

**HETA 93-0562-2464  
OCTOBER 1994  
OHIO UNIVERSITY  
ATHENS, OHIO**

**NIOSH INVESTIGATORS:  
John Kelly, M.S.  
Thomas Van Gilder, M.D.**

## **I. SUMMARY**

In January 1993, the National Institute for Occupational Safety and Health (NIOSH) received a request from Ohio University for technical assistance in evaluating workers' exposures to organic solvents during the removal of asbestos-containing tile mastic. On May 12, 1993, industrial hygiene personnel at Ohio University collected personal breathing zone (PBZ) air samples and end-of-shift urine samples from workers. NIOSH provided the sampling equipment and analyzed the samples.

Nine PBZ air samples were collected and analyzed quantitatively for 2-butoxyethanol (2-BE) and refined petroleum solvent (RPS). Twelve end-of-shift urine samples were collected and analyzed quantitatively for butoxyacetic acid (BAA), a metabolite of 2-BE.

Workers' PBZ exposures to 2-BE ranged from 8.9 to 95 milligrams per cubic meter ( $\text{mg}/\text{m}^3$ ), with an arithmetic mean and median of 53 and 60  $\text{mg}/\text{m}^3$ , respectively. Workers' exposures to RPS ranged from 56 to 760  $\text{mg}/\text{m}^3$ , with an arithmetic mean and median of 450 and 510  $\text{mg}/\text{m}^3$ , respectively. Average exposures to both 2-BE and RPS were above the NIOSH recommended exposure limits (RELs) of 24 and 350  $\text{mg}/\text{m}^3$ , respectively.

Urine concentrations of BAA ranged from 0.42 to 330 milligrams/gram creatinine. These results demonstrate that 2-BE was absorbed into the workers' bodies despite the use of respirators equipped with organic vapor cartridges.

Workers' average PBZ exposures to 2-BE and RPS were above the NIOSH RELs. In addition, dermal exposures might have significantly contributed to workers' overall exposures. Recommendations for controlling exposures, including the use of chemical protective clothing, are provided in section VIII of this report.

**KEYWORDS:** SIC 1799 (Special Trade Contractors. Not Elsewhere Classified); tile mastic; asbestos abatement; solvents; ethylene glycol monobutyl ether; 2-butoxyethanol; butyl cellosolve.®

## **II. INTRODUCTION**

In January 1993, the National Institute for Occupational Safety and Health (NIOSH) received a request from Ohio University for technical assistance in conducting an evaluation of workers' exposures to organic solvents during the removal of asbestos-containing tile mastic.

During the months of February and March, NIOSH investigators attempted to visit the job site, but scheduled visits were cancelled because of unexpected changes in tile-removal dates. Because of concerns that the abatement project would be completed before a site visit could be coordinated, the NIOSH investigators and the Environmental Safety Coordinator at Ohio University decided that the samples should be collected by an industrial hygiene team consisting of personnel already at the job site.

In April, NIOSH provided sampling equipment to Ohio University's Health and Safety Department. On May 12, an industrial hygiene team, consisting of the Environmental Safety Coordinator at Ohio University and the environmental consultant for the abatement project, collected personal breathing zone (PBZ) air samples and end-of-shift urine samples from workers. The analysis of the air and urine samples was completed by NIOSH in July 1993, and February 1994, respectively. Information in this report regarding the use of personal protective equipment and work procedures or practices during tile mastic removal was reported to NIOSH by the Environmental Safety Coordinator at Ohio University.

## **III. BACKGROUND**

A contractor was employed by Ohio University to remove asbestos-containing materials (ACM) from Copeland Hall, a five-story structure built in 1956. The project included the removal of acoustical plaster, thermal system insulation, and floor tile. The floor tile removal included removal of the tile mastic, the adhesive which bonds the tile to the floor.

Sentinel 747™, a mixture of refined petroleum solvents (RPS) and 2-butoxyethanol (2-BE), was used to remove the mastic. Removal was performed under containment, with outside walls and doorways sealed off with polyethylene plastic and air filtration devices (AFDs) used to maintain negative pressure in the containment area.

The abatement crew consisted of 10 workers, 9 of whom worked inside the containment on the day of sampling. Removal was performed by first pouring the solvent onto the floor surface from a 5-gallon container, agitating the mastic-coated surface for approximately 10 minutes using heavy-bristle push brooms, collecting the mixture of solvent and dissolved mastic using a squeegee and a shovel, and then placing this mixture into the empty 5-gallon containers. The 5-gallon containers were double-bagged for disposal as ACM.

## Page 3 - Health Hazard Evaluation Report No. 93-0562

During the removal of the mastic, workers inside containment wore coveralls and half-face air-purifying respirators (APRs), which were provided by the employer. The coveralls were made of 100% spun-bonded polypropylene or Tyvek (depending on which one the worker preferred). The respirators were equipped with combination cartridges consisting of a high-efficiency particulate air (HEPA) filter coupled with an organic vapor cartridge. Workers also wore cotton gloves and rubber boots. Eye protection was not worn by any of the workers.

### IV. METHODS

The objective of the study was to measure workers' exposures to 2-BE and RPS. Air monitoring was performed to measure potential inhalation exposures. Biological monitoring was performed to determine if 2-BE had been absorbed into the workers' bodies.

#### Questionnaire

A questionnaire was distributed to each of the crew members, the environmental consultant, and the Environmental Safety Coordinator at Ohio University, to obtain information about demographics, work history, medical history, personal protective equipment use, personal habits, and hazard communication training.

#### Air Monitoring Method

Personal breathing zone (PBZ) air samples were collected from the nine workers inside the containment using a modification of NIOSH Method 1500.<sup>1</sup> The air inlet of the samplers was located at the workers' collars, outside their respirators. Sample air was drawn through a 150 milligram (mg) charcoal tube at a flow rate of 50 cubic centimeters per minute milliliters (ml). Each PBZ sample consisted of two charcoal tube samples, one collected in the morning and the other collected in the afternoon. Sample periods are provided in Table 1. A bulk sample of the solvent was analyzed qualitatively by gas chromatography combined with mass spectroscopy (GC-MS). Based on the results from the qualitative analysis, the PBZ samples were analyzed quantitatively by GC for 2-BE and RPS. The solvent used for desorption of the analytes from the charcoal was 5% isopropanol in carbon disulfide. The isopropanol was added to improve the desorption of 2-BE from the charcoal. Analysis standards for RPS were made using the bulk solvent. The limits of detection (LOD) provided by the laboratory were 0.007 and 0.03 milligrams (mg) per sample for 2-BE and RPS respectively. The limits of quantitation (LOQ) provided by the laboratory were 0.022 and 0.095 mg per sample for 2-BE and RPS respectively. For the purpose of calculating 8-hour time-weighted-average (TWA) exposures, workers' exposures outside the containment zone were assumed to be negligible (PBZ air monitoring was only conducted during work performed inside containment). This assumption was based on the results from the area sample collected next to the containment

## Page 4 - Health Hazard Evaluation Report No. 93-0562

area. Additionally, when not in the containment area, workers reportedly were either outside the building or at a considerable distance from the containment area.

### Biological Sampling Method

End-of-shift urine samples were collected on May 12 from the nine crew members working inside the containment area, the one crew member working outside the containment area, the environmental consultant for the project, and the Environmental Safety Coordinator at Ohio University. The samples were collected in sterile urine containers, poured into two vials (for a total of 24 vials), and immediately placed on ice. The samples were shipped frozen by overnight mail to NIOSH on May 13. From May 14, 1993, until analysis was completed on February 22, 1994, the samples were stored at  $-70^{\circ}\text{C}$ .

Sample preparation was performed as follows. First, 200 microliters ( $\mu\text{l}$ ) of sample, contained in a culture tube with a teflon-lined cap, was diluted with 1.8 ml of 0.1 tetrabutylammonium hydrogen sulfate in 0.2 M phosphate buffer at pH 6. Two ml of methylene chloride and 10  $\mu\text{l}$  of pentafluorobenzyl bromide were added to this solution. Each sample was then tumbled for 20 hours. Next, 1.5 ml of the lower methylene chloride layer was transferred to a separate tube, and the methylene chloride was evaporated off under nitrogen. One ml of a 2-propanol/toluene mixture (1:1 v/v) was added to the residue in the tube, and the mixture was sonicated for 5 minutes. The sample extract was then transferred to an amber crimp-capped injection vial for analysis.

The sample extract was analyzed by gas chromatography (GC) equipped with an electron capture detector. The samples were analyzed for pentafluorophenylmethyl butoxyacetate, the derivative formed during sample preparation. The sample injection volume was 2  $\mu\text{l}$ . Calibration over the range of the field samples was performed using standards of pentafluorophenylmethyl butoxyacetate in toluene. The pentafluorophenylmethyl butoxyacetate in the standards was synthesized and purified in the NIOSH laboratory.

Creatinine levels in the urine samples were determined using a kinetic modification of the Jaffe reaction. Triplicate analysis of each sample was performed. Butoxyacetic acid (BAA) levels were then normalized to the creatinine levels.

Quality control (QC) samples were used to determine % recovery for the method. The range of BAA concentrations (0.27 to 2700 micromolar) for the QC samples covered the range of concentrations measured in the field samples. Stability of samples over time was determined by dispensing seven samples from a 760 micromolar urine stock solution of BAA into sample bottles, and storing these samples with the field samples from May 1993 until analysis in February 1994.

## V. EVALUATION CRITERIA

### General

In evaluating the hazards posed by workplace exposures to chemical and physical agents, NIOSH field staff use various environmental evaluation criteria. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to ten hours per day, 40 hours per week, for a working lifetime without experiencing adverse health effects. However, the criterion may not protect workers who are more susceptible to the exposure agent, such as those with a pre-existing medical condition. Furthermore, these criteria generally do not account for the combined effects that some hazardous substances have with other factors, such as other workplace exposures, ambient or residential exposures, medications, or the personal habits of the worker. Also, these criteria generally do not account for multiple exposure routes. For example, in addition to inhalation exposures of chemical agents, the exposure route for which most criteria are developed, some compounds are absorbed by direct contact with the skin and mucous membranes, which can increase the overall exposure. Finally, evaluation criteria may not reflect what is currently known about the exposure agent.

The primary sources of environmental evaluation criteria for workplaces in the construction industry are: (1) NIOSH Criteria Documents and Recommended Exposure Limits (RELs),<sup>2</sup> (2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs),<sup>3</sup> and (3) the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs) for the construction industry. For most chemicals regulated by OSHA, these PELs are the same as the 1970 ACGIH TLVs<sup>4</sup>, which OSHA adopted for the construction industry.<sup>5</sup> The OSHA exposure limits may be required to take into account the feasibility of controlling exposures in various industries where the agents are used, while the NIOSH-recommended exposure limits are based primarily on concerns relating to the prevention of occupational disease. Employers are legally required to comply with OSHA standards and meet those levels specified by OSHA PELs.

The NIOSH RELs, OSHA PELs, and ACGIH TLVs are TWAs. A TWA exposure refers to the average airborne concentration of a substance over a defined period of time. An 8- to 10-hour TWA refers to the airborne concentration of substance measured during a normal workshift. Some substances have recommended short-term exposure limits (STELs) or ceiling values (C) which are intended to supplement the TWA exposure limit where there are recognized toxic effects from high, short-term exposures. A STEL is defined as a 15-minute TWA exposure limit which should not be exceeded at any time during the workshift even if the 8-hour TWA exposure is within the established criterion. Ceiling values are instantaneous concentrations which should not be exceeded at any time during the work shift.

## Page 6 - Health Hazard Evaluation Report No. 93-0562

In comparing the air sampling results to the exposure criteria, the reader should be aware that the criteria are intended to be used as general guidelines and do not define an exact level of safety. Also remember that environmental monitoring was conducted over a relatively short period of time and that workers' exposures are likely to vary. The results obtained in a short-term evaluation of this type should not be considered definitive. In general, exposure measurements which approach or exceed exposure criteria indicate the need for improved controls and further evaluation.

### **2-Butoxyethanol**

2-butoxyethanol, also known as ethylene glycol monobutyl ether (EGBE) and Butyl Cellosolve,<sup>®</sup> is a colorless liquid with a mild ether odor. Inhalation of 2-BE has been reported to cause eye and mucous membrane irritation in humans at air concentrations of approximately 500 milligrams per cubic meter ( $\text{mg}/\text{m}^3$ ), and to be hematotoxic\* in animals (rodents).<sup>6</sup> The NIOSH REL is  $24 \text{ mg}/\text{m}^3$  as an 8-hour TWA. This value was calculated by extrapolation of animal toxicity data (rats). It is intended to prevent hematotoxicity, but should also prevent eye and mucous membrane irritation. The OSHA PEL is  $240 \text{ mg}/\text{m}^3$  as an 8-hour TWA for the construction industry. This level was intended to prevent irritation.<sup>7</sup>

In addition to uptake from inhalation exposures, 2-BE is absorbed through the skin.<sup>8</sup> For this reason, uptake from dermal absorption should also be considered when evaluating workers exposures to 2-BE. One method of evaluating combined exposure routes, such as dermal and inhalation in this case, is biological monitoring. Biological samples, such as urine or blood, are collected from workers and analyzed for the compound of exposure or a metabolite. For 2-BE, the urine concentration of butoxyacetic acid (BAA), a metabolite of 2-BE, can be used to confirm the recent uptake of 2-BE. However, the level of BAA excreted in the urine may be influenced by factors other than the level of exposure, such as work load (increasing work load may increase 2-BE uptake, leading to increased BAA excretion), ethanol consumption (which may decrease urinary BAA excretion), and other individual factors which influence urine concentrations of many metabolites (for example, fluid intake). The relationship between specific urinary BAA levels and air concentrations of exposures to 2-BE is uncertain. However, NIOSH estimated that in the absence of skin exposure, an end-of-shift urine BAA concentration of  $60 \text{ mg}/\text{g}$  creatinine approximates the concentration that would result following an 8-hour TWA exposure to 2-BE of  $24 \text{ mg}/\text{m}^3$ .<sup>6</sup>

### **Refined Petroleum Solvents**

---

\* Toxic damage of the blood forming system.

## Page 7 - Health Hazard Evaluation Report No. 93-0562

The term refined petroleum solvents refers to organic solvents derived from the refining of crude oil, usually through fractional distillation. NIOSH recommends an exposure limit of 350 mg/m<sup>3</sup> as an 8-hour TWA for RPS that contain less than 20% aromatic hydrocarbons.<sup>9</sup> This recommendation was based on toxicity data that related animal and human exposures to eight mixtures of organic solvents with resulting health effects. Of these mixtures, the one closest in composition to Sentinel 747™ is "140 flash aliphatic solvent," a class of Stoddard solvent comprised of approximately 96% aliphatic hydrocarbons with five to twelve carbon atoms, and the remaining 4% comprised of aromatic hydrocarbons. The REL of 350 mg/m<sup>3</sup> for Stoddard solvent is intended to prevent sensory irritation and long-term health effects that include renal and nervous system toxicity. The OSHA PEL for Stoddard solvent is 1150 mg/m<sup>3</sup> for the construction industry. This level was intended primarily to prevent irritation.<sup>7</sup>

Dermal exposure to Stoddard solvents, and organic solvents in general, are capable of causing irritant contact dermatitis (inflammation of the skin). The clinical signs associated with solvent exposures may include reddening, scaling, and fissuring of the skin.<sup>10</sup> In addition, dermatitis can reduce the effectiveness of the skin as a protective barrier to the absorption of chemicals, thereby increasing the potential for exposure.<sup>11</sup>

## VI. RESULTS

### Questionnaire

On the day of sampling, the abatement crew removing the tile mastic consisted of 9 Hispanic men with a median age of 36 years (range 21-42), and an average length of time working for the contractor of 1.5 years (range 1 month-3 years). On the day of sampling, they worked between six and seven hours inside the containment area. All nine workers reported that they had received training from an outside educator about the hazards of working with mastic remover, and that they ate lunch on site on May 12. Three other workers (two white and one Hispanic), who ranged in age from 25 to 41, provided support for the containment crew. One maintained area control and supplies, one was the Environmental Safety Coordinator for Ohio University, and the other was the environmental consultant who spent periods of time inside the containment area while performing air sampling. Two of them ate lunch on site; one in the cafeteria, the other in a room remote from the containment area. The third worker did not eat on site.

### Air Monitoring

Workers' PBZ exposures to 2-BE ranged from 8.9 to 95 mg/m<sup>3</sup> with an arithmetic mean and median of 53 and 60 mg/m<sup>3</sup>, respectively. Workers' exposures to RPS ranged from 56 to 760 mg/m<sup>3</sup>, with an arithmetic mean and median of 450 and 510 mg/m<sup>3</sup>, respectively. Average

## Page 8 - Health Hazard Evaluation Report No. 93-0562

exposures to both 2-BE and RPS were above the NIOSH RELs of 24 and 350 mg/m<sup>3</sup>, respectively. The exposures for each worker are provided in Table 1.

### Biological Monitoring

BAA concentrations in the urine samples collected from the 10 persons who worked inside the containment area, 9 crew members and the environmental consultant, ranged from 21 to 330 mg/g creatinine, with an arithmetic mean and median of 120 mg/g creatinine. The concentration of the samples collected from the two persons who did not enter the containment area, the remaining crew member and the Environmental and Safety Coordinator, were less than 4 mg/g creatinine. The urine concentrations for each worker are provided in Table 1.

The percent recovery of the analytical method ranged from 80 to 100% depending on the analysis set. The results listed in Table 1 were corrected for percent recovery. The average loss due to storage was 20%. However, because of the large variability in these results (95% confidence limits of 0 to 51% loss) the true value is unknown. The results listed in Table 1 are not corrected for percent loss due to storage.

## VII. DISCUSSION

The air monitoring results indicate that the majority of workers inside the containment were exposed to potentially hazardous air concentrations of 2-BE and RPS. The biological monitoring results show that 2-BE was absorbed into the workers' bodies. Furthermore, the following information indicates that dermal exposure might have significantly contributed to workers' overall exposure to 2-BE: (1) The workers had elevated BAA urine levels even though they wore respirators which should have protected them from vapor exposures in the range that was measured, (2) the absence of effective hand and arm protection from the solvent (observations made by NIOSH personnel during a past survey demonstrated a potential for substantial skin contact with the solvent during mastic removal),<sup>12</sup> and (3) information from the scientific literature which indicates that absorption of 2-BE through the skin is a major route of exposure.<sup>8</sup>

A further indication of dermal exposure can be found by comparing the environmental and biological monitoring results for workers two and four. If the NIOSH estimation is accurate, that 60 mg/g creatinine approximates the BAA in urine concentration following an 8-hour TWA exposure to 2-BE of 24 mg/m<sup>3</sup>, then the BAA concentrations for workers 2 and 4 are much greater than would be predicted from their inhalation exposures alone, even if they had not been wearing respirators.

Methods used to control workers' exposures to chemical products can be classified into the following three categories: (1) substitution with a product which has a lower hazard potential, (2) engineering controls, and (3) administrative controls and personal protective equipment (PPE). When feasible, substitution and engineering controls are preferred because their effectiveness usually does not depend on the work practices of the employee.

### **Substitution**

When choosing chemical products, the relative potential hazard presented by the use of various chemical products should be considered in addition to the product's effectiveness. This includes the toxicity of the product and its potential to be absorbed into the body. Unfortunately, this information may not be available to the contractor in any form other than the material safety data sheet (MSDS), which often does not contain adequate information regarding potential hazards from exposure. In this situation, an industrial hygienist or other occupational health professional should be able to provide information on the relative hazards of the products being considered for use.

### **Engineering Controls**

One form of engineering controls is a change in the process. Methods for removing tile mastic, which do not use organic solvents, include mechanically scraping the mastic from the floor using hand-held tools or bead-blasting with hardened steel shot. Scraping by hand is generally not considered to be economically feasible for large projects, and bead-blasting requires expensive equipment. Also, both of these methods may increase workers' exposures to asbestos fibers because they break up the mastic which increases its potential to become friable. In addition, since they are dry methods, they increase the likelihood of the asbestos becoming airborne. For these reasons, many contractors prefer the solvent method.

An alternative to a process change may be a simple process modification, such as reducing the amount of solvent used. For example, the manufacture of Sentinel 747™ recommends using 1 gallon per 75-150 ft<sup>2</sup> of mastic.<sup>13</sup> On the day of sampling, the contractor was reported to have used approximately 1 gallon per 40 ft<sup>2</sup> of tile mastic.

Another form of engineering control is mechanical ventilation, which is often used to control air concentrations of chemicals. There are two general categories of ventilation--local exhaust ventilation (LEV) and general ventilation. If feasible, LEV is the preferred method of control because it is designed to capture emissions at their source. However, because the source of emissions during the removal of mastic is a large floor surface, LEV is not likely to be feasible in this case. General ventilation can lower the concentration of contaminants by exchanging contaminated air with "clean air." The air filtration devices (AFDs), which were used to prevent

the escape of asbestos fibers from the containment area, also provide general exhaust ventilation by exchanging "clean air" from outside the containment area with filtered room air. Increasing the number of AFDs would reduce solvent exposures; however, the amount of ventilation necessary to reduce 2-BE and RPS exposures to below the NIOSH RELs may be impractical. For example, to reduce the highest personal 2-BE exposure of 95 mg/m<sup>3</sup> to below the REL of 24 mg/m<sup>3</sup> would require an increase in ventilation of approximately 400% (assuming similar mixing of room air), a fourfold increase in the number of AFDs. Limiting removal to smaller areas and concentrating the available AFDs in that area may be more practical. However, in order to determine the extent of exposure-reduction needed and the effectiveness of control methods, employers must evaluate exposures.

### **Administrative Controls & PPE**

Administrative controls involve controlling behaviors in the work area or altering work practices. Reducing exposures by reducing the amount of time an employee spends in a contaminated area is an example of an administrative control. Other administrative controls may include company rules regarding work practices such as personal hygiene and PPE use. For these controls to be effective, it is important that employees understand the potential hazards, understand the rules and how they apply, and are motivated to follow safe work practices.

Several standards have been provided by OSHA which are designed to aid workers in controlling their exposures. One such standard is the Hazard Communication Standard, which requires employers to train workers about the potential hazards of chemicals encountered in their job. Another is the respiratory protection standard. The use of respirators to control exposures requires the implementation of a complete respirator program that is consistent with 29 CFR 1910.134<sup>14</sup> (a list of 10 items required under this standard is attached at the end of this report). If this program is fully implemented, the half-face respirators used during mastic removal are approved by NIOSH for environments with an air concentration of up to 10 times that of the exposure limit. Therefore, if the OSHA respiratory protection program were fully implemented by the abatement contractor, the respirators used should have provided adequate protection from 2-BE exposures in environments of up to 10 times the REL or 240 mg/m<sup>3</sup>, which is above the range of concentrations measured.

Chemical protective clothing (CPC) is the type of PPE which is used to control dermal exposures to chemicals. To be effective, CPC must prevent the chemical from contacting the skin but still allow the worker to perform the job. The process of removing tile mastic does not require a high level of hand dexterity; therefore, workers should be able to wear thick gloves made of materials which are highly protective yet don't interfere with work performance. Materials rated highly protective from 2-BE include butyl rubber and Saranex.® If skin areas

other than the hands are exposed to the solvent, they also need to be protected using appropriate PPE. Work practices which minimize the body surface area exposed to the solvent would also aid in reducing dermal exposures.

A recent laboratory exposure study suggests that exposures of the skin to 2-BE vapor alone may result in significant uptake of 2-BE into the body.<sup>8</sup> If this is the case, gas tight suits, which would not allow air to pass through, would be necessary to control dermal exposures.

Eye protection is another important form of PPE when using chemicals which can damage or irritate the eyes. Adequate eye protection can help prevent eye exposures from incidental contact with the chemical, such as from a splash or from rubbing the eye with a contaminated hand. Eye protection can also be used to protect the eyes from exposures to chemical vapors, which can irritate the eyes.

Choices of adequate eye protection from splash include chemical goggles, a face shield, or a full-face respirator. Only unvented chemical goggles or full-face respirators can protect the eyes from irritating vapors. Eye protection must not interfere with the face seal of the respirator. This restricts the use of chemical goggles to those models which have been designed to be worn with a half-face respirator. (These goggles are shaped so as not to interfere with the respirator seal at the nose bridge.) Also, employees may find it cumbersome or uncomfortable to wear the half-face respirator and goggles. The use of a full-face respirator can provide a solution to both of these potential problems.

## **VIII. RECOMMENDATIONS**

1. The use of Sentinel 747<sup>TM</sup>, and other organic solvents to remove tile mastic, represents a potential health hazard that should be evaluated by the abatement contractor. If the employer does not possess the expertise or resources necessary to evaluate exposures, an industrial hygienist should be consulted.
2. The employer should investigate the utility of other methods for mastic removal or use of other chemical products that may provide for a less hazardous procedure.
3. To reduce the potential for dermal exposures to 2-BE, the employer should provide, and require the use of, gloves made of butyl rubber, Saranex®, or a material with comparable resistance to penetration by 2-BE.
4. To reduce the potential for eye exposure to chemicals in general, the employer should provide, and require the use of, adequate eye protection. Only unvented chemical goggles or full-face respirators can protect the eyes from irritating vapors.

5. To identify adverse health effects of 2-BE, the employer should institute medical monitoring for all workers who may be exposed to 2-BE. This monitoring, which includes preplacement and periodic medical examinations and blood tests, is outlined in the NIOSH document "Occupational Exposure to Ethylene Glycol Monobutyl Ether and Ethylene Glycol Monobutyl Ether Acetate."<sup>6</sup>

## **IX. REFERENCES**

1. NIOSH [1984]. Manual of analytical methods, 3rd rev. ed., Volumes 1 & 2. 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.
2. 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, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.
3. ACGIH [1993]. 1993-1994 threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.
4. ACGIH [1970]. 1970 threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.
5. Code of Federal Regulations [1992]. 29 CFR 1926.55. Washington, DC: U.S. Government Printing Office, Federal Register.
6. NIOSH [1990]. Criteria for a recommended standard: occupational exposure to ethylene glycol monobutyl ether and ethylene glycol monobutyl ether acetate. 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. 90-118.
7. ACGIH [1966]. Documentation of the TLVs and BEIs. revised ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.
8. Johanson G, Boman A, Dynesius B [1988]. Percutaneous absorption of 2-butoxyethanol in man. Scand J Work Environ Health 14:101-109.

## Page 13 - Health Hazard Evaluation Report No. 93-0562

9. NIOSH [1977]. Criteria for a recommended standard: occupational exposure to refined petroleum solvents. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Health Services and Mental Health Administration, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-192.
10. NIOSH [1977]. Occupational diseases: a guide to their recognition. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Health Services and Mental Health Administration, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-181.
11. Mathias CGT [1983]. Clinical and experimental aspects of cutaneous irritation. In: Marzulli FA, Maibach HI, eds. Dermatology. Washington, DC: Hemisphere Publishing.
12. NIOSH [1993]. Hazard evaluation and technical assistance report: Ohio University, Athens, OH. 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, NIOSH Report No. HHE 92-314-2308.
13. Sentinel Chemical Co. [1992]. product information: Complete guidelines for flooring adhesive removal. Sentinel Chemical, Inc. Minneapolis, MN.
14. Code of Federal Regulations [1992]. OSHA Standard for Respiratory Protection. 29 CFR 1910.134. Washington, DC: U.S. Government Printing Office, Federal Register.

**X. AUTHORSHIP AND ACKNOWLEDGEMENTS**

Report Prepared By:	John E. Kelly, M.S. Industrial Hygienist Industrial Hygiene Section  Thomas J. Van Gilder, M.D. Medical Officer Medical Section
Field Sampling Performed by:	Charles Hart, C.I.H., C.S.P., R.S. Environmental Safety Coordinator Industrial Hygiene, Occupational Safety and Biosafety Ohio University Athens, Ohio  Doug Beaudion Environmental Technician ACT Environmental Inc. Cincinnati, Ohio
Analytical Support:	
Environmental Samples	Ardith Grote, B.A. Chemist NIOSH Division of Physical Sciences and Engineering  Robert Kurimo, B.S. Chemist NIOSH Division of Physical Sciences and Engineering
Biological Samples	Kenneth Brown, Ph.D. Research Chemist NIOSH Division of Biomedical and Behavioral Science

Originating Office: Hazard Evaluations and Technical  
Assistance Branch  
Division of Surveillance, Hazard  
Evaluations and Field Studies  
National Institute for Occupational  
Safety and Health  
4676 Columbia Parkway  
Cincinnati, Ohio 45226

## **XI. DISTRIBUTION AND AVAILABILITY OF REPORT**

Copies of this report may be freely reproduced and are not copyrighted. Single copies of this report will be available for a period of 90 days from the date of this report from the NIOSH Publications Office, 4676 Columbia Parkway, Cincinnati, OH 45226. To expedite your request, include a self-addressed mailing label along with your written request. After this time, copies may be purchased from the National Technical Information Service (NTIS), 5285 Port Royal Rd., Springfield, VA 22161. Information regarding the NTIS stock number may be obtained from the NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

- 1) Environmental Safety Coordinator, Ohio University
- 2) Environmental Technician, ACT Environmental Incorporated
- 3) Superintendent, American Abatement and Asbestos Removal Corporation
- 4) OSHA Region Five
- 5) Each of the 12 study participants

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

**Table 1: Environmental and Biological Monitoring Results**  
**HETA 93-0562**  
**Ohio University - Athens, Ohio**  
**May 12, 1993**

Worker #	Sample Period	mg/m <sup>3</sup> 2-BE*	mg BAA/ g creat.**	mg/m <sup>3</sup> RPS***
1	0630-0828 0907-1242	9.6	21	79
2	0630-0828 0904-1243	8.9	210	59
3	0630-0827 0910-1238	70	120	740
4	0630-0830 0909-1244	8.7	74	56
5	0630-0827 0903-1242	95	120	760
6	0630-0828 0906-1240	60	150	490
7	0630-0828 0908-1244	60	50	510
8	0630-0829 0906-1241	85	330	740
9	0630-0831 0909-1245	79	130	600
10			3.7	
11			27	
12			0.42	
area	0635-1247	2.1		21
	NIOSH REL	24		350
	OSHA PEL	240		1150

\* 2-BE: 2-Butoxyethanol  
 \*\* creat: creatinine  
 \*\*\* RPS: Refined Petroleum Solvents

**Attachment 1: Ten Items of a Respiratory Protection Program**  
**HETA 93-0562**  
**Ohio University**  
**Athens, Ohio**

The Occupational Safety and Health Administration's General Industrial Standard on respiratory protection, 29 CFR 1910.134, which also applies to construction industry, requires that a respiratory protection program be established by the employer and that appropriate respirators be provided and be effective when such equipment is necessary to protect the health of the employee. They should be used as a primary control for employee protection only where engineering controls are not feasible or are currently being installed. The standard requires the employer to address ten basic requirements which would provide for an acceptable respiratory protection program. These requirements are summarized below for easy reference:

I. Provide Written Operating Procedures

The employer must prepare written standard operating procedures governing the selection and use of respirators. The procedures must include a discussion or explanation of all items specified in 29 CFR 1910.134(b).

II. Proper Selection of Respirator

The proper selection of a suitable respirator is dependant upon a number of parameters including: physical nature of the contaminant, concentration of contaminant in the air, toxicity of contaminant and warning properties of the substance (e.g., odor or irritation, which can indicate the end of the service life of the respirator).

III. Training and Fitting for the Employee

Requires that the user be instructed and trained in the proper use of respirators and their limitations, as well as with their maintenance. Qualitative fit testing of respirators fit in a test atmosphere is required. Some OSHA standards now require quantitative fit testing before assignment of a respirator to any employee. In addition, the employee shall be familiar with personal face fit testing techniques and perform this practice of fitting each time the respirator is worn.

IV. Cleaning and Disinfecting

Respirators should be cleaned and disinfected on a daily basis if used routinely throughout the day or less frequently if used less often. Respirator cleanliness is particularly important in dusty environments or where respirators are shared by several individuals.

V. Storage

Respirators should be stored in a dry, clean storage area which is protected from extremes in temperature, sunlight or physical damage.

VI. Inspection and Maintenance

Inspection schedules vary in frequency for specific types of respiratory protection equipment but should at least be inspected for damage or malfunctions both before and after each daily use. Records must be kept for emergency use respirators of at least monthly inspection dates and the inspectors findings. Developing a check list of items to look for is a good idea when inspecting any reusable respirator.

VII. Work Area Surveillance

Surveillance by the employer of the work area is required and includes identification of the contaminant, nature of the hazard, concentration at the breathing zone, and if appropriate, biological monitoring.

VIII. Inspection and Evaluation of Program

The effectiveness of the instituted program measures should be periodically evaluated. It is the employer's responsibility to administer the respiratory protection program so that it is effective. This includes mandatory employee participation where appropriate and provision of all other items cited herein.

IX. Medical Examination

It is required that a medical assessment of the employees ability to wear a respirator be performed prior to providing him with a respirator.

X. Approved Respirators

Only respiratory protection devices approved by NIOSH or MSHA, or both, can be used. Interchanging parts of different respirators nullifies approval.

Further information on respirators and instructions for establishing an appropriate respiratory protection program can be found in the NIOSH guide to Industrial Respiratory Protection, DHHS (NIOSH) Publication No. 87-116. Single copies are available free and can be obtained from:

Publications Dissemination, DSDTT  
National Institute for Occupational Safety and Health  
4676 Columbia Parkway  
Cincinnati, Ohio 45226  
(513) 841-4287