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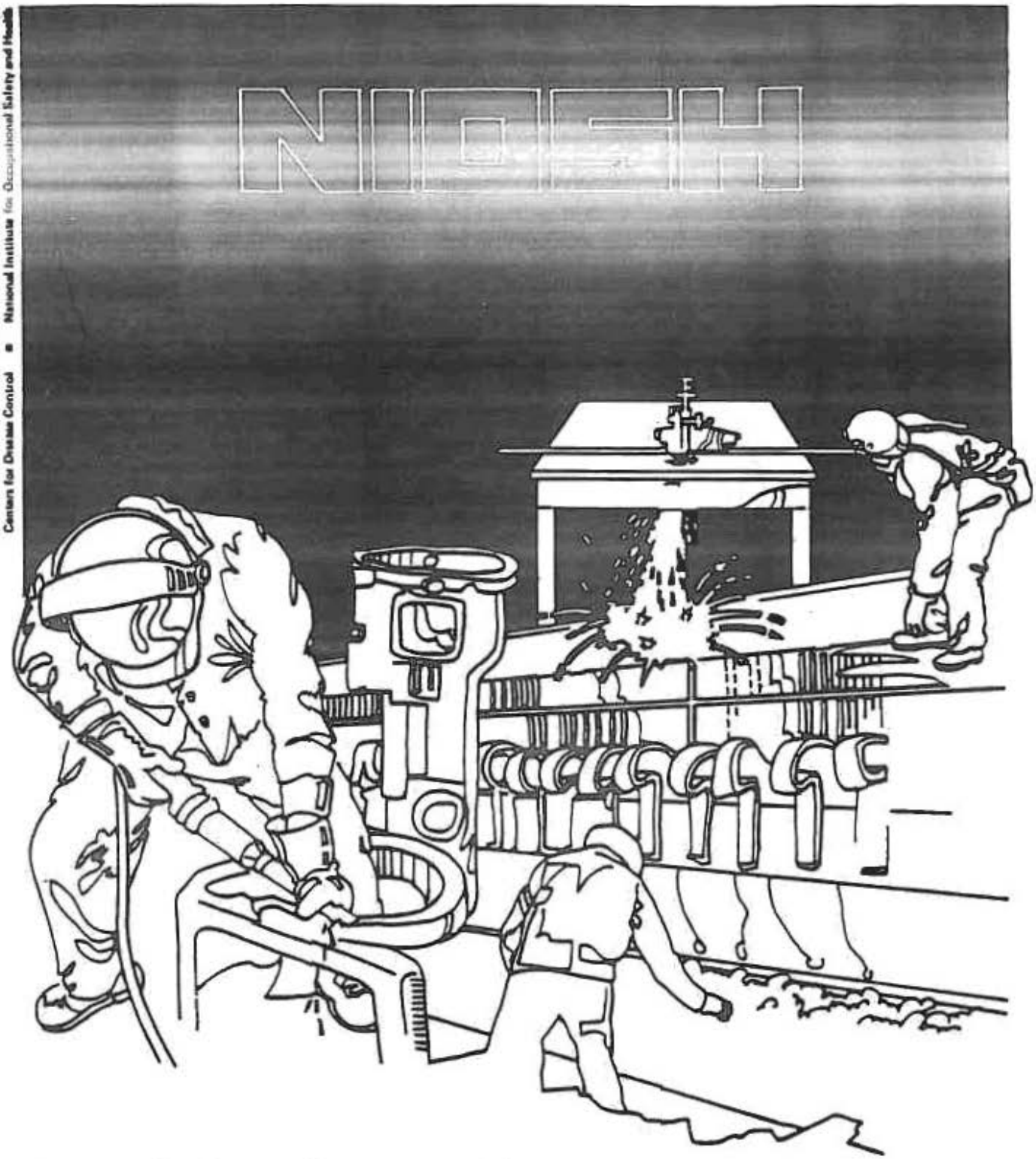

Health Hazard Evaluation Report

HETA 85-152-1684
MILPRINT, INC.
DEPERE, WISCONSIN

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 85-152-1684
April 1986
MILPRINT, INC.
DePERE, WISCONSIN

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I. SUMMARY

On January 24, 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request to assist in determining whether employees at Milprint Inc., DePere, Wisconsin, were at risk of chronic respiratory disease or cancer during the manufacture of printed and coated food wrapping materials.

In February 1985, NIOSH investigators conducted an initial survey. In April 1985, a medical survey was conducted during which confidential employee interviews were administered to all 42 employees working in the Flexoprinting Department. During the survey, records were collected indicating all chemicals in use in the production process. Subsequently, the medical literature was reviewed to determine which of these chemicals might produce chronic allergic respiratory reactions or cancer in exposed individuals.

In September 1985, an environmental survey was conducted during which air samples were collected to assess employee exposures to toluene diisocyanate (TDI), methylene bisphenyl isocyanate (MDI) and various solvents used during the printing of food wrappers.

The medical survey revealed generalized complaints of mucous membrane irritation and headaches associated with working at the printing presses.

No TDI or MDI was detectable in any of the nine samples collected for each isocyanate. In addition, no significant concentrations of any of 9 organic solvents analyzed for were detected in any of the personal or area samples collected.

Based on the data collected during this study, we have not identified any exposure at Milprint, Inc. that would subject the employees to a higher risk of allergy, asthma, or cancer than the general population. Since a potential for mucous membrane irritation and mild narcosis does exist from various solvents in use, recommendations designed to reduce employee exposures in these instances are contained in Section VIII of this report.

KEY WORDS: SIC 2641 (Paper coating and Glazing) and SIC 2751 (Commercial printing, Letterpress and Screen), Flexographic printing, Food wrappers, Pressman.

II. INTRODUCTION

On January 24, 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request from the United Paperworkers International Union, Local 1203 to conduct a health hazard evaluation at Milprint Inc., DePere, Wisconsin. The request was prompted by the UPIU Local's concern that pulmonary sensitization and cancer might exist due to employee exposures to chemicals in use in the facility.

On February 26, 1985, NIOSH investigators conducted an initial survey of the facility. An opening conference was held with representatives of plant management and the local and international union during which the nature of the request was discussed. This was followed by a walk-through inspection of the areas of concern.

On April 12, 1985, a medical survey was conducted and confidential employee interviews were administered by the NIOSH medical officer to all of the 42 employees working in the Flexoprinting Department. The interviews solicited information concerning possible work related health problems and symptoms.

In September 1985, an environmental survey was conducted during which air samples were collected to assess employee exposures to toluene diisocyanate (TDI), methylene bisphenyl isocyanate (MDI) and various solvents used during the printing of food wrappers.

III. BACKGROUND

Milprint Inc. manufactures printed food wrapping (e.g. for candy bars and cigarettes) and coated cheese wrapping. At the time of this evaluation, the plant, which had been in operation since 1947, operated multiple shifts, with approximately 189 employees (39 office and administrative, and 150 production). The request indicated the main operations of concern to be flexoprinting, ink & plate and cheesewrap.

Flexoprinting is now widely used in the packaging industry and is especially suitable for printing on plastic film. The process is similar to letterpress in that the image areas are raised. Most flexoprinting at Milprint occurs on the 4th floor of the plant, where 7 presses are located. The flexopress operators and/or assistants operate the presses and assure the quality of the product by constantly checking the print and making appropriate adjustments. They also set-up the presses, add inks/adhesives to the press reservoirs, insert rolls of wrapping material and remove printed rolls of wrap, and clean the presses between runs. The solvents in the solvent-based inks, adhesives and coatings used in the flexographic printing of food wrappers include isopropyl alcohol, ethyl alcohol, cellosolve, ethyl acetate, n-propyl acetate, ektasolve (ethylene glycol monoethyl ether), n-propyl alcohol, isopropyl acetate, and hexane. Also, some adhesive/coating materials contain TDI and MDI.

In the ink & plate room, also located on the 4th floor, flexible rubber stereo printing plates are prepared. Solvents, adhesives and coatings are dispensed, and/or mixed, from piped systems or drums and inks are formulated for the print operation. The exposures in this department are similar to those in flexoprinting.

Cheesewrap involves coating pre-printed wrapping material with substances such as cornstarch and potato starch which can cause dusty conditions, or with coatings composed of butyl rubber, bareco (a microcrystalline wax), polyvinyl alcohol and sorbic acid, in which xylene and ethyl alcohol are commonly used solvents.

IV. MATERIALS AND METHODS

A. Medical

A standard medical interview was conducted confidentially with each of the employees at the plant. This interview solicited information concerning job designation, work location, years in the plant, years at that job, prior work history, as well as age and sex of the individuals. Inquiries also were made regarding employee complaints related to the respiratory, central nervous, gastroentestinal, and otolaryngolic systems. The interview concluded with questions inquiring as to chronic health problems, allergies, current medications, smoking, and alcohol intake.

Utilizing the list of chemicals in use in the plant, the medical literature was reviewed to determine which of these chemicals might produce permanent respiratory sensitization or cancer in exposed individuals.

B. Environmental

1. Evaluation Design

During the evaluation, information related to potential employee exposures was obtained. This included collecting material safety data sheets, previous environmental data gathered by the State of Wisconsin, Department of Health and Social Services, Division of Health, and reports furnished by the UPIU Occupational Safety and Health Department. Based on a review of this data, as well as the information gathered by the medical survey, it was decided that a limited environmental survey would be conducted to access employee exposures, at or near press #189, to TDI, MDI and/or selected solvents used in the vicinity of press #189.

On September 18, 1985, the environmental survey was conducted by NIOSH investigators. The environmental survey was scheduled to coincide with operations on press #189, the principal press where isocyanate containing materials are used. Personal samples, designed to reflect employee exposures, were collected near the breathing zone of the workers to assess airborne concentrations of TDI, MDI and solvents. General area samples were also collected to assess migration of chemicals away from press #189.

The operation of press #189 is contingent on job orders (many runs are of short duration requiring frequent clean-up and set-up), as well as the press-mechanical performance. Although set-up for a run utilizing isocyanate containing adhesives was scheduled to begin shortly after the start of the 1st shift, the morning of September 18, carryover work from the previous shift and operational problems delayed the process until approximately 2:00 PM. Two actual press #189 runs were evaluated during this survey, one from 2:09 PM to 2:52 PM (43 minutes) and the second from 4:01 PM to 5:14 PM (73 minutes).

2. Sample Collection and Analysis Procedures

Nine sets of samples were collected, one for each isocyanate (TDI and MDI). Personal samples were collected on the 1st shift Ink Compounder/Attendant while he was compounding the isocyanate containing adhesives used on press #189 (approximately 30 minutes). During the time press #189 was set up and in operation, the press operator (on both the 1st and 2nd shifts) wore personal samplers for isocyanate collection and analysis. Also, area samplers were situated on work tables located near press #189 and the adjacent press #182, and three sets of samples were collected during approximately 5 1/2-hours.

Samples for TDI were obtained using battery-powered pumps, operating at a flow rate of 1.0 liter per minute (lpm), connected via tygon tubing to the collection media, a glass tube containing two sections of glass wool coated with a reagent, N-p-nitrobenzyl-N-propylamine. The glass wool samples were separated into A and B sections and analyzed for 2,4-TDI and 2,6-TDI according to NIOSH Method P&CAM 326 [1] with modifications.

The A and B sections of the glass wool samples were prepared for analysis by desorbing each section in 2 milliliters (ml) of methanol with sonication. The samples were filtered through a 0.45 um filter prior to analysis. Aliquots of each resulting solution were injected into a high performance liquid chromatography system under the following conditions: Column - Supelco C_{18}; 250 x 4.6mm, 5u particle size; Mobile Phase - Acetonitrile/methonal buffered with phosphoric acid and triethylamine; Elution - Isocratic; Flow Rate - 1.0 milliliter/minute; Detector Wavelength - 254 nm at 0.02 AUFS; Instrumentation - Water 6000A pump, WISP 710, Perkin-Elmer LC-75 UV.

Standards were prepared by making appropriate dilutions of a solution of known concentration of the urea derivative of 2,4-TDI and 2,6-TDI. The solutions were injected intermittently during the analysis. The analysis is based on the conversion of the isocyanate in the sample to its corresponding urea derivative (TDIU).

Samples for MDI were collected using battery-powered pumps, operating at a flow rate of 1.0 lpm, connected via tygon tubing to the collection media, glass-fiber filters impregnated with 0.1 milligram (mg) of pyridyl piperazine.

The MDI samples were analyzed by a high performance liquid chromatograph equipped with a 450 variable wavelength UV detector set at 254 nm. OSHA Method #47 [2] was used as a guide for analysis with two modifications; the column used was a C_{18}, and no fluorescence detector was used. Analytical standards were analyzed at the same time under the same conditions.

Qualitative and quantitative samples for solvents were collected using battery-powered pumps, operating at flow rates ranging from 41 (long-term) to 200 (short-term) cubic centimeters per minute (cc/m), connected via tygon tubing to the collection media, charcoal tubes.

Qualitative samples were desorbed with 1 ml of CS_2 and screened by gas chromatography using an HP 5880 GC equipped with a 30 meter DB-1 fused silica capillary column (splitless mode) and an FID. The samples were then analyzed by GC/MS for chemical compound identification of detected peaks.

Quantitative samples were desorbed with the proper solvent for detection of the compound of interest requested and/or identified by the qualitative analysis. Four samples were desorbed with 1ml of CS_2, one sample with 1 ml of 5% 2-butanol/CS_2, and one sample (specifically for cellosolve analysis) with 1 ml of 5% methanol/methylene chloride. All of the samples were then analyzed by GC/FID. Those samples to be analyzed for ethyl acetate and hexane were rerun by GC/FID using an HP 5840 GC equipped with a 20', 10%, SP-1000 stainless steel packed column because ethyl acetate and hexane could not be separated on the 30 meter DB-1 fused silica capillary column.

Based on the results of the screening samples, five of the previously collected charcoal tube samples were quantitatively analyzed for ethyl acetate, hexane, isopropanol, methylcyclopentane, 2-methylpentane, 3-methylpentane, n-propyl acetate, and xylene. The press #189 operator on the day shift wore a personal sampler during the 43 minutes of printing and clean-up operation. A sample for solvent exposure was collected on the evening shift press operator for 3 1/2 hours. Also, the assistant on the evening shift on press #189 was monitored for 20 minutes, during clean-up of the press following a print run. Area sampling was conducted for 5 1/2 hours, from 2:00 PM to 7:30 PM, with samplers located on the work tables near press #189 and the adjacent press #182.

V. EVALUATION CRITERIA

A. General

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent becomes available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor/Occupational Safety and Health Administration (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is required by the Occupational Safety and Health Act of 1970 (29 USC 651, et seq.) to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8 to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures.

B. Qualitatively Identified Substances

Acetates[3]

The acetate group includes n-propyl acetate and ethyl acetate. In higher concentrations, acetates are irritants to the mucous membranes. All irritate eyes and nasal passages in varying degrees. Prolonged exposure can cause irritation of the intact skin. These local effects are the primary risk in industry. All acetates may cause headache, drowsiness, and unconsciousness if concentrations are high enough. Those effects are relatively slow and gradual in onset and slow in recovery after exposure.

The current OSHA standard for ethyl acetate is 400 ppm (1,400 mg/m^3) and for n-propyl acetate, 200 ppm (840 mg/m^3).

Alkanes (C5-C8)[3]

For this evaluation, the alkanes include hexane, 2-methylpentane, and 3-methylpentane. These saturated aliphatic hydrocarbons are asphyxiants and central nervous system depressants. Lower members of the series, methane and ethane, are pharmacologically less active than higher members of the series, their main hazards resulting from simple displacement of oxygen and from fire and explosion. Higher members of the series cause narcosis. At least one member (hexane) has neurotoxic properties. Another common effect is irritation of the skin and mucous membranes of the upper respiratory tract. Repeated and prolonged skin contact may result in dermatitis, due to defatting of skin. Due to its low viscosity, aspiration of liquid may result in diffuse chemical pneumonitis, pulmonary edema, and hemorrhage. Contamination of aliphatic hydrocarbons by benzene significantly increases the hazard. Therefore, it is important that benzene content, if suspected, be determined.

The current OSHA standard for hexane is 500 ppm (1800mg/m^3).

NIOSH has recommended that the occupational exposure to airborne C5-C8 alkanes shall be controlled so that no employee is exposed at concentrations greater than 350 mg/m^3 as a TWA of total alkanes. This concentration is equivalent to about 120 ppm of pentane, 100 ppm of hexane, 85 ppm of heptane, or 75 ppm of octane.[4]

Isocyanates[3]

Both toluene diisocyanate (TDI) and methylene bisphenyl isocyanate (MDI) are liquids and may exist in different isomers: 2,4-toluene diisocyanate and methylene bisphenyl 4,4'-diisocyanate. TDI and MDI may cause irritation of the eyes, respiratory tract, and skin. The irritation may be severe enough to produce bronchitis and pulmonary edema. Nausea, vomiting, and abdominal pain may occur.

If liquid TDI is allowed to remain in contact with the skin, it may produce redness, swelling, and blistering. Contact of liquid TDI with the eyes may cause severe irritation, which may result in permanent damage if untreated. Swallowing TDI may cause burns of the mouth and stomach.

Sensitization to TDI and HDI may occur, which may cause an asthmatic reaction or hypersensitivity pneumonitis with wheezing, dyspnea, and cough. These symptoms may first occur during the night following exposure to these chemicals. Decreases in lung function in the absence of sensitivity have been observed in some workers exposed to TDI for long periods of time. Recent data suggests that TDI is carcinogenic in rats and female mice[5].

The OSHA standard for MDI and the 2,4 isomer of TDI is 0.02 ppm (0.2 mg/m^3) as a ceiling value. However, the standard recommended in the NIOSH Criteria Document for TDI is 0.005 ppm (0.036 mg/m^3) as a TWA and 0.02 ppm for any 20-minute period.

Isopropanol (isopropyl alcohol)[3]

The vapors of isopropanol are mildly irritating to the conjunctiva and mucous membranes of the upper respiratory tract. No cases of poisoning from industrial exposure have been recorded. Isopropanol is potentially narcotic in high concentrations.

The current OSHA standard for isopropyl alcohol is 400 ppm (980 mg/m^3). NIOSH has recommended that the permissible exposure limit be changed to 400 ppm as a TWA, with a ceiling of 800 ppm averaged over a 15-minute period.

Methylcyclopentane[6]

Methylcyclopentane belongs to the chemical category of alicyclic hydrocarbons and is a colorless liquid with a sweetish odor. The alicyclics, in general, are CNS depressants with low acute and chronic toxicities, owing to their rapid excretion in unchanged form or prompt conversion into water-soluble metabolites. Inhalation by humans and laboratory animals at high concentrations may cause excitement, loss of equilibrium, stupor, and coma, but rarely death. Methylcyclopentane resembles cyclopentane in its toxicity (i.e., it is a CNS depressant and lipid solvent). Experiments with mice have demonstrated that no safety margin exists between minimal narcotic concentration, loss of reflexes, and lethal dose, all occurring at 110 mg/liter. When ingested, cyclopentane presented a low to moderate aspiration hazard in mice. Cyclopentane applied to guinea pig skin produced slight erythema and dry appearance.

No environmental criteria currently exists for methycyclopentane.

Xylene[3]

Xylene vapor may cause irritation of the eyes, nose, and throat. Repeated or prolonged skin contact with xylene may cause drying and defatting of the skin which may lead to dermatitis. Liquid xylene is irritating to the eyes and mucous membranes, and aspiration of a few milliliters may cause chemical pneumonitis, pulmonary edema, and hemorrhage. Repeated exposure of the eyes to high concentrations of xylene vapor may cause reversible eye damage.

Acute exposure to xylene vapor may cause central nervous system depression and minor reversible effects upon liver and kidneys. At high concentrations xylene vapor may cause dizziness, staggering, drowsiness, and unconsciousness. Also at very high concentrations, breathing xylene vapors may cause pulmonary edema, anorexia, nausea, vomiting, and abdominal pain.

The OSHA standard for xylene is 100 ppm (435 mg/m^3) averaged over an eight-hour work shift. NIOSH has recommended a permissible exposure limit of 100 ppm averaged over a work shift of up to ten hours per day, forty hours per week, with an acceptable ceiling level of 200 ppm averaged over a 10-minute period.

VI. RESULTS

A. Medical

The medical survey revealed that approximately half of the employees experienced some mucous membrane or skin irritation associated with exposure to chemicals used at the printing presses, primarily presses 181 & 189, and the tank room. Less than 25% of the employees reported frequent headaches. A small number of gastrointestinal complaints were reported, primarily nausea. No employees with work related allergy, hypersensitivity, or asthma were identified.

Among those substances used at Milprint with a potential for substantial exposure, a review of the medical and environmental literature did not identify any that were known or suspected human carcinogens.

B. Environmental

No TDI or MDI was present in any of the samples analyzed. The limit of detection (LOD) for MDI was 11 ug/sample, and the limit of quantitation (LOQ) was 22 ug/sample. The LOD for both 2,6 and 2,4-toluene diisocyanate was 0.3 ug/sample.

Qualitative analysis of a general area sample (located on the table near press #182) identified the presence of isopropanol, ethyl acetate, hexane, and n-propyl acetate. Also identified were small quantities of methylcyclopentane, 1-methoxy-2propanol, toluene, xylene, and a glycol ether such as 2-propoxyethanol.

No cellosolve was detected on a sample collected on the table near press #189 and analyzed specifically for cellosolve; however, n-propyl acetate, xylene, hexane, and ethyl acetate were detected. Because 5% methanol/methylene chloride is not the suggested desorbing solution for these compounds, they were not quantitated. The LOD and LOQ for cellosolve are 8 and 13 micrograms per sample (ug/sample), respectively.

All solvent sampling data are presented in Table 1. A desorption efficiency study was prepared for each of the quantitated compounds and the reported values have been corrected for desorption efficiency where necessary. As evidenced by this data, all values were below their respective environmental criteria.

VII. DISCUSSION AND CONCLUSIONS

A. Medical

Several studies over the past twenty years have demonstrated an elevated risk of lung cancer[7-9,12], cancer of the oral cavity[9-11], leukemia[11], and renal cancer[11], amongst newspaper pressmen. Lloyd and co-workers demonstrated increased rates of pancreatic and rectal cancer among commercial printers[13]. However, none of these studies were able to identify particular contributing exposures.

The presence of a number of carcinogenic substances have been identified in compounds in some printing pressrooms. These include the mineral oil-carbon black ink mists (possibly containing carcinogenic PNAs), and a number of dyes and pigments used in printing inks (i.e., chromates, possibly containing chrome VI). Furthermore, all of the subjects in these studies had a potential exposure to benzene, a known human carcinogen. Whether, these or as yet unidentified factors caused the elevations noted is unknown.

Since the literature review did not reveal actual or suspected human carcinogens among chemicals identified as currently in use at this plant, the employees at Milprint would not appear to be at increased risk of the development of cancer due to their employment. However, the literature does support a higher frequency of cancer in printers without evidence for specific etiologic exposures.

No significant exposures to respiratory sensitizers (i.e., TDI or MDI) was demonstrated during the environmental survey, and no employees indicated allergic, asthmatic or hypersensitive reactions related to their employment. Therefore, these employees would not appear to be at risk of respiratory sensitization due to their employment.

B. Environmental

The information obtained during the environmental survey indicated that concentrations of solvents and isocyanates were below the evaluation criteria during the operations monitored. However, since printing conditions can be variable, ongoing employee education regarding the proper use of solvents should be conducted. In addition, periodic monitoring should be continued with particular attention given to short-term (15-minute) exposures, especially during solvent use (i.e., mixing, cleaning, etc.).

VIII. RECOMMENDATIONS

1) Since a variety of printing inks containing various pigments are utilized on occasion, workers should exercise caution in handling these substances to avoid inhalation, skin contact, and possible inadvertent ingestion of the ink or its mist, particularly when working with inks which may contain lead or chromates.

2) Cleaning solvents should be used in a manner so as to avoid unnecessary inhalation or skin contact. Where a possibility of significant skin contact exists, protective gloves or barrier creams should be utilized when possible to prevent dermatitis. However, gloves should not be used around any moving machinery (i.e., when jogging presses). Solvent rags should be disposed of properly in covered containers to reduce the escape of solvent vapor into the work area.

3) Good personal hygiene should be encouraged among pressroom employees. Hands should be washed thoroughly prior to eating or smoking in order to minimize the possibility of ingestion of any materials.

4) The company should continue to purchase pressroom materials which are free of recognized carcinogenic agents such as PNAs or benzene.

5) Prior to the introduction of new chemicals, the toxicity of these substances should be carefully evaluated. Employees should be trained regarding the potential adverse effects, the safe use of the materials, and the need for personal protective equipment.

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XI. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination 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 through the National Technical Information Services (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from the NIOSH publications office at the Cincinnati, address. Copies of this report have been sent to the following:

A. United Paperworkers International Union, Local 1203
B. Milprint, Inc.
C. U. S. Department of Labor, OSHA - Region V
D. NIOSH Regional Offices/Divisions

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

Table 1
RESULTS OF AIR SAMPLES COLLECTED FOR SOLVENTS DURING PRINTING OPERATIONS
Milprint, Inc., DePere, Wisconsin; September 18, 1985

Sample Description	Sample Time Minutes	Sample Volume Liters	TWA Concentrations in Milligrams Per Cubic Meter of Air(mg/M3) Isopropyl alcohol	2-Methyl-pentane	3-Methyl-pentane	Methyl-cyclo-pentane	n-Propyl acetate	Xylene	Hexane	Ethyl acetate
AREA SAMPLES Located on work tables adjacent to:										
Press #182	315	16.2	19.9	<LOQ*	0.2	<LOD**	34.9	0.2	1.1	10.2
Press #189	325	17.7	6.7	0.3	0.6	0.4	11.2	0.5	2.9	9.3
PERSONAL SAMPLES Located on:										
#185 Pressman (day shift)	43	2.4	19.0	<LOD	<LOD	4.0	26.3	<LOD	32.7	57.9
#189 Pressman (evening shift)	220	8.9	10.4	0.3	0.6	<LOQ	17.1	<LOQ	3.1	34.8
#189 Assistant (evening shift)	20	3.8	43.4	<LOQ	0.8	<LOD	61.3	<LOD	4.7	134.5
Environmental Criteria :										
OSHA			980	---	---	---	840	435	1800	1400
NIOSH			980	350†	350†	---	---	434	350†	---
Limit of Detection			4	1	1	2	6	1	6	20
Limit of Quantitation			8	2	2	4	10	2	11	34

Abbreviations and Key:
TWA - Time-weighted average concentration calculated for the duration of sample collection only.

* - <LOQ = Less than the Limit of Quantitation
** - <LOD = Less than the Limit of Detection.
† - Environmental limit of total alkanes as a TWA concentration.