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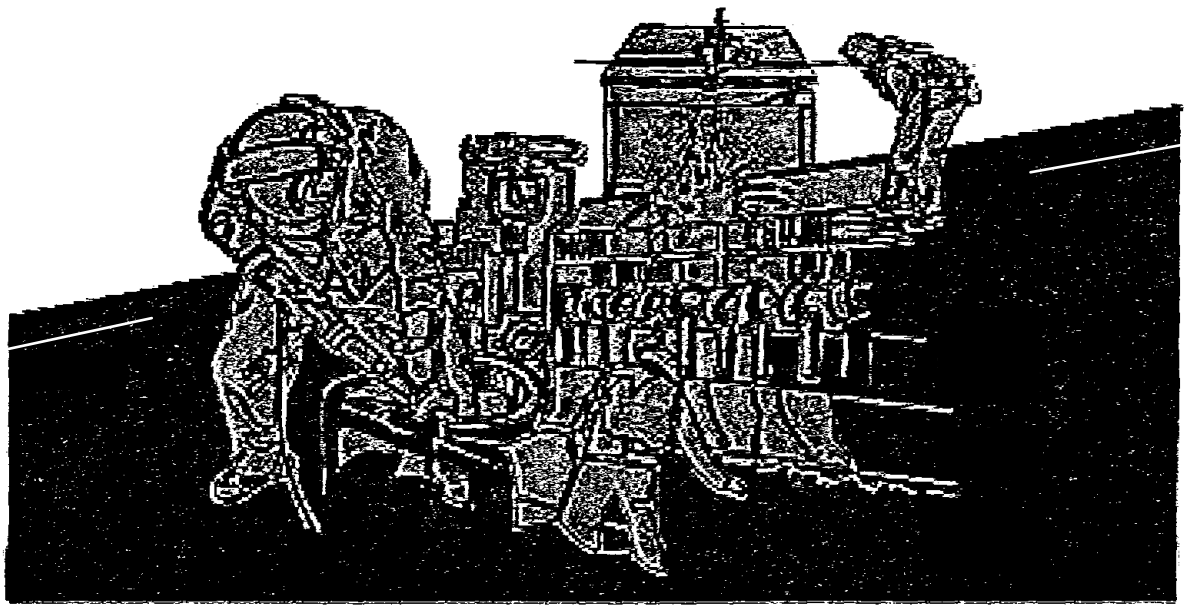
CDC Workplace Safety and Health

NIOSH HEALTH HAZARD EVALUATION REPORT

HETA 2000-0233-2845
Trilithic, Inc.
Indianapolis, Indiana

Christopher M. Reh, PhD, CIH
Jeffrey B. Nemhauser, MD



DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention

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 Dr. Christopher M. Reh and Dr. Jeffrey B. Nemhauser of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Joshua Harney, MS. Analytical support was provided by Data Chem in Salt Lake City, UT. Desktop publishing was performed by Ellen Blythe and David Butler. Review and preparation for printing were performed by Penny Arthur.

Copies of this report have been sent to employee and management representatives at Trilithic, Inc., 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:

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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 Solvent Exposures from the Degreaser

NIOSH was asked to determine if health problems were related to the new solvent used in the cold vapor degreaser (1-bromopropane [1-BP]). We also evaluated 2-bromopropane (2-BP) exposures; 2-BP is a contaminant commonly found in 1-BP formulations. We conducted site visits in July 2000 and November 2000, and this handout summarizes the findings from this evaluation.

What NIOSH Did

- We collected breathing zone air samples to measure assemblers' 1-BP and 2-BP exposures.
- We collected air samples in and around the degreasing room, to measure 1-BP and 2-BP levels in the areas near the degreaser.
- We talked with the requestors and management representatives about health effects which they associated with the degreaser.

What NIOSH Found

- Assemblers are currently exposed to low levels of 1-BP
- No 2-BP was detected in any of the air samples.
- Employees described symptoms of past solvent exposure.
- The symptoms disappeared once the degreaser was enclosed and ventilated.

What Trilithic Managers Can Do

- Give employees who use the degreaser more protective gloves.
- Give chemical splash aprons that will protect employees from 1-BP.
- Train employees on the hazards associated with 1-BP, and on safe work practices associated with the use of the degreaser.

What the Trilithic Employees Can Do

- Use the gloves and apron every time you use the degreaser.
- Attend every safety and health training session that is offered.
- Do not eat, drink, or smoke in work areas.

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 # 2000-0233-2845

Health Hazard Evaluation Report 2000-0233-2845
Trilithic, Inc.
Indianapolis, Indiana
January 2001

Christopher M. Reh, PhD, CIH
Jeffrey B. Nemhauser, MD

SUMMARY

On April 7, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a health hazard evaluation (HHE) at Trilithic, Inc., in Indianapolis, Indiana. The request centered on health effects possibly associated with the introduction of a new solvent called NPB in the cold vapor degreaser. The solvent contained 1-bromopropane (1-BP, also called n-propyl bromide), which is commonly contaminated with 2-bromopropane (2-BP, isopropyl bromide). The NIOSH investigators conducted site visits on July 18, and November 8, 2000. During the latter site visit, 1-BP and 2-BP personal breathing zone and area air concentrations were measured to determine employees' exposures to these compounds when cleaning small parts in the cold vapor degreaser.

Approximately one year before submission of the NIOSH HHE request, Trilithic changed the degreaser's cleaning solvent to a product containing 1-BP. Soon after the change in solvents, employees working in and near the assembly areas experienced headaches, nausea and vomiting, near syncope ("feeling faint"), and mucous membrane irritation. In response, Trilithic built a room to enclose the degreaser. In addition, a local exhaust ventilation system was installed to vent the vapors from within the room to the outside of the building. Construction of the ventilated room was completed approximately 3 months prior to the initial NIOSH site visit. At the time of the initial NIOSH site visit in July 2000, neither management representatives, nor the worker representative nor the requestor were aware of ongoing or persistent health complaints.

Full-shift time-weighted average 1-BP and 2-BP exposure measurements were obtained from 20 assemblers in the Components, Tech Station, Engineering Support, Filters, Custom Filters, and Tunables Departments. The 1-BP exposures ranged from 0.01 parts per million (ppm) to 0.63 ppm, and 13 of the measurements (65%) were equal to the minimum quantifiable concentration (0.02 ppm) or less. All the 2-BP exposure measurements were below the minimum detectable concentration (MDC) of 0.004 ppm.

Two short-term, task-based 1-BP exposure measurements obtained from employees using the degreaser were 2.3 and 8.4 ppm. No 2-BP was detected in either of these samples (short-term 2-BP MDC was 0.06 ppm).

Area air sampling was conducted in the degreaser room, and in areas adjacent to that room. The highest area air concentrations were found in the samples collected in the degreaser room. A 1-BP concentration of 4.42 ppm and a 2-BP concentration of 0.02 ppm were found at the degreaser, and a 1-BP concentration of 1.7 ppm was found 5 feet from the degreaser. All other 1-BP and 2-BP concentrations were either very low, or no analyte was detected.

Based on the current knowledge concerning occupational exposures to 1-BP and 2-BP, the NIOSH investigators conclude that there is no current health hazard related to the use of NPB in the cold vapor degreaser at Trilithic. Recent enclosure of the cold vapor degreaser and improvements in ventilation appear to have effectively controlled levels of 1-BP. Moreover, improved work practices (allowing parts to more thoroughly drip dry prior to transporting them out of the room containing the degreaser unit) may have also served to decrease exposure to 1-BP. Since the degreasing operation was enclosed and the local exhaust ventilation improved, the previously reported nonspecific symptoms and health effects appear to have resolved.

Keywords: SIC 3663 (Radio and Television Broadcasting and Communication Equipment), degreasing operations, cold vapor degreasers, n-propyl bromide, isopropyl bromide, 1-bromopropane, 2-bromopropane, gloves, small parts cleaning, 1-BP, 2-BP, NPB.

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INTRODUCTION

On April 7, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a health hazard evaluation (HHE) at Trilithic, Inc., in Indianapolis, Indiana (hereinafter referred to as Trilithic). The request focused on the requesters' perception of health effects associated with 1-bromopropane (1-BP, also called n-propyl bromide) exposures during the use of a cold vapor degreaser. The NIOSH investigators conducted an initial site visit on July 18, 2000, which included a walk-through survey of the areas mentioned in the HHE request and informal discussions with management and employee representatives. On November 8, 2000, NIOSH investigators conducted a follow-up site visit and collected 1-BP and 2-bromopropane (2-BP, also called isopropyl bromide) inhalation exposure data from employees cleaning small parts in the cold vapor degreaser.

BACKGROUND

Trilithic is a manufacturer of instrumentation and components for the radio frequency and microwave communications industry. At the time of our site visit, the plant was running 2 shifts, 5 days a week and employed 75 - 85 persons over these 2 shifts. Many of the employees at Trilithic are involved in the hand assembly of small filters, subsystems, and other parts used in these instruments or components. During assembly, approximately 40 employees (over the 2 shifts) may have the need to clean parts, and this cleaning is performed using the cold vapor degreaser (hereinafter referred to as the degreaser). Degreasing may be performed by any given employee, on average, 2 - 3 times per week.

In order to clean parts using the degreaser, an employee first places the parts in a metal wire basket. Next, the cover from the degreaser is removed and the basket of parts is lowered by hand into the degreasing solution. After a brief period the basket is raised and allowed to drip-dry inside the degreaser. The degreasing solution used at Trilithic is NPB, distributed by Tulstar Products, Inc. (Tulsa, Oklahoma). NPB is a halogenated hydrocarbon mixture, the main component being 1-BP.

The parts cleaning task is performed infrequently by the assemblers, on an as-needed basis. It is common for an assembler to clean parts only a few times a week. Employees wear nitrile gloves and splash-proof goggles when using the degreaser to clean parts. A single pair of nitrile gloves is located next to the degreaser, and this same pair is used by each employee who cleans parts during a given work shift. It was unclear to the NIOSH investigators how often the gloves are replaced with a new pair.

The degreaser formerly contained 1,1,1-trichloroethane as the cleaning solvent. Then, approximately one year before submission of the NIOSH HHE request, Trilithic changed the degreaser's cleaning solvent to a product containing 1-BP. At that time, the degreaser was not equipped with local exhaust ventilation. Soon after the change in solvents, employees working in and near the assembly areas began to report a variety of symptoms. These symptoms included headaches, nausea and vomiting, near syncope ("feeling faint"), and mucous membrane irritation; the cause of these symptoms was believed to be due to exposure to 1-BP. In response, Trilithic management built a room to enclose the degreaser. In addition, a local exhaust ventilation system was installed to vent the vapors from within the room to the outside of the building. Construction of the ventilated room was completed approximately 3 months prior to the initial NIOSH site visit. Subsequent to the enclosure of the cold vapor degreaser unit and improvements in ventilation, no further health effects have come to the attention of the HHE requestors.

METHODS

Industrial Hygiene

We attempted to assess inhalation exposures in all employees potentially exposed to 1-BP. Employees (assemblers) in the Components/Subsystems/EAS (hereinafter referred to as Components), Filters, Custom Filters, Tech Support, Engineering Support, and Tunables Departments were targeted for a full-shift inhalation exposure measurement. Additional short-term, task-based inhalation exposures were measured for employees using the degreaser. The inhalation exposure measurements were determined by sampling the air in the employee's breathing zone. Area air sampling was also conducted at the

degreaser, in the degreaser room, and in the areas near the degreaser room. All breathing zone and area air samples were analyzed for 1-BP and 2-BP, the latter being included since it is a commonly found contaminant of 1-BP products and formulations. Employee participation in this study was voluntary.

Air sampling was conducted using a NIOSH draft analytical method for 1-BP and 2-BP. In this method, air is drawn through a standard charcoal tube (SKC Anasorb® CSC Lot 2000) at a nominal flow rate of 100 to 200 milliliters per minute (ml/min) using a calibrated personal sampling pump. After sampling, the charcoal tubes were capped and shipped refrigerated to the analytical laboratory. The front and back sections of the charcoal tubes were placed in glass vials, and each section was desorbed for 30 minutes with 1 milliliter of carbon disulfide. Each sample was analyzed for both 1-BP and 2-BP using gas chromatography with a flame ionization detector.

The 1-BP limit of detection (LOD) and limit of quantification (LOQ) for the draft NIOSH method are 1 microgram per sample (μg/sample) and 4 μg/sample, respectively. The LOD and LOQ for 2-BP are 0.9 μg/sample and 3 μg/sample, respectively. LODs and LOQs are values determined by the analytical procedure used to analyze the samples, and are not dependent on sample volume. Minimum detectable concentrations (MDCs) and minimum quantifiable concentrations (MQCs) are determined by dividing the LODs and LOQs by air sample volumes appropriate for the given set of samples. In determining the MDC and MQC for the exposure data, we used a sampling period of 8 hours (480 minutes) and a flow rate of 100 ml/min to calculate an air sample volume of 48 liters (L). This results in a 1-BP MDC and MQC of 0.004 parts per million (ppm) and 0.02 ppm, and a 2-BP MDC and MQC of 0.004 ppm and 0.01 ppm. The MDC and MQC reflect the sensitivity of the air sampling and analysis protocol, *i.e.*, the lowest 1-BP and 2-BP exposure concentrations that could be reliably detected and quantified by the procedures used in this study.

Medical

On July 18, 2000, NIOSH conducted an opening meeting with management and employee representatives. Health effects believed due to exposure to 1-BP were shared at that time. A telephone interview conducted with the requestor of this HHE revealed several health concerns thought to be related to inhalation of vapors of 1-BP. No interviews with individual employees potentially exposed to 1-BP were conducted.

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 this 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) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs),[1] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[2] and (3) NIOSH Recommended Exposure Limits (RELs).[3] Employers are encouraged to follow the OSHA limits, the ACGIH TLVs, the NIOSH RELs, or whichever are the more protective criteria.

Employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). Nonetheless, 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)]. 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.

1-Bromopropane (1-BP)

Currently, there are no OSHA, ACGIH, or NIOSH exposure evaluation criteria for 1-BP.[1,2,3] Albemarle Corporation has developed its own recommended occupational exposure guideline for 1-BP. This limit is based on initial, unaudited data from the Albemarle Corporation's own ongoing two-generation reproductive study in rats.[4] In this study, young male and female rats received a daily 6-hour inhalation exposure to a known concentration of 1-BP for a minimum of 70 days. After this period, the animals were paired for mating, and the daily exposures continued through the 14-day mating period and day 20 of gestation. No litters were observed in the 750 ppm exposure group, and a significant decrease was observed in the number and size of litters in the 500 ppm exposure group. A slight (statistically insignificant) decrease was observed in the mean number of pups born and live pups per litter for the 250 ppm exposure group. Based on these results and a 10-fold safety factor, Albemarle set their 1-BP recommended exposure limit at 25 ppm as an 8-hour TWA exposure.[5]

2-Bromopropane (2-BP)

The South Korean Ministry of Labor has developed an occupational exposure guideline/limit for 2-BP. In 1998, the Ministry of Labor issued a standard limiting 2-BP exposure to 1 ppm as an 8-hour TWA.[6] This standard was based on a limited number of workplace epidemiological studies and animal toxicological studies which found that 2-BP exposure produces effects in the organs of reproduction in both males (low sperm count) and females (ovarian dysfunction) and also affects the hematopoietic (blood forming) system.[7,8,9,10,11,12,13] There are no OSHA, ACGIH, or NIOSH exposure evaluation criteria for 2-BP.[1,2,3]

RESULTS

Industrial Hygiene

Full-shift TWA 1-BP and 2-BP exposure measurements were obtained from 20 assemblers in the Components, Tech Station, Engineering Support, Filters, Custom Filters, and Tunables Departments. The results from these exposure measurements are in Table 1. The 1-BP exposures ranged from 0.01 ppm to 0.63 ppm, and 13 of the measurements (65%) were less than the MQC (0.02 ppm). None of these 13 employees used the degreaser during the work shift. The seven measurements that were above 0.02 ppm were from employees who used the degreaser at least once during the work shift, and the highest exposure (0.63 ppm) was from an employee who used the degreaser twice during the work shift. All the 2-BP exposure measurements were below the MDC of 0.004 ppm.

Two short-term, task-based exposure measurements were obtained from employees using the degreaser (Table 2). These measurements were obtained by having the employee wear the breathing zone air sampling equipment only while using the degreaser. Due to the short amount of time any single employee spent in the degreaser room, degreasing tasks from several employees were combined until the total approximate sample time was 15 minutes. The degreasing task-based 1-BP exposure concentrations were 2.3 and 8.4 ppm. No 2-BP was detected in either of these samples (short-term 2-BP MDC was 0.06 ppm).

The results from the area air samples collected in and near the degreasing room can be found in Table 3. The highest area air concentrations were found in the

samples collected in the degreaser room. A 1-BP concentration of 4.42 ppm and a 2-BP concentration of 0.02 ppm were found at the degreaser, and a 1-BP concentration of 1.7 ppm was found 5 feet from the degreaser. All other 1-BP and 2-BP concentrations were either very low, or no analyte was detected.

Medical

Discussions with the HHE requestor and management and employee representatives revealed that the primary health complaints among employees working with or around the degreaser prior to its enclosure and the addition of local ventilation were headaches, nausea and vomiting, near syncope ("feeling faint"), and mucous membrane irritation. According to both management and the requestor, employees most likely to be adversely affected by exposure to 1-BP were those directly involved with degreasing parts or those whose work stations were most immediately proximate to the cold vapor degreaser. According to both management and the requestor, reports of headaches and nausea were among the most common symptoms reported by those employees working in the vicinity of the degreaser. Two employees were transported to hospital for evaluation as a result of feeling ill while in close proximity of the cold vapor degreaser. These persons were observed in the emergency department, recovered, and were discharged from the hospital to return to work.

Subsequent to the enclosure of the cold vapor degreaser unit and improvements in ventilation, no further health effects have come to the attention of Trilithic management or the HHE requestor. Based on interviews conducted with both the management and employee representatives of Trilithic and the HHE requestor, there are no current complaints of headaches, nausea, or other symptoms among those workers who use the degreaser or who work in its proximity.

DISCUSSION

At the time of the NIOSH site visit, the full-shift TWA 1-BP exposures were all very low. In fact, 6 of the 20 full-shift exposure measurements were below the MQC, and the highest 1-BP exposure (0.63 ppm) was almost 40 times less than the Albemarle recommended exposure guideline of 25 ppm. The 1-BP exposures were highest among employees who used the degreaser during the shift, but all of these exposures were still low. No 2-BP was detected in any of the 20 full-shift exposure measurements.

The two task-based exposure measurements revealed 1-BP exposures of 8.4 and 2.3 ppm. It is difficult to determine if these levels pose a health hazard, since no evaluation criteria are available for short-term 1-BP exposures. Based on current knowledge, however, these exposures probably do not constitute a serious health risk or hazard. No 2-BP was detected in the two task-based exposure measurements.

Area air sampling in the degreaser room also found levels of 1-BP below the Albemarle recommended exposure guideline of 25 ppm. The 1-BP concentration at the degreaser was 4.4 ppm, and the general room concentration was 1.7 ppm. The 1-BP concentrations outside the degreaser room were in the 0.02 to 0.03 ppm range. Finally, 2-BP was detected only in the area air sample collected at the degreaser; the concentration was 0.02 ppm.

The current practice at Trilithic is for employees to don nitrile gloves when using the cold vapor degreaser. According to Albemarle, these gloves provide limited protection, as 1-BP penetrates the nitrile glove in less than 30 minutes.[14] Conversely, gloves made from flexible laminates (*e.g.*, Viton™, 4H™ (PE/EVAL), Silver Shield™) will offer 8 or more hours of protection.

Enclosure of the cold vapor degreaser and improvements in ventilation appear to have effectively controlled levels of 1-BP which were higher prior to the installation of the engineering controls. Moreover, improved work practices (allowing parts to more thoroughly drip dry prior to transporting them out of the room containing the degreaser unit) may have also served to decrease exposure to 1-BP.

Given the nonspecific nature of the symptoms experienced by some employees working with or near the degreaser in the past, it is not possible to determine the cause of those symptoms. Many solvents, at sufficiently high ambient levels, are capable of causing headaches, nausea and vomiting,

lightheadedness, and mucous membrane irritation. Given the fact that 1-BP has been the solvent in use in the degreaser, it is possible that the previously reported symptoms were related to past exposure to 1-BP.

CONCLUSIONS

Based on the current knowledge concerning occupational exposures to 1-BP and 2-BP, the NIOSH investigators conclude that there is no current health hazard related to the use of NPB in the cold vapor degreaser at Trilithic. Since the degreasing operation was enclosed and the local exhaust ventilation improved, the previously reported symptoms appear to have resolved. The measured 1-BP and 2-BP exposures and area air concentrations were low, and probably not at levels currently thought to be potentially hazardous.

RECOMMENDATIONS

The NIOSH investigators offer the following recommendations based on the data, findings, and observations:

1. If Trilithic continues to use nitrile gloves to protect employees using the degreaser, then these gloves should be for one-time use and discarded by the employee after each degreasing task. Alternatively, gloves made from flexible laminates (e.g., Viton™, 4H™ (PE/EVAL), Silver Shield™) should be used during degreasing, and these gloves should be replaced at the end of each work shift.

2. Employees should wear a splash-proof apron composed of flexible laminates when using the degreaser.

3. If further local exhaust ventilation improvements for the degreaser are desired, recommended design specifications may be found in the book "Industrial Ventilation, A Manual of Recommended Practice, 23rd Edition." by the ACGIH (1330 Kemper Meadow Road, Cincinnati, Ohio, 45240-1634).[15]

4. Trilithic should conduct periodic training on the hazards associated with 1-BP and 2-BP, and on safe work practices associated with the use of the degreaser.

5. Eating, drinking, and smoking should be prohibited in work areas.

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Table 1
1- and 2-Bromopropane Full-Shift Exposure Data for Assemblers
Trilithic, Inc.
HETA 2000-0233
November 6, 2000

Job Title	Location	Sample Time[1]	Sample Volume[2]	[1-BP][3]	[2-BP][4]
Assembler	Components	0753-1520	45.1	0.02	ND
Assembler	Components	0750-1500	43.2	0.18[1]	ND
Assembler	Components	0750-1520	45.3	(0.01)	ND
Assembler	Components	0748-1520	46.1	(0.02)	ND
Assembler	Tech Station I	0745-1520*	42.0	0.02	ND
Assembler	Tech Station I	0745-1520	45.7	0.02	ND
Assembler	Tech Station I	0730-1520	47.2	0.02	ND
Assembler	Custom Filters	0735-1457	42.0	0.08[1]	ND
Assembler	Custom Filters	0725-1520	47.8	0.02	ND
Assembler	Custom Filters	0725-1520	47.6	0.02	ND
Assembler	Filters	0730-1520*	45.3	0.17[1]	ND
Assembler	Filters	0745-1415	40.7	0.04[1]	ND
Assembler	Filters	0745-1520	45.9	(0.02)	ND
Assembler	Filters	0725-1515	44.4	0.05[1]	ND
Assembler	Filters	1245-1525	16.9	(0.01)	ND
Assembler	Tunables	0740-1520	45.9	(0.02)	ND
Assembler	Tunables	0740-1520*	42.5	(0.02)	ND
Assembler	Tunables	0834-1415	34.7	0.02	ND
Assembler	Tunables	0834-1415*	27.8	0.08[1]	ND
Assembler	Engineering Support	0730-1520	47.6	0.63[2]	ND

1 All times are in military time. An asterisk (*) next to the time indicates the pump faulted during sampling, but no data related to sample time or volume were lost.
2 Sample volumes are in liters of air.
3 The 1-BP exposure concentration are in parts per million. Concentrations in parentheses are between the MDC and MQC and are considered semi-quantitative. The number in brackets next to a given exposure concentration indicates the number of times the employee used the degreaser during the work shift.
4 The 2-BP exposure concentration are in parts per million. ND = none detected, less than the MDC.

Table 2
Task-Based 1- and 2-Bromopropane Exposure Data for Assemblers Using the Degreaser
Trilithic, Inc.
HETA 2000-0233
November 6, 2000

Job Title	Elapsed Sample Time[1]	Sample Volume[2]	[1-BP][3]	[2-BP][3]
Assembler	1	2.8	2.3	ND
Assembler	5			
Assembler	1			
Assembler	5			
Assembler	2			
Assembler	3	2.6	8.4	ND
Assembler	2			
Assembler	1			
Assembler	1			
Assembler	2			
Assembler	4			

1 Elapsed sample times are in minutes.
2 Sample volumes are in liters of air.
3 The 1-BP and 2-BP exposure concentration are in parts per million. ND = none detected, less than the MDC.

Table 3
1- and 2-Bromopropane Area Air Sampling Data
Trilithic, Inc.
HETA 2000-0233
November 6, 2000

Location	Sample Time[1]	Sample Volume[2]	[1-BP][3]	[2-BP][3]
On exhaust duct above the degreaser	0725-1503	81.0	4.42	0.02
On cart, 5 feet from degreaser	0726-1502	82.8	1.70	ND
On cabinet, near degreaser room door	0728-1505	86.4	0.03	ND
On metal rack, near degreaser room door	0729-1522	95.7	0.02	ND
Near the degreaser room window	0731-1505	82.1	0.02	ND
5' from the degreaser room window	0730-1505	75.6	0.02	ND
Office next to degreaser room	0731-1503	90.4	0.02	ND

[1] All times are in military time.
[2] Sample volumes are in liters of air.
[3] The 1-BP and 2-BP exposure concentration are in parts per million. ND = none detected, less than the MDC.

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