NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2003-0203-2952
Wallace Computer Services
Clinton, Illinois

January 2005

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

PREFACE

The Hazard Evaluation and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (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 (OSHA) 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 employers 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.

HETAB also provides, upon request, technical and consultative assistance 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 NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Melissa Finley and Elena Page of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Acacia Bledsoe, Chad Dowell, Anthony Cantrell, and Brian Case (NIOSH/DSHEFS). Analytical support was provided by Ardith Grote (NIOSH/ DART) and DataChem Laboratories (Salt Lake City, Utah). Desktop publishing was performed by Robin Smith and Ellen Blythe.

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Highlights of the NIOSH Health Hazard Evaluation

Volatile Organic Compounds and Noise in the Press Area

In March 2003, investigators from the National Institute for Occupational Safety and Health (NIOSH) received a Health Hazard Evaluation (HHE) request from employees of Wallace Computer Services, Clinton, Illinois. We evaluated reports of dizziness, nausea, skin and eye irritation, exhaustion, nose bleeds, coughing, and sore throat believed to be caused by exposure to solvents and inks during printing processes in the pressroom.

What NIOSH Did

- We took air samples in the press area for volatile organic compounds (VOC), carbon monoxide, and ozone.
- We measured noise levels in the press area
- We checked the air flow and ventilation around the presses and workbenches.
- We talked to employees in the press room and office areas about their job duties, exposures, and symptoms.

What NIOSH Found

- All but one VOC air sample result were very low and below any occupational exposure limits.
- All noise measurements taken in the press area exceeded the NIOSH exposure limit.
- There was poor air distribution around some of the press towers.
- Symptoms consistent with solvent and VOC exposure were reported by press operators.

What Wallace Managers Can Do

- Replace the Metering Roller Wash (which contains TCE) with one not containing TCE.
- Start a hearing conservation program and develop controls to reduce excessive noise.
- Provide employees with and encourage the proper use of appropriate personal protective equipment.

(Note: By the end of this evaluation the company had begun all of these changes.)

What Wallace Employees Can Do

- Keep containers of inks/solvents and waste closed, keep tools clean, and dispose of used rags promptly.
- Use the proper personal protective equipment for printing operations.
- Do not eat, drink, or smoke in work areas.
- Report work-related symptoms to health and safety personnel.

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #2003-0203-2952

Health Hazard Evaluation Report 2003-0203-2952
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SUMMARY

Investigators from the National Institute for Occupational Safety and Health (NIOSH) responded to a confidential request for a health hazard evaluation (HHE) from printing press operators at Wallace Computer Services, Clinton, Illinois. These employees had symptoms perceived to be caused by exposure to inks and solvents on the job. NIOSH investigators visited the facility to characterize workers' exposures, evaluate symptoms, and provide recommendations to reduce potential health effects.

Personal breathing zone (PBZ) air sampling was conducted for trimethylbenzenes (TMBs) and trichloroethylene (TCE); results ranged from 0.3 to 9.5 parts per million (ppm) and not detected to 25 ppm, respectively. The NIOSH recommended exposure limit (REL) for both of these chemicals is 25 ppm for up to a 10-hour time-weighted average (TWA). Only 1 of 20 full-shift PBZ air samples for TCE reached the NIOSH REL of 25 ppm, and this exposure was likely due to a press operator's use of the cleaner which contained TCE. Other press operators did not routinely use this product, and the company has replaced this cleaner with one not containing TCE. Area air samples were collected for 2-butoxyethanol, carbon monoxide (CO), and ozone. Concentrations of 2-butoxyethanol ranged from 0.2 to 1.2 ppm (below the REL of 5 ppm). Concentrations of CO ranged up to 17 ppm, below the REL of 35 ppm. Ozone was not detected. Noise dosimetry revealed that 12 of 13 employees monitored exceeded the NIOSH REL of 85 dB(A). Questionnaires covering personal, medical and work histories, as well as work-related symptoms, were administered to press operators and to office workers as a comparison. There was a significantly higher prevalence of rash/skin irritation on the hands or arms, and burning/runny nose among press operators. There was also a higher prevalence of work-related wheezing, burning/watery eyes, and sore throat among press operators, but this was not statistically significant. These symptoms are consistent with solvent exposure.

NIOSH investigators concluded that a health hazard existed due to dermal exposures to solvents, noise exposures, and the improper use of personal protective equipment. Recommendations which included eliminating solvents that contained TCE, starting a hearing conservation program, enforcing the use of appropriate protective gloves, and covering unused solvent containers, were implemented by the company.

Keywords: SIC- 2752 (*Commercial Printing, Lithographic, Offset printing, Photo-offset printing, and Photolithographing*), printing press, solvents, ultraviolet (UV) inks, heat cured inks, trimethylbenzenes, trichloroethylene, TCE, 2-butoxyethanol, volatile organic compounds, VOC, noise, skin irritation, rash, eye irritation, watery eyes, runny nose, sore throat, wheezing, dizziness

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INTRODUCTION

In March 2003, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a health hazard evaluation (HHE) from employees of Wallace Computer Services, Clinton, Illinois. The request stated that employees were experiencing dizziness, nausea, skin and eye irritation, exhaustion, nose bleeds, coughing, and sore throat believed to be caused by exposure to solvents and inks during printing processes in the pressroom. These chemicals included Barsol A-3978, ultraviolet (UV) and heat cured inks, adhesives, varnish, and other solvents. The request also mentioned poor ventilation in the press area and a lack of health and safety programs.

An initial site visit was conducted June 16-17, 2003, during which NIOSH industrial hygienists collected air samples for volatile organic compounds (VOCs) in the press area of the facility and used ventilation "smoke" tubes to visually check air flow patterns. The NIOSH medical officer administered questionnaires to workers in the press and office areas. A NIOSH interim letter to the company dated July 18, 2003, summarized the medical and industrial hygiene findings of the initial survey.

A follow-up site visit was conducted July 22-24, 2003. During this visit, NIOSH industrial hygienists collected air samples for VOCs, carbon monoxide (CO), and ozone (O_3) in the press area of the facility, and conducted noise dosimetry on the press operators. A NIOSH interim report to the company dated December 19, 2003, summarized the activities of the second visit and discussed the industrial hygiene and medical findings from both the first and second surveys and offered interim recommendations.

In March 2004, NIOSH investigators made a third visit to discuss future research at the facility. During the visit, a meeting was held with management and employee representatives and a walk-through inspection of the plant was conducted. During the meeting and walk-through inspection, it was discovered that many steps had been taken to implement the recommendations provided in the NIOSH interim report. The management also provided NIOSH investigators with a letter distributed to their employees outlining these changes. For example, the company had begun implementing a hearing conservation program by educating and training employees on hearing protection devices and contracting a company to perform audiometric testing. The workers had been educated on glove maintenance, and glove liners had been disseminated to test their ability to help prevent rash among the press operators. The use of a product containing trichloroethylene (TCE) had ceased and the solvent had been removed from the facility. In addition, general housekeeping practices had been improved, including providing solvent containers equipped with lids, educating workers on the importance of keeping these containers closed, and purchasing equipment to clean paint from the presses and workbenches. Employees were also educated on the hazards of eating or storing food and drinks in their work areas and were provided paid time away from machines for eating breaks.

This final report contains the results of the air sampling and medical evaluations, a discussion of sampling methods and potential health effects of solvents, carbon monoxide and noise, and recommendations.

BACKGROUND

Wallace Computer Services is located in a 270,000 square foot facility. In the spring of 2003, the facility merged with Moore to become Moore-Wallace. In the spring of 2004, the facility underwent another merger to become R.R. Donnelley. The plant employs 81 hourly and 37 administrative employees over 7 shifts. There are 44 employees in the pressroom, the area of interest for this evaluation.

The company primarily produces direct mail flyers and provides printing, binding, and distribution services for its customers. The highly automated printing process prints, dries, cuts, folds, and assembles direct mail via heat-

set or UV presses. The 17 high-speed printing presses are each manned by press operators. Various colored inks are mixed by the ink technician and each press consists of several towers, each designated to a specific color. Plates are attached to the rollers to transfer these colors to wide-web rolls of bleached paper per customer requirements. After printing, the ink is set and dried via UV light (UV presses, including the high speed "RDP" UV press) or gas-fired ovens (on heat-set presses). The printed paper rolls are then transported to another area where they are cut, folded, and collated into a final product.

Press operator tasks include adding ink to presses and using solvent solutions to manually remove ink from press equipment. During the printing operation, these workers routinely use blanket and roller wash solutions to remove ink from press equipment. The solvents are manually applied using shop rags by the press operators while wearing nitrile rubber gloves for skin protection. Over the course of a workday, solvent-saturated shop rags are stored in open metal containers. Press equipment pieces (blankets and rollers) are manually wiped down after each roll of paper and removed and thoroughly cleaned at the end of each job. Other solutions, including Starfount WP-932, are manually applied to printing plates several times each shift to maintain print quality. A complete cleaning of each press is done annually. The press operations observed during these NIOSH visits included three blanket roller washes, involving two fountain solutions and several inks. A list of these chemicals and their ingredients is included in Table 1.

METHODS

Industrial Hygiene Evaluation

Volatile Organic Compounds

During the initial site visit on June 16, 2003, NIOSH investigators collected general area (GA) air samples in several press area locations, typically on or near a press operator's work-bench. These GA air samples were collected using thermal desorption tubes to identify VOCs. Because of the large number of chemicals in use at the facility, thermal desorption tubes were used to qualitatively identify which compounds were present in the highest concentrations. These compounds were selected for further quantitative analysis during the return survey.

The thermal desorption tubes were attached by Tygon® tubing to sampling pumps calibrated at a flow rate of 50 cubic centimeters per minute (cc/min). Each thermal desorption tube contained three beds of sorbent material: the first section contained Carbopack Y, the second section contained Carbopack B, and the last section contained Carboxen 1003. The thermal desorption tubes were analyzed using a Perkin-Elmer ATD 400 automatic thermal desorption system equipped with a gas chromatograph with a mass selective detector (TD-GC-MSD). The sampling and analytical techniques for this method are in accordance with NIOSH method 2549-Volatile Organic Compounds (Screening).[1]

Based on the initial thermal desorption sample analyses, NIOSH investigators collected personal breathing-zone (PBZ) samples for specific VOCs (trimethylbenzene [TMB], TCE, and total volatile organic compounds [TVOC]). These PBZ samples were collected on 13 press area workers (9 workers were on 8-hour shifts, the remaining 4 on 12-hour shifts). GA air samples were collected and analyzed for 2-butoxyethanol (2-BE). Six short-term task-based samples were taken during press cleaning operations and analyzed for TMB, TCE, and TVOC. All VOC samples from this second visit were collected using charcoal tubes attached by Tygon® tubing to sampling pumps calibrated at a flow rate of 200 cubic centimeters per minute (cc/ min). The charcoal tubes were quantitatively analyzed using a Hewlett-Packard Model 5890A gas chromatograph equipped with a flame ionization detector.[1]

Ozone

Area air samples for O_3 were collected using direct-reading colorimetric (detector) tubes in the press area, primarily near the UV units. As O_3 is drawn across a pale-blue indicating layer, the layer turns white. The length of the discoloration indicates the concentration. These samples were collected because UV light has the potential to form O_3 when it reacts with oxygen in the air. Also, NIOSH investigators noted an odor similar to O_3 near the printing presses on the initial site visit.

Carbon Monoxide

During the follow-up survey, CO was sampled in the pressroom. Eight GA samples for CO were collected using direct-reading Biosystems Toxiultra CO gas detectors placed near two heat-set presses and two UV presses. Carbon monoxide is a by-product of combustion and could potentially be present in areas near the gas oven heat-set printers.

Noise

During the initial site visit, press operators and plant management expressed concerns about noise and hearing loss. As a result, noise dosimetry was included on the sampling plan. Quest® Electronics Model Q-300 noise dosimeters were used to measure the time-weighted average (TWA) noise levels on 13 press workers during their shift.

Ventilation

Ventilation assessments were conducted during both the initial and follow-up surveys and consisted of air velocity measurements and smoke tube observations. A VelociCalc® (TSI, Inc) Model 8386A thermoanemometer was used to measure air velocity in feet-per-minute (FPM) in press operators work areas. A qualitative assessment of the airflow around the presses was performed using a flow visualization technique where an aerosolized cloud of low-toxicity chemical "smoke" is released at various points around the press towers and exhaust hoods. The movement of the smoke shows the pattern and relative speed of the air flow into the exhaust hoods.

Medical Evaluation

Questionnaire

NIOSH investigators distributed a brief questionnaire to employees in the press area during the initial site visit to assess the prevalence of work-related symptoms. Employees in the office area were included in the survey as a comparison group. The questionnaire included occupational, environmental, and medical histories, with special attention to the nervous, respiratory, and dermatologic systems as these are most commonly affected by solvent exposure. The questionnaire included items regarding respiratory, central nervous system (CNS), and skin symptoms and their relationship to work, the use of personal protective equipment, as well as age, gender, job title, tenure, atopy and smoking. Atopy was defined as having a history of hay fever or other allergies (not including allergies to medications), eczema, or asthma. Workers were asked if they had experienced symptoms of wheezing, cough, rash or skin irritation on their hands or arms, burning or watery eyes, burning or runny nose, sore throat, dizziness, and headache at work during the previous four weeks. They also reported if symptoms improved, remained the same, or worsened on days away from work. A symptom was classified as work-related if it was present at work in the previous four weeks and improved or disappeared on days off work. Press operators were asked how often they wore gloves while cleaning the presses and how often their clothes got wet with solvents.

Statistical Analysis

SAS software Version 8.2 (SAS Institute, Cary, North Carolina) was used to conduct statistical analysis of the questionnaire results. The two departments were compared on age, tenure,

gender, smoking and atopy. Single symptoms were compared between groups to test for statistical significance using the Chi-square test or Fisher's exact test for dichotomous variables. T-tests were used to compare the two departments on age and tenure. A p-value of <0.05 was considered statistically significant. Logistic regression was also used to evaluate associations between exposure and outcome variables. Odds ratios (OR) were used as a measure of association. Along with the OR, a 95% confidence interval (CI) was calculated. A CI excluding one was considered significant. All participants were included in the analyses unless specific necessary data were missing; therefore, the denominators may vary for some analyses.

A comparison of symptom prevalence rates by department was stratified by the following variables: smoking status and atopy. For the smoking status variable, three strata were defined. Workers who answered negatively to current smoking and former smoking on the questionnaire were classified as never smokers. Workers who answered negatively to current smoking but affirmatively to former smoking were classified as former smokers. Current smokers were those who answered affirmatively to current smoking.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the 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 even though 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 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 Recommended Exposure Limits (RELs),[2] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[3] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[4] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 91–596, sec. 5(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

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

Organic Solvents

The term solvent applies to any substance that dissolves another substance, yielding solution. They can be water based (aqueous) or hydrocarbon based (organic). Most industrial solvents are organic, and are used for tasks such as cleaning, degreasing, thinning, and extraction.[5] Inhalation and dermal exposure are both important routes of exposure in industrial settings. Absorption through the skin depends upon the degree of both lipid and water solubility of the solvent.[5] Almost all organic solvents cause irritation of the skin because they remove fat from the skin. Inhalation of organic solvents can irritate the respiratory system; however, this irritation is usually restricted to the upper airways, mucous membranes and eyes, and it generally resolves quickly without long-term effects.[5] In addition, almost all volatile, fat-soluble organic solvents can acutely cause nonspecific CNS depression. In fact, several were used as surgical anesthetics in the past.[5] The symptoms are similar to those from drinking alcoholic beverages, ranging from headache, nausea and vomiting, dizziness, slurred speech, impaired balance, disorientation, and confusion at lower exposure levels to death from respiratory depression at very high exposure levels. Studies have measured wide variations in VOC concentrations in the workplace, as well as differences in the mixtures of chemicals present. In this HHE, TMB was selected to represent TVOCs since it most closely approximated the solvent mixture in the printing areas of the facility.

Trimethylbenzene

Trimethylbenzene is a clear, colorless liquid with a distinctive, aromatic odor. There is no OSHA PEL for TMB; however, NIOSH and ACGIH have each set their occupational exposure limits at 25 parts per million (ppm), TWA.

Trichloroethylene (TCE)

TCE is a volatile liquid at room temperature. Experimental studies in animals have shown that TCE may be carcinogenic.[9] After a review of experimental and epidemiologic data, NIOSH concluded that TCE is a potential occupational carcinogen, although not a potent one.[10] While the NIOSH REL is 25 ppm for up to a 10-hour TWA, exposure should be limited to the lowest possible concentration. The OSHA has an 8-hour TWA PEL of 100 ppm, a ceiling limit at 200 ppm, and a 5-minute maximum peak (for any 2 hour period) set at 300 ppm. ACGIH has established an 8-hour TWA TLV of 50 ppm.

2-Butoxyethanol

Also known as ethylene glycol monobutyl ether or butyl Cellosolve®, 2-BE is a colorless liquid solvent with a mild ether-like odor of 0.1 ppm.[11] It is a widely used solvent and cleaning agent. The low vapor pressure of this substance makes high air concentrations unlikely; however, the material can be absorbed through the skin. The NIOSH REL for 2-BE is 5 ppm as a 10-hour TWA. The OSHA PEL and ACGIH TLV (as 8-hour TWAs) are 50 and 20 ppm, respectively.

Mixtures

Synergistic action and potentiation are two phenomena whereby some chemical combinations result in adverse health effects in excess of what might be caused by any individual chemical exposure. Synergistic action describes a situation in which the combined toxic effects of two (or more) chemicals significantly exceed the sum of the individual toxic effects of those same chemicals. Potentiation occurs when one chemical makes another chemical much more toxic (while alone the potentiating chemical may produce little or no toxic effect). Thus, applying exposure criteria without considering the possible effects of synergism or potentiation may underestimate the true potential for impairment to a worker's health as a result of exposure to chemical mixtures.

In the absence of information to the contrary, concurrent exposure to two or more hazardous substances acting on the same target organ system should be considered as an additive exposure (and not as synergistic action or potentiation). To measure the effect of an additive exposure on a particular organ system, each substance in the mixture is computed as a fraction of its own occupational health evaluation criterion. If the sum of these fractions exceeds 1, employee exposure to that particular mixture of substances is considered excessive.[3] This concept has been described by the following formula:

C1/T1 +C2/T2 + ... + Cn/Tn

where *Cn* refers to the observed atmospheric concentration of an air contaminant and *Tn* to its corresponding occupational health exposure criterion.

Ozone

Ozone is an air pollutant that irritates and damages mucous membranes and lung tissues and is federally regulated in the ambient and occupational environments.[7] The OSHA PEL for O_3 is 0.10 ppm for an 8-hour TWA. NIOSH recommends a ceiling concentration (not to be exceeded at any time) of 0.10 ppm. ACGIH has adopted TLVs for O_3 which are based on exertion, ranging from 0.10 ppm (light work) to 0.05 ppm (heavy work).

Carbon monoxide

Carbon monoxide is a colorless, odorless gas that is a product of incomplete combustion. Engine exhaust, tobacco smoking, and inadequately ventilated combustion products from heaters that use hydrocarbon fuel are sources of CO. It combines with hemoglobin and interferes with the oxygen carrying capacity of blood. Overexposure to CO may cause symptoms such as weakness, confusion, headache, dizziness, drowsiness, and nausea. More serious effects such as loss of consciousness, myocardial ischemia, collapse, or death can occur if high exposures are encountered.[12] The NIOSH RELs for CO are 35 ppm (10-hour TWA) and 200 ppm (ceiling). The ACGIH TLV for CO is 25 ppm, 8-hour TWA. The OSHA PEL is 50 ppm for an 8-hour TWA.

Noise

Noise-induced loss of hearing is an irreversible, sensorineural condition that progresses with exposure. Although hearing ability declines with age (presbycusis) in all populations, exposure to noise produces hearing loss greater than that resulting from the natural aging process. This noise-induced loss is caused by damage to nerve cells of the inner ear (cochlea) and, unlike some conductive hearing disorders, cannot be treated medically.[13] While loss of hearing may result from a single exposure to a very brief impulse noise or explosion, such traumatic losses are rare. In most cases, noise-induced hearing loss is insidious. Typically, it begins to develop at 4000 or 6000 Hz (the hearing range is 20 Hz to 20000 Hz) and spreads to lower and higher frequencies. Often, material impairment has occurred before the condition is clearly recognized. Such impairment is usually severe enough to permanently affect a person's ability to hear and understand speech under everyday conditions. Although the primary frequencies of human speech range from 200 Hz to 2000 Hz, research has shown that the consonant sounds, which enable people to distinguish words such as "fish" from "fist," have still higher frequency components.[14]

The A-weighted decibel [dB(A)] is the preferred unit for measuring sound levels to assess worker noise exposures. The dB(A) scale is weighted to approximate the sensory response of the human ear to sound frequencies near the threshold of hearing. The decibel unit is dimensionless, and represents the logarithmic relationship of the measured sound pressure level to an arbitrary reference sound pressure (20 micropascals, the normal threshold of human hearing at a frequency of 1000 Hz). Decibel units are used because of the very large range of sound pressure levels which are audible to the human

ear. Because the dB(A) scale is logarithmic, increases of 3 dB(A), 10 dB(A), and 20 dB(A) represent a doubling, tenfold increase, and 100-fold increase of sound energy, respectively. It should be noted that noise exposures expressed in decibels cannot be averaged by taking the simple arithmetic mean.

The OSHA standard for occupational exposure to noise (29 CFR 1910.95)[15] specifies a maximum PEL of 90 dB(A) for a duration of 8 hours per day. The regulation, in calculating the PEL, uses a 5 dB time/intensity trading relationship, or exchange rate. This means that a person may be exposed to noise levels of 95 dB(A) for no more than 4 hours, to 100 dB(A) for 2 hours, etc. Conversely, up to 16 hours exposure to 85 dB(A) is allowed by this exchange rate. The duration and sound level intensities can be combined in order to calculate a worker's daily noise dose according to the formula:

Dose = 100 X (C1/T1 + C2/T2 + ... + Cn/Tn),

where Cn indicates the total time of exposure at a specific noise level and Tn indicates the reference duration for that level as given in Table G-16a of the OSHA noise regulation. During any 24-hour period, a worker is allowed up to 100% of his daily noise dose. Doses greater than 100% are in excess of the OSHA PEL.

The OSHA regulation has an additional action level (AL) of 85 dB(A); an employer shall administer a continuing, effective hearing conservation program when the 8-hour time-weighted average (TWA) value exceeds the AL. The program must include monitoring, employee notification, observation, audiometric testing, hearing protectors, training, and record keeping. All of these requirements are included in 29 CFR 1910.95, paragraphs (c) through (o). Finally, the OSHA noise standard states that when workers are exposed to noise levels in excess of the OSHA PEL of 90 dB(A), feasible engineering or administrative controls shall be implemented to reduce the workers' exposure levels.

NIOSH, in its Criteria for a Recommended Standard,[16] and the ACGIH, propose exposure criteria of 85 dB(A) as a TWA for 8 hours, 5 dB less than the OSHA standard. The criteria also use a more conservative 3 dB time/intensity trading relationship in calculating exposure limits. Thus, a worker can be exposed to 85 dB(A) for 8 hours, but to no more than 88 dB(A) for 4 hours or 91 dB(A) for 2 hours. Twelve hours of exposures have to be 83 dB(A) or less according to the NIOSH REL.

RESULTS

Industrial Hygiene

Volatile Organic Compounds

Based on the thermal desorption tube analysis, TCE, TMB, 2-BE, and TVOC were quantitatively analyzed from the VOC samples collected during the follow-up visit. As presented in Table 2, only 1 of 20 full-shift PBZ air samples for TCE reached the NIOSH REL of 25 ppm, 10-hour TWA. Concentrations of TMB and 2-BE were below applicable occupational exposure limits. Using the equation shown below, the sum of the solvent mixture did not exceed unity (1.0), indicating that exposures to a chemical mixture were not at an excessive level.3 In this mixture calculation equation *C* refers to the average contaminant concentration in air and *T* to its corresponding occupational exposure limit.

[TCE (*C/T*) = 8.88/134.25] + [TMB (*C/T*) = 7.18/125] + [2-BE (*C/T*) = 2.58/24] + [Total hydrocarbons (*C/T*) = 22.75/125] = 0.41

Ozone

All O_3 concentrations of samples collected were below the limit of detection (less than 0.05 ppm).

Carbon monoxide

Peak concentrations of CO ranged up to 17 ppm, below applicable occupational exposure limits.

Noise

The Quest dosimeters collect data in a manner that allows comparison with the three different noise criteria used in this survey, the OSHA PEL and action level (AL), and the NIOSH REL. The OSHA criteria use a 90 dB(A) criterion and 5 dB exchange rate for both the PEL and AL. The difference between the two is the threshold level employed, with a 90 dB(A) threshold for the PEL and an 80 dB(A) threshold for the AL. The threshold level is the lower limit of noise values included in the calculation of the criteria; values less than the threshold are ignored by the dosimeter. The NIOSH criterion differs from OSHA in that the NIOSH criterion is 85 dB(A), the threshold is 80 dB(A), and it uses a 3 dB exchange rate. It is thus a more conservative criterion compared to the OSHA PEL. One employee monitored exceeded the OSHA PEL, four exceeded the OSHA AL and 12 exceeded the NIOSH REL. The results of the noise monitoring are presented in Table 3.

Ventilation

Use of the velometer and ventilation smoke tubes revealed that the air around the presses moves quickly upward and away from the operator. However, the air in several press areas was more stagnant, moving at a lower velocity or towards the operator. The only mechanical ventilation in the press area was the general heating, ventilating, and air conditioning (HVAC) system.

Medical Evaluation

A total of 68 employees (35 in the office and 33 in the press area, or 100 % of workers present) filled out the questionnaire. There were no women in the pressroom, and pressroom workers had significantly longer tenure than office workers. The workers in both departments were similar in age. The prevalence of atopy was higher among office workers, but this was not statistically significant. Finally, there were more current smokers in the pressroom, but this was not statistically significant (See Table 4).

There was a significant difference in the prevalence of work-related rash between departments. Fifteen percent of pressroom workers reported a work-related rash or skin irritation on their hands or arms, compared to none of the office workers ($p<0.05$). Of pressroom workers, 18% reported work-related burning or runny nose compared to none of the office workers ($p=.02$). Pressroom workers had higher prevalence rates of work-related burning or watery eyes, sore throat, and wheezing, but these differences were not statistically significant. The prevalence of work-related dizziness and headache was similar between departments. Multivariate analysis was conducted to control for the effects of smoking status on wheezing and cough, but the findings did not change significantly (See Table 5).

Skin contact with solvents can cause rashes, and absorption through the skin may also cause systemic symptoms such as headache and dizziness. In addition, solvent soaked clothing provides a source for volatilization and inhalation of solvents. Therefore, pressroom workers were asked if they never, sometimes, or always wore gloves when cleaning the presses. They were also asked how often their clothing got wet with solvents: never, occasionally, and daily. No workers reported never wearing gloves. None of the workers who reported sometimes wearing gloves reported rash on their hands, but 19% of those who always wore gloves reported a work-related hand rash. These differences were not statistically significant. There was no difference in the prevalence of headache and dizziness between workers who sometimes wore gloves and those who wore gloves all the time. There was not a significant difference in the prevalence of any respiratory symptom, headache, dizziness, or rash, between workers whose clothes never, occasionally or daily got wet with solvents.

DISCUSSION AND CONCLUSIONS

Although only one of 20 PBZ air samples equaled the NIOSH REL for TCE, there was a statistical association between working in the pressroom and reporting symptoms consistent with solvent exposure. Pressroom workers were more likely to report work-related wheezing, burning or watery eyes, burning or runny nose, sore throat, and rash or skin irritation, as depicted in Figure 1. These differences in work-related symptoms suggest that solvent exposures present in the work place are likely responsible for the symptoms. Since we collected air samples for only a few days, it is possible that the variable nature of solvent mixtures at this plant may affect their irritant potential. It is also possible that some people may experience effects at concentrations below occupational exposure limits. Therefore, it is important to further reduce employees' exposures to organic solvents. A recent study showed that there was a high prevalence of pulmonary and upper respiratory tract symptoms among newspaper pressroom workers exposed to solvents even though the degree of exposure was within permissible exposure limits.[17]

Nineteen percent of workers who reported always wearing gloves reported a work-related hand rash. However, no workers who sometimes wore gloves reported a work-related hand rash. It was expected that wearing gloves would protect the hands from solvent exposure; however, gloves are a frequent cause of dermatitis, both irritant and allergic. A work-related hand rash could be caused by solvent being trapped inside the glove, especially if the gloves were too short and allowed solvents to drip inside. Workers at Wallace were observed re-using soiled gloves, a practice which may contribute to dermatitis. Another possibility is that workers who noted that getting solvents on their hands caused them problems were more likely to wear gloves than those in whom skin contact with solvents did not cause a rash.

While several studies have shown a high prevalence of skin disease from exposure to solvents, inks, or paper [17,18,19,20], instituting a glove maintenance program[23], enforcing regular glove changes, and using gloves that are clean and made of the most appropriate type of material during cleaning operations may help reduce the incidence of this work-related hand rash. The nitrile gloves in current use at Wallace are appropriate for use for approximately one work shift with the majority of the most frequently used chemicals in the press operations.[21] Tests performed by a protective clothing testing laboratory would be able to determine the most appropriate type of glove for the specific solvent mixtures used in this facility.[22] These tests would determine breakthrough, permeation, and degradation of various glove materials and establish their duration of use for the solvent mixture.

The highest solvent exposure (to TCE) occurred to an employee who operated a UV press. Although his PBZ sample exceeded the REL for TCE, NIOSH investigators did not observe any unusual work practices. Thus, this exposure is likely due to the press operator's use of the Metering Roller Wash (which contained TCE), especially considering that the other press operators did not routinely use this product. Replacing the Metering Roller Wash with one preferably not containing TCE should eliminate this overexposure. The nitrile gloves (worn by this operator at the time of the July 2003 NIOSH survey but subsequently replaced) are not recommended for use with TCE.[23]

NIOSH investigators observed pressroom workers using rags soaked with solvent to wipe down the presses several times daily (during the July 2003 survey these used rags were stored in aluminum cans after cleanup). Open buckets of ink and solvents were also observed in the work area. These practices potentially allow solvents to volatize and may contribute to the workers airborne exposures.

The highest noise exposures occurred with operators of the "RDP" press. This press was unique in its high speed and printing

capabilities, which may be affecting the noise levels. Additional noise monitoring is necessary to determine what engineering controls may be necessary to attenuate the noise levels generated by this machine.

The only ventilation in the department was provided by the heating, ventilating, and air conditioning (HVAC) system. This system is not designed to capture and remove ink and solvent vapors.

RECOMMENDATIONS

The following recommendations, included in the first interim report and repeated in this final report, were based on observations made during the initial and follow-up surveys. Based on information obtained during the last survey of this facility in 2004, corrective action had been taken by the company to address all of these recommendations.

1. Evaluate noise levels from "RDP" press and develop controls to attenuate excessive noise.
2. Replace the Metering Roller Wash (which contains TCE) with one not containing TCE.
3. Start a hearing conservation program per NIOSH recommendations[16] and OSHA regulations.[15]
4. Use glove materials (such as Nitrile) that are suitable for solvents and inks, and ensure glove length is sufficient to prevent skin contact with chemicals. The use of soiled gloves should be stopped. Clean gloves should be readily available. Nitrile gloves could be used for approximately one work shift with the most frequently used chemicals in the press operations.
5. Improve general housekeeping practices by keeping containers of inks/solvents closed, keeping tools cleaned/free of ink, disposing of rags used in the process promptly, and keeping waste containers covered.
6. Discourage operators from eating and drinking at their workbench to avoid contamination and possible ingestion of potentially harmful substances. Encourage workers to wash hands prior to eating and drinking during their shift.

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Table 1

Solvent and Ink Composition
Wallace Computer Services, Clinton, Illinois
Survey Dates: July 23-24, 2003
HETA 2003-0203-2952

Solvent	Use	Components	CAS No.
Barsol A-3978	UV Blanket Roller Wash	Ethylene Glycol Monobutyl Ether	111-76-2
		Light Aromatic Solvent Naptha	64742-95-6
		1,2,4-Trimethylbenzene	95-63-6
		Xylenes (mixed)	1330-20-7
		Ethyl Benzene	100-41-4
		Medium Aliphatic Solvent Naptha	64742-88-7
Wallace B R Wash	Heatset Blanket Roller Wash	Aromatic Petroleum Distillates	64742-95-6
		Aliphatic Hydrocarbons (Stoddard Type)	8052-41-3
		Ethylene Glycol Monobutyl Ether	111-76-2
		Diacetone Alcohol	123-42-2
		Ethylene Glycol Monopropyl Ether	2807-30-9
		1,2,4-Trimethylbenzene	95-63-6
		1,3,5-Trimethyl benzene	108-67-8
		Xylene	1330-20-7
		Isopropylbenzene	98-82-8
Metering Roller Wash	Roller wash	Aromatic Hydrocarbon	1330-20-7
		Trichloroethylene	79-01-6
Starfount WP-932	Plate cleaner	Butyl Oxitol	111-76-2
		Butyl Carbitol	112-34-5
Starfount WP-800	Plate cleaner	Butyl Carbitol	112-34-5
		Propylene Glycol	57-55-6
Sta-Open	Plate cleaner	Petroleum Lubricant	64742-52-5
		2,6,-di-tert-butyl-p-Cresol	128-37-0
		Light Hydrotreated Solvent	64742-47-8
Terminator Plus	Plate cleaner	Aromatic Hydrocarbon	64742-95-6
		Cumene	98-82-8
		1,2,4-Trimethylbenzene	95-63-6
		Xylene isomer	1330-20-7
		Aliphatic Hydrocarbon	64742-48-9
		Nonylphenoxypoly(Ethyleneoxy)Ethanol	9016-45-9
True Blue Plate Cleaner	Plate cleaner	Petroleum Naptha	64742-95-6
		Petroleum Naptha	64742-88-7
UV Mac Process Ink	Ink	Polyester Acrylate Prepolymer	NA
		Three Functional Acrylate Monomer	NA
		Aromatic Ketone	NA
		Aromatic Tertiary Anine	NA

CAS = Chemical Abstract Society
NA = Not applicable

Table 2
Results of Air Sampling at Wallace Computer Services, Clinton, Illinois
Survey Dates: July 23-24, 2003 HETA 2003-0203-2952

	Location	Sample Type	Concentration			
			TCE (ppm)	TMB (ppm)	2- BE (ppm)	Total VOC (mg/m^3)
July 23, 2003	Press 25-3	PBZ	0.03	0.73	10	NS
	Press 22-7	PBZ	0.05	0.47	6.8	NS
	Press 17-3	PBZ	0.04	0.35	4.4	NS
	Goebel press	PBZ	0.06	0.51	7.6	NS
	Perf 3 press	PBZ	0.01	1.0	17	NS
	Press 22-1	PBZ	0.89	0.50	7.9	NS
	Ink station	PBZ	0.02	0.32	4.2	NS
	Perf 2 press	PBZ	0.06	0.38	6.2	NS
	Press 25-4	PBZ	0.03	0.64	9.3	NS
	RDP press	PBZ	0.06	0.39	5.7	NS
	Press 17-3	PBZ-TB	ND	1.7	17	NS
	Perf 2 press	PBZ-TB	ND	1.3	16	NS
	RDP press	PBZ-TB	ND	4.5	61	NS
	Press 25-3	AREA	NS	NS	NS	0.38
	RDP press	AREA	NS	NS	NS	0.90
	Press 22-7	AREA	NS	NS	NS	0.45
	Goebel press/22-1	AREA	NS	NS	NS	0.51
	Perf 2 press	AREA	NS	NS	NS	0.36
July 24, 2003	Press 25-2	PBZ	0.13	0.57	NS	10
	Press 22-7	PBZ	0.73	0.86	NS	14
	Press 17-3	PBZ	0.13	0.64	NS	9.3
	Press 25-3/22-9	PBZ	0.49	1.6	NS	25
	Perf 3 press	PBZ	0.20	0.89	NS	15
	Press 22-1	PBZ	0.68	0.45	NS	8.3
	Ink station	PBZ	0.08	0.34	NS	5.1
	Press 25-4	PBZ	25	1.2	NS	53
	RDP press	PBZ	0.09	0.43	NS	6.3
	Perf 2 press	PBZ	0.35	0.88	NS	14
	Press 25-3	PBZ-TB	0.06	9.4	NS	140
	Press 22-1	PBZ-TB	7.3	1.6	NS	26
	Perf 2 press	PBZ-TB	0.41	5.8	NS	80
	RDP press	AREA	NS	NS	1.1	NS
	Press 25-3	AREA	NS	NS	0.49	NS
	Press 22-7	AREA	NS	NS	0.21	NS
	Press 22-1	AREA	NS	NS	0.37	NS
	Perf 2 press	AREA	NS	NS	0.40	NS
NIOSH Recommended Exposure Limit			25	25	5	None
OSHA Permissible Exposure Limit			100	None	250	None
ACGIH Threshold Limit Value			50	25	20	None

TCE = trichloroethylene TMB = trimethylbenzene 2-BE = 2-butoxyethanol TVOC = total volatile organic compounds
ppm = parts per million NA = Not applicable PBZ = personal breathing-zone mg/m^3 = milligrams per cubic meter
PBZ-TB = PBZ- task based NS = no sample collected ND = not detected (below 0.00005 ppm)

Table 3
Results of Noise Monitoring
Wallace Computer Services, Clinton, Illinois
Survey Dates: July 23-24, 2003 HETA 2003-0203-2952

Employee ID	Location	Run Time, hours	TWA, dB(A)		
			AL	PEL	REL
Day 1					
1	Press 25-3	7:40	87.5	80.6	88.2
2	Press 22-7	7:36	88.4	83	89.6
3	Press 17-3	7:40	85.5	70.6	86.3
4	Goebel Press	7:26	88.4	83.7	89.6
5	Perf 3 Press	7:07	85.5	75.8	86.7
6	Press 22-1	7:18	87.1	80	88.2
7	Ink station	7:36	81.3	74	85.5
8	Perf 2 Press	10:00	89.3	82	89.8
9	Press 25-4	11:16	90.5	84.8	90.7
10	RDP Press	11:24	96.4	96	97.2
Day 2					
1	Press 25-2	7:43	84.8	67.6	85.5
2	Press 22-7	7:51	89.1	84.9	90.1
3	Press 17-3	7:55	87.9	82.5	89.2
4	Press 25-3/ Press 22-9	7:49	89.5	86	90.4
5	Perf 3 Press	7:34	85.5	75.9	86.9
6	Press 22-1	7:44	84.8	75.8	86.2
7	Ink station	7:43	78	65.7	82
11	Press 25-4	10:00	90.9	86.1	91.8
12	RDP Press	10:00	91.4	89.9	93.6
13	Perf 2 Press	10:14	89.8	84.4	90.7
Exposure Limit			85	90	85

AL = OSHA Action Level
PEL = OSHA Permissible Exposure Limit
REL = NIOSH Recommended Exposure Limit
TWA = Time-Weighted Average

Table 4
Demographics and Selected Characteristics by Exposure Group
Wallace Computer Services, Clinton, Illinois
Survey Dates: July 23-24, 2003 HETA 2003-0203-2952

	Pressroom	Office
Mean Age (years)	41	38
Mean Tenure (years)	17	11[#]
Gender		
Male	33/33 (100%)	20/35 (57%)[#]
Female	0/33 (0%)	15/35 (43%)[#]
History of Atopy	10/33 (30%)	17/35 (49%)
Smoking Status		
Current	13/30 (43%)	8/28 (29%)
Former	9/30 (30%)	7/28 (25%)
Never	8/30 (27%)	13/28 (46%)
Participation Rate	33/33 (100%)	35/35 (100%)

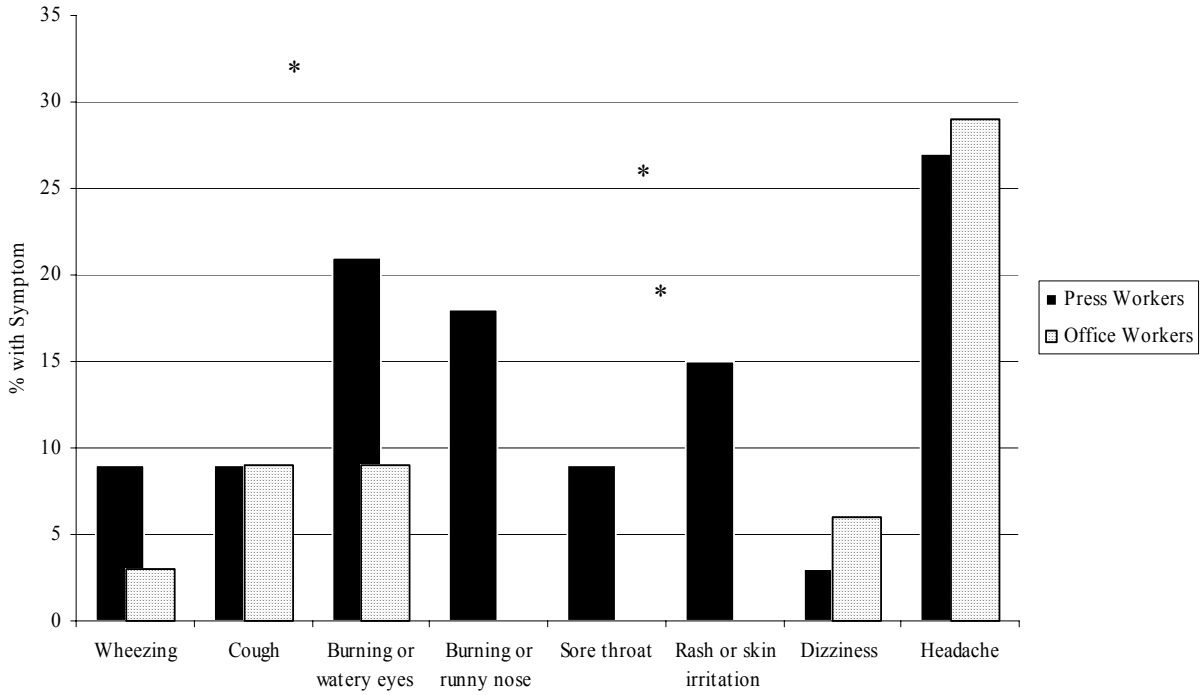
[#]Statistically significant difference between departments ($p < 0.05$)

Table 5
Prevalence Rates of Work-Related* Symptoms by Department
July 23-24, 2003
Wallace Computer Services, Clinton, IL
HETA 2003-0203-2952

	Pressroom n=33	Office n=35
Wheezing	3 (9%)	1 (3%)
Cough	3 (9%)	3 (9%)
Burning or watery eyes	7 (21%)	3 (9%)
Burning or runny nose	6 (18%)	0 (0%)[#]
Sore throat	3 (9%)	0 (0%)
Rash or skin irritation	5 (15%)	0 (0%)[#]
Dizziness	1 (3%)	2 (6%)
Headache	9 (27%)	10 (29%)

*****defined as present at work, but improved on days away from work
[#]Statistically significant difference between departments ($p < 0.05$)

Figure 1
Prevalence Rates of Work-Related† Symptoms
Wallace Computer Services, Clinton, IL
Survey Dates: July 23-24, 2003 HETA 2003-0203-2951



† defined as present at work, but improved on days away from work
*statistically significant difference between departments ($p < 0.05$)

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