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GRAY PRINTING COMPANY
FOSTORIA, OHIO

NIOSH INVESTIGATORS:
MICHAEL S. CRANDALL, CIH
ANNE T. FIDLER, ScD
FREDRIC CANTOR, DVM, MPH

I. SUMMARY

On November 13, 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Graphics and Communication International Union (GCIU) to evaluate health problems possibly related to exposures to solvents at Gray Printing Company in Fostoria, Ohio. Environmental and medical evaluations were conducted on March 18-19, 1986.

Sheet-fed press operator alcohol exposures ranged from 247 to 501 mg/m³, and averaged 407 mg/m³ (standard deviation (sd) ± 89) over two workdays. The personal breathing zone naphtha concentrations ranged from less than 0.03 mg/m³ to 8.9 mg/m³ and averaged 4.2 mg/m³ (sd ± 3.2). These results are well below the exposure limits recommended by NIOSH (980 mg/m³ for isopropanol and 350 mg/m³ for naphthas).

The web-fed press operator naphtha exposures ranged from less than 0.03 mg/m³ to 7.7 mg/m³ and averaged 2.2 mg/m³ (sd ± 1.2) mg/m³ for two shifts. These workers were also exposed to low concentrations of isopropanol (<100 mg/m³ as an 8-hr TWA).

The highest short-term isopropanol exposure was 726 mg/m³. The lowest short-term criterion for isopropyl alcohol (American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Value - Short-Term Exposure Limit (TLV-STEL)) is 1225 mg/m³. Short-term exposures to blanket and roller cleaning solvent were low, generally <10 mg/m³. One measured exposure was near 40 mg/m³. The NIOSH short-term recommended exposure limit (REL) for these solvents is 1800 mg/m³.

A questionnaire was administered to 80% of current employees to assess the prevalence of neurotoxic and other medical symptoms potentially associated with exposures to organic solvents. Final analyses were limited to males working on Shifts 1 and 2. There was a higher prevalence of each of 37 symptoms, with the exception of headache, among the 36 men employed in printing operations than among the 16 men employed in the bindery, where there was no direct exposure to solvents. These differences were statistically significant for symptoms related to central nervous system depression, difficulty concentrating, dizziness, cough, chest pain, and dry skin.

Although on the day of the NIOSH survey, air concentrations of naphthas and isopropyl alcohol were well below the OSHA and NIOSH evaluation criteria, NIOSH investigators documented an increased prevalence of neurotoxic, respiratory, and skin problems among workers employed in printing operations, which use a variety of organic solvents. Recommendations to minimize worker exposure to solvents are provided in Section VII of this report.

KEYWORDS: SIC 2752 (commercial printing, lithographic), solvents, naphthas, alcohols, neurotoxic symptoms

II. INTRODUCTION

On November 13, 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Graphics and Communications International Union (GCIU) at the Gray Printing Company, Fostoria, Ohio to evaluate potential exposures to solvents used in offset printing processes, and to determine whether health problems reported among workers at the plant could be related to these exposures. Neurotoxic effects of solvents used at the plant were the primary concerns.

A survey to collect environmental and medical data was conducted on March 18-19, 1986. The environmental investigators collected personal air samples over two workshifts to measure exposure to isopropyl alcohol and cleaning solvents. The medical investigators issued a self-administered questionnaire to workers on all workshifts to collect demographic, work history, medical history, and symptom information.

III. BACKGROUND

The Gray Printing Company began operation in 1888. At the time of this evaluation, production included 30 monthly magazines plus various commercial catalogs and brochures. The total plant employment was 185 workers. This plant produces printed material using photographic typesetting, and sheet-fed and roll-fed (web-fed) offset lithographic printing processes.

The basis of the lithographic process is the chemical treatment of a printing plate to make it selectively water-repellent (ink-receptive) and water-receptive (ink-repellent). This requires dampening as well as inking systems on lithographic presses. The sheet-fed presses at the Gray plant used the Dahlgren dampening system. This system uses a mixture of 10-15% isopropyl alcohol with water. The fountain solution for the web-fed presses was a mixture of a glycol with water (1-3 ounces per gallon of water).

The primary use of solvent in the pressrooms, other than isopropyl alcohol, was for washing printing plates, cylinders, blankets, and screens. Qualitative chemical analyses revealed that the solvent (blanket and roller wash) used at the time of this evaluation was predominantly a C₉-C₁₂ naphtha mixture (RT-41054 Solvent). It contained a small amount of toluene. A solvent used for the same purpose, for approximately seven years prior to May 1985 (3304A Solvent), contained 10% 2-ethoxyethanol. For a short time period (about two weeks) 3304C solvent, which contained 10% propylene glycol monomethyl ether, was used. There were many additives and special use solvents here, mostly used in small amounts. The frequency of use was variable.

Production area ventilation was provided by several rooftop units (GE, YC-A series, gas/electric), with varying capacities for heating and cooling. Manually adjusted dampers on each unit were set to provide approximately 20% fresh air to plant areas. The only local exhaust provided was for the driers for web-fed printed material. There was a wall-mounted exhaust fan (approx. 4' diameter) of unknown capacity in the web-fed press ink storage area.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Worker exposures to the organic solvents and isopropanol used in the printing operations were measured using standard air sampling techniques. Full-shift personal breathing zone and area air samples were collected by drawing a known volume of air through glass tubes containing activated coconut shell charcoal (150 mg), using battery-powered sampling pumps, at a nominal flow rate of 50 milliliters per minute (ml/min) for the organic solvent samples and 20 ml/min for the isopropanol samples. For personal samples the pump was attached to the worker's belt and the charcoal tube was clipped to the collar or lapel in the worker's breathing

zone. The same sampling apparatus was used to collect short-term personal samples (up to 60 minutes duration), but at a flow-rate of 200 ml/min. It should be noted that the full-shift sample for isopropanol was split into two sampling periods due to sample air volume limitations of the method.

Higher flow-rate (200 ml/min) area air samples (five) and bulk liquid material samples (eight) were collected to be used for qualitative air contaminant and solvent characterization. The charcoal tubes were desorbed with carbon disulfide (CS₂) and initially screened by gas chromatography (GC) and flame-ionization detection (FID). Portions of each of the bulk liquid samples were either mixed or extracted with CS₂ and screened by GC-FID. Representative samples were then analyzed by GC-mass spectrometry to identify components (30-meter DB-1 fused silica capillary column for all analyses).

The qualitative analyses showed that the constituents of the bulk liquid and air samples were mixtures of aliphatic and aromatic hydrocarbons, differing in boiling point range. The aromatic content was generally small. Common mixtures were C₉-C₁₂ aliphatics, C₁₂-C₁₉ aliphatics, and C₁₄-C₂₀ aliphatics in the liquid bulks, and C₉-C₁₂ aliphatics in the air bulk samples. Minor peaks on the chromatograms were identified as 1,1,1-trichloroethane and toluene. One liquid bulk sample was markedly different from the rest. It was an essentially equal mixture of ethyl acetate and 2-ethoxyethyl acetate. This was a solvent being used during the teardown maintenance of the 4-unit Goss web-fed press.

Forty-three air samples were quantitatively analyzed for the C₉-C₁₂ naphtha mixture (quantitated as total hydrocarbons), 1,1,1-trichloroethane, and toluene identified by the qualitative analyses. The charcoal tubes were divided into front and back sections and analyzed by GC according to NIOSH Method 1501.² The samples were first desorbed with 1 ml CS₂, then analyzed by GC-FID. The limit of detection (LOD) for this mixture was 0.03 mg/sample, and the limit of quantitation (LOQ) was 0.06 mg/sample.

Thirty-four samples were quantitatively analyzed for isopropanol. These samples were divided into front and back sections and analyzed by GC according to NIOSH Method 1400.¹ The samples were first desorbed with 1 ml of CS₂ containing 1 microliter/ml of toluene as an internal standard and 1% sec-butanol as an aid in desorption. The samples were then analyzed by GC-FID. The LOD for this mixture was 0.03 mg/sample, and the LOQ was 0.09 mg/sample.

Personal exposures for the full work shift were monitored, as well as short-term (task dependent) exposures. All workers in the press areas were monitored over two work shifts. Overhaul maintenance was being performed on one of the web-fed presses. Otherwise, all press areas were operating in a normal fashion.

B. Medical/Epidemiologic

A brief self-administered questionnaire was provided to workers on all three shifts to ascertain information regarding demographics, job and medical history, and symptoms potentially related to exposure to organic solvents. Upon completion, the questionnaire was reviewed with each participant by a NIOSH investigator. The symptom questionnaire is a modification of the "Swedish 16" neurotoxic questionnaire² and has been used in a number of other studies of the effects of solvents.³ Each of the 37 symptoms was scored on a 4-point scale: "not at all" (score=0), "a little" (score=2), "moderately" (score=3), and "quite a bit" (score=4). The symptoms were combined into eight symptom clusters, based largely on previous factor analyses³ and biologic plausibility. The clusters related to symptoms of affective disturbances, memory loss, respiratory symptoms, somatic complaints, skin problems, peripheral motor and sensory problems, and symptoms of central nervous system depression. Headache was considered separately. Each cluster score ranged from 0 to 4 (average score for each symptom in the cluster). Such scores reflect both frequency and intensity of the symptoms.

Because neurotoxic symptoms occur primarily as a response to acute or recent exposure to solvents, workers were classified on the basis of department in which they were currently employed. Four such departments were identified: printing (offset press), bindery, office, and "other" (included art, copy preparation, camera, negative stripping, plating, composing and maintenance). Because of the differences in the demographics and job characteristics of office workers and the mixed nature of the personnel and potential exposures among the workers classified in "other" departments, most of the analyses of the relationship of solvent exposure and the occurrence of symptoms compare the results of the solvent-exposed printers and the unexposed binders. Statistical analyses were performed using SPSS/PC.⁴ The symptom scores were analyzed using both parametric (assuming normal distribution of data) and non-parametric statistical procedures. Analysis of covariance was used to adjust for the influence of potential confounders (age, education, smoking status, caffeine and alcohol consumption).

Persons were subject to exclusion from data analysis if they had worked with neurotoxicants prior to employment at Gray Printing, if they participated in a hobby in which exposure to neurotoxic substances was probable, or if they had a history of a medical condition or took medications which could cause symptoms similar to those under investigation.

V. EVALUATION CRITERIA

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 become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommended exposure limits (REL's), 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH REL's and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA permissible exposure limits (PEL's) 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 legally required 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.

A. Naphthas

The offset blanket & roller wash solvent used at Gray Printing was considered a high flash naphtha with a boiling point range of 110-200°C (230-390°F). Effects of exposure to these solvents are primarily acute, unless significant amounts of substances shown to be more chronically toxic are present, such as benzene or glycol ethers. Epidemiologic studies have shown that exposure to similar refined petroleum solvents (mineral spirits, Stoddard solvent) can cause dry throat, burning or tearing of the eye, mild headaches, dizziness, respiratory irritation, and dermatitis.⁵ (The manufacturer reported these types of effects, including anesthesia after inhalation exposure to excessive air concentrations (>100 ppm), in the material safety data sheet for this solvent. Skin contact was not recommended, and eye and respiratory protection were recommended.)

The NIOSH REL for mineral spirits and Stoddard solvent is a 350 mg/m³ (60 ppm) TWA exposure for up to a 10-hour work shift, 40-hour workweek. In addition, a ceiling concentration limit (15 minutes duration) of 1800 mg/m³ is recommended. The ACGIH TLV-TWA for Stoddard solvent is 525 mg/m³ (100 ppm).⁶ The OSHA PEL for Stoddard solvent is 2900 mg/m³ (500 ppm).⁷

B. Isopropyl alcohol

Isopropyl alcohol is considered to be of low toxicity by any route of exposure. In common with other alcohols, it has mild central nervous system depressant properties. At 400 ppm it has been found to cause mild irritation of the eyes, nose, and throat.^{8,9}

The NIOSH REL for isopropyl alcohol is a 984 mg/m³ (400 ppm) TWA exposure for up to a 10-hour work shift, 40-hour workweek. In addition, a ceiling (15 minutes duration) concentration of 1968 mg/m³ (800 ppm) is recommended. The ACGIH TLV-TWA for isopropyl alcohol is also 984 mg/m³ (400 ppm).⁶ The TLV-STEL is 1225 mg/m³ (500 ppm). The OSHA PEL is 984 mg/m³ (400 ppm) for an 8-hour TWA exposure.⁷

C. Glycol ethers (2-ethoxyethyl acetate)

In its 1983 review of the toxicity of the glycol ethers 2-methoxyethanol (2ME) and 2-ethoxyethanol (2EE), NIOSH recommended that these substances be regarded in the workplace as having the potential to cause adverse reproductive effects in both male and female workers. These recommendations were based on the results of several studies that demonstrated dose-related embryotoxicity and other reproductive effects in several species of animals exposed by different routes of administration. Exposures of pregnant animals to concentrations of 2ME or 2EE at or below their respective OSHA PELs led to increased incidences of embryonic death, teratogenesis, or growth retardation. Exposure of male animals resulted in testicular atrophy and sterility. NIOSH urges employers to reduce exposures to 2ME and 2EE to the lowest extent possible. In addition, NIOSH recommends caution in the use of other structurally-related glycol ethers, including 2-ethoxyethyl acetate. Preliminary test results indicate that they also have the potential to cause reproductive effects similar to those of 2ME and 2EE. NIOSH recommends that worker exposure to these glycol ethers be controlled to the fullest extent possible.¹⁰

VI. RESULTS AND DISCUSSION

A. Environmental Results

Six sheet-fed press workers were monitored for full-shift isopropanol and solvent exposures over two work shifts. Results are presented in Table 1. Alcohol exposures ranged from 247 to 501 mg/m³, and averaged 413 mg/m³ (standard deviation (sd) ± 101) on the first day. The personal naphtha concentrations ranged from 4.1 to 8.9 mg/m³ and averaged 5.7 mg/m³ (sd ± 3.3) on this day. Second day exposures were similarly low, ranging from 263 to 468 mg/m³ and averaging 402 mg/m³ (sd ± 84) for isopropanol and less than the limit of detection (0.03 mg/m³), or none detected (ND), to 2.8 mg/m³ for naphthas. These results are well below the evaluation criteria.

The full-shift exposure results for the web-fed press workers are presented in Table 2. The naphtha exposures were very low, ranging from ND (<0.03 mg/m³) to 7.7 mg/m³ on the first day and ND to around 2 mg/m³ on day two. These workers were also exposed to low concentrations of isopropanol. The results could not be quantitated since isopropanol is not desorbed well without adding a desorption aid. It is unlikely that any of these workers were exposed to alcohol concentrations greater than 100 mg/m³ as an 8-hr TWA.

Table 3 presents the results of sixteen short-term samples collected over the two day evaluation. These were collected during various washup, setup, and changeover tasks, and during the replenishing of the alcohol dampening systems for the sheet-fed presses.

The sheet-fed press operators may perform up to 20 blanket and roller washes per shift. This task takes about two minutes. Web-fed press operators clean blankets and rollers up to five times per shift, a 20-minute task. Typically, a gloved hand is used to apply the solvent. A rag is dipped into a solvent bucket and then the surfaces are wiped. It is possible for the solvent to get into the glove and be trapped there. Sometimes the solvent is applied to the surfaces using a squirt bottle while the rollers are spinning; then they are wiped down.

Replenishing the Dahlgren dampening system for the sheet-fed presses with isopropyl alcohol is a potentially high-exposure task. This was done twice per shift and took from five to fifteen minutes for the worker to do. Depending upon the press operating conditions there may be other additives with the alcohol, in small amounts. Included could be gum arabic, subtractive plate gum, No Mold, and fountain solution.

The highest isopropanol exposure resulting from the replenishing activity (Table 3), on the days that we monitored, was 726 mg/m³. Three of the four measurements made averaged 665 mg/m³. The other measurement was 4.1 mg/m³. The lowest short-term criterion for isopropyl alcohol (ACGIH TLV-STEL) is 1225 mg/m³. Exposures to blanket and roller wash were low, generally <10 mg/m³. One measured exposure was near 40 mg/m³. The NIOSH short-term criterion for these solvents is 1800 mg/m³.

Two personal samples were submitted for analysis for ethyl acetate and 2-ethoxy ethyl acetate. These were collected from workers performing maintenance on the web-fed press being overhauled. Neither of the analytes were detected on either sample.

B. Medical/Epidemiologic Results

Of a total of 185 workers employed at Gray Printing Company, 146 (79%) completed questionnaires. Thirty-nine of 46 (85%) printers participated, as well as 48/65 (74%) binders, 20/25 (80%) office personnel, and 39/49 classified as "other" (Table 4). Overall, there were 20 individuals with previous or

extraneous exposures or medical conditions who were considered to be eligible for exclusion from analysis. They were distributed among the departments as shown in Table 4. All analyses were performed both with all participants and without those eligible for exclusion. There were no substantive or significant differences in the analyses. Only the results in which all subjects are included are presented here.

Demographic information about the four department groups is presented in Table 5. There is a significant difference in the male/female ratio between the exposed group (printing department) and the unexposed control group (bindery department). Only 33% (16/48) of the bindery workers were male, whereas 92% (36/39) of the printers were male. In addition, the bindery workers had a significantly higher ($p=0.001$) length of employment than did the printers. The two departments were, however, similar in terms of race, age, education, current smoking status, and consumption of caffeine. The printing department had a higher median number of alcoholic drinks per week, though the difference was not statistically significant.

Symptom scores were calculated for each department by gender (Table 6). Overall, comparison of symptom scores between the bindery and printing departments revealed no statistically significant differences, with the exception of headache. In that instance, workers in the bindery complained of significantly more occurrence of headache. In almost all cases, females had higher symptom scores than males, regardless of the department in which they worked.

Because most of the symptoms assessed in this evaluation occur normally in the general population, persons with higher reporting of symptoms (i.e., higher than would be considered to be within normal limits in the general population) were arbitrarily defined as those with symptom scores of 2.0 or greater. To achieve this score, an individual would have to report an average of 2 ("a little") for all of the symptoms within a symptom cluster. From Table 7, it can be seen that, with the exception of headache, the highest prevalence of more serious complaints were of skin problems and memory disturbances.

The higher prevalence of symptom complaints and the higher symptom scores among women is of particular concern in this evaluation, because of the large disparity in the gender make-up of the two groups (printing and bindery departments) under investigation. Because there were too few women in the printing department (3/39) to perform a stratified analysis to control for confounding by gender, further analyses of symptom scores were restricted to males in the printing and bindery departments. There were significantly higher mean symptom scores among the five printers on Shift 3 than among the printers working on either of the other two shifts. Because there were no significant differences in the mean scores of Shifts 1 and 2, their results were pooled. Table 8 presents the comparison of mean symptom scores for Shifts 1 and 2 vs. Shift 3. In all cases, Shift 3 had higher scores than the day and evening shifts, yet there was no evidence of a higher exposure potential during the night shift to account for this difference. Because there were no Shift 3 bindery department workers to allow stratification by shift in the analysis, the final group analyses were restricted to males on Shifts 1 and 2.

Because no substantial differences were seen between the simple parametric and non-parametric analyses (e.g., Student's t-test vs. Mann-Whitney U test), the use of analysis of covariance, a parametric test, was deemed valid for the assessment of potential confounders. Because of the relatively small number of participants, symptom scores were modeled on department (bindery=0, printing=1) and only one potential confounder at a time. The factors assessed in these analyses were age, years employed in current job, years of school, smoking status (current or non-current), caffeine level, and alcoholic drinks per week. The latter two variables were categorized into low, moderate, and high consumption. None of these factors had a significant effect on the symptom score; therefore, unadjusted means of the symptom scores were compared for males on Shifts 1 and 2 in the printing and bindery departments. These results are presented in Table 9. In all cases, except headache and somatic complaints, the mean symptom scores were higher among the solvent-exposed

printers than among the unexposed bindery workers. This difference was statistically significant for respiratory/chest symptoms ($p=0.02$), peripheral sensory symptoms ($p=0.04$), and central nervous system depression ($p=0.004$).

To assess the contribution of each individual symptom to the symptom clusters, the prevalence of each symptom is presented in Table 10. Each symptom was rated as absent (score=0) or present (score=2,3, or 4). Meaningful comparisons among the exposed and unexposed females cannot be made because of the few women in the printing department. Among the males, there was a higher prevalence of all symptoms relating to affect; however, only the differences in "trouble concentrating" and "dizziness" reached statistical significance ($p < 0.10$). The symptoms of CNS depression were all statistically significantly elevated among the printers. The symptoms of trouble concentrating and dizziness may, in fact, relate to a similar depressant effect on the central nervous system. All three symptoms associated with memory disturbances were more prevalent among the solvent-exposed workers, though none of these differences was statistically significant. Reporting of the symptoms in the respiratory/chest group was elevated among the printers, most notably chest pain ($p=0.05$) and cough ($p=0.07$). Although most of the somatic complaints were more prevalent among printers, there is a relatively high background rate of these symptoms among the unexposed bindery workers. The symptom primarily responsible for the increase in the skin problems is dry skin, rather than skin rash. Disturbances in both motor and sensory aspects of the peripheral nervous system appear to be more prevalent among the printers, with the elevation in numb fingers being statistically significant ($p=0.05$). This, however, could be either a reflection of peripheral nerve damage or associated with dry skin. There is evidence that the latter may be true. Of the 30 printers with dry skin, 9 (30%) also complain of numbness in the fingers. However, only 1 of the 22 individuals without dry skin (4.5%) also has a complaint of numbness in the fingers (Relative Risk=6.7; $p=0.03$).

Several questions were asked of study participants pertaining to work practices and use of personal protective equipment, the results of which are presented in Table 11. Among the solvent-exposed workers, none indicated the use of cartridge respirators and only 2 (5%) said they normally wore a smock or protective clothing. Although most (97%) printers wore gloves, more than half of those who did said that the gloves did not fit properly. Most printers (92%) eat at the worksite, increasing their potential for ingestion of toxic materials.

C. Discussion

The environmental results show that, during the time period of the evaluation, personal inhalation exposures were less than the evaluation criteria. Isopropyl alcohol exposures were generally less than half of the NIOSH REL, and naphtha exposures an order of magnitude less than the NIOSH REL. There is the possibility, however, of synergistic action due to the combined exposure to isopropanol and the naphthas. Percutaneous absorption of these solvents was likely, but not able to be measured. The greatest potential for acute, high inhalation and cutaneous exposures are the replenishing of dampening systems (isopropanol), and the set-up, washup, and job changeover tasks (naphthas). Extra personal protection at these times would diminish this potential. Most workers wear gloves to prevent direct contact with solvents; however, unless the gloves fit well, they may offer little or no protection and, in fact, may increase skin contact by trapping the solvent between the glove and the hand. While inhalation exposures in excess of the evaluation criteria were not measured, the uncontrolled use of solvents provides a potential for high exposures.

There was a good participation rate in the questionnaire evaluation of Gray Printing Company. Overall, 79% (146/185) of the total workforce completed questionnaires. Reasons for not participating included vacation (3), sick leave (7), at work but unavailable (21), and refusals (3). There was no reason to believe that persons

were unavailable for testing for reasons related to a possible association between health status and exposure, which could lead to a significant selection bias. However, if workers were no longer employed because of illness or a sensitivity to the chemicals in the workplace, they would not have been included in this evaluation. The potential for this type of "healthy worker" bias exists in cross-sectional evaluations such as this survey.

In the crude analysis of the symptom questionnaire, there were no significant elevations in neurotoxic, respiratory, or dermatologic symptoms among the solvent-exposed press operators, as compared to the unexposed bindery workers. However, analysis of questionnaire data from the men in the printing and bindery departments (who worked on the first 2 shifts) disclosed several significantly higher prevalences among the solvent-exposed workers. These included symptoms of CNS depression, such as a feeling of being "high" from the chemicals used at work, a decreased tolerance to alcohol, and difficulty driving home from work. This type of symptom has been associated with exposure to solvents. Although the symptoms usually result from acute exposure and resolve after a few hours, they are of particular concern because persons experiencing them are more subject to accidents.

Sensory problems, notably numb fingers, were also elevated among the printers. There is some evidence, however, that this symptom may be an indication of skin problems, also associated with exposure to organic solvent exposure. Also associated with work in the solvent-exposed areas were respiratory chest symptoms, especially cough and chest pain. Both isopropyl alcohol and naphtha are known to be respiratory irritants,^{11,12} although these symptoms are usually seen at levels higher than were measured during the environmental survey.

VII. RECOMMENDATIONS

1. To better control potential skin absorption, workers should always use well-fitting gloves when handling alcohol and naphtha solvents. Gloves should be changed daily or whenever solvent gets inside of the glove.
2. The safety and health committee should consider the implementation of a respiratory protection program at Gray Printing Company. Although overexposures to solvents were not measured during the two-day evaluation, the likelihood should not be overlooked, particularly during short-term jobs which present opportunity for acute, high exposure to alcohol or blanket and roller solvent. Such a program would be required to conform to the OSHA standard (29 CFR 1910.134). This would include medical evaluation, training, fit testing, and periodic environmental monitoring.
3. Although ingestion is not a major route of absorption of solvents, eating at the worksite should not be encouraged. Smoking at the worksite is of even more importance in its potential for increasing the absorption of solvents, as it increases inhalation of such substances. Smokers who choose to continue smoking should be encouraged not to do so in areas of potential solvent exposure.

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IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

Investigators:

Michael S. Crandall, MS, CIH
Industrial Hygiene Engineer
Industrial Hygiene Section

James M. Boiano, MS, CIH
Industrial Hygienist
Industrial Hygiene Section

Anne T. Fidler, ScD
Supervisory Epidemiologist
Medical Section

Fredric Cantor, DVM, MPH
Medical Officer
Medical Section

Originating Office:

Hazard Evaluations and Technical
Assistance Branch
Division of Surveillance, Hazard
Evaluations, and Field Studies

X. DISTRIBUTION AND AVAILABILITY

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1. Gray Printing Company, Fostoria, Ohio
2. Graphics Communication International Union, Local 566
3. OSHA Region 5

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

TABLE 1
 Sheet-Fed Press Worker Exposures, Full-Shift
 Gray Printing Company
 Fostoria, Ohio
 March 18-19, 1986
 HETA 86-053

Press	Job	Sample Duration	<u>Concentration, mg/m³</u>	
			Isopropanol	Naphtha Mixture (C ₉ -C ₁₂)
<u>March 18</u>				
4-Color (Harris)	Head Pressman	0731-1455	489	6.7
	2nd Pressman	0733-1457	501	8.8
	Feeder Operator	0745-1452	355	4.2
2-Color (Miller)	Head Pressman	0738-1457	491	5.4
	Feeder Operator	0748-1452	394	8.9
2-Color (Heidelberg)	Head Pressman	0753-1447	247	4.1
Heidelberg press (#66)	Area	0800-1500	300	6.5
<u>March 19</u>				
4-Color (Harris)	Head Pressman	0702-1455	468	2.5
	2nd Pressman	0659-1455	467	2.8
	Feeder Operator	0656-1455	408	2.4
2-Color (Miller)	Head Pressman	0705-1455	342	2.5
	Feeder Operator	0702-1455	464	ND*
2-Color (Heidelberg)	Head Pressman	0736-1453	263	ND
Heidelberg press (#66)	Area	0810-1453	300	(1.3)
	Criteria:	NIOSH	984	350
		OSHA	984	2900
		ACGIH	984	525
Analytical Limit of Detection (LOD, mg/sample)			0.03	0.03
Analytical Limit of Quantitation (LOQ, mg/sample)			0.09	0.06

* ND = none detected, value was below the analytical LOD

TABLE 2

Web-Fed Press Worker Exposures, Full-Shift
 Gray Printing Company
 Fostoria, Ohio
 March 18-19, 1986
 HETA 86-053

Press	Job	Sample Duration	Concentration, mg/m ³ Naphtha Mixture (C ₉ -C ₁₂)
<u>March 18</u>			
2-Unit	Head Pressman	0637-1509	(1.6)**
	2nd Pressman	0643-1509	2.4
	Jogger	0642-1509	3.4
6-Unit	Head Pressman	0916-1450	(3.1)
	2nd Pressman	0702-1450	2.9
	3rd Pressman	0704-1450	2.7
	Web Tender	0707-1450	(1.4)
	Jogger	0711-1450	ND****
4-Unit*	Head Pressman	0715-1410	4.4
	Jogger	0715-1410	7.7
<u>March 19</u>			
2-Unit	Head Pressman	0634-1518	(1.3)
	2nd Pressman	0635-1518	ND
	Jogger	0633-1518	1.6

(continued)

Table 2 (continued)

Press	Job	Sample Duration	<u>Concentration, mg/m³</u> Naphtha Mixture (C ₉ -C ₁₂)
<u>March 19</u>			
6-Unit	Head Pressman	0715-1450	ND
	2nd Pressman	0715-1450	(2.3)
	3rd Pressman	0718-1450	ND
	Jogger	0716-1450	ND
	Criteria	NIOSH OSHA ACGIH	350 2900 525
Analytical Limit of Detection (LOD, mg/sample)		0.03	
Analytical Limit of Quantitation (LOQ, mg/sample)		0.06	

* - 4-Unit press undergoing teardown maintenance

** - values in parentheses are between the analytical LOD and LOQ

*** - none detected, value was below the analytical LOD

TABLE 3
 Short-Term Press Worker Exposures
 Gray Printing Company
 Fostoria, Ohio
 March 18-19, 1986
 HETA 86-053

Press	Job Title	Task Performed	Sample Duration	Concentration, mg/m ³	
				Isopropanol	Naphtha Mixture (C ₉ -C ₁₂)
<u>March 18</u>					
6-Unit, webfed	2nd Pressman	Blanket and roller wash up	1043-1112	—	38
	3rd Pressman	Blanket and roller wash up	1042-1102	—	ND*
	Web Tender	Blanket and roller wash up	1042-1107	—	(8.3)**
Sheetfed, all	Press Cleanup	Blanket and roller wash up	1445-1900	—	7.7
2-color sheetfed (Miller)	Feeder Operator	Replenish roller dampening solution with isopropanol	1024-1030	726	—
4-color sheetfed	2nd Pressman	Replenish roller dampening solution with isopropanol	1356-1408	600	—
<u>March 19</u>					
6-Unit, webfed	Head Pressman	Wash and setup for new job	0803-0836	—	ND
	2nd Pressman	Wash and setup for new job	0802-0834	—	(8.2)
2-Unit, webfed	2nd Pressman	Wash and setup for new job	1423-1518	—	ND
	Jogger	wash and setup for new job	1422-1518	—	8.4
4-Color, sheetfed (Harris)	2nd Pressman	Job changeover, blanket wash, change plates	0830-0934	238+	(3.1)
	Feeder Operator	Job changeover, blanket wash, change plates	0830-0934	344+	(3.9)
4-Color, sheetfed (Harris)	2nd Pressman	Job changeover (as above)	1248-1340	ND	ND
	Feeder Operator	Job changeover (as above)	1248-1340	230+	(3.9)
2-Color, sheetfed (Miller)	Feeder Operator	Replenish roller dampening solution with isopropanol	1330-1337	4.1	—
4-Color, sheetfed (Harris)	2nd Pressman	Replenish roller dampening solution with isopropanol	1217-1231	669	—
		Criteria (15-minute exposure)	NIOSH ACGIH	1960 1225	1800 —
		Analytical limit of detection (LOD), mg/sample		0.03	0.03
		Analytical limit of quantitation (LOQ), mg/sample		0.09	0.06

* - none detected, value was below the analytical LOD

** - values in parentheses are between the analytical LOD and LOQ

Table 4
HETA 85-053
Gray Printing Company
Fostoria, Ohio

March 1986

Study Participants

	<u>PRINTING</u>	<u>BINDERY</u>	<u>OFFICE</u>	<u>OTHER</u> *
Total employees	46	65	25	49
# Participated	39 (85%)	48 (74%)	20 (80%)	39 (80%)
- No exclusion criteria **	31	41	19	35
- 1 or more exclusion criteria	8	7	1	4

* Other: art, copy prep, negative stripping, plating, composing, maintenance

** Exclusion criteria:

- previous occupational exposure to neurotoxicants
- hobbies using neurotoxicants
- pre-existing neurologic disease
- use of pschoactive medications

Table 5

HETA 85-053
 Gray Printing Company
 Fostoria, Ohio

March 1986

Demographics of Printing and Bindery Departments

	<u>PRINTING</u>	<u>BINDERY</u>	<u>OFFICE</u>	<u>OTHER</u>
NUMBER OF PARTICIPANTS	39	48	20	39
RACE				
% white	97	98	95	95
SEX				
% male	92*	33*	50	67
AGE				
mean (s.d.)	36.3 (9.4)	39.3 (12.6)	41.9 (14.0)	43.4 (12.9)
YEARS IN CURRENT JOB				
mean (s.d.)	7.5 (8.3)**	13.1 (9.1)**	12.2 (10.5)	10.7 (10.4)
YEARS OF SCHOOL				
mean (s.d.)	12.5 (1.5)	12.0 (.9)	14.3 (1.8)	13.0 (1.6)
SMOKING				
% never smoked	34	15	65	44
% ex-smokers	21	43	20	33
% current smokers	45	43	15	23
CAFFEINE (cups/day)				
mean (s.d.)	3.8 (2.2)	4.0 (3.6)	2.3 (1.5)	3.4 (2.4)
ALCOHOL (drinks/wk)				
median (range)	3.0 (0-35)	0.2 (0-35)	0.2 (0-10)	1.2 (0-34)

Comparisons between Printing and Bindery:

* p=0.00001 (Chi-square)

** p=0.001 (Student's t test)

Table 6

HETA 85-053
 Gray Printing Company
 Fostoria, Ohio

March 1986

Symptom Scores (possible range: 0-4)
 (Mean (S.D.))

	AFFECT	MEMORY	RESPIRATORY	SOMATIC	SKIN
<u>PRINTING</u> (N [@] =39)	1.0 (1.1)	1.3 (1.3)	0.8 (1.1)	0.6 (0.7)	1.5 (1.4)
Males (N=36)	1.0	1.3	0.8	0.5	1.4 ***
Females (N= 3)	1.7	1.6	1.1	0.8	3.2
<u>BINDERY</u> (N=48)	0.9 (0.9)	1.2 (1.1)	0.6 (0.8)	0.6 (0.8)	1.2 (1.1)
Males (N=16)	0.5 **	0.9	0.2 ***	0.4 *	0.6 ***
Females (N=32)	1.1	1.3	0.9	0.8	1.4
<u>OFFICE</u> (N=20)	0.4 (0.6)	0.8 (0.8)	0.1 (0.3)	0.2 (0.4)	0.1 (0.6)
Males (N=10)	0.2	0.6	0.0	0.2	0.0
Females (N=10)	0.6	0.9	0.1	0.2	0.2
<u>OTHERS</u> (N=39)	0.9 (0.9)	1.1 (1.1)	0.5 (0.8)	0.5 (0.7)	1.1 (1.2)
Males (N=26)	0.7 *	1.1	0.4 *	0.3 *	0.8 *
Females (N=13)	1.2	1.1	0.9	0.8	1.6

@: N = number of participants

Comparisons between males and females (Student's t test):

* p < 0.10

** p < 0.05

*** p < 0.01

Table 6 (cont.)

HETA 85-053
 Gray Printing Company
 Fostoria, Ohio

March 1986

Symptom Scores (possible range: 0-4)
 (Mean (S.D.))

	MOTOR	SENSORY CNS	DEPRESSION	HEADACHE
<u>PRINTING</u> (N=39)	0.7 (1.1)	0.5 (1.0)	0.8 (1.1)	1.0 (1.4)
Males (N=36)	0.7	0.6	0.8	0.9
Females (N= 3)	0.4	0.0	0.8	2.0
<u>BINDERY</u> (N=48)	0.6 (1.0)	0.3 (0.8)	0.4 (0.6)	1.8 (1.6)
Males (N=16)	0.2 *	0.0	0.0	1.1 **
Females (N=32)	0.8	0.5	0.6	2.1
<u>OFFICE</u> (N=20)	0.2 (0.5)	0.1 (0.4)	0.1 (0.2)	0.7 (1.3)
Males (N=10)	0.2	0.2	0.1	0.3
Females (N=10)	0.2	0.1	0.1	1.1
<u>OTHERS</u> (N=39)	0.4 (0.8)	0.2 (0.6)	0.3 (0.5)	1.1 (1.7)
Males (N=26)	0.4	0.2	0.2 *	0.2 ***
Females (N=13)	0.6	0.2	0.6	2.8

Comparisons between males and females (Student's t test):

* p < 0.10

** p < 0.05

*** p < 0.01

Table 7
 HETA 85-053
 Gray Printing Company
 Fostoria, Ohio

March 1986

Number (%) with Symptom Score > 2

	AFFECT	MEMORY	RESPIRATORY	SOMATIC	SKIN	MOTOR	SENSORY CNS	DEPRESSION	HEADACHE
<u>PRINTING</u> (N=39)	7 (18)	12 (30)	7 (18)	3 (8)	13 (33)	8 (21)	5 (13)	6 (16)	16 (41)
Males (N=36)	6 (17)	11 (31)	6 (17)	2 (3)	10 (28)	8 (22)	5 (14)	6 (17)	14 (39)
Females (N=3)	1 (33)	1 (33)	1 (33)	1 (33)	3 (100)	0 (0)	0 (0)	0 (0)	2 (67)
<u>BINDERY</u> (N=48)	6 (13)	13 (27)	3 (6)	6 (13)	16 (34)	7 (15)	4 (8)	2 (4)	28 (58)
Males (N=16)	1 (6)	3 (19)	0 (0)	0 (0)	2 (13)	1 (6)	0 (0)	0 (0)	7 (44)
Females (N=32)	5 (16)	10 (31)	3 (9)	6 (19)	14 (44)	6 (19)	4 (13)	2 (6)	21 (66)
<u>OFFICE</u> (N=20)	0 (0)	2 (10)	0 (0)	0 (0)	1 (5)	0 (0)	0 (0)	0 (0)	5 (25)
Males (N=10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (10)
Females (N=10)	0 (0)	2 (10)	0 (0)	0 (0)	1 (10)	0 (0)	0 (0)	0 (0)	4 (40)
<u>OTHERS</u> (N=39)	4 (10)	11 (28)	2 (5)	2 (5)	11 (28)	2 (5)	2 (5)	0 (0)	12 (31)
Males (N=26)	2 (8)	7 (27)	1 (4)	0 (0)	5 (19)	2 (8)	1 (4)	0 (0)	2 (8)
Females (N=13)	2 (15)	4 (31)	1 (8)	2 (15)	6 (46)	0 (0)	1 (8)	0 (0)	10 (77)

Table 8
HETA 85-053
Gray Printing Company
Fostoria, Ohio

March 1986

Comparison of Symptom Scores by Shift Among Male Printers

	<u>Shifts 1&2 (N=31)</u>	<u>Shift 3 (N=5)</u>	<u>t-test (p value)</u>
AFFECT	0.8 (0.8)	2.3 (1.4)	.07
MEMORY	1.1 (1.2)	2.8 (1.3)	.04
RESPIRATORY/CHEST	0.5 (0.8)	2.1 (1.1)	.03
SOMATIC	0.4 (0.6)	1.1 (0.9)	.19
SKIN	1.1 (1.1)	2.8 (1.6)	.08
MOTOR	0.4 (0.9)	2.3 (1.5)	.05
SENSORY	0.4 (0.9)	1.6 (1.5)	.16
CNS DEPRESSION	0.6 (0.9)	1.9 (1.5)	.11
HEADACHE	0.9 (1.3)	1.2 (1.1)	.60

Table 9
HETA 85-053
Gray Printing Company
Fostoria, Ohio

March 1986

Symptom Scores (Mean (S.D.)) by Department Among Males, Shifts 1 and 2

	<u>PRINTING (N=31)</u>	<u>BINDERY (N=16)</u>	<u>t test (p value)</u>
AFFECT	0.8 (0.8)	0.5 (0.8)	.22
MEMORY	1.1 (1.2)	0.9 (1.0)	.57
RESPIRATORY	0.6 (0.8)	0.2 (0.2)	.02
SOMATIC	0.4 (0.6)	0.4 (0.4)	.85
SKIN	1.1 (1.1)	0.6 (0.8)	.08
MOTOR	0.4 (0.9)	0.2 (0.8)	.08
SENSORY	0.4 (0.9)	0.0 (0.0)	.04 *
CNS DEPRESSION	0.6 (0.9)	0.0 (0.0)	.004 *
HEADACHE	0.9 (1.3)	1.1 (1.3)	.69

* non-parametric Mann-Whitney U test

Table 10
 HETA 85-053
 Gray Printing Company
 Fostoria, Ohio

March 1986

Presence of Each Symptom (Rated as Present/Absent)
 (Percentage)

	FEMALES		MALES	
	PRINTING (N=3)	BINDERY (N=32)	PRINTING (N=36)	BINDERY (N=16)
<u>AFFECT</u>				
tired	33	69	39	19
weak	33	47	39	25
depressed	67	44	36	25
irritable	67	56	47	38
excitable	67	31	44	19
mood swings	67	36	25	13
trouble concen- trating	67	44	47	19 *
confused	33	22	31	13
sleeping more	67	39	31	25
trouble falling asleep	33	59	28	19
dizziness	67	53	50	20 *
<u>MEMORY</u>				
trouble remembering	67	59	58	50
relatives notice				
trouble remember	33	41	36	25
make notes	67	56	53	38
<u>REPIRATORY/CHEST</u>				
short of breath	33	50	33	19
cough	33	31	25	0 *
chest pain	33	34	44	13 **
palpitations	33	22	31	0

Comparison of males in printing and bindery departments:

(Fisher's exact test)

* p < .10

** p < .05

*** p < .001

Table 10 (cont.)
 HETA 85-053
 Gray Printing Company
 Fostoria, Ohio

March 1986

Presence of Each Symptom (Rated as Present/Absent)
 (Percentage)

	FEMALES		MALES	
	PRINTING (N=3)	BINDERY (N=32)	PRINTING (N=36)	BINDERY (N=16)
<u>SOMATIC</u>				
decreased appetite	33	31	11	6
weight loss	33	6	3	0
dianthea	0	32	25	44
indigestion	67	34	42	31
nausea	33	47	26	13
<u>SKIN</u>				
dry skin	100	69	67	38 *
rash	100	22	25	20
<u>MOTOR</u>				
incoordination	67	32	33	13
dec. arm strength	0	39	25	6
dec. leg strength	0	31	19	6
<u>SENSORY</u>				
numb fingers	0	23	28	0 **
numb toes	0	16	14	0
<u>CNS DEPRESSION</u>				
trouble driving				
home	33	22	22	0 *
"high" from				
chemicals	67	31	42	0 ***
dec. tolerance				
to alcohol	0	26	21	0 *
<u>HEADACHE</u>	67	66	39	44

Comparison of males in printing and bindery departments:
 (Fisher's exact test)

- * p < .10
- ** p < .05
- *** p < .001

Table 11
 HETA 85-053
 Gray Printing Company
 Fostoria, Ohio

March 1986

Work Practices (Number, %)*

	<u>PRINTING</u>	<u>BINDERY</u>	<u>OFFICE</u>	<u>OTHER</u>
Use of PPE **: <ul style="list-style-type: none"> Cartridge Respirator Gloves Gloves fit Smock 	<ul style="list-style-type: none"> 0 (0) 38 (97) 18 (47) 2 (5) 	<ul style="list-style-type: none"> 0 (0) 6 (12) 2 (33) 0 (0) 	<ul style="list-style-type: none"> 0 (0) 1 (5) 1 (100) 0 (0) 	<ul style="list-style-type: none"> 0 (0) 7 (18) 4 (57) 14 (36)
Eat at worksite	36 (92)	10 (21)	7 (37)	20 (51)
Eat in clean area	8 (20)	34 (74)	8 (80)	15 (44)
Wash before eating	36 (92)	45 (96)	13 (72)	33 (85)
Among smokers: <ul style="list-style-type: none"> Smoke at worksite Wash before smoking 	<ul style="list-style-type: none"> 2 (12) 2 (12) 	<ul style="list-style-type: none"> 3 (14) 3 (14) 	<ul style="list-style-type: none"> 0 (0) 0 (0) 	<ul style="list-style-type: none"> 2 (22) 2 (22)

* (Percentages are based on number of persons responding to question; therefore, denominator is not constant)

** PPE: Personal protective equipment

TABLE 12

AREA SAMPLING RESULTS
 GRAY PRINTING COMPANY
 FOSTORIA, OHIO
 MARCH 18-19, 1986
 HETA 86-053

Area	Sample Duration	Concentration, mg/m ³	
		Isopropanol	Naphtha Mixture (C ₉ -C ₁₂)
<u>March 18</u>			
Negative stripping area	0830-1500	ND	(1.3)
Color-key/transfer-key area	0959-1500	35	---
<u>March 19</u>			
Color-key/transfer-key area	0650-1500	50	---
Mailing area	0645-1455	110	ND**