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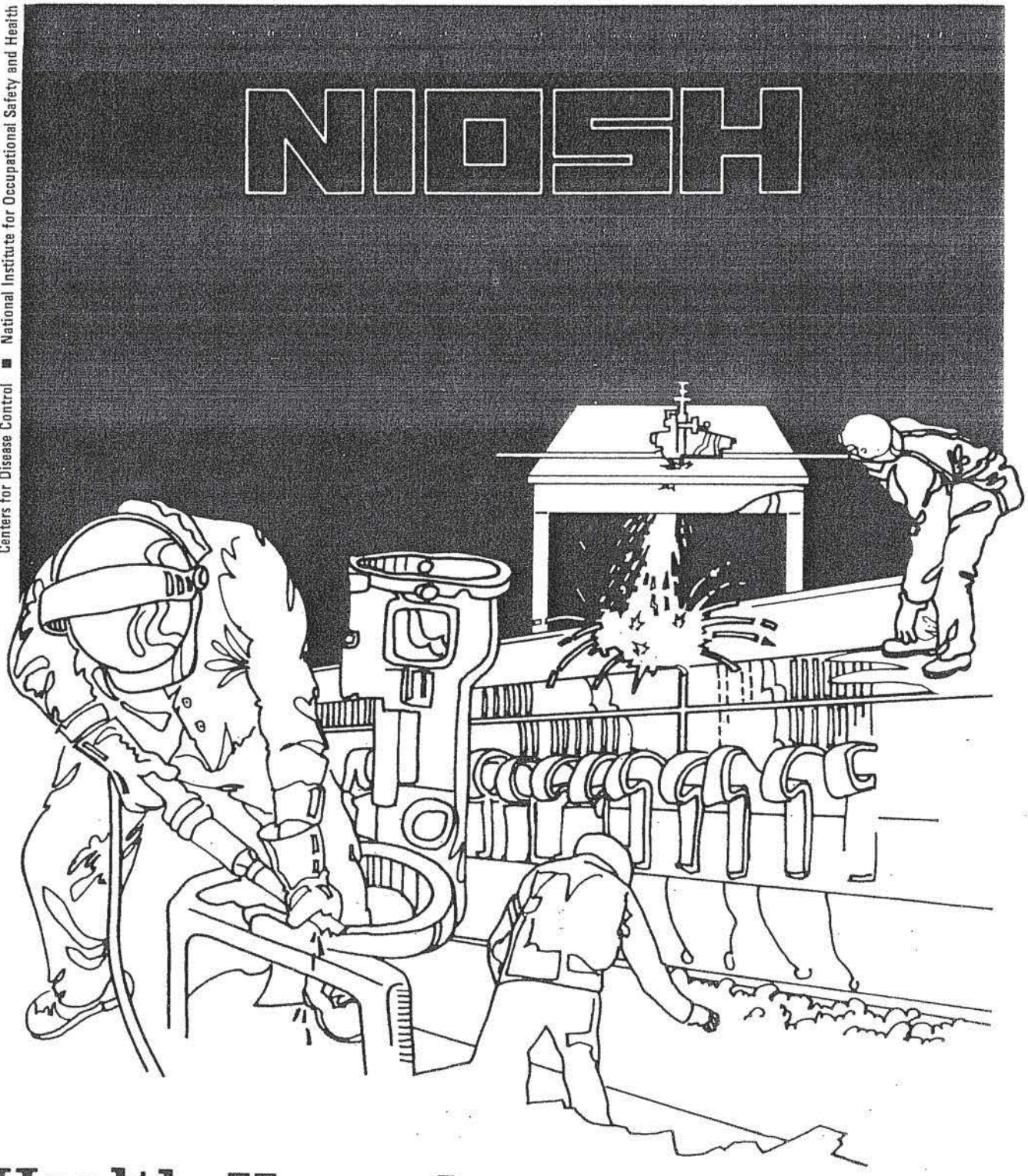
NIOSH



# Health Hazard Evaluation Report

HHE 80-103-827
JOEL & ARONOFF
RIDGEFIELD, NEW JERSEY

# PREFACE

The Hazard Evaluation 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.

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.

HE 80-103-827
FEBRUARY 1981
JOEL & ARONOFF
RIDGEFIELD, NEW JERSEY

NIOSH INVESTIGATORS:
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## I. SUMMARY

In April 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation at Joel and Aronoff, Ridgefield, New Jersey, to evaluate reports of burning eyes and tongue, sore throats, breathing difficulties, chest pains, dizziness, nausea, and rashes among workers engaged in the manufacture of decals. At the time of the study, the plant employed 54 workers.
Major operations consisted of the printing, chopping, laminating, cutting, and sewing of decals.

An environmental-medical survey was conducted April 22-24, 1980. We obtained personal breathing-zone air samples for organic vapor determination and made ventilation measurements of local exhaust systems. Medical interviews were conducted with 35 (65%) of the employees to determine the type and prevalence of health effects and their relationship to work exposures.

Environmental data indicated that the four screen-printers were exposed to substantial amounts of organic vapors. One 8-hour time-weighted average (TWA) sample for isophorone was 14 parts per million (ppm), which exceeded the NIOSH recommended TWA exposure of 4 ppm, but was below the current Occupational Safety and Health Administration (OSHA) permissible exposure limit of 25 ppm. Short-term overexposures to cleaning solvents were found among the printers when they spray-cleaned inks from printing screens. Ten-minute exposures to toluene ranged from 150 to 360 ppm, with a mean of 260 ppm. Three samples for toluene were above the NIOSH-recommended 10-minute ceiling of 200 ppm. The screen-cleaning solvent also contained xylene, methyl ethyl ketone (MEK), and methyl isobutyl ketone (MIBK). The additive short-term exposures of toluene, xylene, MIBK and MEK ranged from 128 to 292% of NIOSH and ACGIH-recommended exposure limits in all of the printers sampled. The most common symptoms were eye and respiratory tract irritation and dizziness. The dizziness and other neurologic symptoms were reported to be intermittent and were associated with the use of solvents. The respiratory tract and eye irritation were also intermittent and temporally associated specifically with the use of the "reducer" in the screen printing area. The prevailing opinion among those inter- viewed was that the health effects started after the installation of the screen printing operation about 5 years ago.

In the printing area there were no 8-hour TWA overexposures to xylene, toluene, methylene chloride, trimethylbenzene, or 2-ethoxyethyl acetate. There were no detectable exposures to any of these in other areas.

On the basis of the data obtained in this investigation, NIOSH has determined that a hazard to screen printers from overexposure to cleaning solvents and isophorone existed during the time of the NIOSH survey.

Recommendations for improved local exhaust ventilation and product substitution have been incorporated into this report as a guide for the control of organic vapors.

KEYWORDS: SIC 2750 (commercial printing), screen printing, cleaning solvents, isophorone, toluene, xylene, methyl isobutyl ketone, methyl ethyl ketone, methylene chloride, trimethylbenzene, 2-ethoxyethyl acetate, formaldehyde, respiratory irritation, neurological symptoms.

## II. INTRODUCTION

In April 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation at Joel and Aronoff, Ridgefield, New Jersey to evaluate reports of burning eyes and tongue, sore throats, breathing difficulties, chest pains, dizziness, nausea, and rashes among workers engaged in the manufacture of decals. NIOSH conducted a medical and environmental survey on April 22-24, 1980. In June 1980, an interim report describing the methods of the evaluation, preliminary data obtained, and future actions was sent to employer and employee representatives.

## III. BACKGROUND

A major product of this plant is printed decals which are mass-produced on large sheets by the screen printing process as depicted in Figure I.[1] Generally the operation consists of: (1) placing the sheet of material to be printed under the frame, (2) lowering the screen frame onto the sheet, (3) placing ink on the screen and spreading it with a squeegee, and (4) lifting the frame and removing the printed sheet. The other main areas of the plant include the chopping, laminating, cutting, sewing, trimming and packaging of decals.

There were normally three or four semiautomated printing presses in operation during the day. Some organic vapor exposure occurred during printing as the volatile portion of the inks evaporated. Periodically, a solvent known as an "anti-static agent" was sprayed on the screens from a small spray bottle. Another solvent, also contained in a spray bottle, was used to clean ink stains from work surfaces in the printing area. Potential short-term exposure to cleaning solvents occurred when printers were spray-washing ink off the screens. Each printer washed his own screens three or four times per day with each washing lasting 5 to 7 minutes. Screens were washed with a spray hose in a small closed room (approximately 450 cubic feet). A local-exhaust canopy hood was located against the wall about three feet over the spraying area.

OSHA had conducted several inspections at this plant in the past four years and had sampled for a wide range of solvent vapors, formaldehyde, and diisocyanates. No overexposures (by OSHA standards) to any of these compounds have been found. No detectable levels of diisocyanates have been found anywhere in the plant. Personal breathing zone samples of laminating employees for formaldehyde had ranged from non-detectable levels to 0.20 milligrams per cubic meter ($mg/M^3$) in a 30-minute sample. The mean TWA exposure was 0.04 $mg/M^3$. The NIOSH recommended standard for formaldehyde is 1.2 $mg/M^3$ as a 30-minute ceiling. There were two laminating employees at the time of the NIOSH survey.

## IV. EVALUATION DESIGN AND METHODS

### A. Environmental

Bulk samples of inks, cleaning solvents, and the anti-static agent were collected for qualitative analysis by gas chromatography/mass spectro- photometry. Fourteen personal breathing zone samples for organic vapors were collected on activated charcoal tubes through battery powered sampling pumps at a flow rate of 20 cc/min for 7 hours. Samples were desorbed in carbon disulfide and analyzed by gas chromatography (NIOSH Method P&CAM 127). All printers that were present during the survey were sampled along with selected employees throughout the rest of the plant. In addition, short-term personal breathing zone samples were collected on the printers during 5-7 minute screen cleaning operation. These sampling pumps were operated at 150 cc/min for a total of 10 minutes.

Ventilation measurements were taken with an Alnor Velometer Jr. Model 8100 to determine capture velocities of local exhaust systems over the printing presses and in the screen cleaning room.

B. Medical

An attempt was made to interview as many employees on the day shift as time permitted, starting with those working in and around the screen printing department and moving outward. Thirty five of the fifty employees that were present on the day shift were interviewed.

## V. EVALUATION CRITERIA

Environmental evaluation criteria and the principle health effects of the substances sampled in this study can be found in Table I. NIOSH recommended exposure limits were used as the evaluation criteria for this study. Current ACGIH recommended threshold limit values were used to evaluate those substances for which NIOSH has not yet developed recommended standards.

Simultaneous exposure to substances, such as solvents, which affect the body in a similar fashion might produce additive effects. To determine these additive short-term exposures, the exposure level of each substance is computed as a percentage of the standard for that particular substance. The percentages are then added to yield a total percent of all the standards involved. If the total exposure to all substances exceeds 100%, the employee is considered overexposed.

## VI. RESULTS

A. Environmental

The major volatile solvents found in the analysis of the bulk ink samples were xylene, 2-ethoxyethylacetate, isophorone, and trimethylbenzenes. Small amounts of hexamethylene diisocyanate (HMDI) were also detected. The "anti-static agent" was found to consist

mostly of isophorone (the term "reducer" was also used to describe isophorone in the spray bottle).

The cleaning solvent used to clean ink from the tables and other work surfaces in the printing area was methylene chloride. The components identified in the screen cleaning solvent were xylene, toluene, MIBK and MEK.

Personal breathing zone samples showed non-detectable levels of organic vapors throughout the plant, except for the screen printers. Printers were exposed to 8-hour TWA concentrations of toluene, 19 to 37 ppm (mean 27); xylene, 2 to 9 ppm (mean 6); methylene chloride, 3 and 5 ppm the others had no detectable (N.D.) exposures ; and isophorone, 0.7 and 14 ppm (others ND). Trimethyl benzene levels ranged from ND to 1 ppm and 2-ethoxyethyl acetate concentrations all were below detectable levels. See Table II for the 8-hour TWA exposure levels.

The 10-minute samples collected during screen cleaning were analyzed for xylene, toluene, MIBK and MEK. Toluene concentrations ranged from 149 to 356 ppm with a mean of 260 ppm. Xylene levels ranged from 42 to 85 ppm with a mean of 64 ppm. MIBK concentrations ranged from 55 to 126 ppm with a mean of 92 ppm. MEK levels ranged from 12 to 25 ppm with a mean of 20 ppm. However, NIOSH has not set short term ceiling limits for MEK or MIBK. ACGIH has set 15-minute ceiling standards. In order to compare the 10-minute sample results with the ACGIH standards, 15-minute exposure levels were computed by assuming the exposure during the remaining 5 minutes to be zero. Therefore, MIBK 15-minute exposure levels ranged from 36 to 83 ppm with a mean of 60 ppm and MEK levels ranged from 8 to 17 ppm with a mean of 14 ppm.

The additive short-term exposure levels of the four solvents ranged from 128 to 292% of NIOSH and ACGIH recommended exposure limits, with a mean of 212%. See Table III for the short term exposure levels.

The capture velocities of the local exhaust hoods over the printing presses were below measurable limits. The capture velocity of the local exhaust system in the screen cleaning room ranged from below measurable limits to 50 feet per minute.

B. Medical

Twenty seven of the 35 employees interviewed (77%) reported one or more periodic work-related symptoms. The most common symptoms were irritation of the eyes (15 cases) or mucous membranes (12); irritation of the respiratory tract, such as cough, chest tightness and/or wheezing (17); and dizziness (10). In addition there were reports of nausea (8); headache (5); and skin problems such as dryness, rash, itching and/or darkening (5). The neurologic symptoms (e.g. dizziness, drowsiness, "high" feeling) were intermittent and

associated with heavy use of solvents such as occurred while cleaning screens in the screen room. The respiratory tract and eye irritation were also intermittent and associated by those in areas peripheral to the screen printing area with strong odors emanating from this area. Symptomatic employees working in this area associated the symptoms with the use of "retarder" ("reducer").

The breathing problems were described as a choking or suffocating feeling, with cough, chest tightness or pain, and/or wheezing, which were generally sudden in onset and quick to resolve upon leaving the area or building. Some employees have had more severe symptoms than others and on occasion have had either to leave the work area for several minutes or go home. The health problems tend to be worse in winter when the windows are closed. The prevailing opinion was that the health problems began after the screen printing operation was installed approximately five years ago.

## VII. DISCUSSION

The results of the environmental investigation showed that screen cleaning was the plant operation most likely to cause adverse health effects. Environmental criteria for organic vapors were exceeded by an average of 212% during screen cleaning. These overexposures, which were short-term and intermittent, were the result of poor ventilation design. "Long-term" or 8-hour TWA exposure levels of printing and cleaning solvents were found to be well below all environmental criteria, except isophorone. Isophorone was reportedly used infrequently by printers. In fact, it appeared that only one printer used isophorone to any extent during the NIOSH survey since it was detected in appreciable amounts in his breathing zone only. The concentration found, however, was over 3 times the NIOSH recommended standard. None of the above substances were detected elsewhere in the plant. The most commonly reported symptoms were intermittent eye and respiratory tract irritation. The latter was typically described as transient episodes of choking, gasping, "suffocating", or rapid, heavy, difficult breathing. Several workers reported symptoms so severe that they had to leave their work area for several minutes to recover. Some reportedly even had to leave work on occasions. These and other symptoms of mucous membrane irritation were temporally associated with the use of "reducer" (by symptomatic printers) or with "strong odors" emanating from the screen printing department (by those in areas peripheral to the screen printing area). All were consistent with overexposure to solvents. Isophorone, which was present in the breathing zone of one printer, is particularly irritating and can cause mucous membrane irritation at relatively low levels. While some of these solvents may have periodically migrated to surrounding areas, it is unlikely, based on our sampling data, that they would have been present in high enough concentrations to cause symptoms of irritation. The cause of the symptoms among those working in areas outside of the printing department is, therefore, unclear.

Employees reported that in the past, in addition to dizziness, they have experienced more severe neurologic symptoms such as drowsiness, euphoria and staggering gait after washing

several screens at a time. Practices such as this required them to spend long periods of time in the screen room. These symptoms have largely been eliminated through work practices which reduce solvent exposure, for example, by limiting the amount of time spent in this room by washing only one screen at a time. In some instances a bucket and rag instead of the hose have been used to wash screens. Even with these changes, however, dizziness is a recurrent problem in some employees.

Formaldehyde probably did not contribute to the mucous membrane irritation among employees because of the relatively low levels and because the laminating process had been used since the plant was opened. The present health problems reportedly did not begin until after the installation of the screen printing operation 5 years previous.

## VIII. RECOMMENDATIONS

NIOSH recommends that local exhaust ventilation be increased in the screen cleaning room. The main problem with the existing ventilation system was the long distance from the spraying area to the exhaust hood (about 3 feet). Although hood face velocities ranged from 100-175 feet per minute, the actual capture velocity was minimal. Simply lowering the exhaust hood would increase its efficiency. A much better approach would be to enclose as much of the spraying area as possible within the exhaust system. This could be mostly easily achieved by hanging solvent-resistant curtains from the sides and front of the hood while leaving an opening just large enough to allow the spray cleaning of the screens inside. The ideal solution would be to replace the existing system with one of the spray booths depicted in Figure 2.[5] The Ventilation Manual published by the American Conference of Governmental Industrial Hygienists (ACGIH) should be consulted before designing this system. In any case, a minimum capture velocity of 100 feet per minute is required to control organic vapors. Screenwashing should be suspended in this area when the fan is not working.

It was also recommended that isophorone exposure among printers be reduced. Discussion with the management representative indicated that several different "anti-static" solvents were available and that substitution would not be a problem. NIOSH, OSHA, or ACGIH Criteria should be consulted before choosing a product. Also, the vapor pressure of the solvent is a critical physical property to consider. Solvents with high vapor pressures volatilize faster, resulting in higher exposures.

## IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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## X. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this report are currently available, upon request, from NIOSH, Division of Technical Services, Publications Dissemination, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161.

Copies of the report have been sent to:

a. Joel and Aronoff
b. United Textile Workers of America - Local 211
c. U.S. Department of Labor, Region II
d. NIOSH, Region II

For the purpose of informing the 50 "affected employees", the employer shall promptly "post" the Determination Report for a period of 30 days in a prominent place where exposed employees work.

## XI. REFERENCE

1. Printing Ink Handbook, ed 3. Harrison, NY, National Association of Printing Ink Manufactures Inc., Product and Technical Publications Committee, 1976, 95 pp.

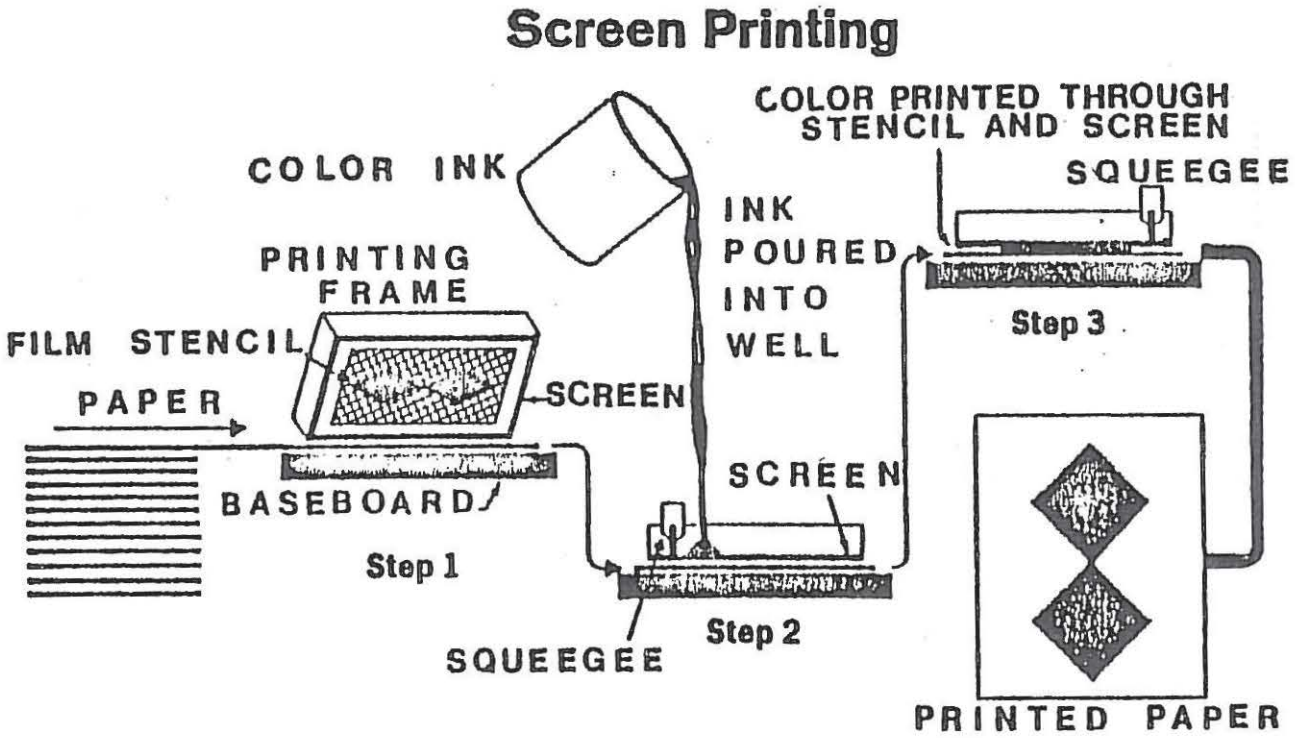
2. Criteria for a Recommended Standard, Occupational Exposure to Toluene, NIOSH Pub. No. 73-11023, U.S. Department of Health and Human Services, 1973, 98 pp.

3. Criteria for a Recommended Standard, Occupational Exposure to Xylene, NIOSH Pub. No. 73-168, U.S. Department of Health and Human Services, 1975, 101 pp.

4. Criteria for a Recommended Standard, Occupational Exposure to Ketones, NIOSH Pub. No. 78-173, U.S. Department of Health and Human Services, 1978, 244 pp.

5. Industrial Ventilation, A Manual of Recommended Practice, 16th ed. American Conference of Governmental Industrial Hygienists, 1980. ACGIH, P.O. Box 1937, Cincinnati, Ohio 45201.

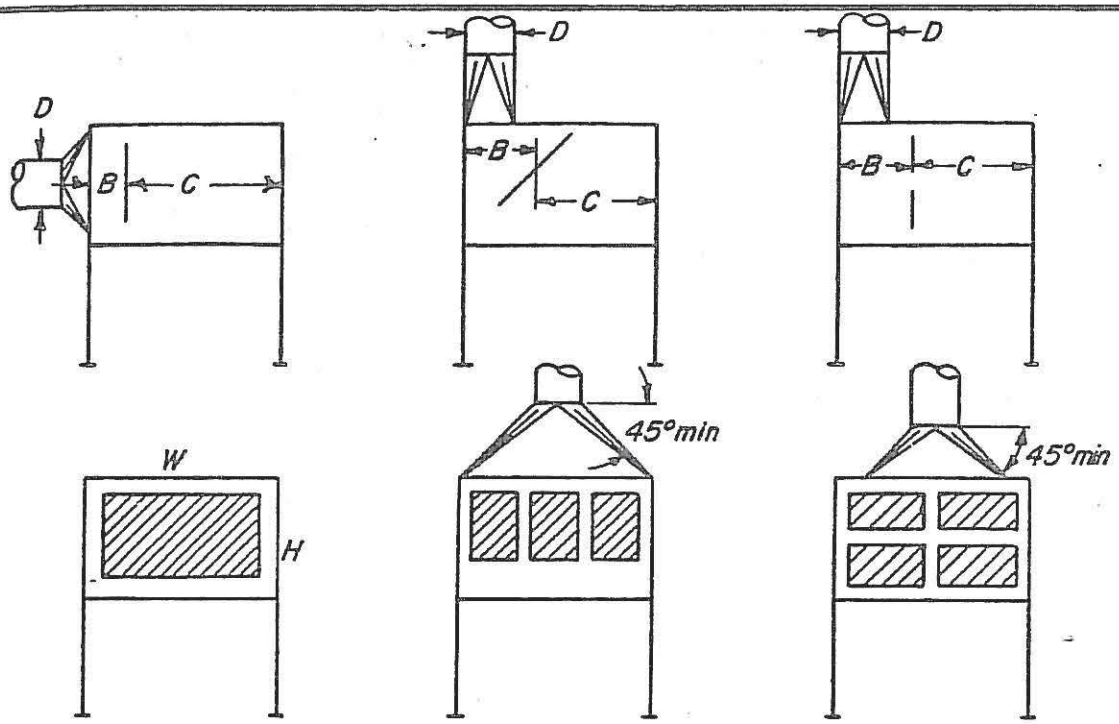
FIGURE 1




BASIC PRINCIPLES OF SCREEN (POROUS) PRINTING

Adapted From Reference 1

FIGURE 2




1. Solid Baffle
   B=0.75D
   Baffle area =0.60WH

2. Angular Baffle
   B=D+6"
   Baffle area=0.60WH

3. Split Baffle or Filters
   B=D+6"
   Baffles or filters=0.75WH
   Filter combustibility Class 2 or better. Consult NBFU or insurance underwriters.

Air spray paint design data
Any combination of branch ducts and baffles may be used
W=work size + 12"
H=work size + 12"
C=0.75 W or H, whichever is larger.
Q=200 cfm/sq ft (200WH) – for face area up to 4 sq ft
= 150 cfm/sq ft – for face area over 4 sq ft
Entry loss = Baffles: 1.78 slot VP + 0.50 duct VP
= Filters: Dirty filter resistance +0.50 duct VP
Duct velocity = 1000–3000 fpm

Airless spray paint design data
Q=125 cfm/sq ft (125WH) – for face area up to 4 sq ft
= 100 cfm/sq ft – for face area over 4 sq ft

Note: Baffle arrangements shown are for air distribution only. Filters and/or other air cleaning devices may be required to meet air pollution codes or local conditions.

For construction and safety, consult NFPA(113)

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS

SMALL PAINT BOOTH

DATE 1-80 | VS-604

TABLE I

EVALUATION CRITERIA FOR HAZARDOUS SUBSTANCES

| CONTAMINANT | OSHA PERMISSIBLE EXPOSURE LIMIT | ACGIH THRESHOLD LIMIT VALUE | NIOSH RECOMMENDED STANDARD |
|---|---|---|---|
| Toluene | 200 ppm<br>300 ppm, 10 minute ceiling<br>500 ppm, peak | 100 ppm<br>150 ppm, 15 minute ceiling | 100 ppm<br>200 ppm, 10 minute ceiling |
| Xylene | 100 ppm | 100 ppm<br>150 ppm, 15 minute ceiling | 100 ppm<br>200 ppm, 10 minute ceiling |
| MIBK | 100 ppm | 100 ppm<br>125 ppm, 15 minute ceiling | 50 ppm |
| MEK | 200 ppm | 200 ppm<br>300 ppm, 15 minute ceiling | 200 ppm |

con-

TABLE I
(Continued)

| CONTAMINANT | OSHA PERMISSIBLE EXPOSURE LIMIT | ACGIH THRESHOLD LIMIT VALUE | NIOSH RECOMMENDED STANDARD | |
|---|---|---|---|---|
| Isophorone | 25 ppm | 5 ppm | 4 ppm | |
| Methylene Chloride | 500 ppm | 200 ppm | 75 ppm | |
| Trimethyl Benzene | --- | 25 ppm | --- | |
| 2-ethoxyethyl acetate | 100 ppm | 100 ppm | --- | |
| Formaldehyde | 4.5 mg/$M^3$<br>7.5 mg/$M^3$, 10 minute ceiling<br>15 mg/$M^3$, peak | 3 mg/$M^3$ | 1.2 mg/$M^3$<br>30 minute ceiling | irritation, re |

* American Conference of Governmental Industrial Hygienists

TABLE II

Personal Breathing Zone, Time Weighted Average
Concentrations of Organic Vapors in Parts Per Million (ppm)
Joel and Aronoff
April 23, 1980

| Location | Sampling Time | Xylene | Toluene | Trimethyl Benzene | Methylene Chloride |
|---|---|---|---|---|---|
| Screen image making | 8:40 am-3:00 pm | N.D.* | N.D. | N.D. | N.D. |
| Printing | 8:25 am-3:00 pm | 9 | 21 | N.D. | N.D. |
| Printing | 8:25 am-3:00 pm | 9 | 19 | N.D. | 3.0 |
| Printing | 8:30 am-3:00 pm | 5 | 37 | 1.0 | N.D. |
| Printing | 8:35 am-3:00 pm | 2 | 29 | N.D. | 5.0 |
| Chopping | 8:30 am-3:00 pm | N.D. | N.D. | N.D. | N.D. |
| Trimming | 8:05 am-3:00 pm | N.D. | N.D. | N.D. | N.D. |
| Trimming | 8:05 am-3:00 pm | N.D. | N.D. | N.D. | N.D. |
| Trimming | 8:05 am-3:00 pm | N.D. | N.D. | N.D. | N.D. |
| Trimming | 8:10 am-3:00 pm | N.D. | N.D. | N.D. | N.D. |
| Cutting | 8:10 am-3:00 pm | N.D. | N.D. | N.D. | N.D. |
| Cutting | 8:10 am-3:00 pm | N.D. | N.D. | N.D. | N.D. |
| Sewing | 8:15 am-3:00 pm | N.D. | N.D. | N.D. | N.D. |
| Sewing | 8:15 am-3:00 pm | N.D. | N.D. | N.D. | N.D. |

N.D. - Non Detectable (approximately 0.5 ppm)

| | | | | | |
|---|---|---|---|---|---|
| Evaluation Criteria | | 100 | 100 | 25 | 75 |

TABLE III

Short Term Solvent Exposure During Screen Cleaning
in Parts Per Million (ppm)
Joel and Aronoff
April 23, 1980

| Sampling Time | Xylene | Toluene | MIBK | MEK | MIBK, Computed Average l5 min. exposure | MEK, computed Average l5 min. exposure |
|---|---|---|---|---|---|---|
| 9:00-9:10 AM | 65 | 266 | 96 | 25 | 63 | 17 |
| 1:00-1:10 PM | 42 | 149 | 55 | 12 | 36 | 8 |
| 2:00-2:10 PM | 85 | 356 | 126 | 23 | 83 | 15 |
| 2:15-2:25 PM | 64 | 247 | 89 | 21 | 59 | 14 |

* See Table I for Evaluation Criteria

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