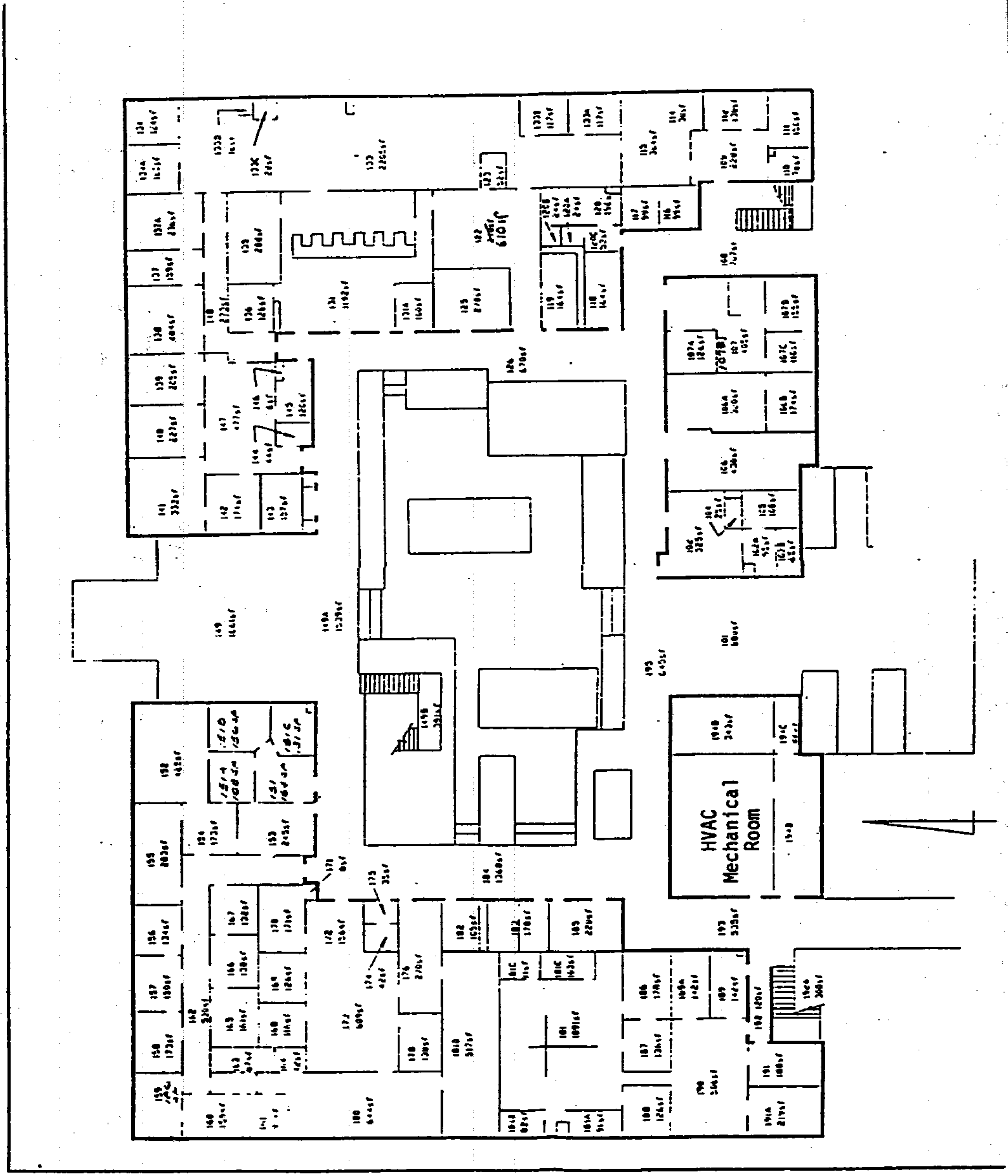
Microorganisms identified on samples

Aspergillus sp.
Penicilium sp.
Fusarium sp.
Paeciliomyces sp.
Cladosporium sp.
Alterneria sp.

ADM 1

Figure 1

HETA 91-238

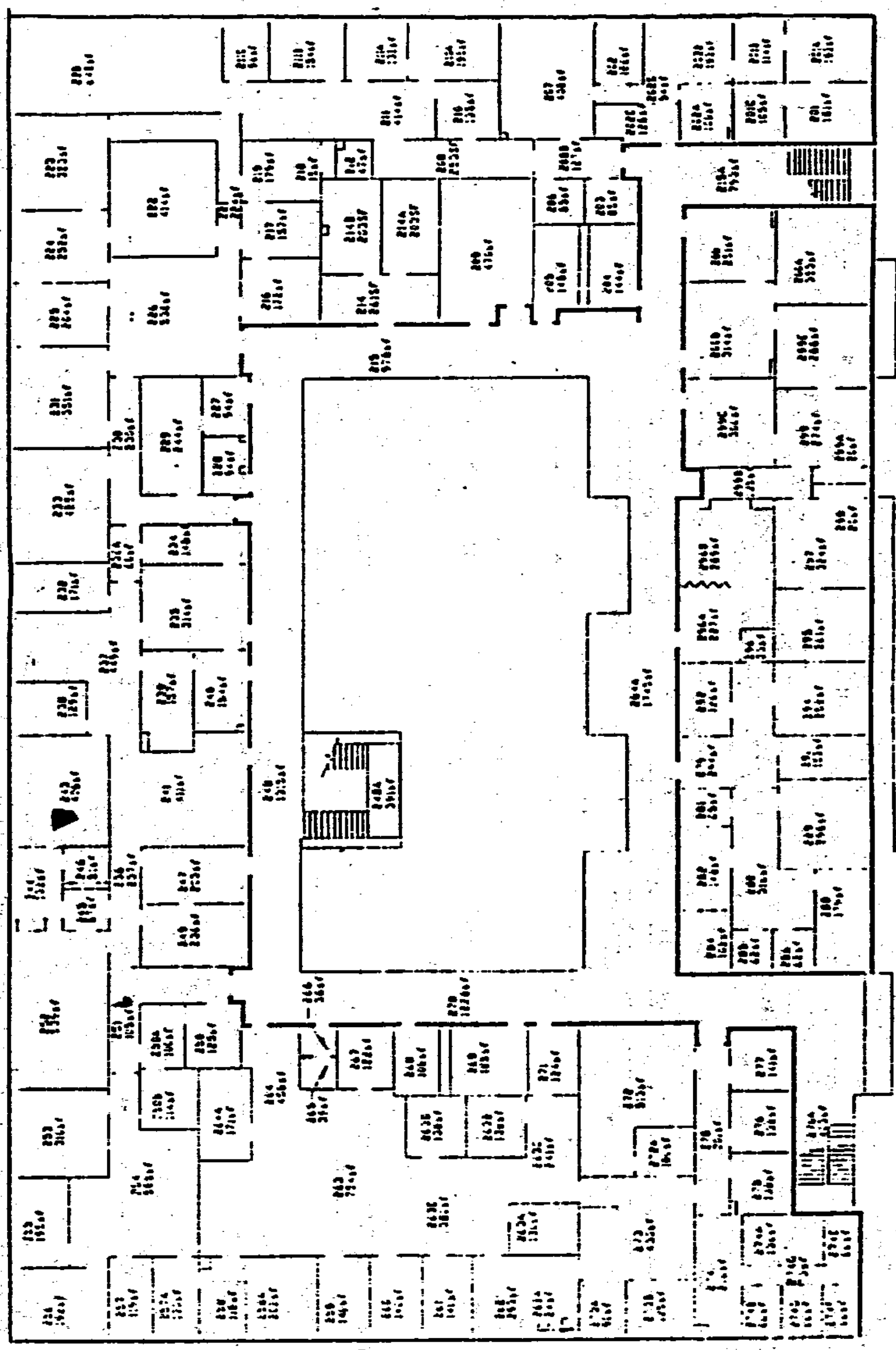


University of South Florida
Administration Building

First Floor

ADM 2

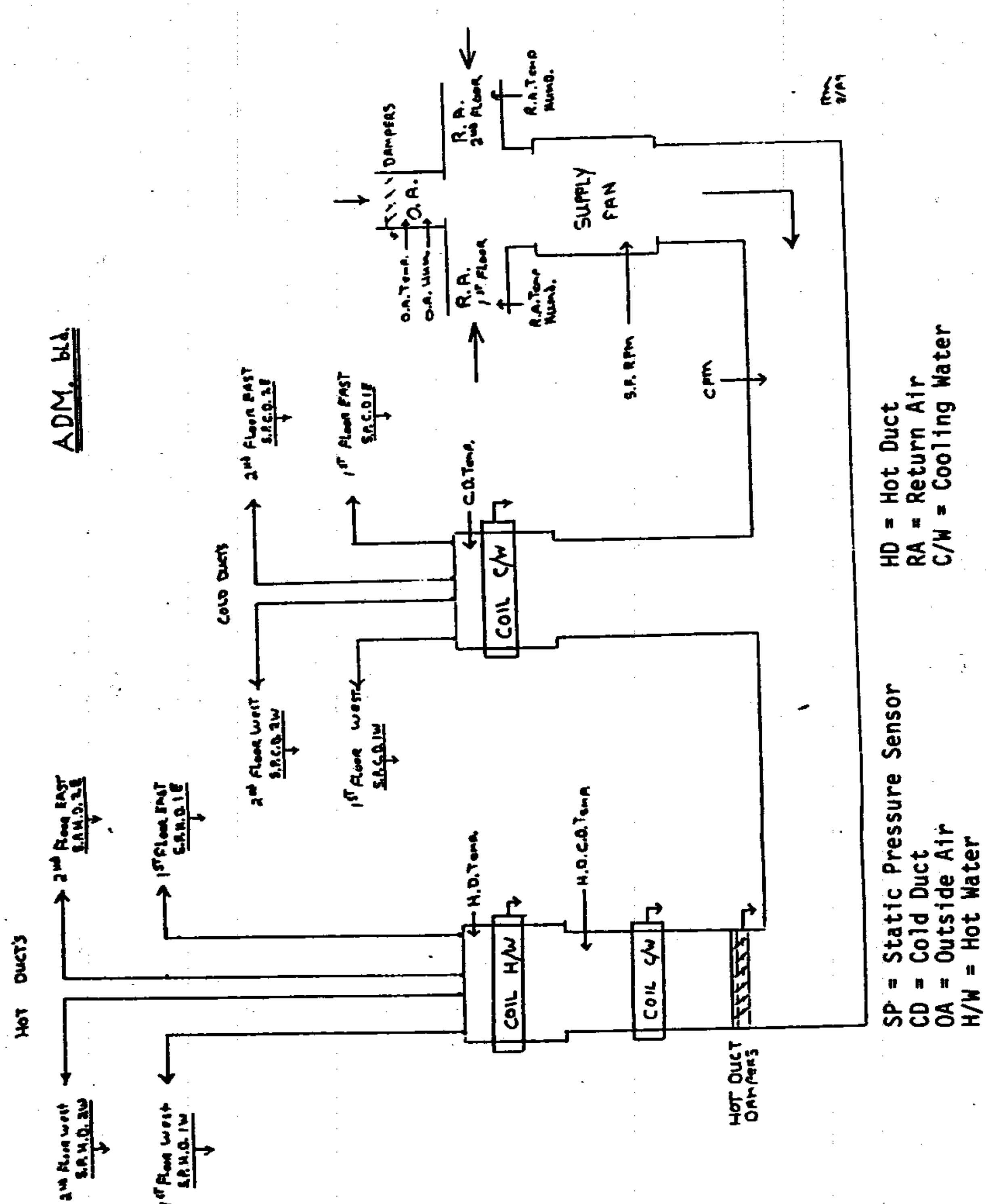
Figure 1A



University of South Florida

Administration Building

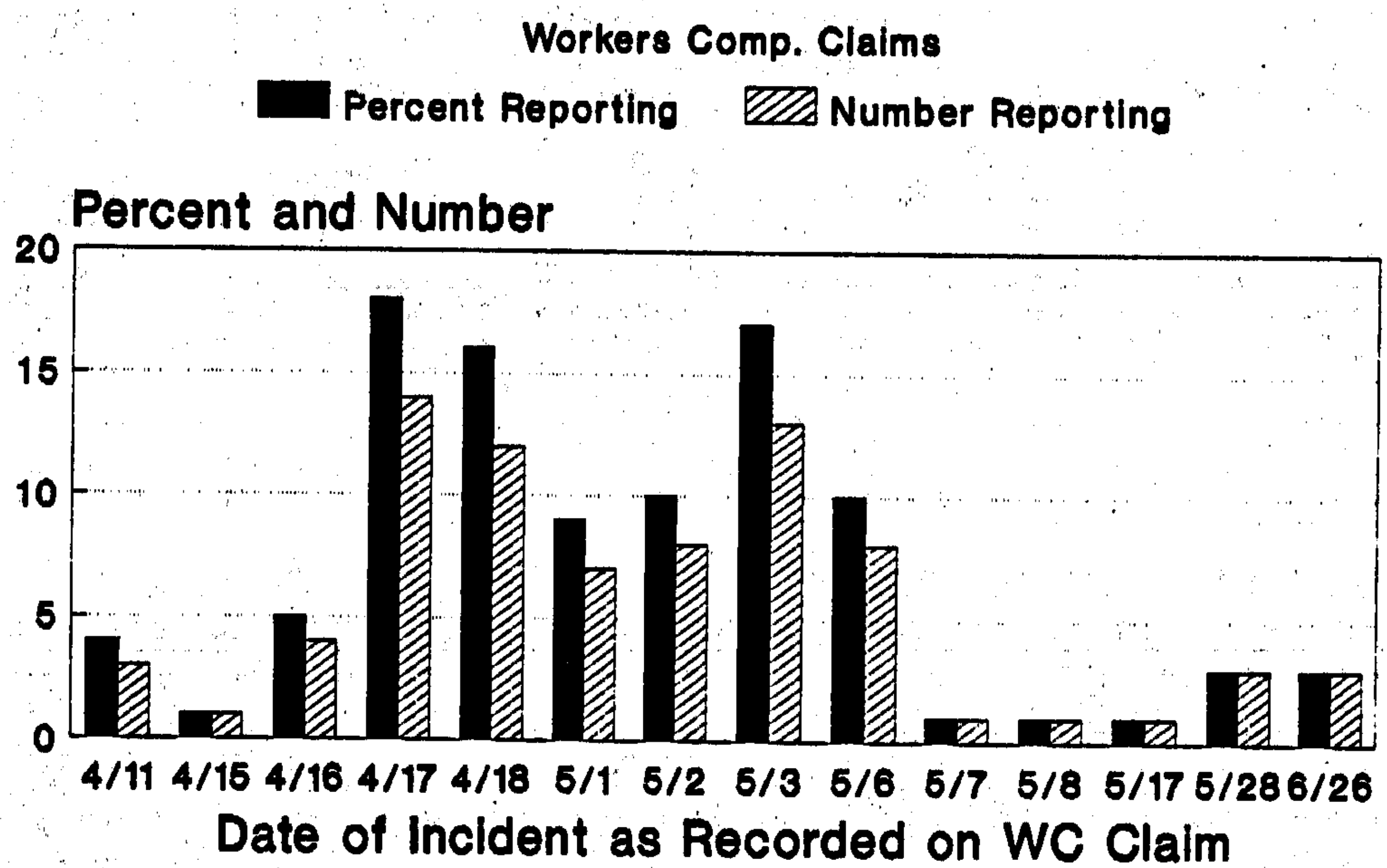
Second Floor



University of South Florida
Administration Building

Schematic of HVAC System

FIGURE 3
UNIVERSITY OF SOUTH FLORIDA: TAMPA, FL



Represents claims attributed to indoor air in May/April, 1991. The first day of the reported incident was used.

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