HETA 2001-0059-2861
Boat America Corporation
Alexandria, Virginia

Kristin K. Gwin, M.S.
Debra M. Feldman, M.D.

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 employer 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 Kristin K. Gwin and Debra M. Feldman of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Analytical support was provided by Data Chem Laboratories, Inc. Desktop publishing was performed by Robin Smith. Review and preparation for printing were performed by Penny Arthur.

Copies of this report have been sent to employee and management representatives at Boat America Corporation and the OSHA Regional Office. This report is not copyrighted and may be freely reproduced. Single copies of this report will be available for a period of three years from the date of this report. To expedite your request, include a self-addressed mailing label along with your written request to:

NIOSH Publications Office
4676 Columbia Parkway
Cincinnati, Ohio 45226
800-356-4674

After this time, copies may be purchased from the National Technical Information Service (NTIS) at 5825 Port Royal Road, Springfield, Virginia 22161. Information regarding the NTIS stock number may be obtained from the NIOSH Publications Office at the Cincinnati address.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Highlights of the NIOSH Health Hazard Evaluation

Evaluation of the Boat Graphics Department

In February 2001, NIOSH investigators conducted a health hazard evaluation at Boat America Corporation's boat graphics department. We looked into employee concerns about potential exposures to compounds in the vinyl material used to make lettering and decals for boats.

What NIOSH Did

- We took air samples for toluene, ethyl acrylate, and volatile organic compounds (VOCs).
- We took temperature, relative humidity, and carbon dioxide measurements.
- We checked the ventilation by releasing a "smoke" to see air flows.
- We talked with graphics department employees about their health concerns.

What NIOSH Found

- Very low levels of toluene, well below the standards, were found in the air.
- No ethyl acrylate was found in the air.
- The VOCs found in the air were either in amounts too small to measure, or were found in extremely low levels.
- Average temperatures in the graphics department were for the most part within the recommended comfort range (68°-74°F in the winter).
- Average relative humidity levels in the graphics department were below the recommended comfort range (30%).
- All carbon dioxide measurements were greater than 800 parts per million. This suggests that too little outside air is being brought into the graphics department.
- Air was flowing into the graphics department. This helps to prevent any odors from escaping the graphics area.
- The existing exhaust fan in the graphics department does not remove odors well.
- No evidence was found to show chemical exposures in the workplace caused the symptoms reported.

What Boat America Corp.'s Managers Can Do

- Make sure the "on and off" times for the air handling unit (AHU) servicing the graphics department are carefully maintained and not manually adjusted.
- The heating, ventilation, and air-conditioning system should run at least 1 hour before to 1 hour after the occupants leave for the day.
- Check the outdoor air dampers to make sure they are adjusted properly to bring in enough outdoor air.
- Increase the amount of outdoor air to the graphics department.
- Reduce the amount of vinyl material stored directly in the graphics department.

What the Boat Graphics Department Employees Can Do

- Employees with health concerns should see their health care provider to determine the cause and proper treatment.

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 # 2001-0059-2861

Health Hazard Evaluation Report 2001-0059-2861
Boat America Corporation
Alexandria, Virginia
September 2001

Kristin K. Gwin, M.S.
Debra M. Feldman, M.D.

SUMMARY

In November 2000, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a health hazard evaluation (HHE) at the Boat America Corporation in Alexandria, Virginia. The request was prompted by health concerns, including severe nosebleeds, respiratory irritation, eye irritation, headaches, and nausea, suspected to be caused by the handling of the vinyl material used in the boat graphics department.

On February 23, 2001, NIOSH investigators conducted an environmental evaluation which included two full-shift personal breathing-zone (PBZ) air samples to assess worker exposure to toluene and ethyl acrylate. Six full-shift area air samples were also collected for volatile organic compounds (VOCs), toluene, and ethyl acrylate. Measurements of occupant comfort indicators (temperature, carbon dioxide [CO_2], and relative humidity [RH]) were also collected. In addition, qualitative ventilation measurements were performed to determine airflow patterns. The medical evaluation consisted of confidential employee interviews and a review of OSHA 200 injury and illness logs and medical records.

The full-shift PBZ samples revealed 8-hour time-weighted average (TWA) toluene concentrations of 0.04 and 0.05 parts per million (ppm). The full-shift area samples detected 8-hour TWA toluene concentrations ranging from 0.04 to 0.07 ppm. None of the air samples detected ethyl acrylate. All toluene concentrations were well below the most stringent occupational exposure criteria of 50 ppm. The predominant VOCs detected, toluene, ethyl hexyl acetate, and ethyl hexyl acrylate, were present in extremely low levels. Temperatures were generally within the winter range of 68°-74°F recommended by the American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE), but RH measurements were below the ASHRAE recommended range of 30% - 60%. All CO_2 measurements exceeded 800 ppm, a level indicating an inadequate amount of supplied outdoor air to the work area.

The employees interviewed (3 current, 1 former) all reported nosebleeds and headaches of varying intensity; one employee required an emergency department visit to control the bleeding. A review of the health concerns of all four employees was not found to be consistent with exposures at this work site.

NIOSH investigators conclude that a health hazard was not present in the boat graphics department at the time of the site visit. There was no evidence that the health problems reported by employees were related to an exposure unique in the work environment. Recommendations addressing the low RH levels and elevated CO_2 concentrations are included in the report.

Keywords: SIC 8999 (Services, Not Elsewhere Classified), vinyl, toluene, ethyl acrylate, VOC, ventilation, relative humidity, nosebleed, epistaxis, headache

TABLE OF CONTENTS

INTRODUCTION

In November 2000, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request to conduct a health hazard evaluation (HHE) to evaluate possible occupational exposure to emissions from the vinyl material used in the boat graphics department within Boat America Corporation in Alexandria, Virginia. The request was prompted by health concerns including severe nosebleeds, respiratory irritation, eye irritation, headaches, and nausea. In response to the request, NIOSH investigators completed a survey in February 2001. On February 23, 2001, NIOSH investigators held an opening conference with the Human Resources Director and an employee representative. Following this conference, a walk-through inspection of the boat graphics department was performed, after which NIOSH investigators concluded that since very light industrial work occurs in the graphics department, it was more similar to an office environment than a typical industrial environment. Environmental sampling appropriate for an indoor environmental quality (IEQ) investigation, along with confidential medical interviews, were conducted.

BACKGROUND

Building Description

Boat America Corporation is a membership organization for recreational boat owners that offers various services, including boat financing, marine insurance, on-the-water towing, trailering roadside assistance, retail stores, catalog and online services, custom-made decals and lettering, and membership discounts and rebates. There are approximately 500,000 members nationwide. Boat America employs approximately 1,500 people, with about 500 of those located at the headquarters office in Alexandria, Virginia. The headquarters is located in a 40-year old, two-story brick structure with approximately 90,000 square feet (ft^2) of indoor floor space, which is divided into an east, west, and center wing with a large courtyard area separating the majority of the east and west wing. Approximately 80% of the second floor was never developed into useable space. The majority of floor space is designated as office space, with a retail store housed in approximately 9,000 ft^2 of the building, and the remainder of the space used in a warehouse capacity. Boat America leased portions of the facility from 1974 until approximately 1983, at which time the purchase of the entire facility was completed.

The HHE request was generated from concerns within the boat graphics department, a small area (approximately 320 ft^2) adjacent to the retail store and office space. This department is separated into a work area and a small office. The work area consists of a workstation with two computers, a counter where the cutting machine and foil press are located, and a long work table opposite the counter. This department employs two people year-round from 8 a.m. to 5 p.m., Monday through Friday. During the busy season (March through June) two contractors are hired to work after 5 p.m. during the weekdays and during the weekends if needed. There were three current employees in the graphics department at the time of this survey.

Ventilation System

Heating and air-conditioning for the Boat America facility consists of 37 Trane® air-handling units (AHUs). The amount of outdoor air introduced into the building is manually controlled by adjustment of variable air volume box dampers. Boat America has a preventive maintenance agreement with Applied System, Inc., which includes filter changes on a quarterly basis.

The boat graphics department and office area adjacent to the department are served by one Trane® AHU housed in a mechanical room on the second floor above the department. It was reportedly installed in 1994 when the graphics

department was created. Supply diffusers and a ducted return are utilized for this area. The graphics department has four supply diffusers and the adjacent office area has seven. Both areas share a common return which is located in the graphics department. There are three vents near the ceiling that facilitate airflow between the two rooms. A facilities maintenance employee reported that the outdoor air intake for this AHU was located on the roof and the damper was fully open to provide 100% outdoor air. Temperature for this area is automatically controlled by a thermostat located in the department. The cycle times are pre-programmed during the week according to scheduled occupancy. The facilities maintenance employee stated that the temperature in the boat graphics department was not supposed to exceed 72°F at any time due to the vinyl materials stored in the room. However, the temperature was greater than 72°F on the day of the site visit, and employees were observed manually adjusting the thermostat throughout the day according to their comfort level. A small exhaust fan was installed in the ceiling of the graphics department (just to the right of the work table) to remove odors generated by the vinyl sheeting.

Process Description

The three employees in the boat graphics department take orders for custom boat lettering, decals, and signs by telephone, e-mail, fax, or directly from walk-in customers. During the off-season the number of orders received can range from approximately none to ten per day. During the busy season the number of orders can range from approximately 10 to 25 per day. The day shift employees take orders while the contractors who come in after 5 p.m. actually cut the designs and prepare them for shipment or customer pick-up.

After the order is received the image to be created is either scanned into a computer program after it is designed, or a template is used. The image is then sent to a program that operates the cutting machine. A vinyl roll is then placed into the machine and the design is automatically cut into the vinyl. After this process is completed, the material is taken to the work table where the excess vinyl backing is separated from the design. The front of the design logo is then covered with masking tape for protection during shipping. The design backing protecting the adhesive is not removed until the customer has received the product and is ready to apply. Graphics department employees are not exposed to the adhesive backing at any time.

The foil press is a machine that is used when the design requires different colors that fade into each other. This process is also automatically controlled by a computer program. Each process takes approximately one to five minutes, depending on the detail of the design. It was reported that from start to finish standard orders take approximately 10-15 minutes, whereas orders that require reflective vinyl material (common with towing projects) can take up to one hour. The vinyl material comes in 50-yard rolls (15" wide). One roll of each type and color of vinyl is stored in the graphics department in an open cabinet. The remaining supply is stored in a separate area.

The material safety data sheets (MSDSs) for three types of vinyl material used in the graphics department were reviewed. These included an adhesive coated vinyl film and pressure sensitive reflective film, both manufactured by Avery Dennison and available in a variety of colors. The components include plastic film (or film face material for the reflective film), paper liner, and adhesive (acrylic adhesive in the case of the reflective film). The MSDS for the adhesive coated vinyl film stated that no significant hazards were expected following routine handling of the product at room temperature. In addition, it stated that inhalation of fumes or vapors should be avoided when handling the product at elevated temperatures due to possible harmful effects from decomposition products. Fumes or vapors emitted at elevated temperatures were reported to possibly cause irritation of the nose, throat, and respiratory

tract, with symptoms including sore throat, coughing, or labored breathing, depending on the concentration and duration of exposure. It was also noted that although the nature and composition of the decomposition products had not been determined, they may include the following: plastic monomers, solvents, hydrogen chloride, metal oxides, carbon monoxide, carbon dioxide, and traces of incompletely burned products. The MSDS for the pressure sensitive reflective film stated that inhalation of vapors may cause slight irritation if vapors could be generated. It also stated that these vapors were not expected to present an inhalation hazard at room temperature.

The MSDS for the 3M™ Scotchlite™ relective sheeting series 280 & 280i included the following components: silicone/paper, glass microspheres, vinyl polymer, polyester, acrylic polymers, cross linking resins, and miscellaneous (ultraviolet absorber, heat stabilizer, etc.). In addition, a letter from a 3M Senior Product Responsibility Specialist stated that toluene and ethyl acetate were solvent carriers used to coat a trade secret pressure sensitive acrylate polymer adhesive. He stated that most of the solvent is volitalized from the vinyl sheeting during manufacturing via a "drying" process, but that some residual, including isooctyl acrylate, remains causing the sheeting to emit a solvent odor. Isooctyl acrylate has a low odor threshold in the parts per billion (ppb) range. The MSDS states that health effects from inhalation are not expected unless product is heated. If thermal decomposition occurs, upper respiratory irritation may occur, with symptoms including soreness of the nose and throat, coughing, and sneezing.

Previous Workplace Evaluations

The Virginia Occupational Safety and Health Administration (VOSH) conducted an inspection of the graphics department on November 13, 2000, in response to a complaint. NIOSH investigators reviewed a copy of the inspection file. The inspector stated that nothing used by employees was recognized to contain hazardous substances and that the manufacturers of the vinyl material stated that their products were not hazardous if properly used. It was also stated that although toluene, ethyl acetate, and isooctyl acrylate are present in the adhesive, they are present in levels too low to cause concern or warrant further monitoring. As a result, no environmental monitoring was performed and no violations of VOSH standards were issued.

METHODS

On February 23, 2001, a total of eight full-shift air samples (two PBZ and six area samples) for toluene and ethyl acrylate were collected in the following locations: the right and left sides of the workstation where the excess vinyl material is removed, next to the foil press machine, next to the cutting machine, inside the office located within the graphics department, and on top of the cabinet where the vinyl rolls are stored between use. The air samples were collected on coconut shell charcoal tubes at a nominal flowrate of 0.1 liter per minute (L/min). The charcoal tubes were desorbed with 1.0 milliliter (mL) of carbon disulfide and analyzed by a Hewlett-Packard Model 5890A gas chromatography equipped with a flame ionization detector (GC-FID). No analytical method is available for the analysis of both toluene and ethyl acrylate on the same sorbent media. Therefore, analysis was performed according to a combination of the conditions from NIOSH methods 1450 and 1501.[1,2]

In addition, two full-shift area air samples for VOCs were collected on thermal desorption tubes on the right side of the work station and between the foil press machine and cutting machine to capture any compounds that would be emitted as a result of either of these processes. It was thought that the greatest potential for organics to be emitted as a result of a heated process would be from the foil press and cutting machines.

Samples collected on the thermal desorption tubes were used as a qualitative screen to identify any major organic constituents that were present in the Boat Graphics Department. These samples were collected using battery-powered air sampling pumps calibrated to provide a volumetric flowrate of 0.05 L/min. The samples were analyzed in a Perkin-Elmer ATE 400 automatic thermal desorption system. The thermal unit was directly interfaced to an HP6890A gas chromatograph with an HP5973 mass selective detector.

Indicators of occupant comfort were measured at three locations within the graphics department and at two locations outside the department. Real-time CO_2, temperature, and RH measurements were taken using a TSI Q-Track®, Model 8550, hand-held, battery-operated monitor. This portable monitor uses a non-dispersive infrared absorption sensor to measure CO_2 in the range of 0-5000 parts per million (ppm), with an accuracy of ±50 ppm at 25°C. It is capable of measuring temperature in the range of 32 to 122°F, with an accuracy of 1°F. This instrument also measures RH in the range of 5 to 95%, with an accuracy of ±3%. Measurements were taken three times throughout the workday in the following locations: the boat graphics department manager's office, on a table just outside of the manager's office, and on a bookshelf outside of the graphics department.

Qualitative airflow measurements were performed using ventilation smoke tubes to determine airflow patterns. Airflow measurements were made at the entrance to the department, under the exhaust and supply vents in the department, and in the office area adjacent to the department.

All three current graphics department employees were interviewed as part of this evaluation. In addition, a former worker who had experienced problems while working in the graphics department was also interviewed. Employees were asked questions about their medical history as well as work practices.

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 increases 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),[3] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[4] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[5] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion.

OSHA requires an employer to furnish employees a place of employment that is free from

recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 91–596, sec. 5(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

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 STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Carbon Dioxide

CO_2 is a normal constituent of exhaled breath, and if monitored at equilibrium concentrations in a building, may be useful as a screening technique to evaluate whether adequate quantities of outside air are being introduced into an occupied space. The American National Standards Institute (ANSI)/American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE) Standard 62-1999, Ventilation for Acceptable Indoor Air Quality, recommends outdoor air supply rates of 20 cubic feet per minute per person (cfm/person) for office spaces and conference rooms, 15 cfm/person for reception areas, classrooms, libraries, auditoriums, and corridors, and 60 cfm/person for smoking lounges. Maintaining the recommended ASHRAE outdoor air supply rates when the outdoor air is of good quality, and there are no significant indoor emission sources, should provide for acceptable indoor air quality.

Indoor CO_2 concentrations are normally higher than the generally constant ambient CO_2 concentration (range 300-350 ppm). ASHRAE Standard 62-1999 recommends indoor concentrations less than 700 ppm above the outdoor air concentration for comfort (odor) reasons.[6] NIOSH recommends that indoor CO_2 concentrations not exceed 800 ppm. When indoor CO_2 concentrations exceed 800 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected.[7] It is important to note that CO_2 is not an effective indicator of ventilation adequacy if the ventilated area is not occupied at its usual level when the measurements are made.

Temperature and Relative Humidity

Temperature and RH measurements are often collected as part of an indoor environmental quality investigation because these parameters affect the perception of comfort in an indoor environment. The perception of thermal comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperatures.[8] Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. The ASHRAE Standard 55-1992, specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable.[8] Assuming low air movement, 60% RH and sedentary job tasks, the temperatures recommended by ASHRAE range from 68-74°F in the winter, and from 73-79°F in the summer. ASHRAE also recommends that RH be maintained between 30% and 60%.[8] Excessive humidity can support the growth of microorganisms, while low RH could possibly cause the eyes and upper respiratory tract to dry which may result in irritation.

Volatile Organic Compounds (VOCs)

Volatile organic compounds describe a large class of chemicals which are organic (i.e., contain 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.

Toluene

Toluene is a colorless liquid commonly used in the manufacture of paints, lacquers, adhesives, rubber, and in rotogravure printing and leather tanning. It is also used as a raw material in the synthesis of organic chemicals, dyes, detergents, and pharmaceuticals. Inhalation and skin absorption are the major occupational routes of entry.

The main effects reported with excessive inhalation exposures to toluene are central nervous system depression and neurotoxicity.[9] Studies have shown that subjects exposed to 100 ppm of toluene for six hours complained of eye and nose irritation, and in some cases, headache, dizziness, and a feeling of intoxication (narcosis).[10,11,12] No symptoms were noted below 100 ppm in these studies. There are a number of reports of neurological damage due to deliberate sniffing of toluene-based glues resulting in motor weakness, intention tremor, ataxia, as well as cerebellar and cerebral atrophy.[13] Recovery is complete following infrequent episodes, however, permanent impairment may occur after repeated and prolonged glue-sniffing abuse. Exposure to extremely high concentrations of toluene may cause mental confusion, loss of coordination, and unconsciousness.[14,15] Since toluene is a defatting solvent, repeated or prolonged skin contact will remove the natural lipids form the skin, which can cause drying, fissuring, and dermatitis.[9,16]

The OSHA PEL for toluene is 200 ppm for an 8-hour TWA. The NIOSH REL for toluene is 100 ppm for an 8-hour TWA. NIOSH has also set a recommended STEL of 150 ppm for a 15-minute sampling period. The ACGIH TLV® is 50 ppm for an 8-hour exposure level. This ACGIH TLV® carries a skin notation, indicating that cutaneous exposure contributes to the overall absorbed inhalation dose and potential systemic effects.

Ethyl Acrylate

The odor of ethyl acrylate vapor can be readily detected at 1 ppm and has been described as fairly strong and moderately irritating at 4 ppm.[17] Short-term exposure may cause irritation of the eyes, nose, throat, and lungs. Prolonged contact with the skin or eyes may result in severe damage. Skin sensitization as a result of prolonged exposure has been shown to occur in animals. Animal studies have also indicated that severe chronic effects may result from exposure to this substance. Rats exposed to levels of 70, 300, or 540 ppm of ethyl acrylate for up to 30 days showed accelerated mortality and pathologic changes in the lungs, liver, and kidneys. In those animals that developed pneumonia, renal and hepatic lesions were also seen. However, there have been no reports of human injuries from long-term exposure to concentrations ordinarily encountered in the work environment.[18]

NIOSH classifies ethyl acrylate as a potential occupational carcinogen, and as a result recommends that occupational exposure be limited to the lowest feasible concentration. The ACGIH TLV® is 5 ppm for an 8-hour exposure level. ACGIH also recommends a STEL of 15 ppm for an exposure duration not to exceed 15 minutes. The OSHA PEL for ethyl acrylate is 25 ppm averaged over an 8-hour work shift. The PEL includes a skin notation, indicating that cutaneous exposure contributes to the overall absorbed inhalation dose and potential systemic effects.

RESULTS

Industrial Hygiene Evaluation

The predominant compounds detected on the thermal desorption tubes were toluene, 2-ethylhexyl acetate, 2-ethylhexyl acrylate, limonene, isopropanol, acetone, trimethyl benzenes, decamethylcyclopentasiloxane, and various C_6-C_{15} aliphatic hydrocarbons. Other compounds detected included ethanol, xylene, methylene chloride, methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), butyl acetate, phenol, methoxyethanol, styrene, butyl cellosolve, butanol, and benzene. The concentrations of these predominant compounds were either insufficient to quantify, or were detected in extremely low levels, well below any relevant occupational exposure criteria.

None of the eight air samples collected in the graphics department yielded detectable levels of ethyl acrylate. The minimum detectable concentration (MDC) for ethyl acrylate at Boat America was 0.01 ppm. The area air samples collected for toluene revealed full-shift TWA concentrations ranging from 0.04 ppm to 0.07 ppm. The PBZ air samples revealed full-shift TWA concentrations of 0.04 ppm and 0.05 ppm. The toluene concentration in air was well below the most stringent occupational exposure criteria of 50 ppm.

Measurements taken in the late morning indicated average temperatures ranging from 72° to 75°F, average RH ranging from 21% to 23%, and average CO_2 concentrations ranging from 841 ppm to 1234 ppm. Afternoon temperatures averaged 77°F, RH averaged 20% to 22%, and average CO_2 concentrations ranged from 811 ppm to 1118 ppm. Measurements taken in the late afternoon indicated average temperatures ranging from 75° to 77°F, an average RH of 24%, and average CO_2 concentrations ranging from 881 ppm to 1297 ppm.

Figures 1 and 2 graphically illustrate the average CO_2 concentrations and RH levels, respectively, in each location for the three different time periods. Average temperature and RH levels in the boat graphics department remained relatively consistent with the office area surrounding the department. The RH levels in both areas were below the ANSI/ASHRAE specified range (30% to 60%) at which 80% or more of the occupants would be expected to find the environment thermally comfortable. The average CO_2 concentrations within the department were consistently higher than the adjacent office. All but two CO_2 measurements exceeded the NIOSH recommendation of 800 ppm.

Qualitative airflow measurements showed the graphics department to be under negative pressure in relation to the adjacent office area. The airflow measurements also demonstrated that the small exhaust fan in the ceiling of the graphics department was not efficient in exhausting air more than a few inches away from the fan.

Medical Evaluation

All three current graphics department employees, as well as a former worker who had experienced problems while in the graphics department, were interviewed. All described epistaxis (nosebleeds) of varying frequencies and intensity, and one had required hospital care for epistaxis. A review of the medical records of this individual did not reveal an etiology consistent with occupational exposure as the source of this problem.

Three of those interviewed experienced epistaxis at work and expressed concern that the work environment may contribute to the problem. Of those three, one felt certain that the work environment contributed while the others expressed an interest in knowing if the work environment could possibly contribute to their problem. In addition, two employees had histories of chronic sinusitis documented with their physicians.

Headaches are another symptom identified by three of the four employees interviewed. Of these, one had a previous history of tension and migraine headaches and did not attribute any headaches to the work environment. The other two employees described their headaches as mild and intermittent and all three had previously experienced at least one headache while working.

All of the employees interviewed described a noxious odor occasionally associated with the use of the vinyls, although none attributed any specific symptoms to that observation. The odor was most often mentioned in reference to the use of the reflective vinyls.

DISCUSSION AND CONCLUSIONS

Results from air sampling in the graphics department indicated that toluene and ethyl acrylate exposures were either not detectable or were extremely low, well below NIOSH, OSHA, and ACGIH exposure limits. The concentrations of the predominant organic compounds identified on the thermal tubes were insufficient to quantify, with the exception of toluene, which was detected in extremely low levels. These results were expected since no heated processes are used which could result in the release of compounds from the vinyl material. It should also be noted that decomposition of the vinyl material would not be occurring at the room temperatures that were observed in the graphics department.

Measured temperatures in the graphics department and adjacent office area were on average 1°F to 3°F above ASHRAE's recommended range for the winter months (68°-74°F). Temperature patterns were fairly consistent, with a gradual (2°F - 4°F) increase from the morning to the afternoon. Afternoon and evening temperatures remained consistent in both areas. Temperatures should remain uniform and stable during occupied times. RH levels measured in the graphics department and adjacent office were 6% to 10% below the lower limit recommended by ASHRAE Standard 55-1992 for occupant comfort (comfort range 30-60%). Although high humidity levels can lead to excessive moisture and therefore problems with microbial growth, low humidity can contribute to mucous membrane irritation. If the building is capable of being humidified, an engineering firm could be consulted concerning installation of a humidification system. However, any humidification system must be carefully planned and properly maintained to assure that indoor environmental quality is not adversely affected.[19]

The CO_2 concentrations in, and adjacent to, the graphics department consistently exceeded the NIOSH guideline of 800 ppm, a benchmark intended for office environments. NIOSH investigators had concluded that since very light industrial work occurs in the graphics department, it was more similar to an office environment than a typical industrial environment. Increased CO_2 in these areas suggests that the HVAC system is not providing outdoor air supply rates of at least 20 cfm/person, the amount recommended by ASHRAE Standard 62-1999 for office spaces.[6] Inadequate amounts of outdoor air can effect the occupants perceived comfort level. It should be noted, however, that the ASHRAE recommendation is based on an occupant density of 7 people per 1000 ft^2. Since the graphics department has a much lower occupancy density, the CO_2 concentrations may not be as accurate an indicator for ventilation adequacy, and could actually underestimate it.

In the ventilation assessment it was learned that the graphics department and surrounding areas are serviced by the same AHU, which uses manually controlled variable air volume box dampers. Qualitative ventilation measurements showed the graphics department to be under negative pressure in relation to adjacent areas (meaning that air is moving from the office area into the graphics department). This is a preferred situation because it should keep any odors that originate in the

graphics department from migrating into surrounding areas. It should also be noted that the capture effectiveness of the small overhead exhaust fan located in the ceiling of the graphics department is very minimal, meaning that any odors generated when excess vinyl material is removed from the design will not be captured and exhausted from the room.

Epistaxis (nosebleed) is a very common occurrence which ranges in severity from very minor and self-limiting to life-threatening, although the vast majority of nosebleeds are minor.[21] One study demonstrated that 60% of individuals report at least one episode within their lifetime.[20, 21] Excessive dryness of the mucosa and blood vessels of the front portion of the nasal septum is the most common cause for epistaxis.[22] This may be one of the explanations for the seasonal variation noted with epistaxis, occurring more frequently during the winter months.[23] As the air is heated, it dries the nasal mucosa and thin-walled blood vessels most commonly involved with epistaxis.

The primary concern of the employees in the graphics department was whether their occasional nosebleeds could be related to their work environment. For some employees, low RH levels in the workplace may be a contributing factor to epistaxis. For that reason, increasing the indoor humidity in the department may decrease the risk of nosebleeds. However, a review of the medical records revealed no relationship between the health problems of the interviewed employees and exposures from the workplace.

RECOMMENDATIONS

1. Maintain the programmed on and off cycle times for the AHU servicing the graphics department and adjacent office area to ensure the system is running, at a minimum, from 1 hour before the occupants arrive to 1 hour after the occupants leave for the day. They should not be manually adjusted. This should help decrease fluctuations in temperature, improve humidity control, and further dilute odors within the graphics department.

2. Periodically inspect the outdoor air damper systems. Any outdoor air dampers that are closed, not adjusted properly, or not functioning should be repaired.

3. To further reduce odors, excess vinyl material which would not be used during a typical work day should be stored in an adjacent ventilated area and not kept in the graphics department.

4. Ideally, the RH levels in the graphics department should be within the ASHRAE comfort guidelines. However, any humidification system must be carefully planned and properly maintained to assure that the indoor environmental quality will not be adversely affected. Steam humidifiers are the preferable method to humidify commercial spaces since the heated water kills nearly all of the organisms in the water. Before any humidification system is installed, however, a ventilation engineering firm should be contacted to evaluate the building and determine if the work areas can be properly humidified.

REFERENCES

1. NIOSH [1994]. Hydrocarbons, aromatic: method no. 1501. In: Elder PM, ed. NIOSH Manual of Analytical Methods. 4th rev. ed. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 84-100.

2. NIOSH [1994]. Esters I: method no. 1450. In: Elder PM, ed. NIOSH Manual of Analytical Methods. 4th rev. ed. Cincinnati, OH: U.S. Department of Health and Human Services,

Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 84-100.

3. NIOSH [1992]. Recommendations for occupational safety and health: compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

4. ACGIH [2001]. 2001 TLVs® and BEIs®: threshold limit values for chemical substances and physical agents. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

5. CFR [1997]. 29 CFR 1910.1000. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

6. ASHRAE [1999]. Ventilation for acceptable indoor air quality. Atlanta, GA: American Society for Heating, Refrigeration, and Air-conditioning Engineers. ASHRAE/ANSI Standard 62-1999.

7. NIOSH [1994]. NIOSH testimony to the U.S. Department of Labor: statement of the National Institute for Occupational Safety and Health. Presented at the public hearing on the proposed rulemaking on Indoor Air Quality, September 28, 1994. NIOSH policy statements. Cincinnati, OH: Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

8. NIOSH [1986]. Criteria for a recommended standard: occupational exposure to hot environments, revised criteria. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86-113.

9. Proctor NH, Hughes JP, Fischman ML [1991]. Lead. In: Chemical hazards of the workplace. 3rd ed. Philadelphia, PA: J.B. Lippincott Company, Philadelphia, pp 353-357.

10. WHO [1981]. Recommended health-based limits in occupational exposure to select organic solvents. Geneva: World Health Organization, Technical Report Series No. 664.

11. Benignus VA [1981]. Health effects of toluene: a review. Neurotoxicology 2:567-568.

12. Anderson I, et al. [1983]. Human response to controlled levels of toluene in six-hour exposures. Scand J Work Environ Health 9:405-418.

13. EPA [1983]. Health assessment document for toluene. NTIS. Washington, DC: Environmental Protection Agency.

14. Bruckner JV, Peterson RG [1981]. Evaluation of toluene and acetone inhalant abuse I. Pharmacology and pharmacodynamics. Toxicol Appl Pharmacol *61*:27-38.

15. Bruckner JV, Peterson RG [1981]. Evaluation of toluene and acetone inhalant abuse II. Model development and toxicology. Toxicol Appl Pharmacol 61:302-312.

16. NIOSH [1973]. Criteria for a recommended standard: occupational exposure to toluene. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 73-11023.

17. American Industrial Hygiene Association [1966]. Ethyl acrylate. Hygienic Guide Series. Detroit, Michigan.

18. NIOSH [1978]. Occupational health guideline for chemical hazards. Cincinnati, OH: U.S. Department of Health and Human Services,

Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH)/DOL (OSHA) Publication No. 81–123 and supplements 88–118, 89–104.

19. IAQ Update [1991]. The role and control of humidity in IAQ. Indoor Air Quality Update. Arlington, MA: Cutter Information Corporation 4(7):1-5.

20. Doyle DE [1986]. Anterior Epistaxis: a new nasal tampon for fast, effective control. Laryngoscope 96 (3):279-81.

21. Chopra R [2000].Epistaxis: a review. The Journal of the Royal Society for the Promotion of Health. 120 (1):31-33.

22. Anim JT, Baraka ME, et al. [1988]. Morphological alterations in the nasal mucosa in heat stroke. Journal of Environmental Pathol Toxicol Oncol. 39:39-47.

23. Manfredini, R et al. [2000]. Seasonal Variation in the Occurrence of Epistaxis. The American Journal of Medicine. 108(9):759-760.

Figure 1. CO_2 Levels in the Boat Graphics Department

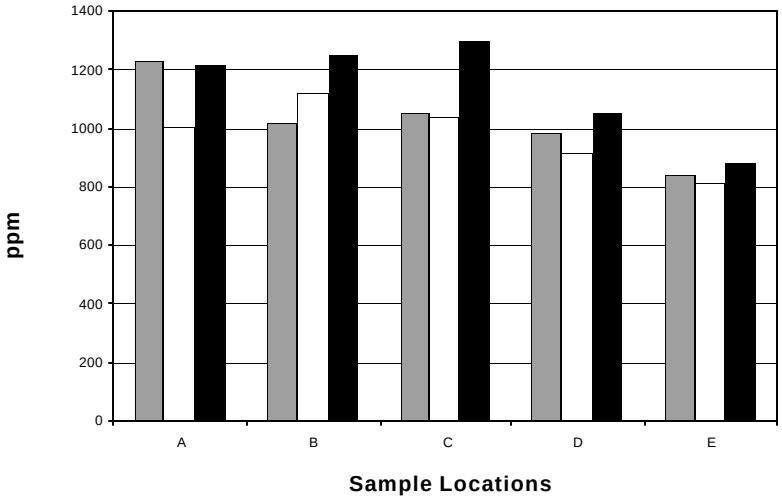
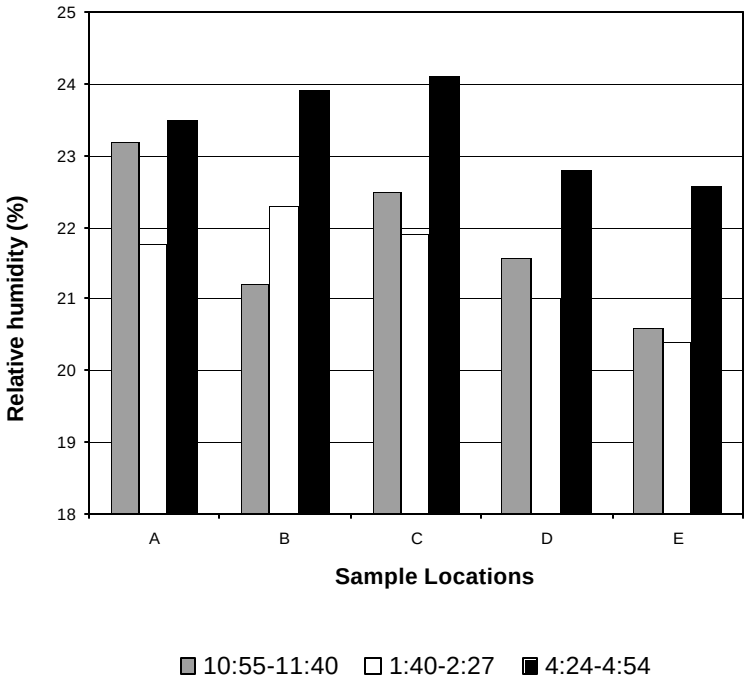


Figure 2. Relative Humidity in the Boat Graphics Department



The corresponding locations for both figures are as follows:

Location A: In the work area by the cutting machine
Location B: Manager's Office
Location C: On the work table

Location D: On a cabinet just outside the Boat Graphics Department
Location E: On a table outside the office area where the Boat Graphics Department is located

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Ceters for Disease Control and Prevention
National Institute for Occupational Safety and Health
4676 Columbia Parkway
Cincinnati, OH 45226-1998

OFFICIAL BUSINESS
Penalty for private use $300

National Institute for Occupational Safety and Health
NIOSH

Delivering on the Nation's promise: Safety and Health at work for all people through research and prevention

To receive NIOSH documents or information about occupational Safety and Health topics contact NIOSH at:

1-800-35-NIOSH (356-4675) Fax:
1-513-533-8573 E-mail: pubstaft@cdc.gov
or visit the NIOSH web site at:
www.cdc.gov/niosh/homepage.html

SAFER • HEALTHIER • PEOPLE™

SAFER • HEALTHIER • PEOPLE™ SAFER • HEALTHIER • PEOPLE™