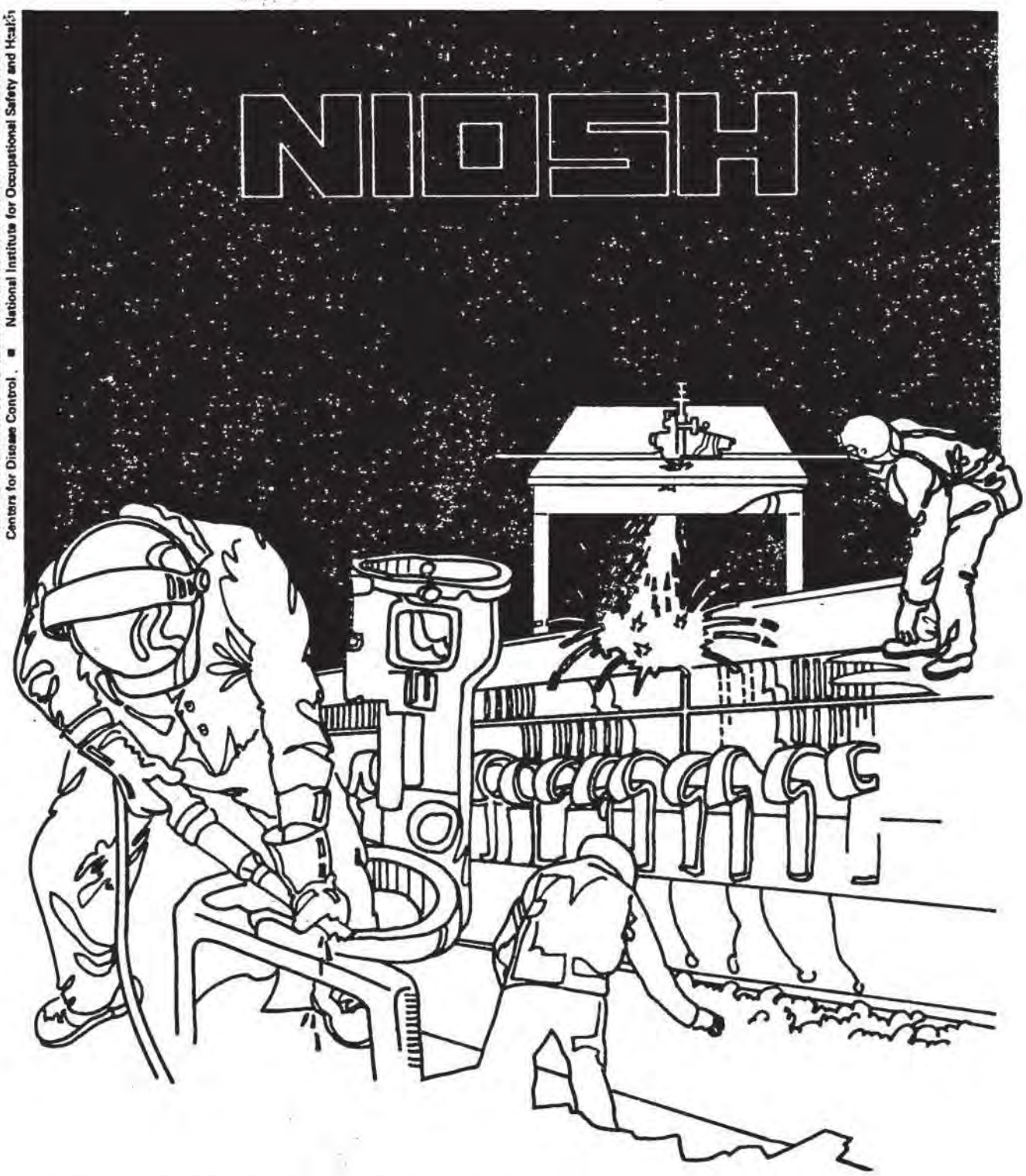
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 82-207-1278
GARDEN CITY ENGRAVING
AUGUSTA, GEORGIA

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.

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GARDEN CITY ENGRAVING
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I. SUMMARY

On April 12, 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from the Garden City Engraving Company, Augusta, Georgia. The company had recently moved the screen printing operations into the main office building. Since that time, employees working in the office and other areas were experiencing headaches, eye irritation, and upper respiratory symptoms. They were concerned that these symptoms were caused by exposures to improperly ventilated printing ink vapors.

On April 22-23, 1982, a NIOSH investigator conducted an industrial hygiene survey at the facility. Interviews were conducted with employees and ventilation systems were inspected. Bulk air samples of vapors released from gloss vinyl inks were qualitatively analyzed by gas chromatography/mass spectrometry (GC/MS) to identify ink volatiles. Personal and general area air samples were collected for toluene, 2-ethoxyethyl acetate (Cellosolve® acetate), diacetone alcohol, isophorone, 2-butoxyethyl acetate (butyl Cellosolve® acetate), and other aromatic solvent vapors such as trimethylbenzene and isopropylbenzene.

Results from personal and area samples found no exposures exceeding current OSHA standards. Screenprinters' exposures to 2-ethoxyethyl acetate ranged from 5.1 to 5.7 ppm and general area concentrations in the Printing Department were from 3.1 to 3.6 ppm. Screenprinters were exposed to 2-ethoxyethyl acetate slightly above the evaluation criteria of 5 ppm, as recomended by the American Conference of Governmental Industrial Hygienists. Only trace amounts of ink vapors (<4 ppm toluene and <1 ppm diacetone alcohol) were detected in other parts of the building. However, most of the employees felt their symptoms were worsened while inside the building.

Local exhaust ventilation in the printing department was not properly located, and there was no provision for outdoor makeup air. One screenprinter interviewed reported to have experienced occasional headaches, dizziness, nausea, chest pains, and a loss of appetite.

From the results of this survey, NIOSH has found that airborne concentrations of ink vapors are below levels which would be expected to cause adverse health effects, yet some employees have apparently been affected under certain conditions. Recent animial studies, indicating 2-ethoxyethyl acetate and other related glycol ethers are potentially embryotoxic or teratogenic at levels below current OSHA standards, highlight the need to provide adequate controls to reduce worker exposures to screen printing ink volatiles.

KEYWORDS: SIC 2751 (Screen Printing), printmaking, gloss vinyl inks, ink volatiles, 2-ethoxyethyl acetate (CAS # 115-15-9), 2-butoxyethyl acetate (CAS # 112-07-1), diacetone alcohol (CAS # 123-42-3), isophorone (CAS # 75-58-1), toluene (CAS # 108-88-3), SC-150, reproductive effects

II. INTRODUCTION

On March 31, 1982, the Office Manager for the Garden City Engraving Company, Augusta, Georgia, submitted a request to NIOSH for a health hazard evaluation of their building and screen printing operations. NIOSH was asked to investigate complaints of headache; nausea; chest tightness; frequent respiratory infections; and eye, nose, and throat irritation believed to be caused from exposure to solvent vapors released from screen printing inks being used in the facility. The screen printing process had recently been moved to this building from another location. Employees were concerned that the present building ventilation systems were not adequate to prevent vapors from spreading throughout the building.

The evaluation was conducted by a NIOSH industrial hygienist on April 22-23, 1982. The investigator conducted confidential interviews with affected employees, inspected existing ventilation and air-conditioning systems, and collected air samples to determine exposure levels to screen printing ink vapors in various parts of the building. An interim report summarizing NIOSH's preliminary findings and recommendations was provided to the company on May 17, 1982.

III. BACKGROUND

The Garden City Engraving Company is a small, privately owned business employing 10 people. The company produces advertising and promotional materials such as decals and bumper stickers. It occupies a 60x100 ft. free standing building and has operated from this location since 1969. Two employees, the receptionist and business manager, have offices in the front of the building. Other employees include the Art Director, two artists, two camera operators, two silkscreen printers, and a part-time bookkeeper. In the Art Department, employees design and compose layouts which are then photographed in the Camera and Stripping Department. In the Printing Department the negative is placed on a silkscreen to which a light sensitive coating has been applied. A high intensity arc light is used to set up the design to be printed. The screen is then washed to remove those portions not hardened by the light exposure. Various solvent based inks such as gloss vinyls, poster inks, plastisols, or plastic inks are spread over and squeezed through the pores of the screen to print the desired image. After printing, the screen is cleaned by hand using a rag soaked with lacquer thinner. This thinner (L-3000) was labeled as extremely flammable by the supplier, Browns Solvent Corp, Charlotte, N.C. According to the label, L-3000 contained alcohol, esters, ketones, methanol, petroleum distilates, and toluene. After cleaning, the screen is sprayed with a water soluble detergent and rinsed with water.

The screen printing process had been located in an older building with excellent natural ventilation. During the summer of 1981, screen printing operations were moved from that building into the main building. This space had been previously used for a photographic engraving process no longer operated by the company. The Printing Department occupied three rooms at the rear of the building, the prep. room (28x32ft.), the decal printing room (16x24ft.), and the T-shirt printing room (12x24ft.). The T-shirt printing machine had been sold and was not in service at the time of this survey. Exhaust ventilation was provided by means of two 18-inch diameter wall fans. One fan was located in the T-shirt room and the other in the 9x12ft. silkscreen wash booth located in one corner of the prep. room. General ventilation to the building was provided by four central heating, ventilation, and air-conditioning (HVAC) systems, each serving various departments. Outdoor makeup air was pulled into the building through ducts leading from the roof to each HVAC return air plenum.

Although all employees, including the bookkeeper and front office personnel, were complaining of strong solvent odors and various symptoms of eye and upper respiratory irritation, the employees with the highest potential exposures to ink solvents were the two silkscreen printers. Their job required continous work with inks and ink cleaning solvents.

IV. EVALUATION DESIGN AND METHODS

A. Industrial Hygiene Survey (April 22-23, 1982)

Prior to conducting the industrial hygiene survey, NIOSH obtained from the company, copies of the material safety data sheets (MSDS) for the inks scheduled to be used during the survey. The inks were gloss vinyls, manufactured by the Naz-Dar Company of Chicago, Illinois. According to the manufacturer's MSDSs, the primary solvents contained in the inks were:

Isophorone	35-40%
SC-150 solvent (aromatic petroleum solvent)	11-13%
Ethylene glycol monobutyl ether acetate (butyl Cellosolve® acetate)	6-7%
Diacetone alcohol	0-11%

During the first day of the NIOSH survey, screenprinters were printing a green and a white design on the front cover of 3-ring vinyl notebooks. The two printers, standing beside a small table, were applying gloss vinyl ink to screen with a rubber squeegee. The printed notebooks were then placed on drying racks and when full, the racks were rolled into the decal printing room where the notebooks were allowed to air dry. The decal printing machine was not being used at the time. In order to determine the screenprinters' individual exposures to ink vapors during this process, personal samples were collected in the workers' breathing

zone by attaching the sampling device to the worker's shirt collar. General area samples were collected concurrently at the screen printing table and near the notebook drying racks. One general area sample was also collected in the Art Department. Two personal samples, collected during two consecutive 15-minute exposure periods, were obtained to determine the ceiling or peak vapor exposures for one of the screenprinters.

On the second day of the survey, at the request of the office manager, additional air samples were collected at various points throughout the building during operation of the decal printing machine. Several of the front office employees complained this machine was not properly ventilated and that solvent odors in the front office were quite strong when the machine was used. The decal machine is a semiautomatic screenprinter which automatically applies and spreads the ink over the screen. The operator placed and removed the decals by hand and loaded them on drying racks. A personal air sample was also taken from the decal machine operator. Since no actual work to produce decals was scheduled that day, the machine was operated for only one hour to simulate actual operations.

Ink vapor concentrations and worker exposures to ink vapors were determined by collecting air samples on organic vapor adsorbing charcoal tubes. The samples were collected by drawing a known volume of air through the tube using a calibrated battery powered air sampling pump. The amount of vapor collected was measured quantitatively by the NIOSH laboratory using gas chromatography methods. The airborne concentrations of the volatile organics (ink vapors) selected for analysis were calculated by dividing the amount of compound found on the charcoal tube (in micrograms) by the volume of air pulled through the tube (in liters).

In order to identify the solvents that were being released from the gloss vinyl inks, NIOSH collected "bulk air" samples. One bulk air sample was taken directly above the silkscreen when printing notebooks with white and green gloss vinyl inks. Another bulk air sample was taken above an open can of blue gloss vinyl ink being used on the decal machine. These samples were collected at a high flow rate (1 liter per minute) in order to saturate the charcoal tubes with vapors. In this way, the vapors present could be collected and concentrated on the tubes for subsequent analysis in the NIOSH laboratory. In the laboratory, the collected vapors were desorbed from the charcoal tubes with carbon disulfide and analyzed qualitatively by gas chromatography/mass spectrometry (GC/MS) to identify the various organic compounds present in the ink vapors.

Two sets of personal and area air samples were collected. The first set was collected at a flow rate of 50 cubic centimeters of air per minute (method A) and analyzed for isophorone, diacetone alcohol, and 2-butoxyethanol acetate (ethylene glycol monobutylether acetate). These compounds were selected based on ink formulation data listed on the manufacturer's MSDSs. The

second set of samples, collected at 100 cc/minute (method B), was analyzed for the organic volatiles identified by the NIOSH laboratory from the two bulk air samples. Short term samples were collected at 200 cc/minute (method C) and analyzed as indicated for the first sample set.

B. Employee Interviews

Eight employees selected for interviews were first asked to complete a one page questionnaire asking employees if they had experienced any symptoms of health related problems since working at their present jobs. Those who had were asked to check from a list the symptoms they had experienced constantly, frequently, seldom, or never. Four of these employees were then interviewed privately by the NIOSH investigator and were asked if they knew of any particular processes, operations, or building locations which they had associated with these symptoms.

C. Building Ventilation

HVAC systems were inspected and air flow patterns in the building were determined. The exhaust air flow rates for the wall fans in the Printing Department were measured using an electronic air velocity meter. HVAC outdoor make-up air ducts were inspected, and if accessible, duct dampers were checked to insure ducts had not been closed off.

V. EVALUATION CRITERIA

A. Environmental Criteria

The primary sources of environmental evaluation criteria selected for this study were: 1) NIOSH criteria documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's),[1] and 3) the U.S. Department of Labor (OSHA) federal occupational health standands.[2] For those compounds with established occupational exposure limits, the various criteria proposed by OSHA, ACGIH, and NIOSH for airborne concentrations of the chemical substances measured in this evaluation are listed in Table 1 of this report. In most cases, the occupational exposure limits are the same from each reference. In those cases where there is a difference, the NIOSH recommended standard or the most stringent value is the criteria used for the purposes of this evaluation. Table 1 also lists the major health effects or sites of action of those chemicals. At the present time there are no established criteria for 2-butoxyethyl acetate and SC 150 solvent.

These criteria are intended to represent the maximum airborne concentrations of substances to which most workers may be exposed for eight hours a day, 40 hours per week (or other durations where indicated) without adverse health effects. The time-weighted average (TWA) exposure refers to the average concentration during a normal 8-hour workday. The Short-Term Exposure Limit (STEL) is

the maximum allowable concentration, or ceiling, to which workers can be exposed during a period of up to 15 minutes, provided that no more than four excursions per day are permitted, with at least 60 minutes between exposure periods. Because of wide variation in individual susceptibility, a small percentage of workers may experience discomfort from some substances at concentrations at or below the recommended criteria.[1] A smaller percentage may be more seriously affected by aggravation of a pre-existing condition or by a hypersensitivity reaction.

Employers are required by current Federal/and or state statutes, to limit the exposures of their employees to airborne concentrations of toxic substances below the OSHA PEL's.

B. Toxic Properties

A brief review of the toxicity for the volatile compounds found by NIOSH in the vapors released from gloss vinyl inks being used by Garden City Engraving at the time of this investigation are discussed below:

TOLUENE--is a colorless liquid with an odor threshold reported to be 2.5 ppm. It is used as a solvent in many paints and coatings. Occupational exposures to toluene are normally through inhalation of toluene vapors and skin absorption of toluene liquid. Chronic exposure to toluene does not produce the severe injury to the bone marrow, characteristic of benzene poisoning. As a result, toluene has been widely substituted for benzene in many products and industrial processes. The predominant effect from exposure to toluene is depression of the central nervous system. Controlled exposures of human subjects to 200 ppm toluene for 8 hours has produced mild fatigue, weakness, confusion, watery eyes, and a tingling sensation of the skin.[3] Prolonged reaction times, decreased pulse rates, and decreases in systolic blood pressure have been detected among human subjects exposed to 200 ppm for 7 hours.[4] At higher concentrations, effects include nerveousness, muscle fatigue, and insomnia.[3] Workers exposed to less than 200 ppm have complained of headaches, lassitude, and nausea.[4] In 1973 NIOSH recommended the occupational exposure limit be reduced to 100 ppm as an 8-hour TWA.[5] Repeated or prolonged skin contact with liquid toluene has a defatting action, causing drying, fissuring, and dermatitis. Toluene causes some irritation to the eyes at 300-400 ppm.[6]

2-ETHOXYETHYL ACETATE--(ethylene glycol monoethyl ether acetate; Cellosolve® acetate) may cause irritation of the eyes and nose at high concentrations. The liquid is not especially irritating to the skin and this compound is less easily absorbed through the skin than its parent molecule, 2-ethoxyethanol (2-EE). Exposure by inhalation, under conditions found in industrial settings, has not been found to be a significant hazard due to the compound's relatively low vapor pressure.[7]

Recently, exposure studies with laboratory animals have shown significant toxicological effects on reproduction from several commonly used glycol ethers. Nagano et al.[8] reported that testicular atrophy (reduced testicular weight) could be induced in mice orally dosed with 2-EE, its acetate ester (i.e., 2-ethoxyethyl acetate), 2-methoxyethanol (2-ME), and its acetate ester (i.e., 2-methoxyethyl acetate). From the same study, it was reported that these chemicals also produced leukopenia (a reduction in the number of white cells in the blood). Vapor exposure to 500 ppm 2-ME for one week resulted in reversible sterility in rats and high frequency of abnormal sperm head morphology in mice.[9]

Inhalation studies with 2-EE conducted by Hardin et al.[10] provide clear evidence of severe embryotoxicity in both rats and rabbits at concentrations above 600 ppm. Fetal toxicity was significant in both species exposed to vapor concentrations near the current OSHA permissible exposure limit (200 ppm). Although further research is needed, it has been suggested that 2-ethoxyethyl acetate is immediately hydrolyzed by certain enzymes in the blood to the parent molecule 2-EE.

Based on the reported testicular effects and by analogy to a proposed reduction for 2-EE, a reduction in the 8-hour TLV for 2-ethoxyethyl acetate, from 50 to 5 ppm, is suggested by the ACGIH with no STEL recommended at this time.[4]

2-BUTOXYETHANOL ACETATE--(Ethylene glycol monobutyl ether acetate; butyl Cellosolve® acetate) has been reported to cause only mild skin irritation in rats and rodents.[11] Although further research is needed to substantiate the theory that the acetate esters of glycol ethers are hydrolyzed in the blood to the parent molecule, it is appropriate to control exposures to levels currently recommended for 2-butoxyethanol (2-BE). Exposure of humans to high concentrations of 2-BE vapors from 300-600 ppm for several hours would be expected to cause respiratory and eye irritation, narcosis, and damage to the kidney and liver. Butoxyethanol is metabolized, at least in part, to butoxyacetic acid and this substance is excreted in the urine of exposed animals and human subjects.[7]

Both 2-BE and butoxyacetic acid increase osmotic fragility of the red blood cells, an effect most pronounced in rodents even at concentrations as low as 50 ppm. From industrial experience and short term exposures of human volunteers, it has been suggested that humans are less susceptible to induced hemolytic anemia from exposure to 2-BE. Although the rat appears more susceptible than other animals and humans in this respect, anemia is not an uncommon condition in the human population. Therefore, the ACGIH has recommended that exposures be maintained below levels which have been found to cause blood changes in experimental animals, with 25 ppm being the most practical "no ill effect" level.[4]

DIACETONE ALCOHOL--causes irritation of the eyes and respiratory tract. Most human subjects exposed to 100 ppm for 15 minutes complained of eye, nose, and throat irritation. Chest discomfort has been reported at 400 ppm. Repeated contact with the skin may produce dermatitis.[3] In view of the eye, nose, and throat irritation occuring in persons exposed to 100 ppm, the ACGIH has recommended an 8-hour TLV of 50 ppm.[4] This is also the current OSHA permissible exposure limit.

ISOPHORONE--was the major solvent component of the gloss vinyl inks. It is irritating to the eyes, nose, and throat at a concentration of 25 ppm, as reported from unconditioned human subjects briefly exposed at this level.[3] Subsequently, information was reported to the TLV committee of the ACGIH that a TLV of 10 ppm was not sufficiently low to prevent complaints of fatigue and malaise from workers even after one month of occupational exposure at 5-8 ppm. These symptoms disappeared when levels were reduced to 1-4 ppm. The current ACGIH TLV (5ppm ceiling) was established to prevent such complaints.[4] The current OSHA limit is still 25 ppm as an 8-hour TWA. In 1978, NIOSH recommended that OSHA reduce the permissible exposure limit to 4 ppm.[12]

SC-150 SOLVENT--is a mixture of aromatic petroleum hydrocarbons. Aromatic solvents are primary skin irritants, and on repeated or prolonged contact with the skin may cause dermatitis. These compounds can depress the central nervous system. Inhalation of high vapor concentrations may cause dizziness, slight incoordination, and unconsciousness.[13] No environmental criteria have been established for SC-150 solvent. Based on the results of the GC/MS analysis of vapors released from gloss vinyl inks, it appears the primary components of SC-150 are a mixture of M.W. 120 aromatics, such as trimethylbenzene and isopropylbenzene (cumene); and 134 M.W. aromatics, such as tetramethylbenzene and monobutylbenzenes. These compounds are commonly used in paint thinners, solvents, and enamels. The current recommended ACGIH TLV for trimethylbenzene is 25 ppm and for cumene, 50 ppm. These levels were established to prevent adverse effects on the central nervous system.[4]

VI. RESULTS AND DISCUSSION

A. Bulk Air Sample Results

Figures 1 and 2 show the results of the GC/MS analyses identifying the organic vapors released from gloss vinyl inks being used at the screen printing table (Figure 1) and decal printing machine (Figure 2). The peak heights give an indication of the relative concentration ratios of components of that particular sample. In general, the larger the peak height, the higher the concentration. The principal organic vapors detected were 2-ethoxyethyl acetate (Cellosolve® acetate), diacetone alcohol, toluene, isophorone, 2-butoxyethyl acetate (butyl Cellosolve®

acetate), and a mixture of C_3-C_4 alkyl substituted benzenes having a molecular weight of 120 and 134 (SC-150 aromatic hydrocarbons). The 120 and 134 aromatics could not be specifically identified but would include such compounds as trimethylbenzenes, isopropylbenzene (cumene), tetramethylbenzene, and monobutylbenzenes.

B. Industrial Hygiene Sample Results

The results from the personal and area air samples are presented on Table 2. None of the exposures measured were above current OSHA permissible exposure limits. However, the exposures to 2-ethoxyethyl acetate did exceed the evaluation criteria based on the most recent TLV recommended by the ACGIH (5 ppm). Personal exposures for the screenprinters ranged from 5.1 to 5.7 ppm compared to the general area concentrations in the printing department which were 3.1 to 3.6 ppm. Personal samples were higher due to the close proximity of the screenprinters breathing zone to the ink evaporating surface. This is consistent with the findings of Samimi[14] in a study of isophorone and other organic solvent exposures in a screen printing plant.

Also as shown in Table 2, the highest concentrations of other vapors detected in the screenprinters' breathing zones were 13.6 ppm toluene, 2 ppm diacetone alcohol, 3.4 ppm isophorone, and 0.8 ppm 2-butoxyethyl acetate. The only ink vapors detected outside the Printing Department were 0.8 ppm diacetone alcohol, in the Art Department and 3.6 ppm toluene and 0.6 ppm diacetone alcohol, in the Bookkeeping Department. Although detected in the vapors from bulk air samples, SC-150 aromatics were below the limit of detection in both the personal and general area air samples.

C. Ventilation

The four HVAC units installed in the building were designed for heating and cooling of general office spaces. The HVAC unit in the Printing Department could not provide adequate dilution ventilation. Exhaust ventilation for the Printing Department was not properly located. Each of the two 18-inch wall fans removed approximately 1325 cubic feet of air per minute from the building. However, the fans were not located close enough to the screen printing and drying operations to efficiently capture the vapors released.

When outside doors to the building are closed, the only means for makeup air is through the outdoor air ducts of the HVAC systems. No source of outdoor make-up air was available to dilute a buildup of ink vapors inside the Printing Department. According to employees, when all outside doors are closed, the negative pressure inside the building created by the exhaust fans has prevented a natural flow of flue gases from the water heater.

The position of the table used for manual screen printing application was such that vapors released were pulled directly into the HVAC return air vent. This allowed printing ink vapors to be dispersed throughout the Printing Department from the HVAC supply vents. Solvent odor in the Printing Department was quite strong. After 30 minutes in the area, the NIOSH investigator experienced a mild throat irritation which persisted throughout the first day of the survey.

D. Employee Interview Results

Of the eight employees interviewed, five employees complained of frequent symptoms including headache (2), shortness of breath (3), chest pains (2), nasal congestion (3), dry or irritated throat (4), and eye irritation (2). The employees felt their symptoms worsened while inside the building. Only one screenprinter had complained about the vapors and reported experiencing occasional headaches, dizziness, nausea, chest pains, and loss of appetite.

VII. CONCLUSIONS

The air sampling results indicate that airborne concentrations of ink vapors are below the levels which would be expected to cause adverse health problems for exposed workers. The results are somewhat surprising considering the poor location of exhaust ventilation systems and lack of adequate outdoor makeup air. Of primary consideration should be the potentially toxic effects of the volatile components found in inks used in printmaking. Recent tests with laboratory animals, showing 2-ethoxyethanol and other related glycol ethers have marked embryotoxic and teratogenic effects at airborne concentrations below current OSHA standards, should highlight the need to provide for adequate protection of workers using inks containing these chemicals. It was interesting to note that volatile ethylene glycol ethyl ether acetate was identified in gloss vinyl inks during this survey, yet the compound was not listed as an ink component on the material safety data sheets provided by the manufacturer.

It would appear that a simple rearrangement of equipment and operations in the Printing Department would provide for more effective control of ink vapor concentrations with a minimum of effort and expense. It was also apparent, from personal interviews conducted during this survey, that workers and managers were not aware of the toxic nature of the chemicals used in the formulation of screen printing inks and solvents.

The conditions under which most building occupants complained (operation of the decal printing machine) could not be properly evaluated during this survey since a full shift operation of the machine was not scheduled at the time. Although the ink vapor concentrations measured in other parts of the building were at

very low levels, some ink volatiles (i.e. diacetone alcohol and toluene) were found above detection limits in the Art and Bookkeeping Departments after only one hour operation of the decal printing machine. However, the claims that these vapors are the cause of symptoms experienced by employees working outside the Printing Department cannot be substantiated from the results of this survey.

VIII. RECOMMENDATIONS

1. Screenprinting operations and machinery should be positioned in the Printing Department to make maximum use of existing exhaust ventilation systems. The screen printing table should be moved away from the HVAC return air vent. Ideally, this table should be positioned in front of a lateral-draft exhaust hood as shown in Figure 3.

2. Additional outdoor makeup air should be provided to the printing department. However, a slight negative pressure should be maintained to prevent ink vapors from contaminating other parts of the building.

3. A drying rack, fully loaded with freshly printed materials, is a source of considerable amounts of ink volatiles. Separate drying areas should be provided to insure the vapors released from these racks are vented to the outside of the building.

4. Until more effective ventilation is provided to the Printing Department, screenprinters are encouraged to wear NIOSH approved organic vapor respirators when performing printing operations. As indicated on the sampling results, personal exposures exceeded the general area concentrations. Wearing of organic vapor respirators is also recommended when screens are cleaned with the L-3000 lacquer thinner. When ink or solvent odors are detected while wearing the respirator, the cartridges should be replaced. Respirators should be cleaned, inspected, and properly stored in plastic bags after use. An adequate respiratory protection program which at least meets the requirements of OSHA Standard 29 CFR 1910.134 should be implemented.

5. Neoprene or butyl rubber gloves should be worn when cleaning and washing screens with lacquer thinner. Gloves should be cotton lined or replaceable cotton liners should be provided to prevent possible dermatitis and chemical leachout from the wearer's sweat inside the glove. Workers should not use thinners or solvents to clean ink from arms or hands as the solvents contain compounds which readily absorb through the skin or cause skin irritation. A waterless cleaner or other industrial cleansers formulated for safe removal of inks and solvents from the skin should be used.

6. Workers should not be allowed to smoke in the Printing Department due to the many combustible and flammable liquids used in this area.

7. All fans on HVAC units should be operated continuously when the building is occupied. This will allow maximum air circulation and will provide some outdoor air to mix with recirculated air through the HVAC plenum. All outdoor air duct dampers should be checked to insure they are in the full open position.

8. The 55 gallon drums of L-3000 lacquer thinner, labeled as highly flammable, should be stored outdoors on properly grounded and bonded racks to reduce the risks of fire or explosions (see Figure 4).

9. Electrical equipment, such as exhausts fans, water pumps, and other electrical devices located near areas where flammable liquids are used should not constitute a source of ignition under normal operating conditions. At the time of this survey, electrical equipment was located within the path of vapor travel for the flammable L-3000 lacquer thinner. This equipment should be tested or inspected to insure all possible sources of ignition such as frictional heat, and mechanical or electrical sparks are eliminated.

10. The company should obtain copies of Material Safety Data Sheets for all screenprinting inks, solvents, and chemicals used in the Printing Department. Printers should be made aware of the potential for exposure to the toxic substances contained in these materials.

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After ninety (90) days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati, Ohio address.

Copies of this report have been sent to:

1. Garden City Engraving Company, Augusta, Georgia
2. U.S. Department of Labor, OSHA, Region IV
3. NIOSH, Region IV
4. Designated State Agencies

For the purpose of informing the approximately 10 "affected employees", the employer will promptly "post" this report for a period of thirty (30) calendar days in a prominent place(s) near where the affected employees work.

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TABLE 1
SUMMARY OF EXPOSURE LIMITS* and HEALTH EFFECTS
for SUBSTANCES MEASURED at GARDEN CITY ENGRAVING
AUGUSTA, GEORGIA

HETA 82-207

SUBSTANCE	OSHA PEL**	ACGIH TLV***	NIOSH RECOMMENDATION	HEALTH EFFECTS CONSIDERED	REFERENCE
Toluene [CAS 108-88-3]	200 ppm 300 ppm ceiling 500 ppm max	100 ppm 150 ppm STEL	100 ppm 200 ppm-10 min.	Central nervous system depression	4,5
2-ethoxyethyl acetate (cellosolve acetate) [CAS 115-15-9]	100 ppm	50 ppm 150 ppm STEL (5 ppm)****	---	Possible reproductive effects	8,9,10
Diacetone alcohol [CAS 123-42-2]	50 ppm	50 ppm 75 ppm STEL	50 ppm	Eye, nose, and throat irritation	3,4,
Isophorone [CAS 78-58-1]	25 ppm	5 ppm ceiling	4 ppm	Eye, nose, and throat irritation; fatigue; malaise	4,12
2-butoxyethyl acetate (butyl cellosolve acetate) [CAS 112-07-1]	---	---	---	Possible reproductive effects & anemia (as 2-butoxyethanol)	4,7,10
SC 150 solvent	---	---	---	Central nervous system depression	4,13

* Limits are 8-hour time-weighted averages (TWA) unless otherwise stated.
** For OSHA standards, see Reference No. 2
*** For ACGIH TLVs, see Reference No. 1
**** Notice of intended change for 1982

ppm = parts per million parts of air
CAS = Chemical Abstracts Service Number

TABLE 2
VINYL INK VAPOR CONCENTRATIONS
GARDEN CITY ENGRAVING
AUGUSTA, GEORGIA
HETA 82-207

Job/Location	Type Sample	Duration	Sampling Method	Concentration in ppm T	CA	DA	I	BCA	C-150
April 22, 1982:									
Screenprinting notebooks	personal	9:14am-4:32pm	A	NS	NS	2.0	0.2	ND	NS
			B	13.6	5.0	ND	1.6	0.5	ND
Screenprinting notebooks (assistant)	personal	9:23am-4:30pm	A	NS	NS	1.0	0.3	ND	NS
			B	9.3	5.7	ND	1.8	0.8	ND
Screenprinting table (near A/C air return)	area	9:42am-4:38pm	A	NS	NS	0.5	0.2	ND	NS
			B	3.5	3.2	ND	1.0	0.5	ND
Drying racks	area	11:13am-4:58pm	A	NS	NS	ND	1.0	ND	NS
			B	3.1	2.5	ND	2.5	0.3	ND
Screenprinting notebooks	personal	1:32pm-1:47pm	C	NS	NS	ND	ND	ND	NS
		1:50pm-2:05pm	C	NS	NS	ND	ND	ND	NS
Art Department	area	9:29am-10:21am	A	NS	NS	0.8	ND	ND	NS
April 23, 1982:									
Bookkeeping Dept. (during decal printing)	area	9:27am-10:23am	B	3.6	ND	ND	ND	ND	ND
			C	NS	NS	0.6	ND	ND	NS
Printing decals	personal	9:12am-10:11am	A	NS	NS	2.1	1.2	ND	NS
			B	5.1	5.1	ND	3.4	ND	ND
Evaluation Criteria (8-hour time weighted average)				100	5	50	4	--	--
Limit of Detection in mg/sample				0.01	0.01	0.01	0.01	0.01	0.1

ppm = parts per million
ND = Not Detected
NS = Not Sampled

Sampling Methods:
A. Organic vapor charcoal tubes @ 50 cc/min.
B. Organic vapor charcoal tubes @ 100 cc/min.
C. Organic vapor charcoal tubes @ 200 cc/min. (short term sample)

T = toluene
CA = cellosolve acetate
DA = diacetone alcohol
I = isophorone
BCA = butyl cellosolve acetate
C 150 = SC 150 solvent vapors

** SPECTRUM DISPLAY/EDIT **

SEQ3462 SALISBURY CT1/CS2 SC30-300 4-28-82

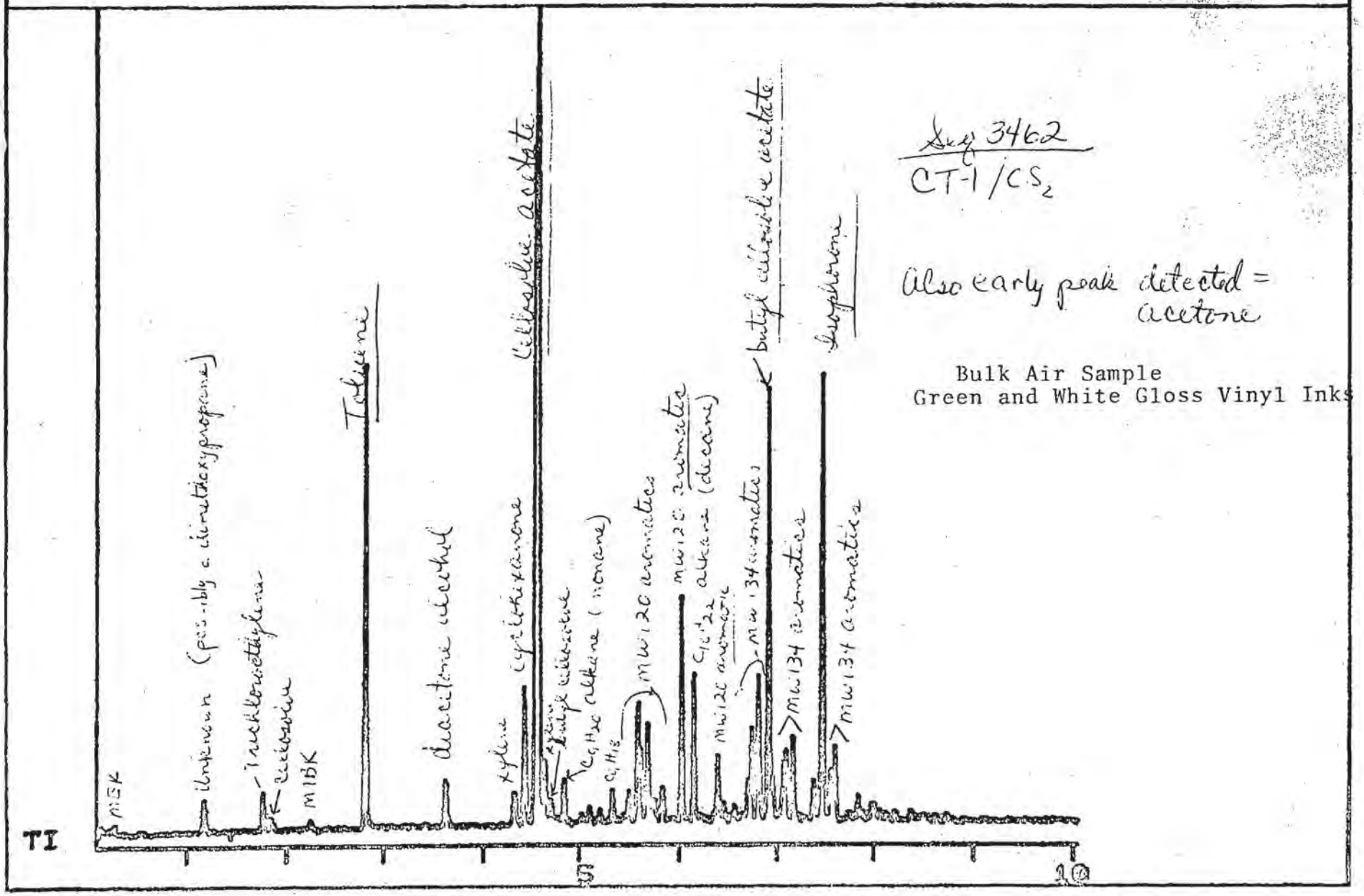
30M DB-1 SPLITLESS .2ULG4

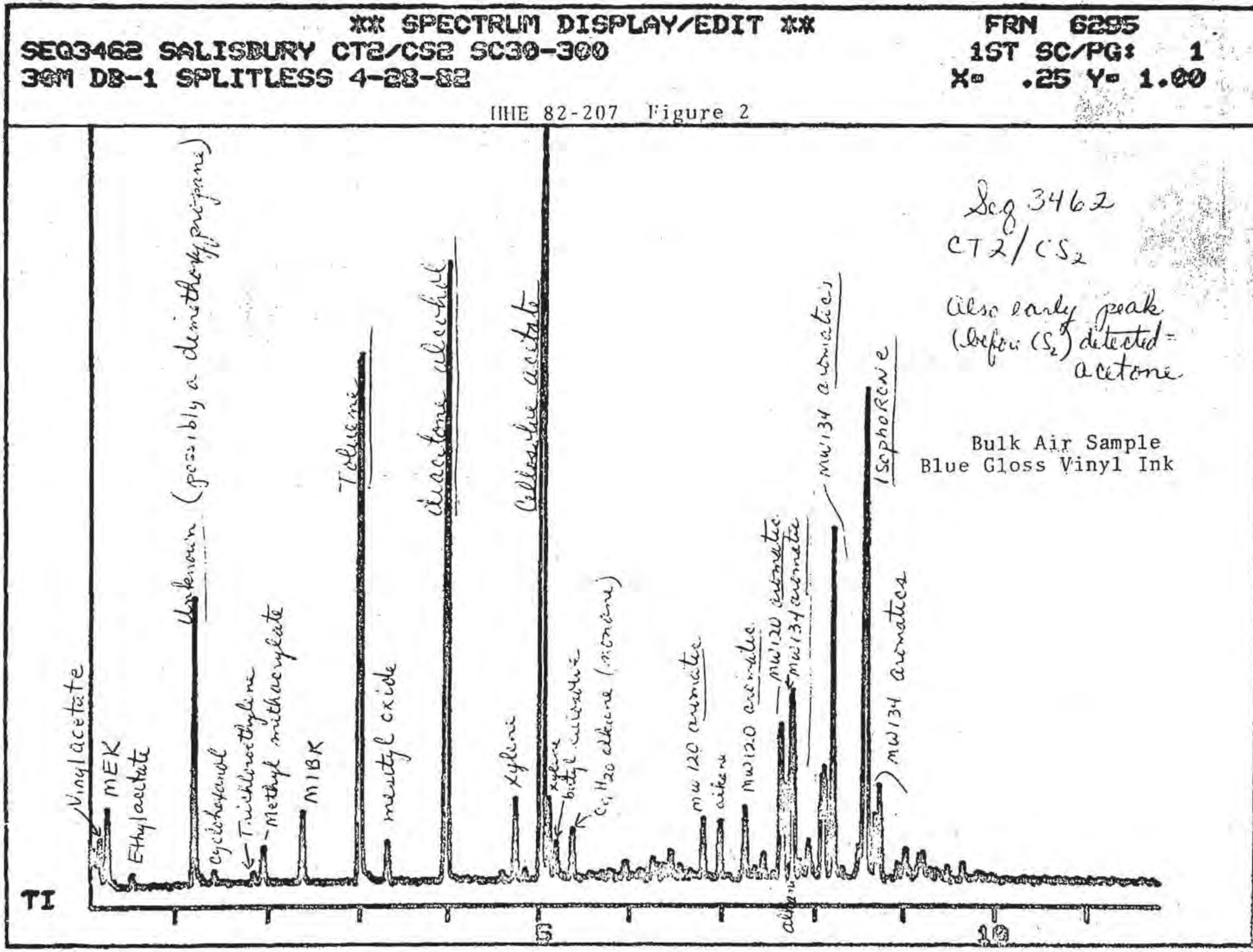
FRN 6294

1ST SC/PG: 1

X= .25 Y= 1.00

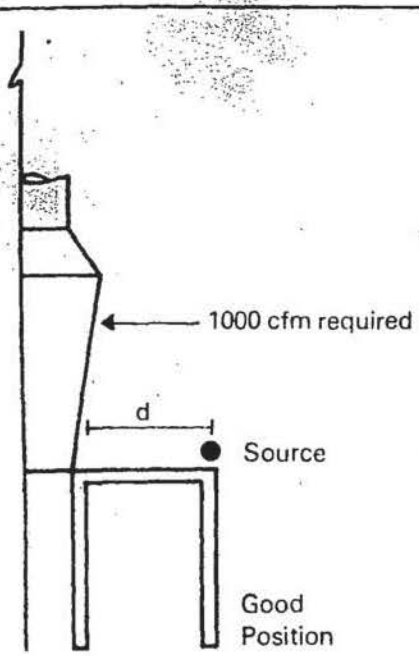
HHE 82-207 Figure 1

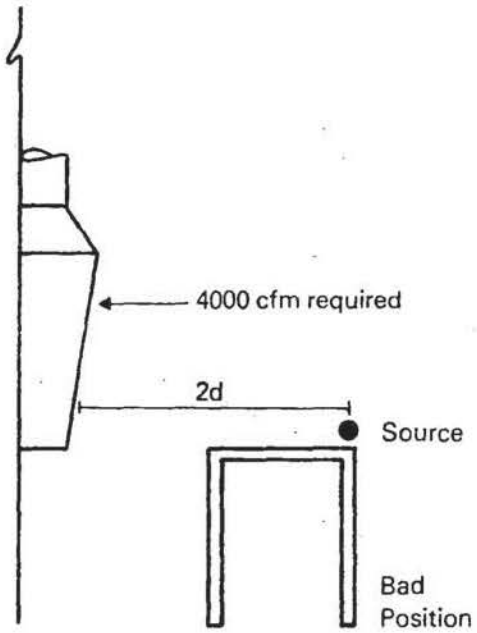




IHE 82-207 Figure 2

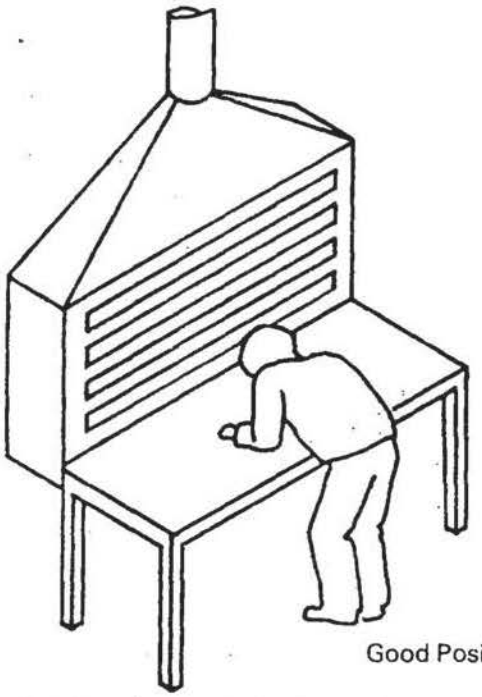
Figure 3
HHE 82-207





Place hood as close to the source of contamination as possible. The required volume of air increases with the square of the distance from the source.

cfm = cubic feet per minute d = distance



Locate the hood so the contaminant is removed from the breathing zone of the printmaker.

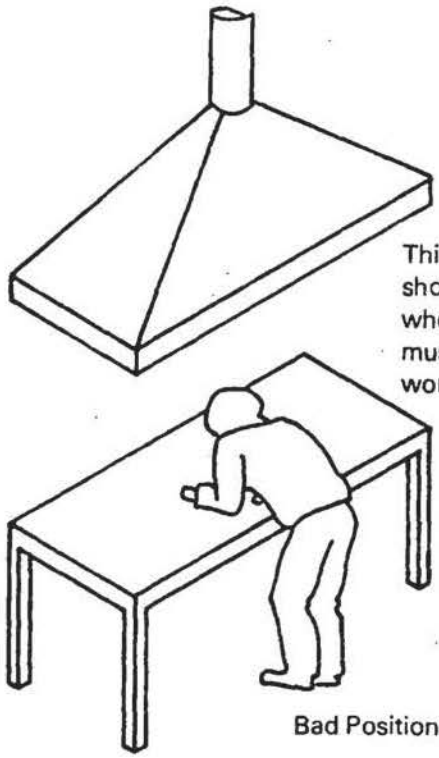
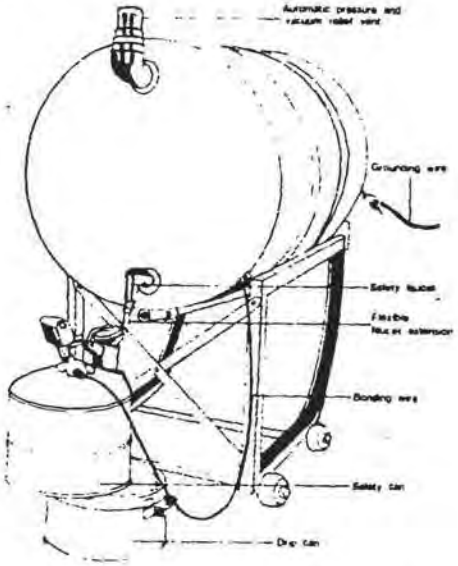


Figure 4
HHE 82-207

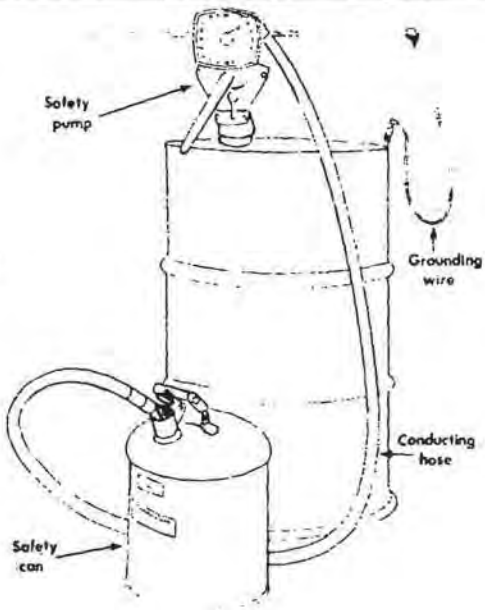
HANDLING LIQUIDS

Liquids can be safely handled with equipment similar to that shown below.

Gravity flow from vented drums



Drum pump



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