U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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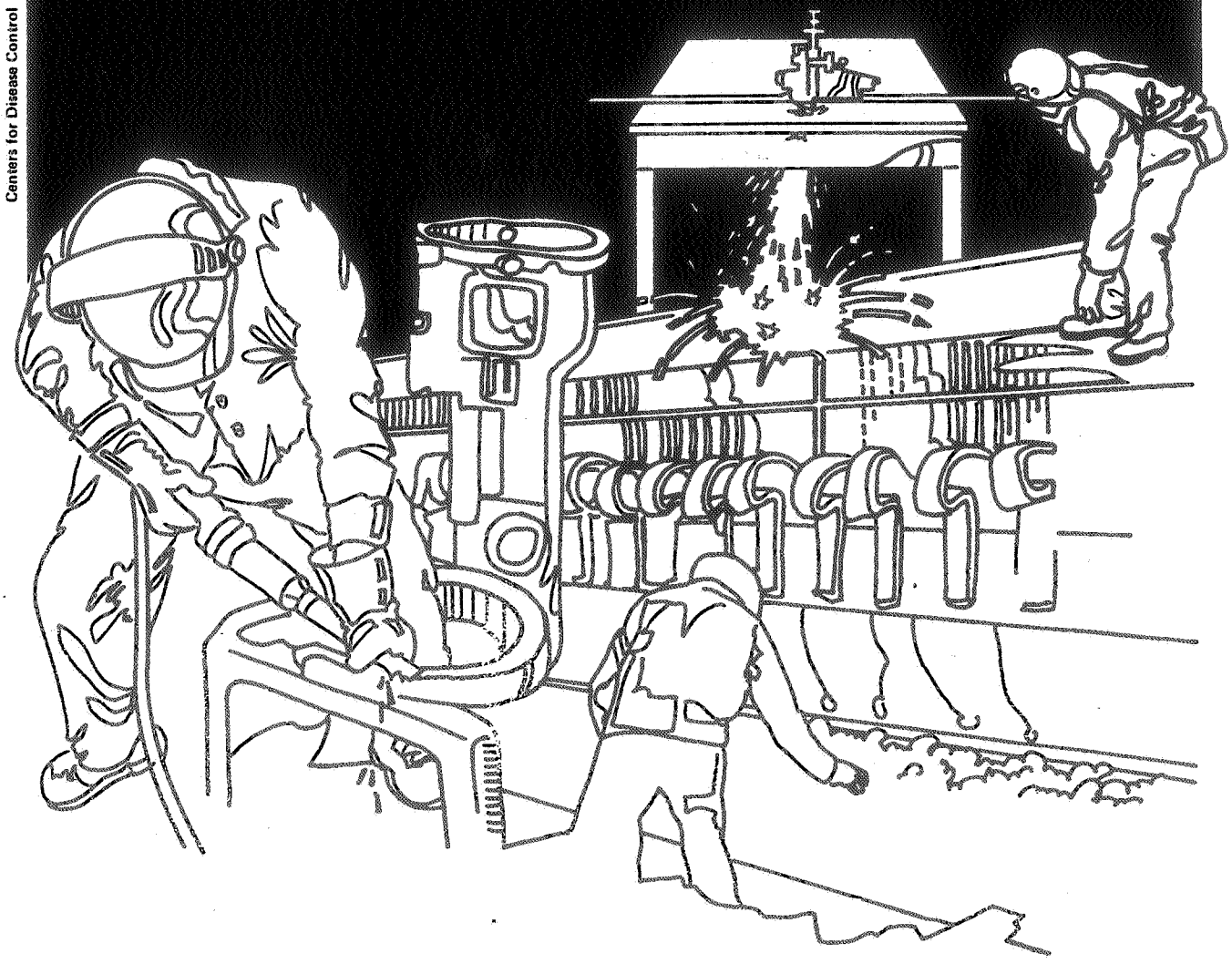
NIOSH



Health Hazard Evaluation Report

HETA 81-106-1003
ABT ASSOCIATES
CAMBRIDGE, MASSACHUSETTS

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 hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HETA 81-106-1003
November 1981
Abt Associates
Cambridge, Massachusetts

Principal Investigator:
Edward L. Baker, MD

I. SUMMARY

In November 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from the manager of the printing shop at Abt Associates, a consulting firm in Cambridge, Massachusetts. The adverse symptoms experienced by employees of the printing shop were headaches, dizziness, nausea, sleepiness, skin irritation, and eye, nose, and throat irritation which occurred particularly on Fridays when the two printing presses were cleaned. To determine whether these symptoms were work-related, an industrial hygiene survey and medical evaluation of the five employees of the shop were conducted.

Forty personal and area air samples collected on charcoal tubes were analyzed for n-hexane, 1,1,1-trichloroethane, methylene chloride, ethanol, benzene, methyl isobutyl ketone, toluene, and xylene. In addition, the shop's ventilation system was evaluated by measuring air velocity at all supply and exhaust vents.

Of forty partial shift samples for the eight solvents, seven samples for methylene chloride exceeded the NIOSH workshift average criteria of 75 ppm. These seven ranged from 104 to 446 ppm. One employee was exposed to a shift average of 130 ppm as compared to the 75 ppm NIOSH recommendation. A composite exposure index, based on central nervous system health effects and combining individual exposure levels as a percent of the survey criteria, indicated exposures for certain employees above the recommended level. The shop's three exhaust hoods were found to have inadequate capture velocities.

The medical survey included a health history questionnaire, neurobehavioral testing, a neurological examination, hematology and liver profiles and analysis of eight-hour urine collections for solvent metabolites.

The workers noted neurologic symptoms including transient numbness and tingling of hands, dizziness, blurred vision, nausea, skin irritation, and eye, nose, and throat irritation. Performance decrements over the Friday workday were seen on difficult items of the neuropsychologic tests. These items were, in most instances, reversed by Monday morning. The neurologic physical exams, and hematologic profiles were normal. No trichloroacetic acid was detected in the urine samples.

The acute symptoms experienced by the employees in the print shop of Abt Associates are determined to be work-related and are associated with the solvent exposures. No chronic health impairment was found. A redesign of the shops ventilation (as outlined in the recommendation section) could alleviate the health problems of the print shop employees as well as the occasional complaints of employees who work in adjacent shops in the Abt basement.

KEYWORDS: SIC 2750 (Commerical Printing), n-hexane, 1,1,1-trichloroethane, methylene chloride, ethanol, benzene, methyl isobutyl ketone, toluene, xylene, numbness and tingling of hands, dizziness, blurred vision, nausea, skin irritation, eye, nose, and throat irritation, ventilation.

II. INTRODUCTION

In November 1980, NIOSH received a request for a Health Hazard Evaluation from the manager of the printing shop at Abt Associates, a consulting firm in Cambridge, Massachusetts.

Employees of the shop were experiencing headaches, dizziness, nausea, sleepiness, skin irritation, and eye, nose, and throat irritation which occurred particularly on Fridays when the two printing presses were cleaned.

To determine whether these symptoms were work related an industrial hygiene survey was conducted on December 11, 1980, and January 9 and 30, 1981. Medical evaluations of the five workers of the shop were conducted on January 9 and 30, 1981.

III. BACKGROUND

The printing shop is on the basement level of the Abt Associates building. Since this floor was once an underground parking garage, the walls and floors are made of concrete, the ceilings are low, and there are no windows. The two printing presses are located under exhaust hoods (Figure 1). The majority of the printing work done is offset.

The shop has five employees, including the manager. One works primarily in the office, another primarily in the darkroom, and the other three work in the central room. The workers are involved in photography, photographic development, platemaking, and binding as well as the printing operations.

There are twelve solvent solutions used in the shop. The manager estimated the following annual volumes for the three most frequently used substances: general cleaning solvent for the presses - 30 gallons; glaze remover - 3 gallons; and ink roll desensitizer - 6 pints. The general cleaning solvent for the presses is composed primarily (75% - 95%) of aromatic and aliphatic petroleum distillates, with methylene chloride accounting for 5% - 10% by volume. It is applied to the presses via squirt bottles. The glaze remover is of similar composition, except that it contains no methylene chloride. The ink roll desensitizer contains glycols primarily, but also 5% methylene chloride, 5% 1,1,1-trichloroethane, and small amounts of copper chloride and hydrochloric acid. It is also used in the press cleaning operations.

Two other substances are possible sources of air contamination. A developer is used at a platemaking table under an exhaust hood (Figure 1), and contains 10% amyl acetate whose characteristic odor had been the source of complaints from workers in the hallway outside the printing shop. It also contains isomers of heptanone. An adhesive is used several times weekly in the binding area, and contains about 28% ethanol.

IV. METHODS

A. Environmental

Bulk samples of the three most frequently used solvents were analyzed by gas chromatography to determine which compounds were contained in these solvents. Accordingly, on Thursday, December 11, 1980; Friday, January 9, 1981; and Friday, January 30, 1981, forty personal and area air samples were collected to determine concentrations of n-hexane, 1,1,1-trichloroethane, methylene chloride, ethanol, benzene, methyl isobutyl ketone, toluene, and xylene. All samples were obtained by using charcoal tubes attached by tubing to sampling pumps calibrated at approximately 100 cubic centimeters per minute (cc/min). The charcoal tubes were analyzed by gas chromatography (NIOSH Method P & CAM 127).[1]

The exhaust ventilation system consists of three ceiling hoods which ultimately exhaust outdoors. Each of the hood faces has an area of 4 feet square (2 feet x 2 feet) and the hood is one foot deep before connecting with an 8 inch round duct, which leads to the main exhaust duct. Linear air velocity measurements (3 point by 3 point traverse) at the face were taken with a thermal anemometer. Estimated supply air flows were provided by the engineering department of Abt Associates.

B. Medical

All of the medical evaluation was conducted on January 9, 1981, except for the neurobehavioral testing which was conducted on both January 9, 1981, and January 30, 1981.

Subjects: Four persons working in this shop were evaluated. Two workers were employed in the operation of printing presses, a third worked developing photographic negatives used in the printing process, and a fourth, a secretary, worked in an adjacent office.

Three of the employees were female and one was male. The age range was 32 - 41 years. The length of employment with the company was 8 years, 3 years, 5 months, and 5 months. The mean length of employment was 3 years.

Health History Questionnaires: Each person was questioned for symptoms of solvent toxicity, history of prior exposure to neurotoxins, past medical history, and history of cigarette and alcohol use.

Neurobehavioral Testing: A battery of neurobehavioral tests, designed to detect the acute and chronic effects of solvent exposure (2) was administered by two psychological technicians. Testing was performed prior to work Friday morning, after work Friday afternoon, and before work on Monday morning. The battery consisted of the Santa Ana test of manual dexterity, selected subtests of the Wechsler Adult Intelligence Scale (digit span, vocabulary, digit symbol, and block design), and of the Wechsler Memory Scale (visual reproduction and associate learning). To reduce the learning effect on performance at the second and third testing sessions, tests were modified by dividing the vocabulary, visual reproductive, and block design subtests into three portions such that each portion contained equal proportions of easy and difficult items. Toward a similar end, supplemental versions of the digit span, digit symbol, and associate learning subtests were used.

Physical Examinations: A neurologic examination, including cranial nerve, motor, sensory, cerebellar function and deep tendon reflexes was performed by a physician.

Laboratory Examinations: An automated chemistry battery and hematologic profile were performed using standard techniques by a commercial laboratory. Venous blood samples were obtained and smears for differential counts were made at that time.

Eight hour urine collections were obtained during the Friday workshift and analyzed for trichloroacetic acid, trichloroethanol, and hippuric acid using gas chromotography.

V. EVALUATION CRITERIA

A. Environmental

The environmental evaluation criteria used for this study are presented in Table 1. Listed in Table 1, for each substance, are the recommended environmental limit, the source of the recommended limit, the principal or primary health effects underlying each recommended limit, and the current OSHA legal standard. The NIOSH and American Conference of Governmental Industrial Hygienists (ACGIH) recommendations are often lower than the legal standards because they incorporate newer information and are mainly based on health considerations and technical feasibility.

A calculation for mixtures is relevant when two or more hazardous substances, which may result in similar health effects, are present in the same environment. The calculation is performed according to the method published by the American Conference of Governmental Industrial Hygienists. If the sum of the following fractions,

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} \quad \text{-----}$$

exceeds unity, then the recommended environmental limit for the mixture is considered as being exceeded. C_1 is the observed air level and T_1 is the corresponding environmental limit. Calculations of solvent vapor mixture fractions were performed for each sample of this study according to: (1) the irritative effects of ethanol, methyl isobutyl ketone, and xylene; and (2) the central nervous system effects of n-hexane, methylene chloride, toluene, 1,1,1-trichloroethane, and xylene.

B. Toxicology

The primary absorption route for the majority of exposures encountered is via inhalation, although skin and gastrointestinal absorption may play a role. Exposures to solvents, including aromatic, aliphatic and chlorinated hydrocarbons, and amyl acetate produce central nervous system (CNS) depression, including narcosis and death at high levels, and multiple CNS symptoms at lower concentrations. These symptoms include light headedness, "drunkenness", confusion, incoordination, numbness and tingling, nausea, vomiting and occasional abdominal pain, prolonged reaction time, headache, fatigue, irritability, temporary deafness and visual disturbances. Hexane and methyl isobutyl ketone may cause peripheral neuropathy.

The aromatic, aliphatic, and chlorinated hydrocarbons, as well as amyl acetate, methyl isobutyl ketone, copper salts, and hydrochloric acid are skin irritants. The hydrocarbons may cause skin defatting, and predispose to infections or hypersensitivity as well as irritant contact dermatitis. These substances also produce mucous membrane irritation, affecting eyes, nose, and throat. Hydrochloric acid may cause burns, ulceration, corrosion of teeth, glottal edema, bronchitis, and pulmonary edema (in high concentrations). Copper salts may lead to corneal turbidity.

1,1,1-trichloroethane and methylene chloride have both been associated with liver toxicity, although less so than other chlorinated hydrocarbons such as carbon tetrachloride and 1,1,2-trichloroethane. Carbon tetrachloride and 1,1,2-trichloroethane were not specifically listed on the material safety data sheets for the solvents, but may be present as "chlorinated hydrocarbons." Methylene chloride is metabolized to carbon monoxide and has been associated with angina and myocardial infarctions secondary to the increased carboxyhemoglobin. 1,1,1-trichloroethane, and other chlorinated hydrocarbons, may produce cardiac arryhthmias. Some chlorinated hydrocarbons have been shown to be both mutagenic by Ames testing and carcinogenic in laboratory animals.

If the aromatic hydrocarbon component is contaminated with benzene, the risk of aplastic anemia and acute myelogenous leukemia must be considered.

Nausea, vomiting and abdominal pain may be related to CNS toxicity (or severe liver toxicity). Copper salts may also cause metallic taste, and gastrointestinal irritation, increased salivation, nausea, vomiting, pain, hemorrhagic gastritis and diarrhea.

VI. RESULTS

A. Environmental

Of the forty charcoal tubes collected and analyzed for the eight solvents, one of the solvents (methylene chloride) exceeded the recommended environment limit of 75 ppm. Seven of the partial workshift samples for methylene chloride exceeded the workshift average criteria of 75 ppm (Table 3). These seven samples ranged from 104 to 446 ppm and all were associated with the printing or press cleaning/checking process (Table 6). On a time weighted average eight-hour workshift basis (assuming no exposure during non-sampling times), one employee (Employee No. 2, January 9, 1981) was exposed to 130 ppm as compared to the 75 ppm criteria for methylene chloride.

Of the solvent vapor mixture fractions based on irritative effects (ethanol, methyl isobutyl ketone, xylene), none of the samples exceeded the survey criteria of 1.0 (Table 6). Based on central nervous system effects (n-hexane, methylene chloride, toluene, 1,1,1-trichloroethane, xylene), ten of the partial shift samples exceeded the survey criteria of 1.0. These ten ranged from 1.19 to 6.14 and all were associated with the printing process. For a time weighted average for the total workshift (but assuming zero exposure during non-sample times) one employee was exposed to a vapor mixture in excess of the survey criteria of 1.0 (Table 5).

The data of Table 4 summarizes task specific personal exposures based on the calculated vapor mixture fractions. These data show that the printing process (particularly press cleaning) creates the greatest exposures for the employees. For press cleaning, the solvent mixture fraction (CNS effects) ranged from 1.69 to 6.14 with a mean of 3.59 for four partial shift personal samples as compared to the survey criteria of 1.0.

The average face velocities for all the hoods ranged from 50 - 60 feet per minute (fpm) (Table 2). From Table 4-1 of Industrial Ventilation (3) the recommended capture velocity for printing press operations is in the range of 100 - 200 fpm. Since all three of the hoods were at least two feet above the point of contaminant generation, Dalla Valle's equation demonstrates that the capture velocity at the point of generation would be negligible relative to the velocity of the general currents of room air. Thus, the hanging hoods have no local exhaust effect, and serve to control the air levels of contaminants by general exhaust dilution only.

Another problem was the imbalance of the supply and exhaust air flows. The engineering department reported that each of the supply air vents was providing greater than 1000 cubic feet per minute (cfm) fresh air. This total supply far exceeds the exhaust capacity of the three hanging hoods and the exhaust vents in the darkroom. The result is that the printing shop is under positive pressure relative to the adjacent corridors, and the direction of general air flow (including solvent vapors) is out of the shop and into the hallways and adjacent work areas.

Finally, we were told that generally 50% fresh air and 50% recirculated air were supplied to the shop in the summer, and 10% fresh - 90% recirculated air in the winter. On the day of our testing, 100% fresh air was supplied.

B. Medical

Health Histories: Two of the four employees examined experienced symptoms which occurred primarily at work (Table 7). Both noted frequent headaches and irritability, and nausea only when solvent odor was particularly strong. Both also felt that they had experienced hearing loss related to excessive noise at work. One of the two (not always the same one) complained additionally of light-headedness, paresthesias, trouble concentrating, flushing, blurred vision, tinnitus, eye, nose, and throat irritation, and skin rash, all of which occurred at work.

Neurobehavioral Testing: Modest performance decrements, for the four subjects, over the Friday workday were seen on difficult items in the block design, associate learning and visual reproduction subtests. These decrements were, in most instances, reversed by Monday morning. Digit symbol subtest performance declined in all four subjects over the workday; Monday morning scores were lower than Friday morning results. Performance on the vocabulary and digit span subtests and the Santa Ana dexterity test did not vary significantly between sessions. Statistical testing was not performed due to the small number of subjects tested.

Laboratory Examinations: There were no abnormalities noted on the chemistry profiles. The hematologic profiles were also normal except for the percent of lymphocytes, which fell above the laboratory's normal range of 20 - 40% in three of the four tested (52%, 49%, 41%). The urine samples were negative for trichloroacetic acid.

Physical Examinations: The physical neurologic exams were within normal limits.

VII. DISCUSSION

The solvent concentrations measured most likely represent underestimates of the range of solvent exposures normally encountered in the print shop because of employee reports that solvent fumes were light compared to previous days. Furthermore, the work load for the days of the evaluation was lighter than most and thus less solvents were used in routine press operations. The ventilation engineer also stated the 100 percent fresh make up air was being sent through the print shop during the days the evaluation was conducted. Prior to the evaluation, no more than 50 percent make up air had been brought into the shop.

Only the eight major solvents were included in the calculation of the mixture fractions. It is likely that there were small amounts of other solvents present (particularly aliphatic hydrocarbons). Had these other solvents been added to the mixture calculations, the resulting values would have been slightly higher.

In this shop, workers exposed to solvents noted significant rates of neurologic symptoms including transient numbness and tingling of hands, dizziness, blurred vision, nausea, skin irritation, and eye, nose, and throat irritation. Furthermore, employees in adjacent shops in the basement level occasionally complained of irritation from "noxious fumes" coming from the print shop. Although most of these symptoms were not experienced on the days of environmental monitoring, neurobehavioral testing indicted that there may still be subtle neuologic health effects at the levels monitored during this survey.

This health hazard evaluation does not show any chronic nerve, blood, or liver damage due to solvents as cited in previous studies of occupational exposures to solvents (4). The workers in these earlier studies had a longer solvent exposure than the employees at Abt Associates. It is possible that no chronic health impairment has been detected in this study population because the duration of solvent exposure has not been long enough or the exposure has not been high enough. However, this investigation does show acute solvent toxicity.

Previous studies of solvent exposure have shown psychomotor deficits in exposed populations (5,6). The results of this study are consistent with these previous findings.

VIII. RECOMMENDATIONS

1. The ventilation system of the printing shop should be balanced by keeping the supply rate at or above the 2,000 cfm that was measured on the day of the evaluation and by increasing the exhaust rate slightly above the supply rate so that a negative pressure is created in the room. These manipulations will prevent undesired transport of air contaminants generated during shop operations to areas outside the shop. It will also reduce solvent vapor concentrations within the shop.

2. Given the location of the press operator and the necessity for accessibility to certain parts of the press during operations, local exhaust ventilation of the presses is not recommended.

3. A well-designed general dilution ventilation system for the shop seems most appropriate in the prevention of hazardous levels of solvent vapors. Relocation of the printing presses and the exhaust vents may be necessary to obtain the desired pattern of air movement in the shop. The printing presses should be located between the worker and the exhaust vents with the supply inlets at some distance from the printing area. In this way, a general pattern of air movement from supply air vent, past the worker, then past the presses, and ultimately to exhaust may be established.

4. Continued use of 100 percent fresh air supply is recommended to prevent a build-up of contaminant concentrations in the workplace air over the course of the workshift.

5. A minimum of solvent should be used at any one time.

6. The employees of this print shop have already begun to educate themselves about the hazards of solvent exposures. This is important for those who must handle solvents in the workplace. This education should continue and should be offered to any new employees.

7. The use of a non-greasy barrier cream is recommended to protect hands from drying and cracking due to solvent exposure.

IX. REFERENCES

1. NIOSH Manual of Analytical Methods, Second Edition Volume 1. DHEW (NIOSH) Publication No. 77-157-A, April 1977.

2. Wechsler, D.A.: Standardized Memory Scale for Clinical Use, Journal of Psych. Vol. 19 pp. 87-95, 1945.

3. American Conference of Governmental Industrial Hygienists, Industrial Ventilation: A Manual of Recommended Practice, 1980, 16th Edition. Committee on Industrial Ventilation, P. O. Box 16153, Lansing, Michigan 48901.

4. Browning, Ethel: Toxicity and Metabolism of Industrial Solvents, Elsevier Publishing Company, 1965.

5. Seppalainen, A.M., Lindstrom, K., Martelin, T.: Neurophysiological and Psychological Picture of Solvent Poisoning, Am. Journal of Industrial Medicine 1: 31-42, 1980.

6. Lindstrom, K.: Changes in Psychological Performances of Solvent-Poisoned and Solvent-Exposed Workers, Am. Journal of Industrial Medicine 1: 69-84, 1980.

X. ACKNOWLEDGEMENTS

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XI. DISTRIBUTION/AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available from the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH at the Cincinnati address.

This report (copies) has been sent to:

1. Abt Associates
2. U. S. Department of Labor, OSHA, Region I
3. U. S. Department of Health and Human Services, NIOSH, Region I
4. Massachusetts Department of Labor and Industries

For purposes of informing the "affected employees" the employer shall promptly post for a period of 30 calendar days, this report in a prominent place(s) near where the exposed employees work.

TABLE 1
ENVIRONMENTAL EVALUATION CRITERIA

SUBSTANCE	RECOMMENDED ENVIRONMENTAL LIMIT (ppm)	SOURCE	PRIMARY HEALTH EFFECTS	OSHA STANDARD (ppm)
Benzene	1.0 (60 minute ceiling)	NIOSH	Blood Changes Including Leukemia	10
Ethanol	1000	ACGIH*	Eye and Resp. Tract Irritation	1000
n-Hexane	50	ACGIH	Neurotoxic Effects - Polyneuropathy	500
Methyl Isobutyl Ketone	50	NIOSH	Respiratory Irritation, Headache, Nausea	100
Methylene Chloride	75 (500 ceiling)	NIOSH	Central Nervous System Effects	500
Toluene	100 200 (10 min. ceiling)	NIOSH	Central Nervous System Depressant	200
1,1,1-Trichloroethane	350 (15 minute ceiling)	NIOSH	Nervous System, Liver and Heart Effects	350
Xylene	100 200 (10 minute ceiling)	NIOSH	Central Nervous System Depressant Airway Irritation	100

All air concentrations are time weighted average (TWA) exposures for a normal (8 to 10 hours) workday of a 40 hour workweek unless otherwise designated.

* American Conference of Governmental Industrial Hygienists. Threshold Limit Values (TLV's) for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1980.

TABLE 2

VENTILATION MEASUREMENTS

1. Face Velocity and Total Exhaust Flow for the Three Ceiling Hoods

Location	Average Face Velocity (fpm)	Face Area (ft^2)	Exhaust Flow (cfm)
E-1	54.4	4	218
E-2	55.6	4	222
E-3	58.9	4	236

2. Calculation of Capture Velocity At Source of Contaminant Generation, Using Dalla Valle's Equation with X = 2 feet Distance From Hood Face

$$V = \frac{Q}{10X^2 + A}$$

Location	Q (cfm)	A (ft^2)	X (ft)	Capture Velocity, V (fpm)
E-1	218	4	2	5.0
E-2	222	4	2	5.0
E-3	236	4	2	5.4

TABLE 3

SUMMARY OF AIR SAMPLING FOR EIGHT ORGANIC VAPORS

COMPOUND	RECOMMENDED ENVIRONMENTAL LIMIT (ppm)	DETECTABLE SAMPLES	PERCENT DETECTABLE	RANGE (ppm)	ARITHMETIC MEAN (ppm)
n-Hexane	50	40 of 40	100	1.0 - 14.3	6.2
1,1,1-Trichloroethane	350	17 of 40	42.5	2.4 - 114.0	34.5
Methylene Chloride	75	18 of 40	45	6.3 - 445.7	93.7
Ethanol	1000	13 of 40	32.5	7.6 - 139.6	55.9
Benzene	1	1 of 40	2.5	- - - - - -	0.02
Methyl Isobutyl Ketone	50	14 of 40	35	0.5 - 21.5	5.1
Toluene	100	22 of 40	55	0.2 - 11.5	2.5
Xylene	100	2 of 40	5	5.3 - 9.8	7.6

NOTE: Of the above analyses, only methylene chloride exceeded the Recommended Environmental Limit on 7 of the 40 partial workshift samples.

TABLE 4

SUMMARY OF TASK SPECIFIC PERSONAL EXPOSURES
BASED ON CALCULATED VAPOR MIXTURE FRACTIONS

WORK TASK	NUMBER OF PERSONAL SAMPLES	FRACTIONS BASED ON IRRITATION[1]		FRACTIONS BASED ON CENTRAL NERVOUS SYSTEM EFFECTS[2]	
		MEAN	RANGE	MEAN	RANGE
Printing	14	0.12	nd-0.57	0.53	0.02-2.35
Cleaning Press	4	0.03	nd-0.10	3.59	1.69-6.14
Darkroom	6	0.01	nd-0.04	0.25	0.04-0.76
Drafting	3	0.04	0.01-0.11	0.17	0.07-0.23
Folding/Collating	3	0.01	nd-0.03	0.51	0.08-1.25

NOTES:

1. Calculated mixture fractions based on irritative effects of ethanol,

TABLE 5
WORKSHIFT EXPOSURE OF INDIVDUAL EMPLOYEES

EMPLOYEE	DATE	NUMBER OF PERSONAL SAMPLES	TOTAL SAMPLING TIME	TIME-WEIGHTED AVERAGE SOLVENT VAPOR MIXTURE FRACTIONS BASED ON TOTAL SAMPLING TIME		TIME-WEIGHTED AVERAGE SOLVENT VAPOR MIXTURE FRACTIONS BASED ON 8-HOURS PER DAY[4]	
				Irritative Effects[1]	Central Nervous System Effects[2]	Irritative Effects	Central Nervous System Effects
1	12-11-80	2	5:37	0.22	0.11	0.15	0.08
	01-09-81	2	2:52	0.33	0.16	0.12	0.06
	01-30-81	3	5:01	0.01	0.70	0.01	0.44
2	12-11-80	2	2:13	0.02	0.39	0.01	0.12
	01-09-81	4	4:43	0.08	2.81	0.05	1.66
3	12-11-80	2	5:28	0.02	0.06	0.01	0.04
	01-09-81	4	5:58	0.06	0.26	0.04	0.19
	01-30-81	3	5:00	nd	0.19	nd	0.12
4	12-11-80	2	2:30	0.05	0.12	0.02	0.04
	01-09-81	3	4:05	0.05	1.39	0.02	0.71
	01-30-81	3	4:30	nd	0.45	nd	0.25

TABLE 6
INDIVIDUAL AIR SAMPLE RESULTS (IN PPM)
DECEMBER 11, 1980

Volume(L)	Employee No. & Activity	n-Hexane	1,1,1-Trichloroethane	Methylene Chloride	Ethanol	Methyl Isobutyl Ketone	Toluene	Xylene	Calculated Vapor Mixture Fractions Irritation[1]	CNS Effects[2]
18.5	1 - Printing	3.2	<2.0	<5.5	140	8.5	9.7	<4.1	0.31	0.16
5.7	4 - Printing	3.6	<1.6	<4.5	<6.7	2.0	2.9	5.3	0.09	0.19
12.1	2 - Printing	3.4	<0.8	6.3	<3.1	0.8	0.6	<1.6	0.02	0.16
15.2	1 - Printing	1.9	<0.6	<1.7	84.9	1.2	0.9	<1.3	0.10	0.05
4.9	Printing Area	6.1	<1.9	<5.2	85.2	1.9	1.5	<3.9	0.13	0.14
17.9	3 - Darkroom	2.4	<2.1	<5.7	17.0	<1.0	<1.0	<4.3	0.02	0.05
14.9	3 - Drafting	3.3	<0.6	<1.7	7.6	<0.3	<0.3	<1.3	0.01	0.07
9.3	4 - Folding	4.2	<1.0	<2.7	30.6	<0.5	<0.5	<2.1	0.03	0.08
14.0	Folding Area	2.7	<1.2	<3.4	17.8	<0.6	<0.6	<2.6	0.02	0.05
3.2	2 - Collating	12.9	14.5	71.6	<11.9	<1.4	<1.5	<6.0	nd	1.25
4.6	Office Area	5.8	5.0	<5.5	49.5	<1.0	<1.0	<4.1	0.05	0.13
17.5	Office Area	2.3	<0.5	8.7	<2.2	<0.3	<0.3	<1.1	nd	0.17
RECOMMENDED ENVIRONMENTAL LIMITS (average exposure for 8 to 10 hour workday)		50	350	75	1000	50	100	100	1.0	1.0
OSHA STANDARD (average exposure for 8-hour workday)		500	350	500	1000	100	200	100		

NOTES:
1. Combined exposure based on irritative effects of ethanol, methyl isobutyl ketone, and xylene.
2. Combined exposure based on central nervous system effects of n-hexane, methylene chloride, toluene, 1,1,1-trichloroethane, and xylene.
3. "nd" means "none detected" at laboratory lower limits of detection.
4. Benzene was detected on just 1 of the 40 air samples at a concentration of 0.02 ppm.

TABLE 6 CONTINUED
INDIVIDUAL AIR SAMPLE RESULTS (IN PPM)
JANUARY 9, 1981

Sample Time	Employee No. & Activity	n-Hexane	1,1,1-Trichloroethane	Methylene Chloride	Ethanol	Methyl Isobutyl Ketone	Toluene	Xylene	Calculated Vapor Mixture Fractions Irritation1	CNS Effects2
9:03-10:29	1-Printing	2.4	<1.0	<2.7	65.3	0.5	0.8	<2.1	0.08	0.06
9:35-10:50	2-Printing	5.5	32.4	161.3	6.3	0.8	0.8	<3.2	0.02	2.36
9:37-10:45	4-Printing	4.7	<1.9	<5.1	<7.6	5.5	0.9	<3.8	0.11	0.10
10:31-11:57	1-Printing	12.4	<1.0	<2.9	138.1	21.5	<0.5	<2.2	0.57	0.25
10:50-11:50	2-Printing	14.3	<2.0	<5.4	<8.1	18.6	9.1	<2.3	0.37	0.38
1:00-1:51 2:06-3.36	4-Printing	9.8	77.7	57.0	<5.3	<0.6	1.3	<2.7	nd	1.19
1:00-2:14	2-Printing	13.8	2.4	120.9	<6.4	<0.8	1.2	<3.2	nd	1.91
3:34-4:26	Printing Area	3.9	<1.8	<4.9	40.6	<0.9	<0.9	<3.7	0.04	0.08
1:55-3:30	Printing Area	9.9	72.6	74.0	<5.1	1.2	1.6	<2.6	0.02	1.42
2:15-3:29	2-Press Checking	8.8	5.8	445.7	<23.7	<2.9	4.4	<11.9	nd	6.14
3:48-4:24	4-Press Cleaning	8.0	114.0	300.4	<9.7	<1.2	<1.2	9.8	0.10	4.60
3:49-4:32	Press Exhaust Area Sample	9.4	94.0	112.4	11.2	1.4	<1.4	<5.6	0.03	1.96
9:05-10:33	3-Darkroom	2.2	<1.0	<2.7	4.0	2.0	<0.5	<2.0	0.04	0.04
10:36-11:57	3-Darkroom	11.4	<1.1	<3.0	22.6	<0.5	<0.6	<2.3	0.02	0.23
3:28-4:25	3-Darkroom Cleaning	8.6	23.2	29.7	6.3	<0.8	11.5	<3.2	nd	0.76
1:14-3:26	3-Drafting	9.6	<0.7	<1.9	2.8	5.7	2.1	<1.4	0.11	0.21

TABLE 6 CONTINUED
INDIVIDUAL AIR SAMPLE RESULTS (IN PPM)
January 30, 1981

Sample Time	Employee No. & Activity	n-Hexane	1,1,1-Trichloroethane	Methylene Chloride	Ethanol	Methyl Isobutyl Ketone	Toluene	Xylene	Calculated Vapor Mixture Fractions	
									Irritation[1]	CNS Effects[2]
9:53-11:59	1-Printing	1.0	<0.6	<1.7	27.8	<0.3	<0.3	<1.3	0.03	0.02

TABLE 7

SYMPTOMS BY HISTORY

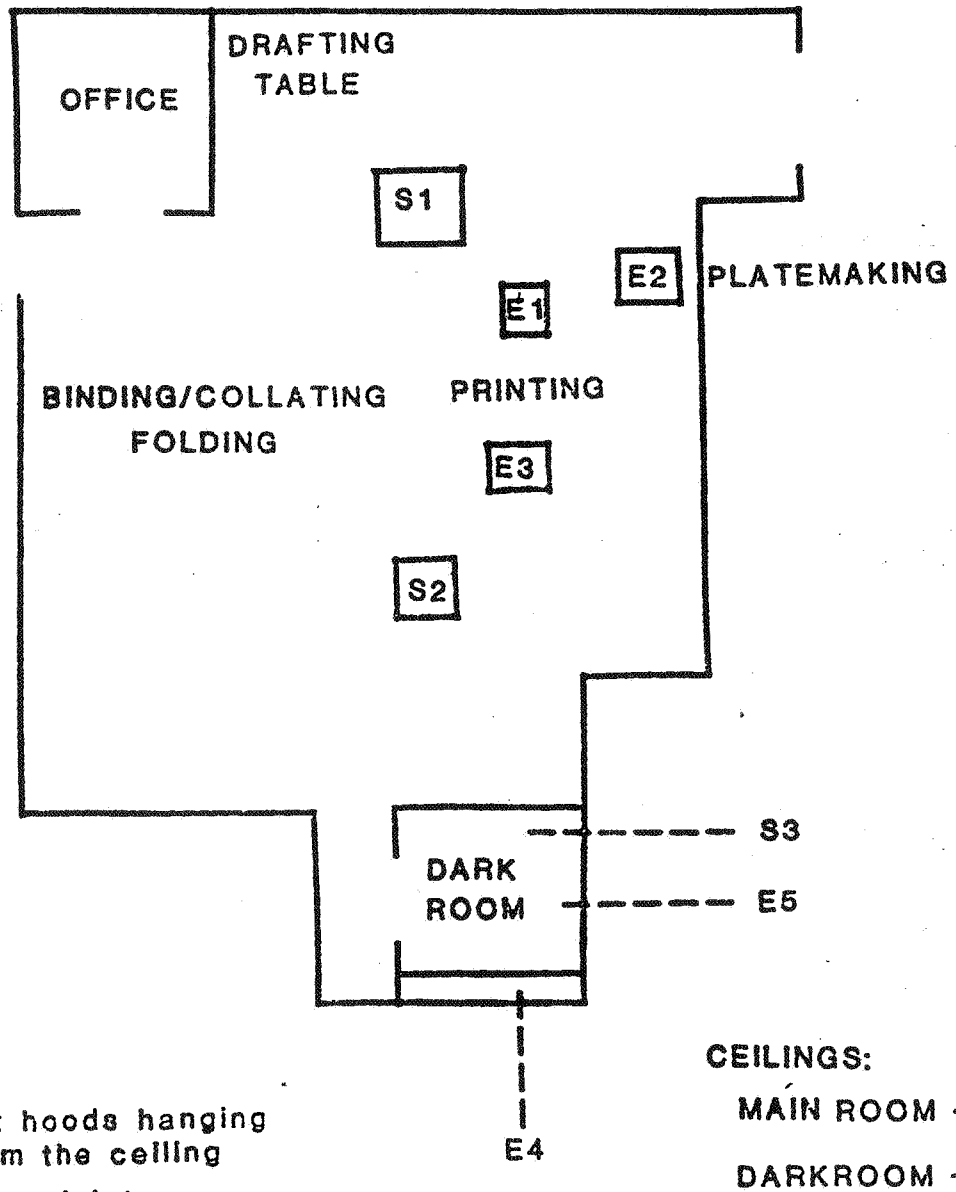
Symptom	No. with Symptom*	Mostly at Work	Frequency
Headache	2	Yes (both)	2-4x/month
Light Headedness, "high" feeling	1	Yes	2x/month
Numbness or tingling hands or feet	1	Yes	1x/month
Trouble Concentrating	1	Yes	2x/month
Irritability	2	Yes	2-8x/month
Flushing	1	Yes	rarely
Blurred Vision	1	Yes	4x/month
Ringing Ears	1	Yes	10x/month
Hearing Loss	2	Yes	
Skin Rash	1	Yes	
Eye, Nose, Throat Irritation	1	Yes	10x/month
Sinus Trouble	1	No	Long Standing
Bloody Nose	1	No	Winter-related
Chest Pain	1	No	Non-cardiac
Occasional Wheezing with a cold	1	No	
Nausea	2	Yes	Infrequently
Vomiting	1	No	With Flu
Diarrhea	1	No	With Flu
Decreased Libido	1	Onset since starting work	
Blood in Urine	1	No	Past hx of cystitis

One person described intermittent cold sensation of left hand, no numbness or color change in the fingers, no weakness.

* The person with "no exposure" had no symptoms. Of the exposed group (3), two had symptoms described as work-related, while the third had non-work related symptoms.

FIGURE 1

Diagram of Abt Associates Printing Shop (Basement Floor)



KEY:

E: Exhaust hoods hanging from the ceiling

S: Supply air inlets

CEILINGS:

MAIN ROOM - 92 IN.

DARKROOM - 78 IN.

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