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Ann Arbor, Michigan

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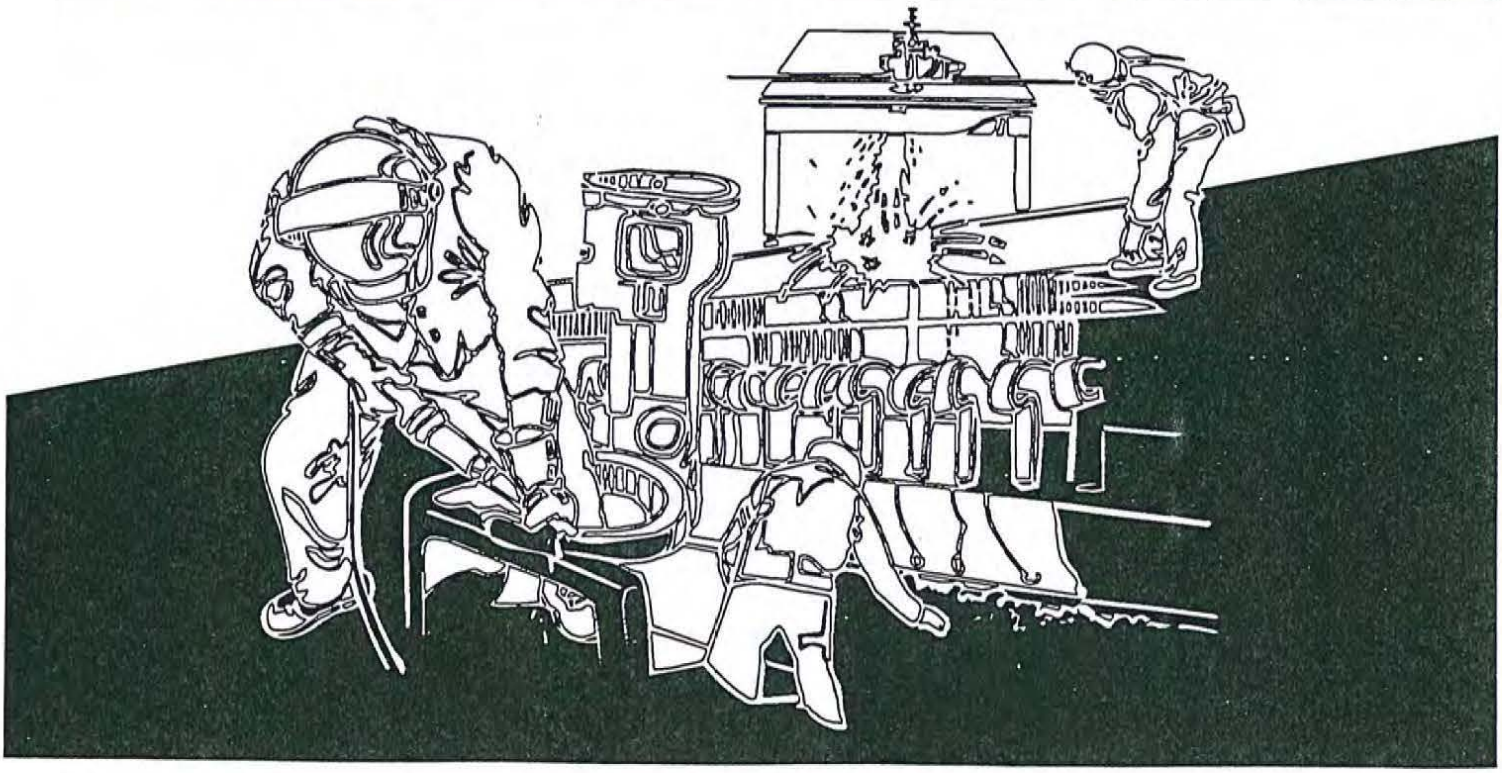

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PREFACE

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

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Deborah B. Friedman and Veronica Herrera-Moreno of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Gregory Burr and Grant Etnyer. Desktop publishing by Ellen Blythe.

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Health Hazard Evaluation Report 95–0313–2589
University of Michigan Hospitals
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SUMMARY

In August 1995, the National Institute for Occupational Safety and Health (NIOSH) received a request from the American Federation of State, County, and Municipal Employees (AFSCME), Local 1583 to conduct a health hazard evaluation (HHE) at the University of Michigan Hospitals in Ann Arbor, Michigan. The request was prompted by employees in the Environmental Services Department (ESD) who were concerned about their potential inhalation and dermal exposures to housekeeping products containing glycol ethers. They reported experiencing flu–like symptoms, including nausea, headache, sore throat, and dizziness which they associated with product use. Increased absenteeism by floor care workers and two documented cases of "severe reactions" were reported by AFSCME.

In October 1995, NIOSH investigators conducted a survey of the facility which included a walk–through inspection of the main hospital, air sampling, employee interviews, and a review of records and programs. Inhalation was expected to be the most likely route of exposure because dermal contact with housekeeping products was observed to be minimal, and gloves were routinely used. Air samples were analyzed for glycol ethers, ammonia, aldehydes, and other volatile organic compounds. Concentrations detected in air samples for glycol ethers and ammonia were below all applicable occupational exposure limits. Formaldehyde and acetaldehyde were detected at levels well below their respective Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH®) criteria. Acetaldehyde, ammonia, and ethylene glycol monobutyl ether (EGBE) were detected at levels greater than their respective odor thresholds, which may explain the strong odors experienced during stripping/waxing activities. Most of the employees selected by the union to be interviewed reported concerns about potential dermal and respiratory exposures to cleaning agents. The average absenteeism rate for floor care workers was similar to that calculated for the ESD department as a whole (based on information provided by ESD for the period between October 1994 and October 1995).

The air sampling results from this evaluation indicate that hospital custodians were not exposed to concentrations of glycol ethers, ammonia, and aldehydes above their respective occupational exposure limits. Although acute irritation of the mucous membranes was reported by some of the interviewed floor waxers and strippers when using several of these housekeeping products, documented cases of chronic illness could not be confirmed. Recommendations were made in the following areas: ventilation; the use of personal protective equipment; and in the functioning of the ESD health and safety program.

Keywords: SIC 8062 (General Medical and Surgical Hospitals), hospital, custodians, floor stripping/waxing, glycol ethers, ammonia, aldehydes

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INTRODUCTION

Investigators from the National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation (HHE) at the University of Michigan Hospitals in Ann Arbor, Michigan, in response to an August 1995 request from the American Federation of State, County, and Municipal Employees (AFSCME), Local 1583. The request was to evaluate floor care workers' exposures to glycol ethers during wax stripping and waxing activities, due to reports of nausea, headaches, sore throats, and dizziness. In phone conversations prior to the NIOSH site visit, AFSCME representatives also expressed concerns regarding any possible reproductive hazards associated with the use of housekeeping products containing glycol ethers.

On October 30 — 31, 1995, NIOSH investigators visited the hospitals and spoke with representatives of the Safety, Building, and Environmental Management Department, the local union, and the Employee Health Services Department. Air monitoring was performed to measure workers' potential exposures to glycol ethers and other solvent vapors. Informal employee interviews were conducted to determine employee concerns and symptoms. Investigators also reviewed Material Safety Data Sheets (MSDSs), previous industrial hygiene sampling data, employee medical and absenteeism records, and cleaning procedures.

BACKGROUND

The Environmental Services Department (ESD) performs custodial functions for the University of Michigan Hospitals. This complex includes three main hospitals with a total of 872 beds. ESD employs approximately 400 custodians in three categories: unit I custodians, unit II custodians, and wall–washers. Floor care is performed by approximately 90 workers from the latter two categories. Full–time floor care employees typically work five eight–hour shifts per week. Stripping and waxing are generally performed by pairs of custodians between 6 p.m. and 7 a.m. A turn–over rate of approximately 50% was documented for floor–care employees between October 1994 and October 1995. Most of these employees transferred to other departments. An average of eight hours per month sick leave, paid and unpaid, was calculated for floor care workers.[1] The average absenteeism rate for floor care workers is similar to that calculated for the ESD department as a whole, as shown in Table 1.

ESD employees reported that floor care products are aerosolized with hand–held chemical sprayers or diluted in water for use with mops or in automatic machines. Hand–held scrubbers are used in areas which are hard to reach using automatic equipment (such as baseboards). A blower is often used to dissipate vapors. In addition to daily floor care, floors are stripped and waxed at least once a year, using at least five coats of finish. High use areas (such as main corridors in the hospitals) are stripped/waxed two to three times a year. Recoating is performed more frequently. Standard floor care tasks are presented in Table 2.

The majority of products used in floor care at the University's hospitals are water–based sprays and liquids manufactured by S.C. Johnson. The products selected to disinfect floors and similar non–critical surfaces were observed to be Environmental Protection Agency (EPA)–registered, as recommended by the Association for Practitioners in Infection Control, Inc. [Rutala, 1990]. Many of these products contain commonly used glycol ethers, such as diethylene glycol monoethyl ether (diEGEE), dipropylene glycol methyl ether (diPGME), and ethylene glycol monobutyl ether (EGBE). For example, Snapback® Spray Buff Liquid,

[1] This information was provided by the Environmental Services Department (ESD) for the period between October 1994 and October 1995.

Showplace®, and Plaza® contain up to 4% diEGEE. Sprint® and Snapback® UHS Restorer contain up to 10% diPGME. Rugbee Solvent Spotter, a mineral spirit–based cleaner, contains 20% to 30% diPGME. Power Foam Bravo® Build–up Remover, and Off–the–Wall® (manufactured by Mantek Chemicals) contain 10 to 40% EGBE. Other products include less commonly used glycol ethers; for instance, Freedom Stripper® contains 5–10% ethylene glycol monophenyl ether (EGPE). Many of these products contain other active ingredients in small quantities, such as ammonium hydroxide (1–13%), sodium hydroxide (1–5%), xylene (1–3%), propane (1–3%), ethanolamines (mono–1–7%, tri–0.1–1%), and formaldehyde (<1%). A more complete list of ingredients for a sample of these cleaning products is presented in Table 3.

On October 30 and 31, NIOSH investigators performed air sampling during representative stripping and waxing activities in the following three locations: the Maternal Child Health Care (MCHC) Lobby (2,061 ft^2); one–half of Corridor 5A (1,257 ft^2); and in an enclosed room, B–1H250 (178 ft^2). All floor care workers participating in sampling were unit II male custodians who rinsed floors with GP Forward® and stripped/waxed using automatic machines. Workers also applied Bravo® to baseboards, with hand–held scouring pads. Area and personal breathing zone (PBZ) samples were collected in the MCHC Lobby, where four coats of Sprint® finish were applied; in Corridor 5A, where five coats of Sprint® finish were applied; and in the enclosed room, where Freedom Speed® stripper and two coats of Sprint® finish were applied. For comparison, PBZ samples were also collected from two female unit I custodians performing general cleaning duties on the 6th and 8th Floor Center Corridors, using cleaners such as Virex®, Glance®, and GP Forward®. All ESD employees were observed to be wearing short–sleeved work shirts, provided by the University. The custodians participating in sampling reported wearing latex gloves, provided by the employer, during direct contact with cleaning products. Although the management representatives reported that it is provided upon request, none of the workers were observed to be wearing eye protection.

METHODS

Industrial Hygiene

Nine area and 17 PBZ air samples were collected between 7 p.m. on October 30 and 2 a.m. on October 31. Sampling periods ranged from one to four hours each. Samples were analyzed for glycol ethers, ammonia, aldehydes, or volatile organic compounds (VOCs).

Glycol Ethers: Thirteen samples were collected and analyzed using NIOSH Method 1403, including three field blanks [NIOSH 1994]. Sample air was drawn through a 150 milligram (mg) charcoal tube at a flow rate of 50 or 500 centimeters per minute (cc/min). Samples were analyzed quantitatively for glycol ethers using gas chromatography (GC) modified with a capillary column. The solvent used to desorb the charcoal was 5% methanol in methylene chloride. The limit of detection (LOD) was 0.001 milligrams per sample. The limits of quantitation (LOQ) were between 0.0033 and 0.0036 milligrams per sample.

Ammonia: Ten samples were collected and analyzed using NIOSH Method 6015, including two field blanks [NIOSH 1994]. Sample air was drawn through a sulfuric acid–treated silica gel tube at a flow rate of 200 cc/min. Samples were analyzed quantitatively for ammonia using visible absorption spectrophotometry. Samples were desorbed using deionized water and neutralized with sodium hydroxide. The LOD was 0.004 milligrams per sample. The LOQ was 0.011 milligrams per sample.

Aldehydes: Seven samples were collected and analyzed using NIOSH Method 2539,

including two field blanks. Sample air was drawn through a treated 180 milligram XAD–2 tube at a flow rate of 100 cc/min. Samples were screened qualitatively for nine different aldehydes using GC and mass spectroscopy (MS). Samples were desorbed by sonication with toluene. The LOD was between 0.0003 and 0.001 milligrams per sample. The LOQ was between 0.001 and 0.0032 milligrams per sample.

VOCs: Six stainless steel tubes were used to collect air samples for qualitative analysis of VOCs, including two field blanks and one outdoor background sample. Samples were collected at a flow rate of 50 cc/min and analyzed using a thermal desorber, interfaced with a GC/MS.

Medical

The medical evaluation included a review of Occupational Safety and Health Administration Log and Summary of Occupational Injuries and Illnesses (OSHA 200 logs), review of relevant medical records, employee interviews, and an interview with the occupational health physician of the Employee Health Services (EHS). The interviewed workers were selected by the AFSCME representatives, based on the workers' availability during their workshift and their concerns about potential work–related health problems. A total of 17 of 77 ESD workers (22%) involved in waxing and stripping, from all four workshifts, participated in a voluntary, private medical interview. The interview consisted of a review of work history, medical history, and work–related symptoms.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre–existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs), (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®), and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs) [NIOSH 1992, ACGIH 1995, OSHA 1993]. In July 1992, the 11th Circuit Court of Appeals vacated the 1989 OSHA PEL Air Contaminants Standard. OSHA is currently enforcing the 1971 standards which are listed as transitional values in the current Code of Federal Regulations; however, some states operating their own OSHA approved job safety and health programs continue to enforce the 1989 limits. NIOSH encourages employers to follow the most protective criterion between the 1989 OSHA limits, the NIOSH RELs, or the ACGIH TLV®s. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of

occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard and that the OSHA PELs included in this report reflect the 1971 values.

A time–weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8–to–10–hour workday. Some substances have recommended short–term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short–term. STELs are defined as 15 minute TWA exposures which should not be exceeded at any time during the workshift. Ceiling values are limits for instantaneous exposures which should not be exceeded at any time during the workshift.

As shown in Table 3, cleaning products may contain a variety of chemicals, including glycol ethers, volatile organic compounds (VOCs), ammonia, and aldehydes.

Ammonia

Ammonia is a severe irritant of the eyes, respiratory tract, and skin. Repeated exposure to ammonia gas may cause chronic irritation of the eyes and upper respiratory tract [Proctor 1991]. Symptoms associated with exposure to ammonia include coughing, burning, and tearing of the eyes; runny nose; chest pain; and cessation of respiration. Symptoms may be delayed in onset. Eye exposures to high gas concentrations may produce temporary blindness and severe eye damage. Skin exposure to high concentrations may cause burning and blistering. The OSHA PEL for ammonia is 35 milligrams per cubic meter (mg/m^3) as an 8-hour TWA. The ACGIH TLV® is 17 mg/m^3 for an 8-hour TWA and 24 mg/m^3 for a short–term exposure limit (STEL). The NIOSH REL is 18 mg/m^3 for up to a 10-hour TWA and 27 mg/m^3 for a STEL.

VOCs

Volatile organic compounds (VOCs) describe a large class of chemicals which are organic (i.e., containing carbon) and 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 numerous indoor sources including, but not limited to, carpeting, fabrics, adhesives, solvents, paints, cleaners, waxes, cigarettes, and combustion sources. Studies have measured wide ranges of VOC concentrations in indoor air as well as differences in the mixtures of chemicals which are present. Research also suggests that the irritant potency of these VOC mixtures can vary. [Molhave et al., 1992; Molhave et al.,1986]

Glycol Ethers

Unlike some glycol ethers, none used in the cleaning products evaluated in this survey have been found to be reproductive hazards. In addition, none have been found to be mutagenic or carcinogenic. Table 4 lists the major glycol ethers identified in floor care cleaning products and describes their health effects. In addition to uptake from inhalation exposures, glycol ethers are readily absorbed through the skin. For this reason, both skin and respiratory uptake should be considered when evaluating workers' exposures.

Aldehydes

Formaldehyde: Formaldehyde and other aldehydes may be released from foam plastics, carbonless copy paper, particle board, and plywood. Formaldehyde is a constituent of tobacco smoke and of combustion gases from heating stoves and gas appliances. This chemical has also been used in the fabric and clothing industry to impart permanent press characteristics, in the manufacturer of some cosmetics, and in disinfectants and fumigants. In 1985, OSHA

estimated that 513,400 workers in 43,500 establishments were potentially exposed to formaldehyde concentrations ranging from 0.6 to 1.3 mg/m³. It has also been estimated that over a million workers are occupationally exposed to formaldehyde nationwide [ACGIH, 1992].

Effects of exposure to low concentrations of formaldehyde may include irritation of the eyes, throat, and nose; headaches; nausea; nasal congestion; asthma; and skin rashes. It is often difficult to ascribe specific health effects to specific concentrations of formaldehyde at concentrations below 0.13 mg/m³; more typically, they begin at exposures of 1.3 mg/m³ and greater. However, some children or elderly persons, those with pre–existing allergies or respiratory disease, and persons who have become sensitized from prior exposure may have symptoms from exposure to concentrations of formaldehyde between 0.06 and 1.3 mg/m³. Cases of formaldehyde–induced asthma and bronchial hyper reactivity have been reported [NRC, 1981].

The fact that formaldehyde is found in so many home products, appliances, furnishings, and construction materials has prompted several agencies to set standards or guidelines for residential formaldehyde exposure. The American Society for Heating, Refrigerating, and Air–Conditioning Engineers has recommended, based on personal comfort, that exposure to formaldehyde be limited to 0.125 mg/m³. This guideline has also been adopted by the governments of Canada, Germany, and the United Kingdom [Gammage and Hawthorne, 1984]. For occupational exposures, NIOSH considers formaldehyde to be a suspected human carcinogen and, as such, recommends that exposures be reduced to their lowest feasible level. The OSHA PEL for formaldehyde is 0.94 mg/m³ for an 8–hour TWA; the OSHA STEL is 2.5 mg/m³. The ACGIH TLV® for formaldehyde is a ceiling limit of 0.37 mg/m³.

Acetaldehyde: Acetaldehyde is an irritant of the mucous membranes at low concentrations. Exposure to acetaldehyde at concentrations of 46 mg/m³ has resulted in irritation in sensitive subjects. The OSHA PEL for acetaldehyde is 360 mg/m³ for an 8– to 10– hour TWA. The ACGIH TLV® for acetaldehyde is a ceiling limit of 45 mg/m³. Acetaldehyde has been shown to be a carcinogen in animal studies [Proctor et al., 1988; IARC, 1985]. Since it is a potential occupational carcinogen, the NIOSH policy is to reduce exposure to the lowest feasible limit.

RESULTS

Industrial Hygiene

NIOSH investigators submitted air samples to either NIOSH laboratories or approved contract laboratories to perform the following chemical analyses: glycol ethers, ammonia, aldehydes, and VOCs.

Glycol Ethers

Glycol ethers were detected in the seven PBZ and two area air samples collected during floor care activities, but not in the PBZ sample collected during general cleaning. Concentrations of diEGEE ranged from not detected (ND) to 4.1 mg/m³ in the area sample from the MCHC Lobby. Concentrations of diPGME ranged from 0.51 mg/m³ in a PBZ sample obtained before stripping/waxing began in Corridor 5A to 14 mg/m³ in the area sample from the MCHC Lobby. Concentrations of EGBE were primarily detected in Corridor 5A, ranging from 0.47 to 5.3 mg/m³. The highest concentration of EGBE was detected in a PBZ sample collected during stripping and before waxing. This worker was observed using both an automatic and hand–held scrubber during this period. Most concentrations greater than 1 mg/m³ were obtained from the two high–volume area air samples which were collected using a sample air flow rate of 500 cc/min. Detected concentrations for diPGME are at least an order of magnitude below

evaluation criteria. Detected concentrations for EGBE are approximately one–fifth of the NIOSH REL. In two out of the nine samples collected during floor care activities, EGBE was detected at levels greater than the odor threshold of 0.48 mg/m^3 [Ruth, 1986]. Results for glycol ethers are presented in Table 5.

Ammonia

Ammonia was detected in five out of the six PBZ samples that were collected during floor care activities, but not in either of those collected during general cleaning. Concentrations ranged from ND in a sample collected in the MCHC Lobby to 1 mg/m^3 in a sample from Corridor 5A. Concentrations detected are all at least two orders of magnitude above the odor threshold for ammonia of 0.026 mg/m^3 [Ruth, 1986]; however, they are at least an order of magnitude below OSHA, ACGIH, and NIOSH evaluation criteria. Results for ammonia are presented in Table 6.

Aldehydes

Results for aldehydes are presented in Table 7. No aldehydes were detected in the area air samples collected in the corridor adjacent to the MCHC Lobby or in the Lobby before stripping/waxing activities began. No aldehydes were collected in the PBZ sample collected during general cleaning activities. Valeraldehyde, hexanal, heptanal, butryaldehyde, propionaldehyde, acrolein, and isovaleraldehyde were not detected in any of the air samples collected.

A trace amount of formaldehyde was detected in an area air sample from Corridor 5A. This concentration is at least an order of magnitude below the ACGIH TLV® and OSHA PEL for this substance and is not unusual in occupational or non–occupational environments. However, NIOSH considers formaldehyde to be a suspect human carcinogen and recommends that exposures be kept to their lowest feasible levels. No formaldehyde was detected in a sample collected from the MCHC Lobby.

Acetaldehyde was detected between 0.45 and 1.1 mg/m^3, respectively, in the area air samples collected during stripping/waxing in the MCHC Lobby and Corridor 5A. These values are several orders of magnitude above the odor threshold for acetaldehyde of 0.0002 mg/m^3 [Ruth, 1986]; however, they are over an order of magnitude below the OSHA and ACGIH standards. NIOSH considers acetaldehyde to be a suspect human carcinogen and recommends that exposures be kept to their lowest feasible levels.

VOCs

Copies of the reconstructed total ion chromatograms (with peak identification) from the analysis of the thermal desorption (TD) tube samples are shown in Figure 1. Compared to the background samples, a number of compounds were present in area air samples collected during stripping/waxing. The highest concentrations were detected in Corridor 5A and the lowest, in the MCHC Lobby. In these samples, diEGEE and diPGME were detected at substantially higher levels than any other VOC in this analysis. Another glycol ether, EGBE, was also detected at an elevated level in the sample from Corridor 5A. Among others, toluene, isopropanol, butyl ether, phenyl acetate, butanol, limonene, xylene, cyclohexanol, benzene, and C_6–C_9 aliphatic hydrocarbons were detected in field samples at lower concentrations.

Medical

Records Review

The ESD OSHA 200 logs for the period of January 1, 1993, through October 30, 1995, did not include any entries for symptoms listed on the request. Of a total of 653 entries, there were 23 (3.5%) entries for eye exposure to chemicals or blood, 24 (3.7%) for skin disease, and 78 (11.9%)

for cut/puncture/laceration, of which 27 (35%) were caused by instruments and needles (sharps). The majority of the entries on the OSHA 200 logs were for musculoskeletal injuries. The medical record review was conducted during an interview with an occupational health physician for the University of Michigan medical center. From April 1993 to October 1995, 28 workers from ESD had sought medical attention at EHS for work–related medical conditions. The diagnoses for these employees included the following: nine workers with skin problems; seven with eye injuries; seven with unspecified respiratory exposures; three with needle sticks; one with radiation exposure and one with chemical exposure. On the day of the NIOSH site visit, medical records for 11 of these ESD employees were available for review. The review of records verified the above diagnoses. All these workers have subsequently returned to work.

Interviews

Of the 17 ESD workers interviewed, 15 (88%) were male. The mean age was 38 years (range 28 to 55 years), and the mean years worked in ESD was 8 years (range 2 to 13 years). Symptoms that were felt to be work–related by the employees are shown in Table 8. Headaches and dizziness were the most frequently reported work–related symptoms. Fourteen workers expressed concerns regarding dermal and respiratory exposures to cleaning agents. The employer provides gloves and eye protection for all workers. Sixteen of the 17 interviewed workers reported wearing gloves regularly, but only 3 of the workers in this group reported using eye protection.

DISCUSSION

None of the chemicals were detected at concentrations exceeding OSHA or ACGIH evaluation criteria. Although formaldehyde and acetaldehyde were detected in one and two samples, respectively, the levels detected have been found in other occupational and non–occupational environments [ACGIH, 1992]. Analytical results provided by the hospitals' Safety, Building, and Management Department from sampling conducted in October 1995 were within the range of the NIOSH results. Acetaldehyde, ammonia, and EGBE were detected at levels greater than the minimum odor thresholds for those chemicals, which helps to explain odors noticed by ESD employees and NIOSH investigators. None of these chemicals has been demonstrated to be acutely toxic at the levels detected in this survey.

Complaints of irritation of the eyes, nose, and throat by floor care employees may stem from a variety of causes. As mentioned above, a small percentage of people may experience adverse health effects even though exposures are maintained below recommended limits. Exposures to mixtures of irritating chemicals may be more irritating than exposure to single chemicals. Workers may experience irritation because they are not using all of the personal protective equipment (PPE) suggested by the manufacturer (refer to Table 3). Some employees may be irritated by compounds not evaluated here (for example, the MSDSs emphasized the irritant effects of chemicals such as ethanolamines and hydroxides). NIOSH investigators observed that many of the products used in other custodial processes contain ingredients similar to those used in stripping/waxing products. Heavy–duty products are likely to contain the most irritating ingredients. The focus on stripping/waxing may be due to the volume of products used during these activities and/or the duration of the process.

Only 3 of 17 workers interviewed reported using eye protection, and NIOSH investigators did not observe any of the workers using eye protection during the visit. Wearing eye protection while organic solvents are being used is warranted to reduce the hazard of a splash into the eyes, and also to help reduce eye irritation. Permanent eye damage may result from overexposure to many of the cleaning products. The MSDSs specify eye

protection for use of several undiluted products, including GP Forward®, Freedom Speed® Stripper, Power Foam Bravo®, Bravo® Extra Heavy Duty Stripper, Virex 256,® and Glance SC®. The MSDSs for many of the other products recommend eye protection for major exposures. Options for adequate eye protection from splashing include chemical goggles or face shields.

Sixteen out of 17 workers reported using rubber gloves regularly. During the visit, NIOSH investigators observed employees using gloves when applying Bravo® with a hand–held scrubber. Custodians reported that the stripping/waxing products eroded their shoes and that some products burned holes in their pants when splashed. Splashing was observed to occur when a worker wiped off the cord of his automatic machine. Some of the ingredients in the cleaning products, such as the glycol ethers, are readily absorbed by the skin. Others, such as sodium hydroxide, are corrosive. Many of the MSDSs recommend skin protection, including long rubber gloves, for direct contact with products. Additional skin protection is also recommended during major exposures to some of the products, such as strippers.

Several of the ESD workers reported increased symptoms in enclosed areas of the hospital, especially during the winter. None of the custodians reported using local exhaust or respiratory protection while cleaning. For some products, MSDSs recommend the use of local exhaust ventilation (LEV) if general ventilation is inadequate. According to an Energy Engineer in the University of Michigan's Faculty Utilities Department, air circulated throughout the hospitals is always composed of at least 20% outdoor air, in accordance with guidelines for hospitals promulgated by the American Society of Heating, Refrigeration, and Air–Conditioning Engineers (ASHRAE) and the Michigan Department of Public Health (MDPH). The main air handling units (AHUs) in the hospital supply areas with multiple uses, so that continuous ventilation is required in most areas. While the use of local exhaust ventilation is not likely to be feasible for floor maintenance, the Energy Engineer for the University recommends setting thermostats in individual rooms to minimum settings during floor care activities. This action will result in increased airflows into individual rooms via the variable air volume (VAV) delivery system.

Finally, over 80% of the employees interviewed expressed concerns about exposures to cleaning agents. Some of them also expressed concerns about needle stick injuries due to unsafe handling practices. Job instructions, however, did not consistently include the necessary personal protective equipment on lists of supplies needed.

CONCLUSIONS

- Concentrations of glycol ethers and ammonia detected in air samples collected during floor care activities were below applicable occupational exposure criteria.

- Although formaldehyde and acetaldehyde were detected in a few samples, the concentrations were well below OSHA and ACGIH criteria, and at levels which have been routinely measured in occupational and non–occupational environments.

- Glycol ethers contained in the cleaning products currently in use by the hosipital staff are not expected to cause long-term reproductive effects. Ethylene glycol butyl ether (EGBE) found in some of the cleaning products may cause hematoxic effects at higher levels than those detected during the NIOSH survey: the maximum EGBE concentration detected in a PBZ sample was approximately one–fifth the NIOSH REL for an 8–hour TWA exposure.

- Many of the cleaning products contained combinations of irritating agents, a factor which may contribute to worker irritation symptoms.

RECOMMENDATIONS

(1) The University should investigate the availability of less irritating cleaning products to replace the ones currently in use. Regardless, products in use and any new products should be carefully reviewed by an industrial hygienist. Each worker, whether of permanent or temporary status, should be educated in potential hazards from cleaning products and appropriate methods for controlling hazards. Workers should be aware of the significance of an MSDS and know how to access MSDSs particular to the cleaning agents they use. Employees should be encouraged to report any severe irritation to Employee Health Services.

(2) The Safety, Building, and Environmental Management Department should consider conducting further focused environmental testing. For example, additional PBZ samples could be collected during stripping/waxing and tested for irritant agents such as ethanolamine, trietholamine, sodium hydroxide, and potassium hydroxide. Exposure monitoring should be performed on an intermittent basis to determine floor care workers' exposures to chemical ingredients in the cleaning products.

(3) Because irritation can be uncomfortable and may interfere with workers' performance, workers should be trained on how to avoid exposures. Unless local exhaust ventilation (LEV) is found to be feasible, general ventilation should be increased by lowering thermostats in each area to minimum settings during stripping/waxing or other potentially irritating activities. This is especially recommended in enclosed areas. Thermostats should be reset when activities are finished.

(4) Eye protection should be used by ESD employees when working with cleaning agents, especially the undiluted formulas, strippers, and other heavy–duty products (see individual MSDSs for product–specific recommendations). Eye protection should also be worn to avoid exposure to body fluids.

(5) Gloves should be used by all employees when working directly with cleaning agents, especially the undiluted formulas, strippers, and other heavy–duty products. Gloves made from butyl rubber or Saranex™ should offer adequate protection from most of the chemicals present in the floor cleaning and waxing compounds.

(6) If exposed, the skin should be rinsed immediately following contact with any of these products. Uniforms for floor care custodians should include long pants and footwear made of a material that offers good resistance to penetration, thus reducing the potential for dermal exposures and deterioration of the custodians' personal clothing. The use of footwear or foot–coverings with non–skid soles would reduce the potential for accidental falls and strains.

(7) An effective hazard communication program is essential to a healthy work environment, and information and training are critical parts of the program. If workers express concern about not understanding hazards of their workplace, then the program is not effective. A better understanding of potential workplace hazards and open lines of communication should not only reduce worker exposures, but should also ameliorate anxieties about exposures that are not hazardous. Proceedings from the joint labor–management health and safety committee meetings (if not done so already) should be clearly communicated to employees. Input from employees should also be encouraged for setting goals and objectives and for determining actions to be taken.

(8) Due to the hazards associated with cut/puncture/laceration injuries, procedures for the disposal of body fluids and sharps should be reviewed with all hospital personnel. Correct procedures should be reinforced.

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Table 1
Average Absenteeism Rates Among Floor Care Workers
University of Michigan Hospitals – HETA 95–0313

Job Category	Number of Employees	Employee Average	
		Sick (hours)	Sick/No–Pay (hours)
ESD	396	79	11
Custodian II	139	74	8
Unit Custodian	229	76	10
Wall Washer	28	86	16
Floor Care	75	86	4

Notes:

This information was provided by the Environmental Services Department (ESD) for the period between October 1994 and October 1995.

Table 2
Standard Floor Care Program
University of Michigan Hospitals – HETA 95–0313

Task	Frequency	Applicator	Dilution	Product(s)
Dust Mopping	Daily	Hand held	n/a	n/a
Wet Mopping/Light Scrubbing	Daily	Hand held and automatic scrubber	1:64	View Neutral® Virex®
Spray Buffing	Daily	Automatic scrubber	n/a (spray product)	Snapback®
Burnishing	Daily	2,000 rpm burnisher	n/a	Sprint® or Snapback® Ultra High–Speed Restorer may be necessary
Scrubbing and Recoating with Automatic Scrubber	≥2 months	Automatic scrubber	1:64	View Neutral® GP Forward® Power Foam Bravo®
Stripping with Automatic Scrubber	1 to 3 times per year	Automatic scrubber	1:3 (Freedom)	Freedom® Speed Stripper Power Foam Bravo®
Stripping with Swing Machine	1 to 3 times per year	Automatic scrubber	1:4	Bravo® Stripper Freedom® Power Foam Bravo®

na = Not Applicable
Note:
The information on this table was consolidated from the Standard Floor Care Program prepared by the Environmental Services Department (ESD) and through informal discussions with University of Michigan officials.

Table 3
Main Active Ingredients for Cleaning Products
University of Michigan Hospitals – HETA 95–0313

Compound	CAS Number	Cleaning Products‡						
		Bravo® Stripper	Freedom® Speed Stripper	GP Forward® Cleaner	Bravo® Power Foam Remover	Snapback® Spray Buff	Snapback® UHS Restorer	Sprint®
Ethylene Glycol Monobutyl Ether (EGBE)	111–76–2	—	—	—	5 to 10%	—	—	—
Ethylene Glycol Monophenyl Ether (EGPE)	122–99–6	—	5 to 10%	—	—	—	—	—
Ethylene Glycol	107–21–1	—	—	—	—	—	—	—
Diethylene Glycol Monoethyl Ether (diEGEE)	111–90–0	—	1 to 5%	—	—	2 to 4%	—	1 to 2%
Dipropylene Glycol Methyl Ether (diPGME)	35590–94–8	—	—	—	—	—	5 to 10%	3 to 6%
Sodium Silicate (or metasilicate)	1344–09–8	3 to 6%	3 to 7%	0.1%	—	—	—	—
Potassium Hydroxide	1310–58–3	—	—	<0.1%	—	—	—	—
Monoethanolamine	141–43–5	3 to 6%	3 to 7%	3 to 6%	1 to 5%	—	—	—
Triethanolamine	102–71–6	—	—	—	—	0.1 to 1%	—	—
Alkylphenoxy Polyethoxyethanol	9016–45–9	—	—	1 to 4%	1 to 5%	1 to 3%	—	—
Tributoxyethyl Phosphate	78–51–3	—	—	—	—	—	1 to 4%	1 to 3%
Ammonium Hydroxide	1336–21–6	—	—	—	—	—	—	1 to 3%
Sodium Hydroxide	1310–73–2	3 to 5%	—	1 to 3%	1 to 5%	—	—	—
VOCs (isoparaffinic hydrocarbons)	64742–48–9	—	—	—	—	10 to 15%	—	—
Isobutane	75–28–5	—	—	—	5 to 10%	—	—	—
Protective Equipment Recommended for Diluted Product		Long rubber gloves, avoid breathing vapors†				N/A	N/A	N/A
Protective Equipment Recommended for Undiluted Product (or for prolonged or repeated use)		Eye protection				Skin and eye protection for major exposures	N/A	N/A
Health Effects for Diluted or Undiluted Product		Permanent eye damage, chemical burns, respiratory irritation				Only known hazards via ingestion	Skin irritation with pre–existing condition	N/A

† = Local exhaust ventilation or respiratory protection may be necessary if general ventilation is not adequate.
‡ = Information obtained from Material Safety Data Sheets (MSDSs) provided by S.C. Johnson and Mantek Chemicals. MSDSs are accessible to all workers in the Environmental Services Department office.

Table 4
Glycol Ethers: Physical Form, Uses, and Toxicity Information
University of Michigan Hospitals – HETA 95–0313

Substance	Synonyms	Physical Form	Uses	Toxicology	Exposure Criteria
Diethylene Glycol monoethyl ether (diEGEE)	2–(ethyoxyethoxy) ethanol Carbitol cellosolve®	Liquid is colorless; odor is pleasant; taste is bitter	As a solvent in lacquer and thinner formulations, quick drying varnishes, as a diluent in hydraulic brake fluids, and in cleaning products.	A moderate eye irritant. Overdose reported to cause central nervous depression, respiratory effects, nausea, vomiting, headaches, acute renal failure. Not a skin sensitizer.	OSHA PEL: None ACGIH TLV: None NIOSH REL: None Other: German occupational standard of 137 mg/m^3
Dipropylene glycol methyl ether (diPGME)	1–(2–methoxy–1–methleth oxy) 2–propanol Dowanol® DPM	Liquid is colorless; mild, ether odor bitter taste	As a component of industrial and consumer products such as hydraulic brake fluid, cosmetics, floor polishes, cleaners for surfactant oil spills, and pesticide formulations	A mild eye irritant. Not a skin sensitizer. Adverse central nervous system (CNS), liver, and kidney effects observed in animals exposed to concentrations of 1800 to 2400 mg/m^3 and higher.	OSHA PEL: 600 mg/m^3 ACGIH TLV: 606 mg/m^3 NIOSH REL: 600 mg/m^3
Ethylene Glycol monobutyl ether (EGBE)	2–butoxyethanol Butyl Cellosolve®	Liquid is colorless; mild, ether odor; taste is bitter	As a solvent in surface coating such as spray lacquers, enamels, and varnishes; as a coupling agent in household cleansers, as a component of herbicides and automatic brake fluids	Irritant of eyes and mucous membranes at concentrations greater than 500 m/m^3. Not a skin sensitizer. Hemotoxic (damage of blood forming system) in rodents. Adverse effects on CNS system.	OSHA PEL: 240 mg/m^3 ACGIH TLV: 121 mg/m^3 NIOSH REL: 24 mg/m^3 *Note: The OSHA PEL is for construction industry and is intended to prevent irritation.*

OSHA PEL = Occupational Safety and Health Administration Permissible Exposure Limit
ACGIH TLV = American Conference of Governmental Industrial Hygienists Threshold Limit Value
NIOSH REL = National Institute for Occupational Safety and Health Recommended Exposure Limit
mg/m^3 = Milligrams per cubic meter

Note: This information was primarily taken from the on–line Hazardous Substances Database (1995 version) and the following NIOSH documents pertaining to EGBE and PGME: [NIOSH, 1990] and [NIOSH, 1991].

Table 5
Results from Personal Breathing–Zone and General Area Air Samples for Glycol Ethers
University of Michigan Hospitals – HETA 95–0313

Sampling Location	Activity	Type of Sample	Sampling Time	Sample Volume (Liters)	Concentration, expressed in milligrams per cubic meter		
					DiEGEE	DiPGME	EGBE
Area B–1, Room 250	Stripping/waxing	PBZ	8:10 pm to 10:40 pm	7.5	Trace	1.5	ND
			8:10 pm to 10:44 pm	7.7	0.58	2.5	ND
Corridor 5A	Stripping/waxing	PBZ	9:03 pm to 11:33 pm	7.5	0.93	3.9	Trace
			7:44 pm to 11:33 pm	11.5	0.96	4.2	0.47
		GA	7:40 pm to 11:35 pm	118	3.3	12	1.8
	Before waxing	PBZ	7:44 pm to 9:03 pm	4.0	ND	Trace	5.3
MCHC Lobby	Stripping/waxing	GA	11:15 pm to 1:18 am	62	4.1	14	0.062
		PBZ	10:17 pm to 1:39 am	10	Trace	0.85	ND
			10:17 pm to 1:39 am	10	Trace	0.54	ND
6th Floor Center Corridor	General Cleaning	PBZ	9:35 pm to 12:55 am	10	ND	ND	ND
Minimum Detectable Concentration				10	0.1	0.1	0.1
Minimum Quantifiable Concentration				10	0.36	0.33	0.33
Evaluation Criteria and Other Information†							
Occupational Safety and Health Administration Permissible Exposure Limit (PEL)					NA	600	240
American Conference of Governmental Industrial Hygienists Threshold Limit Value (TLV)					NA	606	121
National Institute for Occupational Safety and Health Recommended Exposure Limit (REL)					NA	600	24
Estimated Odor Threshold (Minimum)					NA	210	0.48
Estimated Irritation Level					NA	450	NA

ND = Not detected (below the Minimum Detectable Concentration
NA = Not applicable
PBZ = Personal breathing–zone air sample
GA = General area air sample
Trace = Concentration is between the Minimum Detectable and Minimum Quantifiable Concentrations
DiEGEE = Diethylene glycol monoethyl ether
DiPGME = Dipropylene glycol methyl ether
EGBE = Ethylene glycol monobutyl ether
† = The odor threshold thresholds and irritation levels were from Ruth, 1986.

Table 6
Results from Personal Breathing–Zone Air Samples for Ammonia
University of Michigan Hospitals – HETA 95–0313

Sampling Location	Activity	Sampling Time	Sample Volume (Liters)	Ammonia Concentration, mg/m^3
Area B–1, Room 250	Stripping/waxing	8:10 pm to 10:40 pm	30	0.50
		8:10 pm to 10:44 pm	31	0.62
Corridor 5A	Stripping/waxing	7:43 pm to 11:32 pm	46	1.0
		7:43 pm to 11:32 pm	46	0.46
MCHC Lobby	Stripping/waxing	10:17 pm to 1:39 am	40	ND
		10:17 pm to 1:39 am	40	Trace
6th Floor Center Corridor	General Cleaning	9:35 pm to 12:55 am	40	ND
8th Floor Center Corridor	General Cleaning	9:45 pm to 2:00 am	51	ND
Minimum Detectable Concentration			40	0.10
Minimum Quantifiable Concentration			40	0.28
Evaluation Criteria				
Occupational Safety and Health Administration Permissible Exposure Limit (PEL)				35
American Conference of Governmental Industrial Hygienists Threshold Limit Value (TLV)				17
National Institute for Occupational Safety and Health Recommended Exposure Limit (REL)				18
Other Information†				
Estimated Odor Threshold (Minimum)				0.026
Estimated Irritation Level				72

mg/m^3 = Concentration of ammonia in milligrams per cubic meter
ND = Not detected (below the Minimum Detectable Concentration
Trace = Concentration is between the Minimum Detectable and Minimum Quantifiable Concentrations
† = The estimates for the odor threshold thresholds and irritation levels were obtained from Ruth, 1986.

Table 7
Results from Personal Breathing–Zone and General Area Air Samples for Aldehydes
University of Michigan Hospitals – HETA 95–0313

Sampling Location	Activity	Type of Sample	Sampling Time	Sample Volume (Liters)	Concentration, mg/m³‡	
					Acetaldehyde	Formaldehyde
Corridor 5A	Stripping/waxing	GA	7:40 pm to 11:45 pm	29	1.1	Trace
MCHC Lobby	Stripping/waxing	GA	11:15 pm to 1:18 am	12	0.45	ND
	Before waxing	GA	7:05 pm to 9:57 pm	17	ND	ND
	Near stripping/waxing	GA	10:20 pm to 1:14 am	17	ND	ND
8th Floor Center Corridor	General Cleaning	PBZ	9:45 pm to 2:00 am	26	ND	ND
Minimum Detectable Concentration				20	0.025	0.035
Minimum Quantifiable Concentration				20	0.085	0.11
Evaluation Criteria						
Occupational Safety and Health Administration Permissible Exposure Limit (PEL)					360	0.94
American Conference of Governmental Industrial Hygienists Threshold Limit Value (TLV)					45	0.37
National Institute for Occupational Safety and Health Recommended Exposure Limit (REL)					LFL▪	LFL▪
Other Information†						
Estimated Odor Threshold (Minimum)					0.0002	1.5
Estimated Irritation Level					90	1.5

mg/m³ = Concentration expressed in milligrams per cubic meter
ND = Not detected (below the Minimum Detectable Concentration
PBZ = Personal breathing–zone air sample
GA = General area air sample
† = The estimates for the odor threshold thresholds and irritation levels were obtained from Ruth, 1986.
Trace = Concentration is between the Minimum Detectable and Minimum Quantifiable Concentrations
‡ = Valeraldehyde, hexanal, heptanal, butylaldehyde, propionaldehyde, acrolein, and isovaleraldehyde were not detected in any of these samples.
LFL▪ = Lowest feasible level. NIOSH recommends that exposures be kept to their lowest feasible levels.

Table 8
Work-Related Symptoms of 17 Interviewed Environmental Services Department Employees
University of Michigan Hospitals - HETA 95-0313

Symptoms	Number of Workers
Headache	11
Dizziness	7
Eye Irritation	5
Poor Concentration	5
Nausea	4
Skin Rash	4
Sore Throat	4
Nose Irritation	3

Figure 1
Reconstructed Total Ion Chromatograms
From: Qualitative Analysis of Thermal Desorption Tubes for Volatile Organic Compounds
University of Michigan Hospitals - HETA 95-0313

Sampling Location:
5th Floor, Corridor 5A. The sample was positioned on a counter top adjacent to the hallway which was being cleaned and waxed.

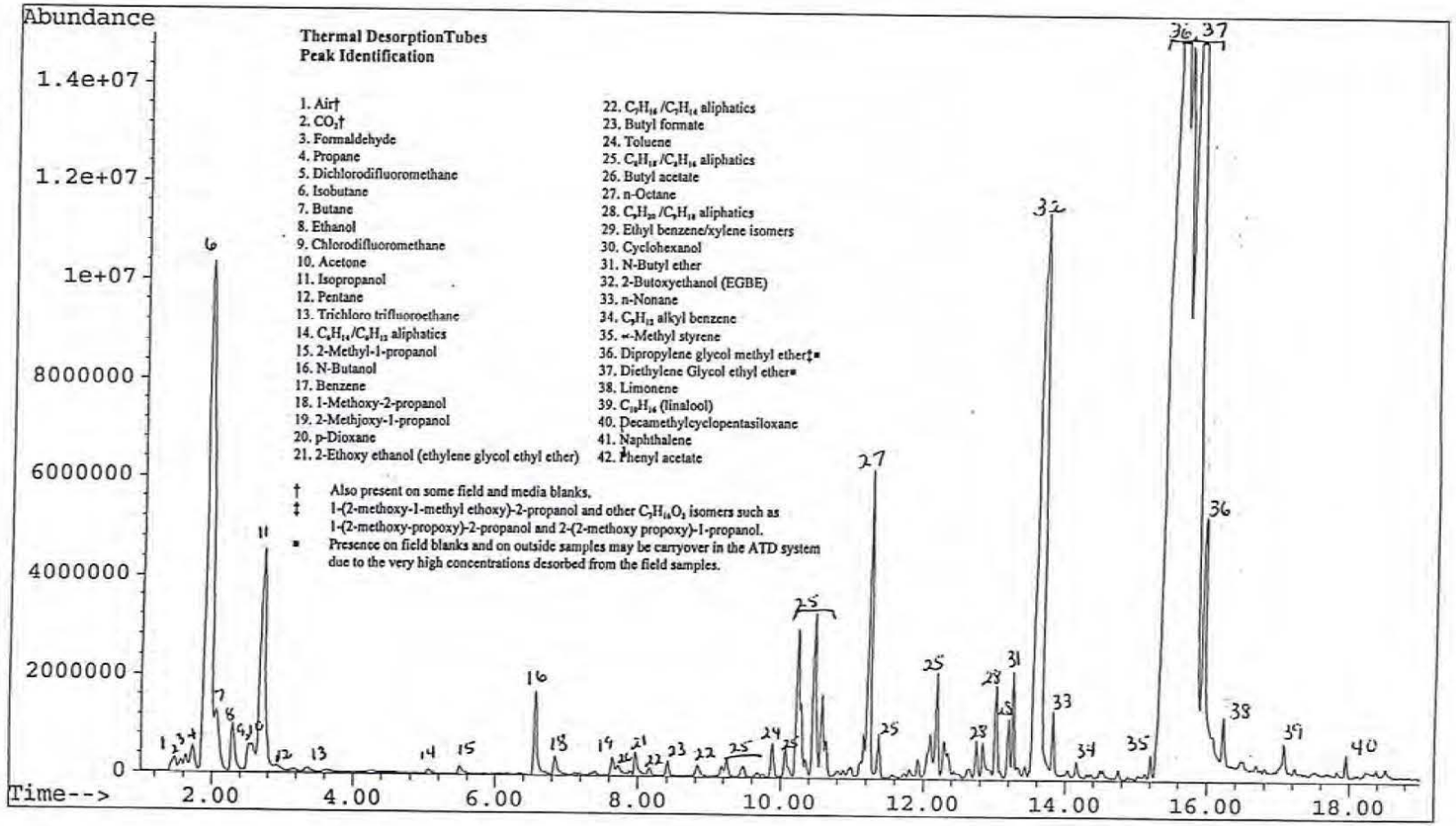


Figure 1, continued
Reconstructed Total Ion Chromatograms
From: Qualitative Analysis of Thermal Desorption Tubes for Volatile Organic Compounds
University of Michigan Hospitals - HETA 95-0313

Sampling Location:
Near MCHC lobby. Sample collected prior to waxing of the lobby floor.

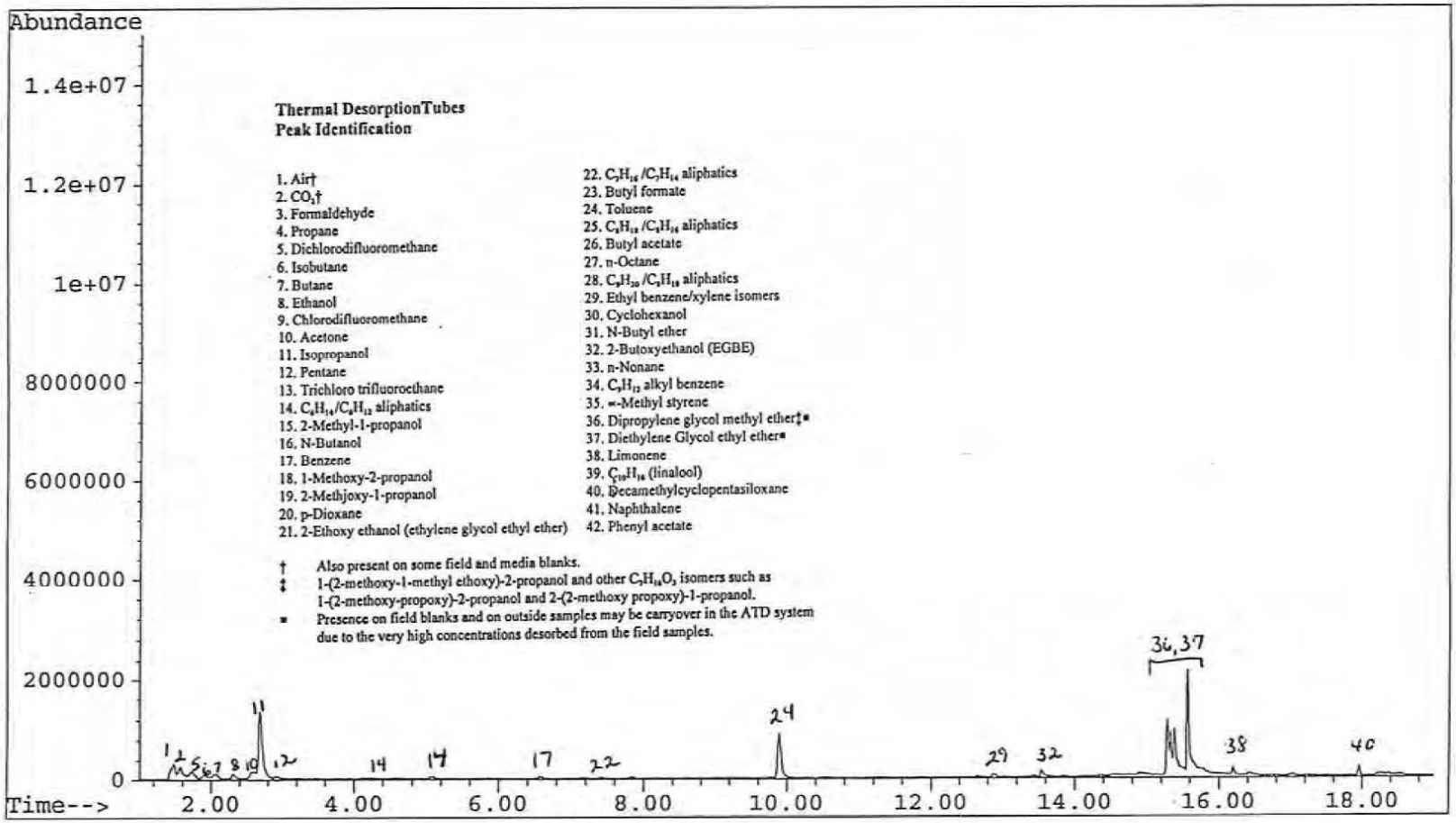


Figure 1, continued
Reconstructed Total Ion Chromatograms
From: Qualitative Analysis of Thermal Desorption Tubes for Volatile Organic Compounds
University of Michigan Hospitals - HETA 95-0313

Sampling Location:
In MCHC lobby. Sample collected during the waxing of the lobby floor.

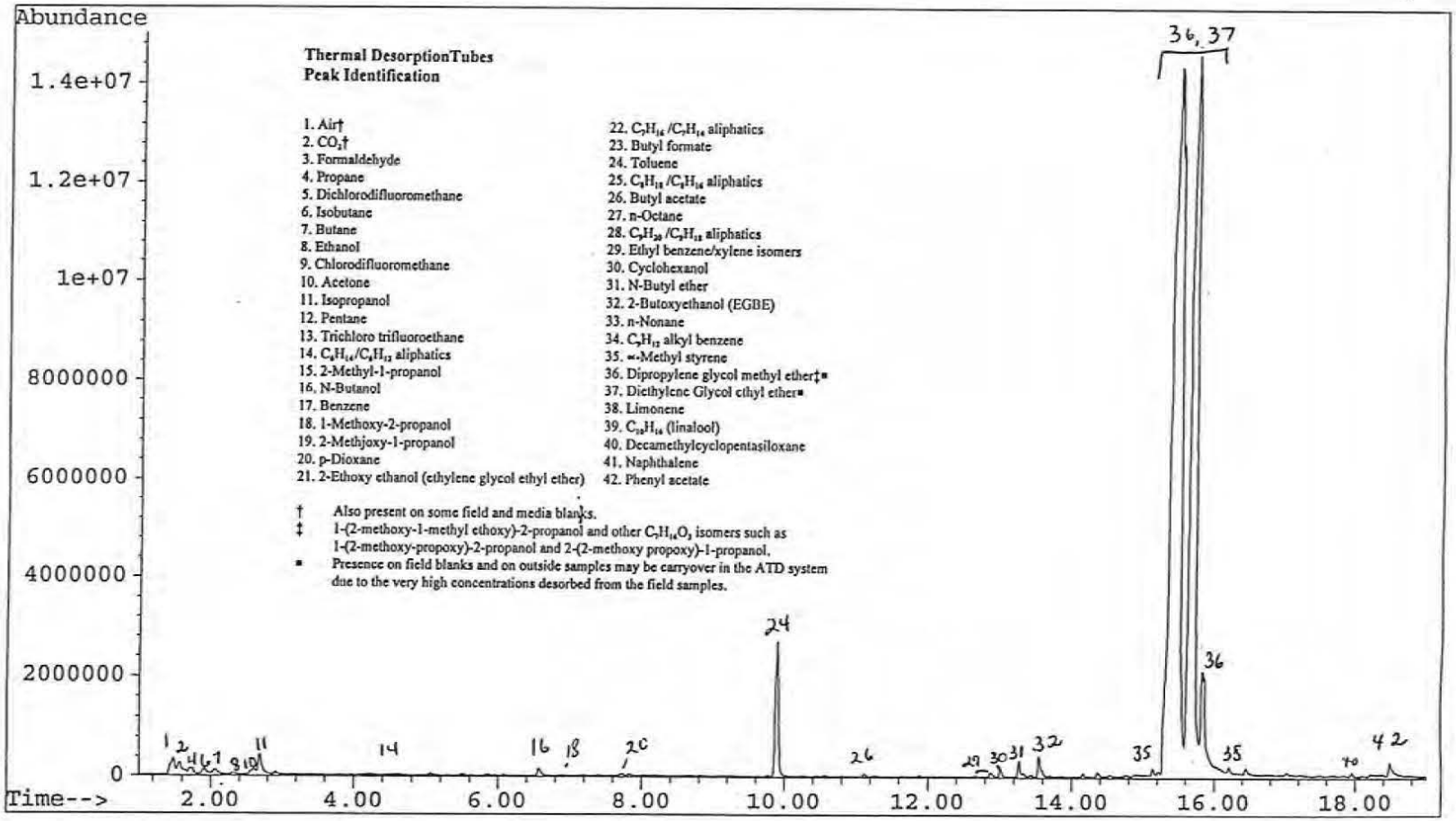
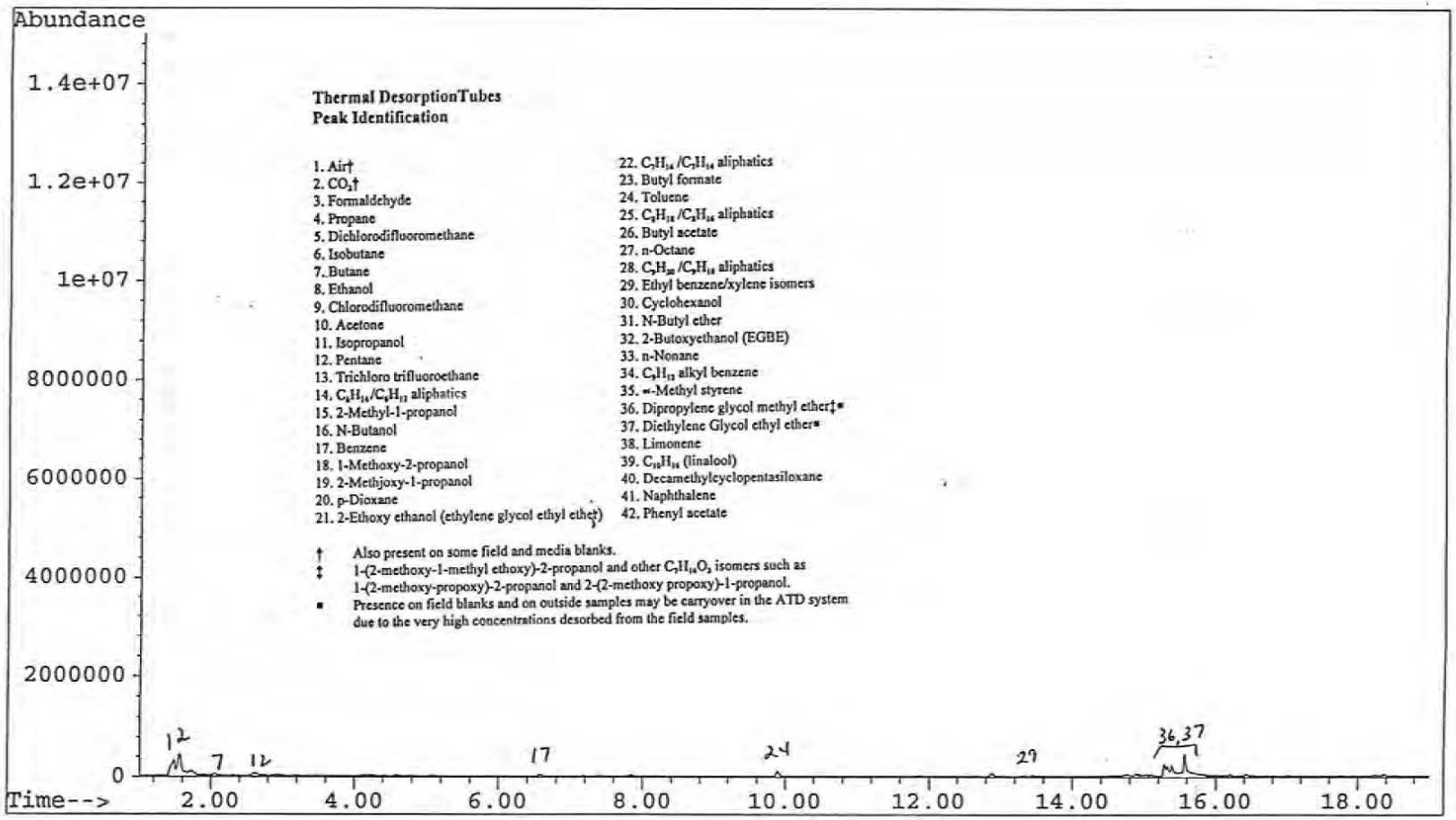


Figure 1, continued
Reconstructed Total Ion Chromatograms
From: Qualitative Analysis of Thermal Desorption Tubes for Volatile Organic Compounds
University of Michigan Hospitals - HETA 95-0313

Sample Location:
Outside the MCHC entrance to the hospital



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