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NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2002-0306-2911
Warren Tech
Lakewood, CO

August 2003

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

PREFACE

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

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Eric J. Esswein, MSPH, CIH, CIAQP of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Charles S. McCammon, PhD, CIH of Tri County Health Department, John Martyny, PhD, CIH and Shawn Arbuckle, MS of National Jewish Hospital, Denver CO.. Analytical support was provided by Data Chem Laboratories, Salt Lake City, Utah and Ardith Grote, NIOSH, Division of Applied Research and Technology, Cincinnati, Ohio.. Desktop publishing was performed by Suzanne Eugster, NIOSH, Denver Field Office.. Review and preparation for printing were performed by Penny Arthur.

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Highlights of the NIOSH Health Hazard Evaluation

Evaluation of Respiratory Problems Among Employees at the Warren Tech Vocational/Technical School Lakewood, Colorado

NIOSH received a management request from the Director of Environmental Services at Jefferson County Schools (hereafter JEFFCO) to investigate indoor environmental quality in Building A of Warren Tech, a vocational/technical school in Lakewood, Colorado. The request asked NIOSH to determine whether indoor health complaints from staff working in Building A were related to chemical compounds generated and released from products used in programs taught in Building A of Warren Tech.

What NIOSH Did

- We conducted a survey of the building and inspected air handling units in Building A.
- We used tracer gas to evaluate air movement out of the print shop and the cosmetology areas.
- We collected air samples for volatile organic compounds, acids, and methacrylates.
- We talked to employees who worked in Building A (and other buildings) that reported health symptoms believed to be related to building occupancy..

What NIOSH Found

- Chemicals used in the print shop can be widely distributed throughout the first floor by the single ventilation system (AHU #7) that serves that floor of the building.
- The exhaust fan installed in the nail tech room does not keep this under negative pressure and chemicals used in this area can escape to the main cosmetology area and the main administration area.
- Air exhausted from the permanent wave room may be entering the outside air intake for the Dental lab.
- Employee health complaints may be due to inhalation exposures of low level concentrations of mixed volatile organic compounds (VOCs) from the print shop on the first floor, and the nail technology and cosmetology program on the second floor.

What the Warren Tech Managers Can Do

- Install a dedicated ventilation system for the print shop so that solvent vapors used in the area are not recirculated to other parts of the Building A.
- Assure that the nail technology room is maintained under negative pressure.
- Insure that the room exhaust from the permanent wave room is not entrained into the outside air intake for the Dental lab or any other building air intakes.

What the Warren Tech Employees Can Do

- Always keep the lid on the parts washer closed when you are not using it.
- Keep lids and caps on containers of chemical products to prevent evaporation. Use the minimum amounts of chemicals necessary to do the job.

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #2002-0306-2911

Health Hazard Evaluation Report 2002-0306-2911
Warren Tech
Lakewood, CO
August 2003

Eric J. Esswein, MSPH, CIH, CIAQP

SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation (HHE) at Warren Tech, a vocational/technical school located in Lakewood, Colorado. NIOSH was asked to investigate whether employee health complaints of headache, upper respiratory irritation, asthma, eye irritation, nausea, and dizziness were related to volatile organic compounds (VOCs) released from products used in vocational and technical programs that are taught in Building A of Warren Tech. According to management and employees, building-related health complaints first began in Building A in spring of 1999 when the building underwent construction and renovation. An opening conference and a building walkthrough survey was conducted on September 10, 2002. The building's air handling units were inspected and a tracer gas study was conducted to determine if VOCs from two suspected source areas (the print shop and cosmetology area) could be distributed to other areas of the building. Interviews were conducted with employees working in Building A, McLain High School and the Longview Temporary building. Air samples were collected for VOCs, acids, and methacrylates. Air sampling results (collected in 2002 and 2003) demonstrate that VOCs from printing operations are widely distributed throughout the first floor of the building by the ventilation system and to a lesser extent, to other areas on the second floor. Tracer gas and chemical smoke tests show that ceiling-mounted extraction fans installed in two areas of the cosmetology program either failed to maintain negative pressurization (as intended), or resulted in exhaust entrainment to other areas of the building.

Employee complaints of upper respiratory irritation, headaches, eye irritation, nausea, dizziness, and exacerbation of asthma at Warren Tech, Building A, may be related to inhalation exposures of low level concentrations of various VOCs emitted from two sources: the print shop on the first floor, and the nail technology and cosmetology program on the second floor. Recommendations are included in this report to change the ventilation systems to control the distribution of VOCs in the indoor environment of Building A.

Keywords: 8249 Trade Schools, not classified elsewhere

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INTRODUCTION

In June 2002, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the Director of Environmental Services, Jefferson County Public Schools (JEFFCO) in Lakewood, Colorado. NIOSH was requested to investigate Building A of Warren Tech to determine if employee health complaints including headache, upper respiratory irritation, asthma, eye irritation, nausea and dizziness were related to exposures in Building A. NIOSH sent an interim letter to the requester in February 2003 that contained results and recommendations of the NIOSH investigation.

BACKGROUND

Warren Tech is a vocational technical school that is part of JEFFCO Public Schools. Students attending Warren Tech receive training and education in three buildings on the campus (A, B, and C). Warren Tech offers 21 career/vocational programs. Approximately 60 employees work in Building A, including administrators, teachers, technicians, secretaries, custodians, and other staff. The following vocational programs are taught in Building A: business services/technology, computer technology, cosmetology, culinary arts, dental assisting,, drafting, graphic communications, graphic design/computer art, library/media services, hospitality, travel and tourism, multimedia communication, and nail technology. Building A is a two story, southwest-facing masonry building that is built into an excavated hillside on the school campus. Buildings B and C are adjacent to Building A, but are physically separated. McClain High School, also part of JEFFCO Public Schools, is located directly west of Building A. The building underwent extensive interior and exterior renovation from spring 1999 through autumn 2000. Prior to spring 1999, employee complaints of poor indoor environmental quality (IEQ) were not reported in Building A. Complaints of poor IEQ began after construction and renovation started, which included floor space additions and interior reconfiguration of existing spaces. The requester reported to NIOSH that during the process of construction and renovation, adequate containment such as dust barriers and negative pressure ventilation was not maintained. Staff who worked in Building A during the time of construction and renovation also reported to NIOSH that construction dust and odors were present and that dust barriers or ventilation controls were not effective. It is unclear why staff complaints of poor IEQ persisted after construction and renovation activities ended. One programmatic change that occurred after building renovation was completed was that the cosmetology program was changed from a night program (4-9 p.m.) to a day program. Some staff at Warren Tech reported to NIOSH they believed that dusts and chemical odors from construction products and building finishes caused people to become sensitized, and that the various chemicals that are currently used in the building are related to the current and ongoing IEQ complaints.

Previous IEQ Evaluation

Previous environmental investigations have been conducted in Building A because of employee complaints of poor IEQ. Investigations were conducted by an engineering firm hired by JEFFCO Public Schools in 2000 and 2001. In February 2000, a consultant investigated various aspects of building IEQ, including daily indoor carbon dioxide (CO_2) concentrations, temperature and relative humidity measurements, and limited air sampling for volatile organic compounds (VOCs) and carbon monoxide. The results indicated that adequate dilution ventilation was being supplied to the building. Indoor temperatures were reported across a wide range (suggesting poor temperature control in the building), and relative humidity was reported to be low (in a range of 10-20%).

Three air samples were collected and the only chemical that was detected was methylene chloride. In 2001, a ventilation test and balance was conducted. The results suggested that for the most part, the HVAC systems provided ventilation to building design specifications. The investigations did not report a specific IEQ problem that could be shown to be associated with the health complaints reported by Warren Tech employees. A number of recommendations were provided in the reports, including: provide local exhaust to the print shop; use appropriate barriers to prevent migration of construction-related contaminants from entering occupied areas of the building; and continue communications with employees, district management and the facilities design team.

Ventilation Systems

Heating, ventilating, and air conditioning (HVAC) is provided to the two floors of Building A by seven constant air volume systems. A single HVAC system (AHU #7) serves the first floor areas, which include the following: business services/technology; computer technology; culinary arts; graphic communications; graphic design/computer art; drafting, multimedia communication; and other areas. Six smaller HVAC units serve the programs on the upper level of the building: cosmetology and nail technology; dental assisting; library; the main office; student services; and other areas. Outside air is supplied to each of the air handling units from air intakes located on the north and west sides of the building and from roof- mounted louvers for the six systems that serve the second floor of the building.

Dedicated, ceiling-mounted exhaust fans are installed in the print shop, the nail technology room (236H), and in the permanent wave room, (240A). The fans in rooms 236H and 240A were replaced shortly after the NIOSH investigation began, apparently because a previously conducted test and balance study determined that these fans did not "achieve desired airflow."

METHODS

On September 10, 2002, NIOSH held an opening conference and conducted a building walkthrough. Later that month, and in October 2002, inspections of the ventilation systems were conducted and blueprints of the building's HVAC systems were reviewed with the requester and a building commissioning engineer for JEFFCO Schools. Background information on IEQ at Warren Tech and material safety data sheets (MSDSs) that were provided to NIOSH by the requester were also reviewed. In November 2002, NIOSH interviewed employees who reported experiencing building-related health complaints. A tracer gas study was conducted in December 2002. Air samples were collected on a series of dates in October, November, December 2002, and in January and February 2003.

Employee Interviews

Fifteen employees that reported health symptoms that they believed were related to working in Building A were interviewed. The principal at Warren Tech provided NIOSH with a list of 15 employees who reported experiencing health symptoms while working in Building A. Four of the fifteen had previously worked in Building A but were relocated to offices or areas in the McClain Community School and the Longview Temporary Building due to their health symptoms. These employees reported that they no longer experienced building-related health symptoms since they had been relocated.

Air Sampling

Sample Locations

In October, November, and December 2002, and in January and February 2003, air samples were collected using thermal desorption tubes to screen for the presence of a wide variety of airborne VOCs in Building A, the Longview Temporary Building and the McClain High School. On October 1, 2002, air samples were collected on the first floor in the return air plenum of AHU #7, inside the print shop, and in room 123 which is across the hall from the print shop. One offset printing press was being used in the print shop at the time the samples were collected and the cosmetology program was in session. On November 26, 2002, thermal desorption tubes were used to collect twelve air samples on the upper and lower levels of the building when neither the print shop nor the nail technology program was training students. Sample locations included: the print shop, hallway outside room 119, and rooms 113 and 140 on the lower level, and library, dental, room 200B, the main office area, and cosmetology on the upper level. On January 16 and 22, and on February 6 2003, air samples were collected for qualitative and quantitative assessment of VOCs. Quantitative sampling was also done for the presence of acids and ethyl and methyl methacrylates.

Air samples were also collected in room 120F of the McClain High School, and at the teacher's desk in the Longview Temporary building. These samples were collected for comparisons with samples collected in Bldg A because neither Longview nor the McClain building had known or suspected sources of indoor air pollutants, which is the reason why staff who complained of health symptoms in Building A were moved to these locations.

Air samples were also collected in outdoor air (on the west side of Building A near the outdoor air intake) to compare with samples collected indoors.

Air Sampling Methods

To sample for a wide range of VOCs, qualitative sampling was conducted with SKC® Pocket Pumps® and Supleco® stainless steel thermal desorption (TD) tubes containing three beds of sorbent material (Carbopack Y, Carbopack B, and Carboxen 1003). Sampling pumps were connected to sample media using Tygon® tubing. The samples were analyzed by the NIOSH Division of Applied Research and Technology according to the NIOSH Manual of Analytical Methods (NMAM), Method 2549 (Volatile Organic Compounds, Screening).

Air samples for methacrylates were collected using XAD-7 solid sorbent tubes connected to SKC® pocket pumps with Tygon® tubing. The sampling trains were calibrated prior to sampling to a flow rate of 100 cubic centimeters per minute. Samples for methacrylates were analyzed according to the NMAM, Method 2537 (Methyl Methacrylate).

Inorganic acids (including hydrofluoric, hydrochloric, hydrobromic, nitric, phosphoric, and sulfuric) were sampled using ORBO 53 solid sorbent tubes connected in-line with Tygon® tubing to Gilian® personal sampling pumps. The sampling trains were calibrated to a flow rate of 100 cc/minute. Samples were analyzed by ion chromatography according to NMAM Method 7903 (Inorganic Acids).

Sampling for specific VOCs (perchloethylene, tri-methyl benzenes and total hydrocarbons, as decane) was

conducted using coconut shell activated carbon solid sorbent tubes connected in-line using Tygon® tubing to Gilian® personal sampling pumps. The sampling trains were calibrated to a flow rates of 50 and 100 cc/minute. Samples were analyzed by gas chromatography (GC) according to NMAM Method 7903 (Hydrocarbons) with modifications.

Tracer Gas Ventilation Assessment

On December 18, 2002, a sulfur hexafluoride (SF_6) tracer gas evaluation was conducted in Building A by NIOSH with assistance from the Tri-County Health Department and National Jewish Hospital in Denver, Colorado.

Sulfur hexafluoride is a colorless, odorless gas that is used as a tracer because it is chemically and toxicologically inert.[1,2] Target concentrations of this gas are typically in the range of 1 to 1000 parts per trillion (ppt), well below the Occupational Safety and Health Administration (OSHA), NIOSH and American Conference of Governmental Industrial Hygienists (ACGIH) time-weighted average exposure limits for SF_6 of 1000 parts per million (ppm.)[3,4,5] Before the tracer gas was released, air samples were collected on the lower and upper levels of the building and also in outside air to evaluate for background concentrations. After the gas was released, samples were collected on both levels of the building. The intent of the study was to assess the migration of the tracer gas to various locations in the building as a surrogate for the distribution of chemical contaminants from suspected source generation areas.

Pure SF_6 was released in three locations (two in cosmetology and one in the print shop) at three different times. Air samples for tracer gas were collected on both levels of the building, including Room 200B, Dental, Library, Rooms 113, 124, and 142, the main administration area, the hallway outside the cosmetology program and the top of the stairs near the main office area. The locations where the tracer gas samples were collected included areas of the building where IEQ complaints were most commonly reported.

Tracer gas was released first on the upper level of the building at 10:30 a.m. in the nail tech room and then at 11:25 a.m. in the permanent wave room. In the afternoon, tracer gas was released in the print shop at 1:20 p.m. Air samples were collected using new 30 cc medical syringes. The syringes was first purged, then the sample was collected by withdrawing the plunger to the 30 cc mark. After the sample was collected, the tip of the syringe was sealed and the sample was brought to the staging area for on-site analysis. Tracer gas was analyzed using an Autotrac Tracer Gas Monitor, Model 101 (Lagus Applied Technologies, San Diego, CA.) The GC was calibrated prior to the investigation at a concentration of 4 parts per billion (ppb), and in a range of 20 ppt to 100 ppb.

To visualize pressurization in various location in the building, chemical smoke tubes were used to produce smoke traces at doorways, and in corridors stairs and hallways. The movement of the smoke was used as a visual tool to understand pressurization in the area being evaluated.

EVALUATION CRITERIA

Indoor Environmental Quality

Environmental Evaluations

Environmental deficiencies observed in the indoor environment have been associated with inadequate ventilation systems, overcrowding, microbiological contamination, outside air pollutants, odors, dust or particulate exposures, or low level chemical exposures from office furnishings, office machines, tobacco smoke, cleaning products, personal hygiene products, and structural components of the building and its contents. Problems related to comfort issues, reduced job satisfaction, and stress are commonly present where IEQ complaints are raised. Comfort problems may be due to improper temperature and relative humidity (RH) conditions, poor lighting, unacceptable noise levels, unfamiliar odors, or adverse ergonomic conditions. Reduced job satisfaction and stress occurring among workers in buildings with IEQ concerns may be related to personnel organizational factors, conflict among personnel, or lack of job security. Poor communication between employees and supervisors is a particularly common finding in workplaces NIOSH has evaluated for IEQ concerns.[6,7,8]

A NIOSH study of 104 buildings where IEQ problems were reported found one or more deficiencies in the operation, design, or maintenance of heating, ventilating, and air-conditioning (HVAC) systems in 93 of the buildings.[9] The same study found symptoms associated with one or more HVAC deficiencies, as well as with poor housekeeping, job conflict, being female, and being over 40 years of age.[10] A literature review in the early 1990s found consistent associations between symptoms and air-conditioning, carpets, crowding, use of video display terminals, introduction of outside air at rates below 10 liters per second per person (ls^{-1}/person), job stress/dissatisfaction, being female, and having allergies or asthma.[11]

Standards specific to the non-industrial indoor environment do not exist. Measurement of indoor environmental contaminants has rarely proved helpful in determining the cause of symptoms except where there are unusual sources, or a proven relationship between specific exposures and disease. With few exceptions, concentrations of frequently measured chemical substances in the indoor work environment fall well below the published occupational standards or recommended exposure limits set by OSHA, NIOSH, and ACGIH. The American National Standards Institute (ANSI)/American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published recommended building ventilation and thermal comfort guidelines.[12,13] The ACGIH has also developed a manual of guidelines for approaching investigations of building-related symptoms that might be caused by airborne living organisms or their effluents.[14] Other resources that provide guidance for establishing acceptable IEQ are available through the Environmental Protection Agency (EPA) at their website; www.epa.gov/iaq. This website includes the joint NIOSH/EP, and a document entitled, Building Air Quality, A Guide for Building Owners and Facility Managers, available at www.epa.gov/iaq/largebldgs/baqtoc.html.

Heating, Ventilating, and Air-Conditioning

One of the most common deficiencies in the indoor environment is the improper operation and maintenance of ventilation systems and other building components. NIOSH investigators have found correcting HVAC problems often reduces worker symptoms. The majority of studies of

ventilation rates and building-related symptoms have shown that rates below 10 liters per second (ls^{-1}) per person (which equates to 20 cubic feet per minute per person [cfm/person]), are associated with one or more health symptoms.[15] Moreover, higher ventilation rates, from 10 ls^{-1} per person up to 20 ls^{-1} per person, have been associated with further significant decreases in the prevalence of symptoms. Thus, improved HVAC operation and maintenance, higher ventilation rates, and comfortable temperature and relative humidity can all potentially serve to improve symptoms without ever identifying any specific cause-effect relationships.

Volatile Organic Compounds

VOCs are a large class of organic chemicals that contain carbon rings or carbon chains of varying lengths (e.g., C_7-C_9 are carbon chains of 7 and 9, respectively) that have a sufficiently high vapor pressure to allow some of the compound to exist in the gaseous state at room temperature. These compounds are emitted in varying concentrations from many sources, including building materials and furnishings, carpeting, fabrics, adhesives, solvents, paints, cleaners, waxes, cigarettes, and combustion sources. IEQ studies have measured widely ranging VOC concentrations in indoor air, as well as differences in the mixtures of compounds present. However, concentrations are usually several fold lower than any occupational standards, except in rare cases with unusual sources. A measurement of total VOCs (TVOCs) has been used in some studies, to try and predict certain types of health effects, but results have been inconsistent.[16,17] Currently no guideline or standard exists for VOCs in nonindustrial workplaces. Recently, the European community has revised the concept of TVOC measurement to include the identification and quantification of 67 specific chemicals. This is outlined in a report by the Nordic Committee on Building Regulations, which recommends 26 chemical guidelines and presents toxicologically-based methodology for preparing more.[18] Although important to IEQ research, these guidelines are still two to three orders of magnitude higher than typical indoor VOC concentrations.[19] A NIOSH health hazard evaluation found that forest service workers who used tree marking paint were exposed to to low level concentrations of mixed solvents including petroleum distillates, petroleum napthas, trimethyl benzenes and methyl ethyl ketone reported respiratory irritation, nausea, vomiting, headaches and fatigue.[20] Employee exposures were all well below any occupational health criterion. Another study (not by NIOSH) reported that ongoing cumulative exposures to multiple chemicals in the indoor environment lowered the threshold for which upper respiratory irritation occurred.[21]

Odors and Irritation

Odors greatly influence how building occupants perceive the quality of the indoor environment because odors are distinguished as either pleasant or unpleasant, acceptable or unacceptable. Irritation caused by exposures to VOCs results from stimulation of mucosal tissues and is a form of chemesthesis or chemically stimulated skin sensation. Only rarely does a VOC lack the potential to cause irritation.[22] Chemically reactive substances that covalently bind to tissues can cause irritation. Potency of irritants including alcohols, acetates, and alky benzenes (all found in this investigation) increases with increasing carbon chain length.[23] Some studies show a general relationship between odors and

irritation thresholds with increasing hydrocarbon carbon chain length.[24] Nasal pungency (irritation), odor thresholds and eye irritation for a series of acetates and aliphatic alcohols were also shown to be related to increasing carbon chain length.[25]

RESULTS

Tracer Gas Evaluation

Results from the tracer gas study are listed in Tables 1 and 2. Tracer gas values are listed in ppt with the exception of a sample from the first release collected in room 236H (the nail tech room) which is several orders of magnitude higher and shown in ppb. Background measurement values (in a range of 6-22 ppt) are due to background electrical signal (also referred to as "noise"). This is not uncommon in GC's equipped with electron capture detectors. A target concentration of SF_6 at 100 ppt or greater was agreed as a positive sample. This determination was made before samples were collected. Samples below 100 ppt were treated as less than the limit of quantitation (LOQ).

In the first release, tracer gas was detected above the LOQ in the main cosmetology area, the hallway at the main entrance to cosmetology area, in the main administrative office area, and in the nail tech room. Smoke testing conducted during the tracer gas evaluation confirmed that room 236H was strongly positively pressurized in relation to the main cosmetology area, but that the general cosmetology area was under slight negative pressure in relation to the hallway outside the entrance to this area. This indicates that VOCs released during nail technology procedures can leave that room and go into the cosmetology area. The exact pathway for tracer gas movement to the main administration area is unclear but may be into the hallway outside that room (due to positive pressurization of the nail tech room) then possibly under the door leading into the hallway that goes toward the main office area, or possibly via the ceiling plenum above the nail tech area to the ceiling plenum above the hallway on the north side of the nail tech room. A floor plan listing room locations in Building A is included as Appendix A in this HHE.

The second column in Table 2 shows results from the second tracer gas release in Room 240A. In this release, tracer gas was detected twice on the first floor in the dental lab, in samples collected 25 minutes apart. Smoke testing confirmed that Room 240A is under strong negative pressure in relation to the main cosmetology area and the dental lab was under slight negative pressure in relation to the hallway near the staff/student entrance. This release demonstrated that tracer gas released in room 240A enters the dental lab, and by extension, chemicals from cosmetology are liable to follow the same pathway. Chemicals from 240A may also be entering dental from re-entranment of exhausted air that is taken into the outside air louver for the dental lab AHU.

The third column of Table 2 describes results of the tracer gas release in the print shop. Tracer gas was detected in every sample location on the lower level (the main hallway, and rooms 113, 123, 140 and 142). Tracer gas was detected at the top of the stairs by the main entrance and in the main administration area. Smoke tube testing confirmed that the print shop is positively pressurized in relation to its main hallway door, as well as the door leading to the hallway by the staff restrooms. Widespread distribution of tracer gas on the first floor was expected because a single AHU supplies ventilation to the entire lower level of the building. This means that VOCs from chemicals used in the print shop can be

entrained into AHU #7 and then recirculated throughout all ventilation zones on the lower level. Positive pressurization of the print shop also plays a role in the distribution of chemicals on the lower level, and to a minor degree, on the upper level of the building.

AIR SAMPLING

Qualitative Sampling for Volatile Organic Compounds (VOCs)

Chemicals identified on the three TD air samples collected on the first floor on 10/1/02 (print shop, return air plenum of AHU #7, and room 123B) included perchloroethylene (peak 27), isopropyl alcohol (peak 7), limonene (peak 35) and a constellation of C_9-C_{14} aliphatic hydrocarbons, alkyl decahydronapthalenes, and C_9-C_{10} alkyl benzenes (i.e.,trimethyl benzenes) which are grouped together and labeled as 28. Chemicals identified at lower relative concentrations (by comparisons of chromatograms) included propylene glycol, methyl ether acetate, toluene, xylene, C_6-C_8 hydrocarbons, acetone, methyl ethyl ketone, 1,1,1, trichloroethane, and trace amounts of ethyl methacrylate. Perchloroethylene, isopropanol and trimethyl benzenes appear in greatest concentrations (based on peak height and area under the peak) in these air samples. These samples were collected as one press was running in the print shop. The sample locations included the print shop, the return air plenum in AHU #7, and in room 123B. The samples collected in the return air plenum of AHU#7 and room 123B are virtually identical, demonstrating that AHU#7 is a pathway for volatile solvents from the print shop to other ventilation zones of the building. All results are shown in the form of chemical chromatographs (and a peak identification sheet) identified for the sampling date of October 1, 2002 (Appendix B).

Major chemical compounds identified on twelve TD air samples collected on November 26, 2002 included percholoethylene (peak 40), isopropyl alcohol (peak 11), limonene (peak 57), ethanol (peak 8), acetone (peak 9), siloxane compounds (peak 61), toluene (peak 35), ethyl acetate (peak 19), and C_6-C_7 alkane hydrocarbons (peaks 16 &17). Other compounds detected in lower abundance included xylene, chloro-dimethyl phenol, methyl methacrylate, ethyl methacrylate, akyl benzenes, 2-ethyl-1 hexanol, phthalic anhydride and other hydrocarbons. In areas other than the print shop and cosmetology, siloxanes (which often originate from copy machines) and toluene appeared in greater abundance. Perchloroethylene was again detected in greatest concentration in the print shop and on the sample collected in the hallway outside room 119. These results are shown in the chromatograms in Appendix B labeled for the sampling date of November 26, 2002.

Additional TD samples for VOCs were also collected on January 16 and 22, 2003, when the print shop and the cosmetology programs were in session. The types and relative concentrations of the major chemical compounds detected varied greatly (as was expected) in the various sample locations. The major compounds identified included a naptha mixture of alkyl benzenes and C_9-C_{12} aliphatic hydrocarbons (grouped as peak 43), ethyl benzene and xylene monomers (peak 42), perchloroethylene (peak 38), ethyl methacrylate (peak 35), toluene (peak 34), butyl acetate (peak 37), limonene (peak 54), ethanol (peak 5), acetone (peak 6) and isopropanol (peak 8). The sample collected in the nail technology program was very concentrated with ethyl methacrylate (peak 36), and the sample

collected in the print shop was very concentrated with perchloroethylene and trimethyl benzenes (peaks 38 and 43). The clear presence of perchloroethylene and trimethyl benzenes were notable in room 142, on the landing of the north stairs leading to the administration area, in the administration area, and in the dental area. Ethyl methacrylate was notable in room 236H (the nail tech area) in the hallway outside room 236H, in the administration area, and in the dental lab.

Almost identical chromatograms indicating the presence of isopropanol, ethyl methacrylate, perchloroethylene, C_9-C_{14} hydrocarbons, napthalenes, and trimethyl benzenes are seen for samples collected in the dental lab, outside room 201D in the administration area, and at the landing of the north stairs. These samples show the clear presence of "marker solvents" known to originate from the print shop (i.e., perchloroethylene, C_9-C_{14} hydrocarbons, napthalenes, isopropanol and trimethyl benzenes) as well as those known to originate from the cosmetology area (ethyl methacrylate, and acetone)

Acids

On January 16 and 22, 2003, five air samples were collected to screen for the presence of acids. The samples were collected for a short period of time (2-3 hours) while the nail technology program was in session and various nail tech products were being used. Each sample was analyzed for the presence of six acids: hydrochloric, hydrofluoric, hydrobromic, phosphoric, nitric and sulfuric acid. Three of the samples were collected on January 16, 2003, two in room 236H and one in the dental lab. These samples were all determined to below the limit of detection for the six acids that were analyzed. Two more samples were collected on January 22, 2003, in room 236H, again when the nail tech program was operating and nail products were being used. These samples both contained low levels of hydrofluoric (HF) and sulfuric acids (H_2S0_4) . A personal breathing zone sample (PBZ) was collected on a nail tech instructor and an area sample was collected on a table near to where the instructor worked. The concentration of HF in the PBZ sample was 0.07 milligrams per cubic meter of air (mg/m^3), the area sample was 0.05 mg/m^3. The concentrations of H_2S0_4 was 0.07 mg/m^3 for both the PBZ sample and the area sample.

Methacrylates

On February 6, 2003, six samples were collected for the presence of ethyl and methyl acrylates. Samples were collected in room 236H, in the hallway outside room 236H, in the library, and in room 113. The nail tech program was operating when the samples were collected. All samples for methyl methacrylate were reported as not detected. Two samples for ethyl methacrylate were at "trace" concentrations (i.e., a value above the limit of detection, but below the limit of quantitation.) A PBZ sample for ethyl methacrylate collected on the nail tech instructor was 7.6 mg/m^3.

Volatile Organic Compounds

On January 16 and 22, 2003, ten air samples were collected for VOCs including perchloroethylene, tri-methyl benzenes, and total hydrocarbons (referenced to decane, a nonaromatic hydrocarbon). On January 16, samples were collected in the print shop, rooms 113, 123, and 230, and the dental lab. On January 22, samples were collected in the print shop, room 200B, the administration area and in the JEFFCO Net Academy (located across from Building A in

the McClain High School). The samples were collected to quantitate the presence of selected VOCs that had been identified in the indoor air of Building A using thermal desorption tube sampling. Only a limited number of samples for quantitative analysis were collected because VOCs in the non-industrial indoor environment are generally present in low concentrations (tenths of microgram amounts) which are below the threshold of detection for the sampling method. Of the 10 samples collected, only one (collected in the print shop on January 16) had detectable concentrations. The sample contained 1.2 mg/m^3 of perchloroethylene, 2.7 mg/m^3 of tri-methyl benzenes, and a trace amount of total hydrocarbons referenced to decane. This sample was collected for a short time in the afternoon, from 1:00 to 4:35pm (315 minutes), when printshop operations occurred. The reason that so many samples were reported as "not detected" is believed to be due to insufficient volumes of air sampled during a short period of time.

Employee Interviews

The most commonly reported health complaints included headache, upper respiratory irritation, eye irritation, congestion, and perceived eye dryness. Shortness of breath or aggravation of asthma was reported by three persons. Two employees reported an onset of physician-diagnosed asthma which occurred during the time of the Building A renovation. Employees reported a range of symptom onset, some said they experienced eye and upper respiratory irritation within minutes of entering the building, others reported that their symptoms begin after a few hours at work. Most employees said their symptoms improved over the weekends and on days when they were away from work and on vacation. Many of the employees interviewed reported that they first noticed their symptoms after the building renovation began in 1999. Employees who were relocated to work areas outside of Building A (McLain High School and the Longview Temporary Building) reported that they did not experience IEQ-related health symptoms in their new work areas. Two employees reported that whenever they entered Building A they experienced health symptoms, and so they avoided spending time in the building if possible. Employees reported that they routinely smelled chemicals, but the perceived strength and pungency varied..

DISCUSSION

The use of tracer gas demonstrated the presence of pathways for volatile chemicals from cosmetology and the print shop to be distributed to other occupied areas of Building A. Tracer gas released on either the lower or upper level of the building generally remained on that level. Tracer gas released in nail tech and the permanent wave room did not move to the lower level of the building, but was distributed to the main office area, suggesting the same distribution would occur for VOCs generated from these areas. Tracer gas was detected in the hallway outside the cosmetology program but this is believed to be due to trace amounts being "walked out" of the area on air currents from people leaving the area.

Less widespread distribution of chemicals was expected on the upper level of the building because six separate AHU's provide ventilation to different areas on this floor, whereas a single AHU serves the entire lower level of the building. When tracer gas was released in the print shop, it was detected throughout the lower level, and also at the top of the stairs near the main entrance to the building, and in the main

office above that entrance. This is probably due to the fact that the door to the print shop is normally open, and that the print shop is positively pressurized. Chemicals originating in the print shop may also be migrating out of this area due to a slight "chimney effect" or upwelling of air through the north stairway that leads to the main office area.

Air sampling demonstrated that chemicals including perchloroethylene, tri-methyl benzenes, isopropanol, and a wide variety of long chain aliphatic and aromatic hydrocarbons are present and widely distributed on the lower level of the building, and to some degree on the upper lever as well. Sampling results also show that chemicals from cosmetology products, including, but not limited to ethyl methacrylate, ethanol, acetone, acetates and aliphatic hydrocarbons, can be detected inside as well as outside the cosmetology area (specifically in the dental lab and the main administration area).

Air sampling revealed the definitive presence of certain "marker solvents", or chemicals that could be associated with certain sources. The sources of perchloroethylene, isopropanol, tri-methyl benzenes, and 1,1,1-trichloroethane were from the print shop. Perchloroethylene, 1,1,1-trichloroethane, and Stoddard Solvent are all listed on the MSDS for Safety Kleen 105. Stoddard Solvent is a mixture of 30-50% C_7-C_{12} aliphatic hydrocarbons, 30%-40% cycloalkanes/napthenes and 12%-20% aromatic hydrocarbons (including tri-methyl benzenes). The presence of isopropanol was confirmed to be from various isopropyl alcohol-based roller and plate cleaners used in the print shop. Acetone, ethyl methacrylate, ethyl and butyl acetates were determined to be from cosmetology and the nail tech program. These chemicals were not evident in samples collected in outside air or in the samples collected in either McClain High School and the Longview Temporary Building, areas where staff had been relocated and currently do not report building-related health complaints based on interviews with these staff. However, certain solvents were detected on air samples from Longview and McClain, including toluene and certain siloxane compounds. Siloxanes are commonly seen in indoor air and are believed to originate from rubber products, silicon containing lubricants, and personal care products. Toluene is commonly seen in low concentrations in the indoor environment from a variety of sources.

Ethyl methacrylate, hexane, ethyl and butyl acetate, and and various other chemicals are listed on the MSDSs for products from the nail tech area and the cosmetology program (i.e., methacrylates in artificial nail products, alcohols and hydrocarbons used as solvents and in aerosol sprays.) Ethyl methacrylate is not currently regulated with an OSHA Permissible Exposure Level (PEL) nor does it have a NIOSH Recommended Exposure Level (REL), or an ACGIH Threshold Limit Value (TLV). Ethyl methacrylate has similar irritant health effects to methyl methacrylate. Methyl methacrylate is regulated with an OSHA PEL of 410 mg/m^3 as an 8 hour TWA. NIOSH has developed a recommended exposure limit (REL) which is also 410 mg/m^3 as an 8 to 10 hour TWA. The ACGIH TLV is 205 mg/m^3 as an eight hour TWA. It is important to note that these criteria are intended for occupational exposures in the industrial environment, they are not intended and may not be suitable for exposures to office workers or workers in the non-industrial environment.

The source for the HF and H_2SO_4 that were detected on the air samples collected in the nail technology program is unclear. Reviews of the MSDSs for products used in

this area did not identify either of these acids but other acids (methacrylic and propenoic) were listed on products used in this area. It is possible that artificial nail products contain various acids in concentrations below the reporting thresholds for MSDSs, which is 1% for chemicals that have not been identified as human carcinogens. Acids were not detected on air samples collected in this area on January 16, but were detected on samples collected on January 22, suggesting that different nail products, or combinations of nail products, or different artificial nail techniques were used on January 22. The samples for acids are considerably below the most stringent occupational exposure criterions established by either OSHA, NIOSH or the ACGIH. The criterion for HF is 2.5 mg/m^3 as an 8 hour TWA, and 6 mg/m_3 as a short term exposure limit (STEL). The criterion for H_2S0_4 is 1 mg/m^3 as a TWA and 3 mg/m^3 as a STEL (a fifteen-minute average). The PBZ exposures were an order of magnitude below the ACGIH criterion when considering the calculation formula for chemical mixtures having additive effects such as these two acids.

CONCLUSIONS

Staff complaints of burning eyes, upper respiratory irritation, headaches, exacerbations of asthma, and chemical odors in Building A of Warren Tech are likely to be from inhalation exposures to a mixture of irritant chemicals including perchloroethylene, tri-methyl benzenes, alcohols, ethyl methacrylate, ethyl and butyl acetates, and long chain aliphatic hydrocarbons. Many of the chemicals detected by air sampling in Building A are eye, skin and strong mucous membrane irritants, especially perchloroethylene, tri-methyl benzenes, ethyl methacrylate, butyl and ethyl acetates, and alcohols including isopropanol.[26] Chronic inhalation exposures to the mixtures of chemicals that could be detected in the building could be expected to cause the symptoms of headache, dizziness, and the upper respiratory and eye irritation symptoms that are reported by the affected building occupants.[27, 28, 29, 30,31]

Because of the irritant potential of many of these chemicals, individuals with asthma would be at a heightened risk for worsening of their symptoms and possibly for acute respiratory effects. Air samples collected in this study clearly demonstrate that the indoor air of building A contains a wide variety of pungent and odorous chemicals, the origin of which can be traced back to known sources - the print shop on the first floor and cosmetology on the second floor. Air samples collected when the print shop and cosmetology were not training students, compared to when these programs were in session, reveal differences in the types and intensity of chemicals present in indoor air. Samples collected in outside air and in the Longview and McClain buildings were not similar to those collected in Building A in type, pattern, or intensity of chemicals.

RECOMMENDATIONS

1) A dedicated air handing system should be installed in the print shop so that ventilation air for this area is not distributed to other areas on the first floor. Exhaust air from this AHU should be located so that it is not near any outside air intakes. A study in a mixed-use university building found that non-recirculating general ventilation (100% exhausted ventilation) effectively eliminated indoor air quality problems.[32]

2) The print shop should be designed so that it can be maintained under slight negative

pressure in relation to the hallway, and to all other programmatic areas on the lower level.

3) The HVAC system and the dedicated exhaust system for room 236H should be evaluated by in-house engineering personnel or a qualified mechanical engineering firm that specializes in commercial ventilation. One goal of the evaluation should be to determine why the room is under positive pressure when the exhaust system was installed to maintain negative presure in this area. Because methacrylates are sensitizers and strong mucous membrane irritants, the nail tech room should always be maintained under negative pressure in relation to the general cosmetology area. Return air from this area should not be recirculated to other areas.

4) Engineering controls should be used in the nail tech room to directly exhaust VOCs generated during the application of artificial nails. Researchers from NIOSH have found that the use of a downdraft ventilation table protects the nail technician against breathing solvents emitted during application of artificial fingernails. Information on design and use of ventilated tables can be found in NIOSH publication HC 28, entitled: *Controlling Chemical Hazards During the Application of Artificial Fingernails*, this publication can be found on the world wide web at: http://www.cdc.gov/niosh/hc28.html.

5) The outside air intakes for all AHUs on the upper level should be evaluated and modified if necessary to prevent entranement of exhaust from any of the rooftop exhaust fans.

6) Keep the lid on the parts wash bath closed whenever possible to limit fugitive emissions escape.

7) Use solvents in the parts wash bath that do not contain chlorinated hydrocarbons.

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Table 1

SF_6 Tracer Gas Evaluation, Warren Tech Building A
Background or "Zero"
December 18, 2002

Concentrations of SF_6 in parts per trillion (ppt)

Time of release 10:00 a.m. **Location**	**Concentration of SF_6** **@ 10:05 a.m.**
Outside	0
Room 200B	6
Dental	0
Library	18
Room 123	14
Room 142	8
Room 113	22

Table 2

SF_6 Tracer Gas Evaluation, Warren Tech Building A
Nail Tech Room, Cosmetology Area (Permanent Wave Room),
and Print Shop
December 18, 2003

Concentrations of SF_6 in parts per trillion (ppt)

Location of Samples	**Room 236H** **Nail Tech Room** **Release: 10:35 a.m.** **Sampling: 10:40 a.m.**	**Room 240A** **Permanent Wave** **Release: 11:25 a.m.** **Sampling: 11:30 a.m.**	**Print Shop** **Release: 1:00 p.m.** **Sampling: 1:05 p.m.**
Outside	19	no sample	14
Room 142	20	29	589
Room 113	44	no sample	962
Room 123	13	37	965
Room 200B	34	no sample	40
Library	39	53	42
Dental	13	504, 136	23
Hallway outside Cosmetology	61	36	no sample
Hallway outside graphics	no sample	57	400
Cosmetology	892	no sample	no sample
Outside air	39	no sample	no sample
Hallway outside Cosmetology	101	no sample	no sample
Main Administration	136	no sample	169
Room 236H (nail tech)	20 ppb*	no sample	no sample
WT logo, top of stairs, main office	no sample	no sample	259
Room 140	no sample	no sample	376
Print shop	no sample	no sample	296

*ppb = parts per billion

Table 3

Air Sampling for Acids
Warren Tech, Building A
January 16 and 22, 2003

Acids **Hydrofluoric (HF), Hydrobromic (HBr), Hydrochloric(HCl) , Phosphoric (PH_3), Nitric (HNO_3)** **Sulfuric (H_2SO_4)**		
Date	**Type of Sample/Location**	**Results**
1/16/03	PBZ/Rm 236H (Nail Tech)	ND
1/16/03	Area, Rm 236H (Nail Tech)	ND
1/16/03	Area, Dental	ND
1/22/03	PBZ/ Rm 236H	HF = 0.07 mg/m^3 # H_2SO_4 = 0.07 mg/m^3 *
1/22/03	Area/Rm 236H	HF = 0.05 mg/m^3 H_2SO_4 = 0.07 mg/m^3

PBZ = Personal Breathing Zone sample
ND = Not Detected
# NIOSH Recommended Exposure Limit = 2.5 mg/m^3
* OSHA Permissible Exposure Limit = 1 mg/m^3
MDC = Minimum Detectable Concentration, MDC for HF = 0.005 mg/m^3, for H_2SO_4 = 0.01 mg/m^3

Table 4

Air Sampling for Ethyl and Methyl Methacrylates
Warren Tech, Building A
February 6, 2003

Date	Type/Location	Ethyl Methacrylate	Methyl Methacrylate	Notes
2/6/03	Area Sample, Rm 234H	Trace	ND	
2/6/03	PBZ , Rm 236H	7.66 mg/m^3	ND	Ethyl methacrylate is not currently regulated by OSHA, nor is there a NIOSH REL
2/6/03	Library, Rm 230	ND	ND	
2/6/03	Rm 113	ND	ND	
2/6/03	In the hallway, outside Rm 236H	0.24 mg/m^3	ND	sample demonstrates migration outside nail tech
1/22/03	Outside Air	ND	ND	

ND = not detected
Trace = above the limit of detection but below the limit of quantitation
PBZ = personal breathing zone sample
MDC = minimum detectable concentration for ethyl methacrylate was 0.0002 mg/m^3

Table 5

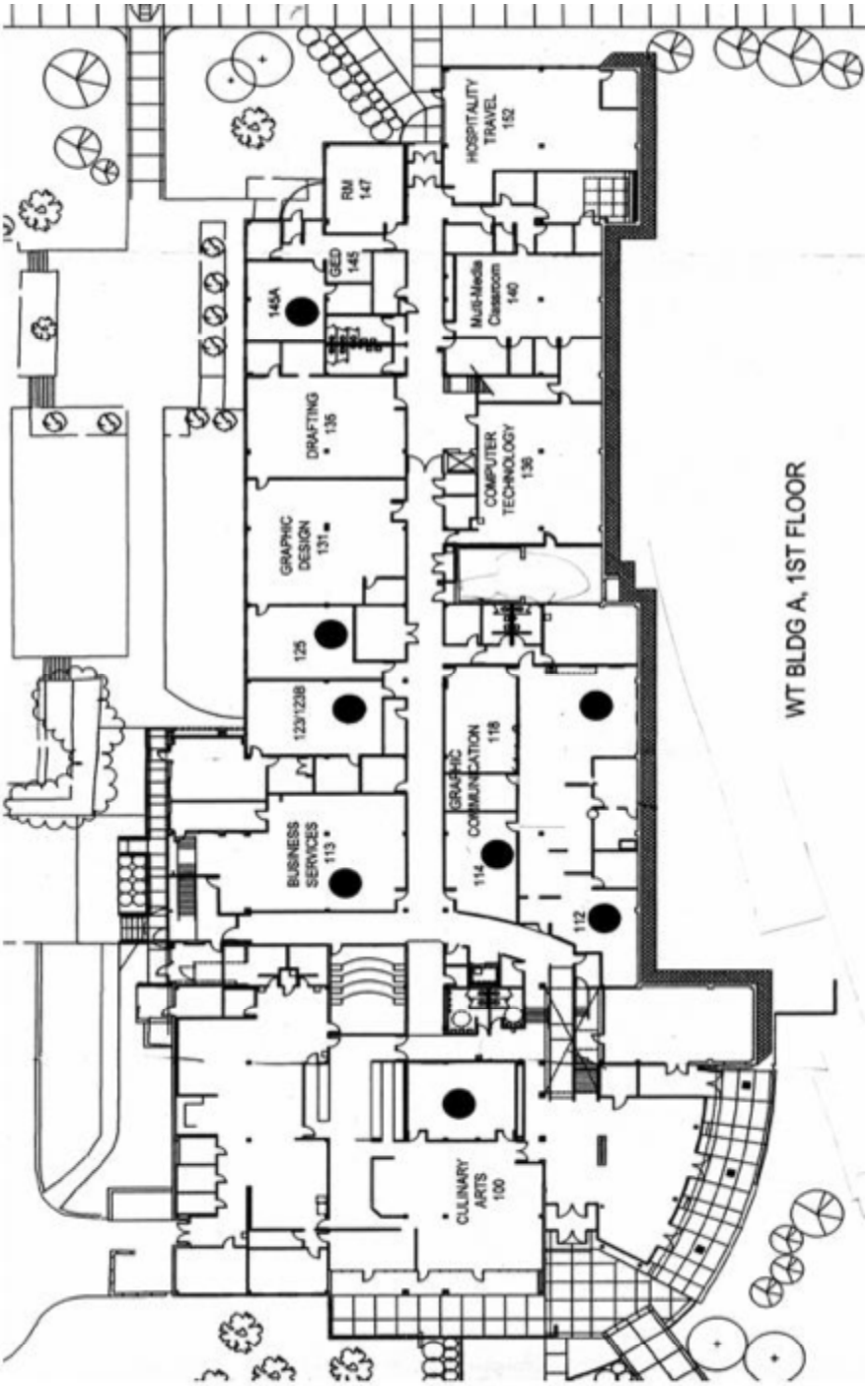
Air Sampling for Total Hydrocarbons, Perchloroethylene and Trimethylbenzenes
Warren Tech, Building A
January 16 and 22, 2003

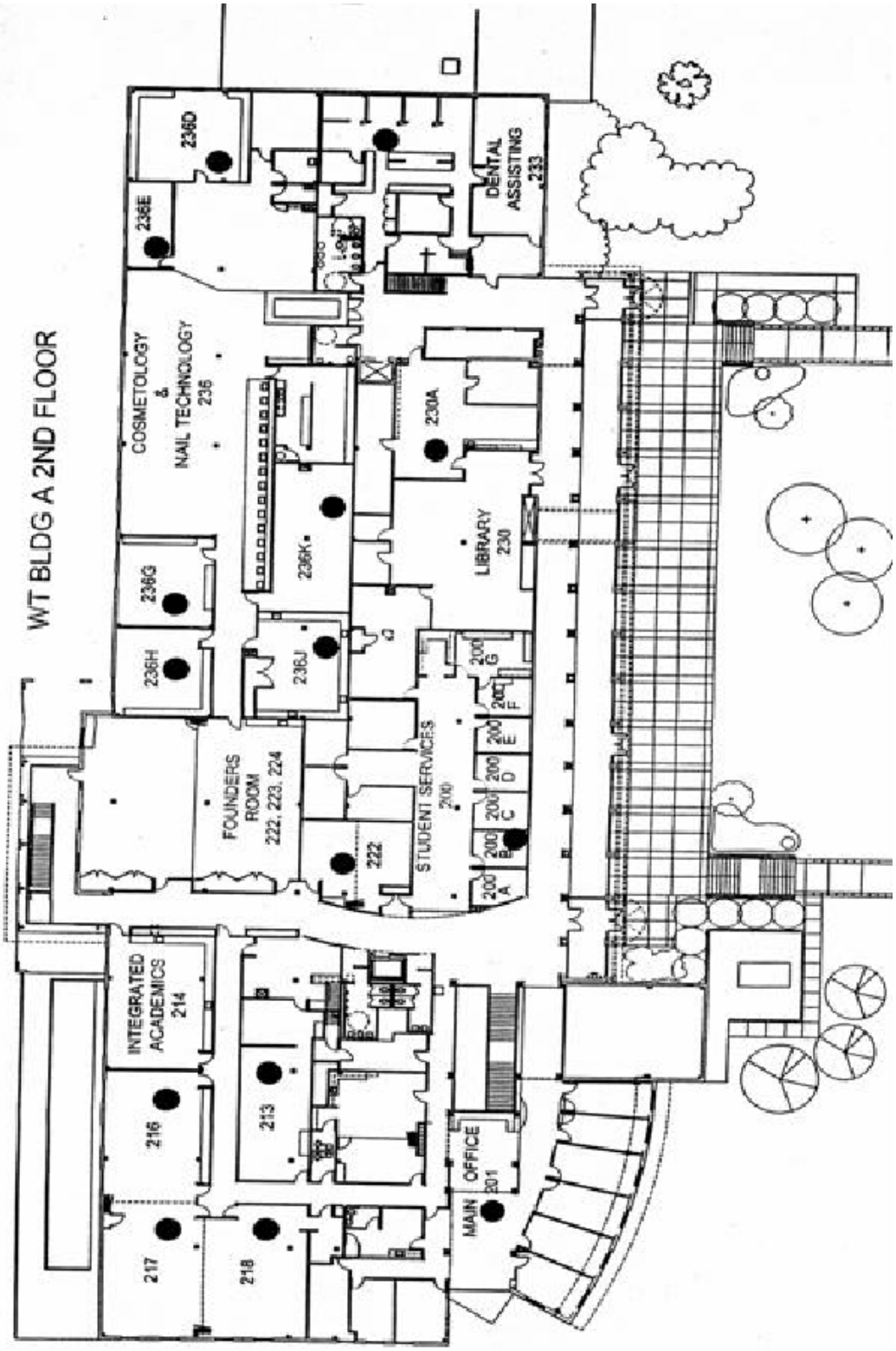
Date	Type/Location	Perchloroethylene	Trimethylbenzenes	Total Hydrocarbons (as decane)
1/16/03	Print Shop Area / Rm 234H	1.2 mg/m^3	2.7 mg/m^3	Trace
1/16/03	Rm 123	ND	ND	ND
1/16/03	Library, Rm 230	ND	ND	ND
1/16/03	Dental Lab	ND	ND	ND
1/16/03	Rm 113	ND	ND	ND
1/22/03	Print shop	ND	ND	ND
1/22/03	Room 200B	ND	ND	ND
1/22/03	Main Admin Area	ND	ND	ND
1/22/03	McLain High School	ND	ND	ND

ND = not detected
Trace = above the limit of detection but below the limit of quantitation

Appendix A

Warren Tech, Building A
First and Second Floor Plans


WT BLDG A, 1ST FLOOR
HOSPITALITY TRAVEL 152
RM 147
GED 145
145A
Multi-Media Classroom 140
DRAFTING 135
COMPUTER TECHNOLOGY 136
GRAPHIC DESIGN 131
125
123/123B
GRAPHIC COMMUNICATION 118
BUSINESS SERVICES 113
114
112
CULINARY ARTS 100


WT BLDG A 2ND FLOOR
236D
236E
COSMETOLOGY & NAIL TECHNOLOGY 236
236G
236H
236K
236J
FOUNDERS ROOM 222, 223, 224
222
INTEGRATED ACADEMICS 214
216
217
218
213
MAIN OFFICE 201
STUDENT SERVICES 200
200 A
200 B
200 C
200 D
200 E
200 F
200 G
LIBRARY 230
230A
DENTAL ASSISTING 233

Appendix B

Chemical Chromatograms of Air Sampling Results from October 1, 2002, November 26, 2002, January 16, 2003 and January 22, 2003.