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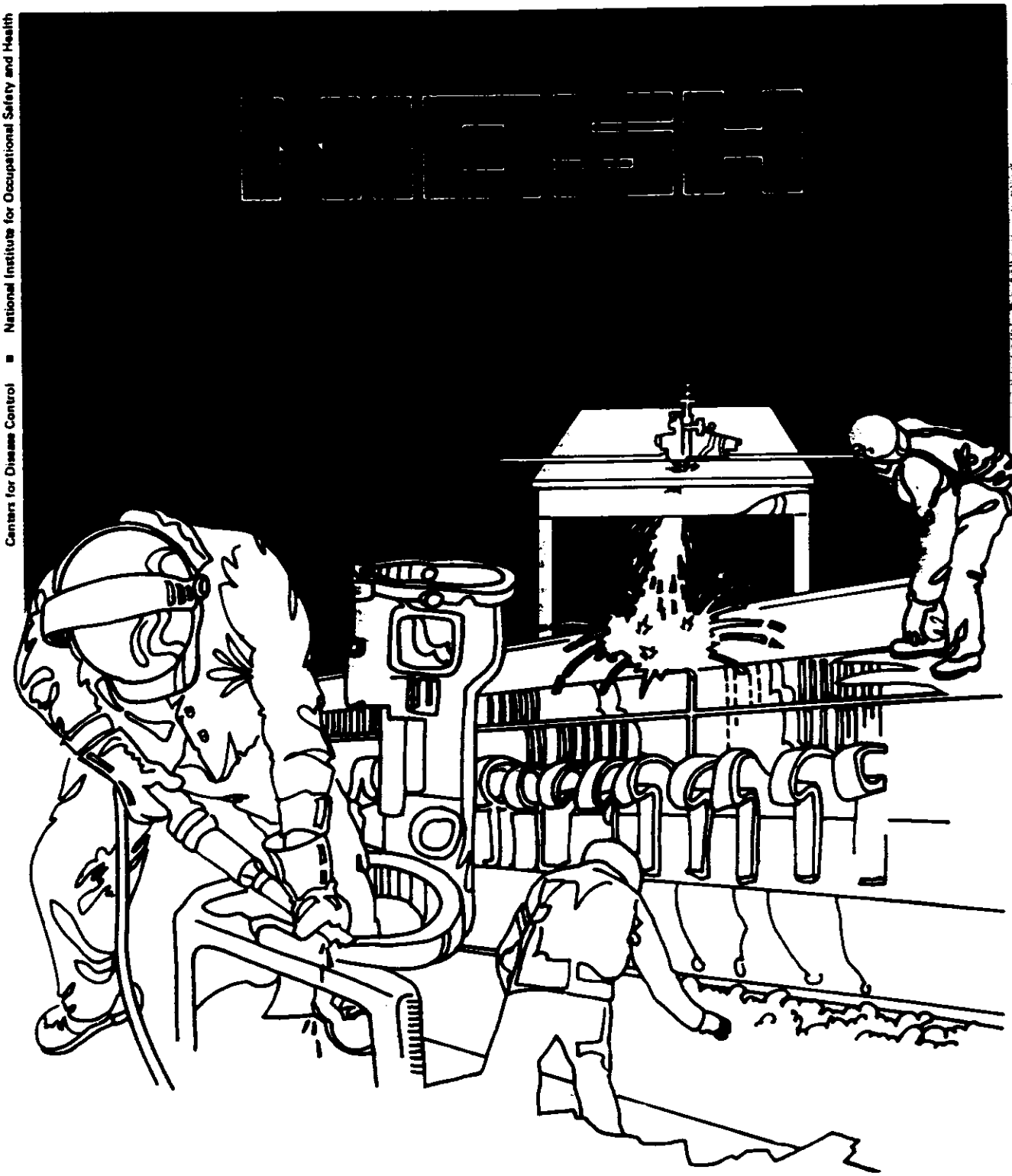

# Health Hazard Evaluation Report

MHETA 87-273-1866
DALB, INC.
RANSON, WEST VIRGINIA

## PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer 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.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial nygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

MHETA 87-273-1866
DALB, INC.
RANSON, WV
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NIOSH INVESTIGATOR
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## I. SUMMARY

On June 23-25, 1987, a NIOSH investigator conducted a Health Hazard Evaluation at Dalb, Inc., located near Ranson, West Virginia. This evaluation was done in response to a request from Dalb management citing health concerns related to Butyl cellosolve solvent (ethylene glycol monobutyl ether) exposures during silkscreening operations.

Personal and area organic vapor samples were collected during silkscreening operations using activated charcoal media and portable sampling pumps. These samples were analyzed by gas chromatography. Existing exhaust ventilation systems were evaluated. Ethylene glycol monobutyl ether (EGBE) was the primary organic vapor exposure for employees at the Dalb silkscreening operations. Six of the fourteen personal samples exceeded the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Exposure Value (TLV) for EGBE. None of these airborne personal exposure measurements exceeded the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for EGBE; however, some of the high exposure job categories also had considerable skin contact with EGBE which would increase exposure through skin adsorbtion. Some aspects of plant ventilation control methods are inadequate.

On the basis of data obtained during this evaluation, some workers received excessive EGBE exposures above the existing exposure guidelines of ACGIH. The additional exposure through solvent/skin contact in certain job categories increases total EGBE exposure and related health hazards. Recommendations for reducing these EGBE exposures at DALB are presented in section VIII of this report.

KEYWORDS SIC 2751, 3499 silkscreening, organic, solvents, ethylene glycol monobutyl ether, butyl cellosolve, 2-ethoxyethanol, inks.

## II. INTRODUCTION

On May 4, 1987, the Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health (NIOSH) received a Health Hazard Evaluation request to evaluate butyl cellosolve (ethylene glycol monobutyl ether - EGBE) exposures at Dalb, Inc., located near Ranson, West Virginia. The request, submitted by Dalb management, cited employee concerns related to odors/irritations from silkscreening operations where EGBE is used. On June 23-25, 1987, NIOSH investigators conducted an environmental evaluation at this facility to evaluate solvent exposures from silkscreening and any related health hazards.

## III. BACKGROUND

Dalb, Inc. silkscreens polycarbonate signs for use on soft drink vending machines. EGBE is the primary solvent used at this facility for silkscreening and for ink cleaning operations. Approximately 26 employees run the silkscreening operations during three overlapping shifts. These employees operate three to four individual silkscreening lines. Each line includes a polycarbonate cleaning/deionization process, silkscreen printing, conveyor supplied oven drying, and finish inspection. Approximately six to seven workers run each line. The primary job categories on each line include: silkscreener/tacker (2); deionizer (1); and finish inspector (3-4). Approximately 350 signs are printed each day. At the end of each shift, the silkscreens are cleaned in a spray trough using EGBE. This is done by workers in the silkscreener/tacker job category. Screened polycarbonate signs with flaws/imperfections are washed with EGBE (to remove all ink) on large tables adjacent to the spray trough. This work is generally done by two materials/inventory workers and by the workers in the deionizer job category from the silkscreening line operations.

The silkscreening lines are located together in one large building with an open bay design. The building is air-conditioned, but there is no outside air supply. The drying ovens, spray cleaning trough, and wash tables have some exhaust ventilation. The building has no other exhaust/dilution ventilation systems.

## IV. METHODS

An industrial hygiene survey was done at Dalb to evaluate exposures to EGBE and other organic chemicals from silkscreening operations. The exhaust ventilation systems serving this facility were evaluated and temperature/relative humidity measurements were taken. This survey was done over a three day period, June 23-25, 1987.

The organic gas and vapor samples were collected on a solid charcoal media in a sorbent tube.[1] These samples were collected using portable sampling pumps calibrated at two different flow rates: 20 cubic centimeters per minute (cc/min.) and 100 cc/min. Personal and area samples were taken; this included both partial shift (1-4 hours) and full shift samples (7 hours or longer). Bulk airborne gas/vapor samples were also collected using similar charcoal tubes at a sampling rate of approximately 100 cc/min. These bulk samples were analyzed qualitatively for organic compounds by gas chromatography (GC).[1] Charcoal tube samples were analyzed quantitatively for those organic gases and vapors detected in the bulk samples using GC.[1] The charcoal tube samples were analyzed quantitatively for EGBE, n-nonane, n-undecane, toluene, and total hydrocarbons. The analytical detection limit for these analytes in milligrams per sample (mg/s) includes: EGBE (0.11 mg/s), n-nonane (0.03mg/s), N-undecane (0.02 mg/s), toluene (0.03 mg/m), and total hydrocarbons (0.04 mg/m). (NOTE: Airborne detection concentrations are variable as based on the different sample volumes collected; they can be calculated from Tables I and II by dividing the analytical detection limit by the individual sampling volume in cubic meters ($m^3$). One $m^3$ equals 1000 liters). Airborne concentrations of the analyates are reported as milligrams per cubic meter of air ($mg/m^3$) or as parts per million parts air by volume (ppm).

Additional direct air readings for organic gases/vapors were taken with a photo-ionization meter to identify major solvent evaporation sources in the facility.[2]

Ventilation system flow rate measurements were made at the exhaust port for the wash table using a rotating vane anemometer.[2]

## V. EVALUATION CRITERIA

Evaluation criteria are used as guidelines to assess the potential health effects of occupational exposures to substances and conditions found in the work environment. These criteria consist of exposure levels for substances and conditions to which most workers can be exposed day after day for a working lifetime without adverse health effects. Because of variation in individual susceptibility, a small percentage of workers may experience health problems or discomfort at exposure levels below these existing criteria. Consequently, it is important to understand that these evaluation criteria are guidelines, not absolute limits between safe and dangerous levels of exposure.

Several sources of evaluation criteria exist and are commonly used by NIOSH investigators to assess occupational exposures. These include:

1. The U.S. Department of Labor (OSHA) permissible exposure limits (PEL's);[3]

2. The American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit (Exposure) Values (TLV's);[4]

3. NIOSH recommended exposure limits (REL's).[5,6]

These criteria have been derived from industrial experience, from human and animal studies, and, when possible, from a combination of the three. Consequently, due to differences in scientific interpretation of these data, there is some variability in exposure recommendations for certain substances. Additionally, OSHA considers economic feasibility in establishing occupational exposure standards; NIOSH and ACGIH do not consider economic feasibility in development of their criteria.

The exposure criteria described below are reported as: time-weighted average (TWA) exposure recommendations averaged over the full work shift; short term exposure limit (STEL) recommendations for a brief (10-15 minute) exposure period; and ceiling levels (C) not to be exceeded for any amount of time. These exposure criteria and standards are commonly reported as parts contaminant per million parts air (ppm), or milligrams of contaminant per cubic meter of air ($mg/m^3$). Occupational criteria for the air contaminants measured during this study are as follows:[3-6]

| SUBSTANCES | NIOSH (REL) | ACGIH (TLV) | OSHA (PEL) |
|---|---|---|---|
| EGBE (2-Butoxyethanol) | No Rec. | 25 ppm - TWA | 50 ppm - TWA |
| n-nonane | No Rec. | 200 ppm - TWA | No STD |
| n-undecane | No Rec. | No Rec. | No STD |
| Toluene | 100 ppm - TWA<br>200 ppm - C | 100 ppm - TWA<br>150 ppm - STEL | 200 ppm - TWA<br>500 ppm - C |
| Total Hydrocarbons | No Rec. | No Rec. | No STD |

VI. RESULTS/DISCUSSION

Material safety data sheets obtained initially for the inks/solvents used in the silkscreening operations at Dalb indicated that EGBE was the primary solvent. Some of the inks contained mineral spirits. Bulk air samples taken from the silkscreening area indicated the presence of EGBE and other organic compounds including: n-nonane; n-undecane; toluene; and other hydrocarbons. EGBE was the predominant hydrocarbon vapor exposure for workers at Dalb. N-nonane, n-undecane, and toluene exposures were low, generally below the lower quantification limits (Tables I and II).

EGBE concentrations in air ranged from a low of 13 parts per million parts air (ppm) to a high of 169 ppm (Tables I and II). EGBE, a colorless liquid with a mild ether odor, is a common solvent for many resins/inks used in surface coatings.[7] EGBE, like other organic solvents, can cause central nervous system disturbance. Eye, nose, and throat irritation from EGBE exposure are mild.[7,8] Hemoglobinuria (the presence of free hemoglobin in the urine) and hemolytic anemia (a low number of red blood cells) can occur with EGBE exposures in excess of existing exposure standards/guidelines.[7,9,10] Depending on exposure levels, related symptoms from EGBE exposure may include nausea, tiredness, weakness, shortness of breath, bloody urine, headache, and anexoria.[8,10,11] EGBE penetrates the skin readily and exposure from excessive skin contact may be more likely than from vapor inhalation.[7,10] Other ethylene glycol alkyl ethers (ethylene glycol monomethyl ether and ethylene glycol monoethyl ether) are reproductive toxins/teratogens; however, EGBE has not been shown to cause these types of health problems.[12-14]

The American Conference of Governmental Industrial Hygienists (ACGIH) recommends a full shift, time-weighted average (TWA) exposure limit (TLV) of 25 ppm.[4] The Occupational Safety and Health Administration (OSHA) enforces a Permissible Exposure Limit (PEL) of 50 ppm as a TWA.[3] NIOSH has no established exposure recommendation for EGBE. Neither ACGIH, OSHA, or NIOSH have exposure standards or criteria to assess the additive effects of EGBE exposure through skin contact.

Area EGBE concentrations from the spray trough at DALB were the highest with an average, short term concentration of 167 ppm. This operation is run for only a part of the work day, about 45 minutes; yet this operation is a substantial exposure source. Additionally, some of the employees involved in screen cleaning at this spray trough did not wear protective gloves or goggles to prevent EGBE absorption through the skin or eye

injury. Average EGBE concentrations from the silkscreening line operations and the wash table ranged from 23 ppm to 29 ppm (Table III). Two of these lines (Line 1 and 3) had average EGBE concentrations above the ACGIH TLV. Line three had the highest oven area EGBE concentration, 39 ppm.

Personal EGBE exposures ranged from 13 ppm to a high of 36 ppm measured in the screener/tacker job category (Table I). Six of the 14 personal exposure measurements exceeded the ACGIH TLV. These overexposures occurred among three job categories: screener/tacker (3 overexposures); deionizer (2 overexposures); and sign washer (1 overexposure). None of the airborne personal EGBE exposure measurements exceeded the OSHA PEL enforced in this industry. The deionizer job category had the highest average EGBE exposure level, 30 ppm as a TWA (Table IV). The screener/tacker job category had an average exposure of 26 ppm. These two job categories had average EGBE exposures above the ACGIH TLV. The finish inspectors had the lowest average EGBE exposure, 22 ppm. Additional EGBE exposure through skin contact in some job categories (screener/tacker, deionizer, and sign washer) greatly increases employee exposure and related health hazards.

Organic vapor measurements taken with a direct reading photoionization meter indicated that the silkscreen printer was a major source of organic vapor release into room air from the silkscreening process. Another major source of vapor release from the silkscreening lines involved open ink containers near the silkscreens. The open conveyor area between the oven and the dryer was another source of solvent release from silkscreen line operations.

The spray trough and the sign wash table, while used only periodically, are both major sources of organic vapor release (and exposures). Both operations use pure EGBE solvent. Both operations have some exhaust ventilation; however, ventilation design and operations is suboptimal. Axial fans located in the building wall are used at both of these operations to exhaust organic vapors directly to the building's exterior; there is no building supply air source for these exhaust fans. Neither operation is enclosed. The average volumetric flow measurement for the wash table exhaust fan is 915 CFM. This wash table is located about 2-3 feet from the wall exhaust fan; occasionally employees would work between this exhaust fan and the wash table resulting in increased EGBE solvent exposures. The exhaust fan for the spray trough was located at floor level; consequently, solvent vapors from this screen cleaning operation are directed through the employees breathing zone prior to removal from the building.

Air temperature at Dalb ranged from 64° F to 78° F during our evaluation. Relative humidity ranged from 44 percent to 48 percent.

## VII. CONCLUSIONS

1. Six of the 14 personal exposure measurements exceeded the ACGIH TLV for Butyl cellosolve. None of the airborne personal EGBE exposure measurements exceeded the OSHA PEL. The screener/tacker and deionizer job categories had the highest average exposure levels in excess of the ACGIH-TLV.

2. Some workers involved in cleaning silkscreens and signs with EGBE wore no protective gloves or goggles. These cleaning operations involve considerable solvent/skin contact and this is a major EGBE exposure source for these employees in addition to respiratory system exposure. There are no adequate health standards or guidelines to assess combined respiratory and skin exposures to EGBE.

3. At the spray trough and the wash table areas, employees use pure EGBE solvent for cleaning activities; consequently, these areas are major sources of vapor release and employee exposure as indicated by the sampling data. The existing exhaust ventilation system design and operation in these two areas is inadequate. Other major areas (sources) of EGBE release during silkscreening operations include the silkscreen printer, open ink containers, and the conveyor area between the oven/dryer.

## VIII. RECOMMENDATIONS

1. Skin and eye contact with EGBE should be prevented with the use of personal protective gloves, eye goggles, and aprons. All employees involved in screen cleaning or sign washing operations should be required to use protective gloves, goggles, and aprons. Only those gloves suitable for work with EGBE solvent should be used. Some glove materials appropriate for use with EGBE solvents include: Neoprene, Butyl, and Nitril materials.[15-19] Consult glove manufacturers for appropriate gloves for EGBE. Some manufacturers offer a disposable glove designed to be discarded after use for one shift. If non-disposable gloves are selected, care should be taken to ensure that the duration of glove use does not exceed manufacturer's recommendations to prevent solvent breakthrough and exposure.

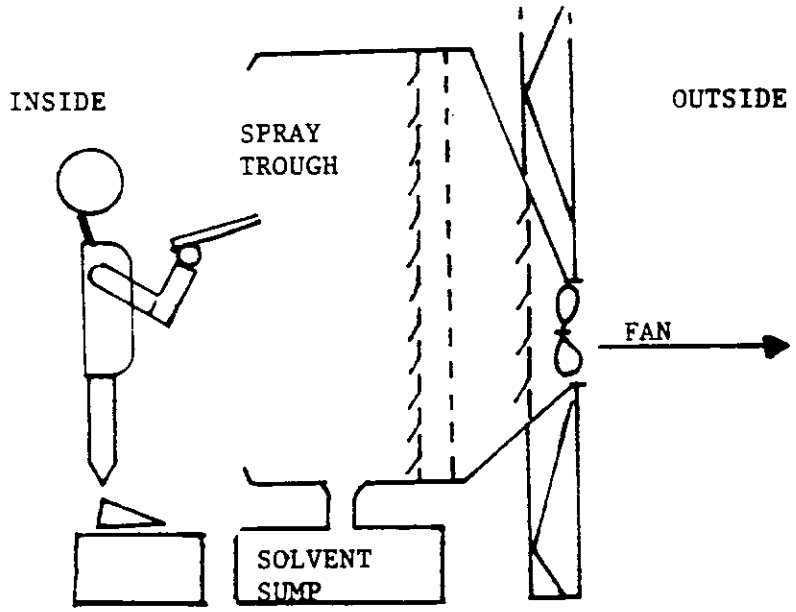
2. Ventilation system controls would be one of the best methods to reduce respiratory EGBE exposures at DALB; these recommendations would include:

A. Install small local exhaust ventilation systems on each of the four silkscreen printers to control EGBE vapor release (and exposure) during printing;

B. Enclose the open conveyor area between the oven and the dryer;

C. The sign wash table should be located against the wall containing the existing exhaust fan to prevent employees from working between the exhaust fan and sign wash table;

D. The exhaust fan for the spray trough should be relocated from its floor position. This fan should be restructured as part of the spray trough to exhaust vapors directly away from the workers breathing zone as detailed in the diagram below. A minimum capture velocity of 100 feet per minute would be required.(20)




E. Install a supply fan to provide outside air intake for the building to compensate for building air loss through exhaust ventilation. The intake for this supply air source should be located away from any ventilation system exhausts, preferably on the roof or on a side of the building with no ventilation exhaust ports, to prevent solvent vapor reentrainment.

3. All open ink and solvent containers should be kept covered to prevent EGBE evaporation.

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## XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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1. Dalb, Inc.
2. NIOSH Regional Office 3
3. OSHA

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

TABLE I
ORGANIC VAPOR EXPOSURES FROM PERSONAL BREATHING ZONE SAMPLES
DALB, INC.
MHETA 87-273

| Job | Location | Date | Sampling Volume (l) | CONCENTRATION Butyl Cellosolve (ppm) | n-nonane (ppm) | n-undecane (ppm) | toluene (ppm) |
|---|---|---|---|---|---|---|---|
| Inspector | Line 1 | 6/24/87 | 8.5 | 22 | LOQ | LOQ | ND |
| Screener | Line 1 | 6/24/87 | 9.5 | 23 | LOQ | LOQ | ND |
| Inspector | Line 2 | 6/24/87 | 7.9 | 24 | LOQ | LOQ | ND |
| Screener | Line 2 | 6/24/87 | 8.5 | 26 | LOQ | LOQ | ND |
| Inspector | Line 3 | 6/24/87 | 9.6 | 21 | LOQ | LOQ | ND |
| Screener | Line 3 | 6/24/87 | 9.8 | 22 | LOQ | LOQ | ND |
| Sign Wash | Wash table | 6/24/87 | 16 | 13 | LOQ | LOQ | ND |
| Deionizer | Line 1 | 6/25/87 | 9.6 | 31 | 0.8 | LOQ | ND |
| Screener | Line 1 | 6/25/87 | 9.1 | 36 | 1.0 | LOQ | ND |
| Screener | Line 2 | 6/25/87 | 8.5 | 20 | ND | ND | ND |
| Deionizer | Line 2 | 6/25/87 | 8.3 | 25 | LOQ | LOQ | LOQ |
| Deionizer | Line 3 | 6/25/87 | 5.6 | 26 | ND | ND | ND |
| Screener | Line 3 | 6/25/87 | 5.6 | 26 | ND | ND | ND |
| Sign Wash | Wash table | 6/25/87 | 7.9 | 33 | 1.0 | LOQ | LOQ |
| | Exposure Standards/Criteria: | | | | | | |
| | NIOSH - REL | | | No REL | No REL | No REL | 100 |
| | ACGIH - TLV | | | 25 | 200 | No TLV | 100 |
| | OSHA - PEL | | | 50 | No PEL | No PEL | 200 |

1- sampling volume in liters.
ppm - parts per million parts air by volume.
ND - samples below the analytical detection limit. Approximate ND levels for the compounds above include: n-nonane - 1 ppm; n-undecane - 0.5 ppm; and toluene - 1 ppm.
LOQ - samples below the lower quantification limit. Approximate LOQ's for the compounds above include: n-nonane - 2 ppm; n-undecane - 2 ppm; and toluene - 3 ppm.

**TABLE II**
**ORGANIC VAPOR CONCENTRATIONS FROM AREA SAMPLES**
**DALB, INC.**
**MHETA 87-273**

| Location | Date | Sampling Volume (l) | CONCENTRATION Butyl Cellosolve (ppm) | n-nonane (ppm) | n-undecane (ppm) | toluene (ppm) |
|---|---|---|---|---|---|---|
| Finish area-Line | 6/24/87 | 9.4 | 23 | LOQ | LOQ | ND |
| Finish area Line | 6/24/87 | 8.1 | 25 | LOQ | LOQ | ND |
| finish area-Line | 6/24/87 | 9.2 | 33 | 1.5 | 0.7 | LOQ |
| Spray trough Line | 6/24/87 | 2.2 | 165 | LOQ | ND | ND |
| Oven area Line | 6/25/87 | 6.4 | 25 | LOQ | LOQ | LOQ |
| Oven area Line | 6/25/87 | 8.2 | 25 | LOQ | LOQ | LOQ |
| Oven area Line | 6/25/87 | 4.9 | 39 | LOQ | LOQ | LOQ |
| Spray trough Line | 6/25/87 | 2.5 | 169 | LOQ | LOQ | LOQ |
| Exposure Standards/Criteria: | | | | | | |
| NIOSH - REL | | | No REL | No REL | No REL | 100 |
| ACGIH - TLV | | | 25 | 200 | No TLV | 100 |
| OSHA - PEL | | | 50 | No PEL | No PEL | 200 |

1- sampling volume in liters.
ppm - parts per million parts air by volume.
ND - samples below the analytical detection limit. Approximate ND levels for the compounds above include: n-nonane - 1 ppm; n-undecane - 0.5 ppm; and toluene - 1 ppm.
LOQ - samples below the lower quantification limit. Approximate LOQ's for the compounds above include: n-nonane - 2 ppm; n-undecane - 2 ppm; and toluene - 3 ppm.

TABLE III
BUTYL CELLOSOLVE CONCENTRATIONS BY AREA
DALB, INC.
MHETA 87-273
CONCENTRATIONS IN PPM

| | Samples | Mean | STD | Range Low | Range High |
|---|---|---|---|---|---|
| Line 1 | 6 | 28 | 6.1 | 22 | 36 |
| Line 2 | 6 | 24 | 2.1 | 20 | 36 |
| Line 3 | 6 | 29 | 7.1 | 21 | 39 |
| Wash Table | 2 | 23 | 14 | 13 | 33 |
| Spray Trough | 2 | 167 | 2.8 | 165 | 169 |

- Includes both personal and area samples.
PPM - Parts per million parts air by volume.
STD - Standard Deviation.

TABLE IV
BUTYL CELLOSOLVE EXPOSURES BY JOB
DALB, INC.
MHETA 87-273
CONCENTRATIONS IN PPM

| Job | Samples | Mean | STD | Range Low | Range High |
|---|---|---|---|---|---|
| Screener/tacker | 6 | 26 | 5.7 | 20 | 36 |
| Finish inspector | 3 | 22 | 1.6 | 21 | 24 |
| Deionizer | 3 | 30 | 4.2 | 25 | 33 |
| Sign washer | 2 | 23 | 14 | 13 | 33 |

- Personal breathing zone samples.
PPM - Parts per million parts air by volume.
STD - Standard Deviation.