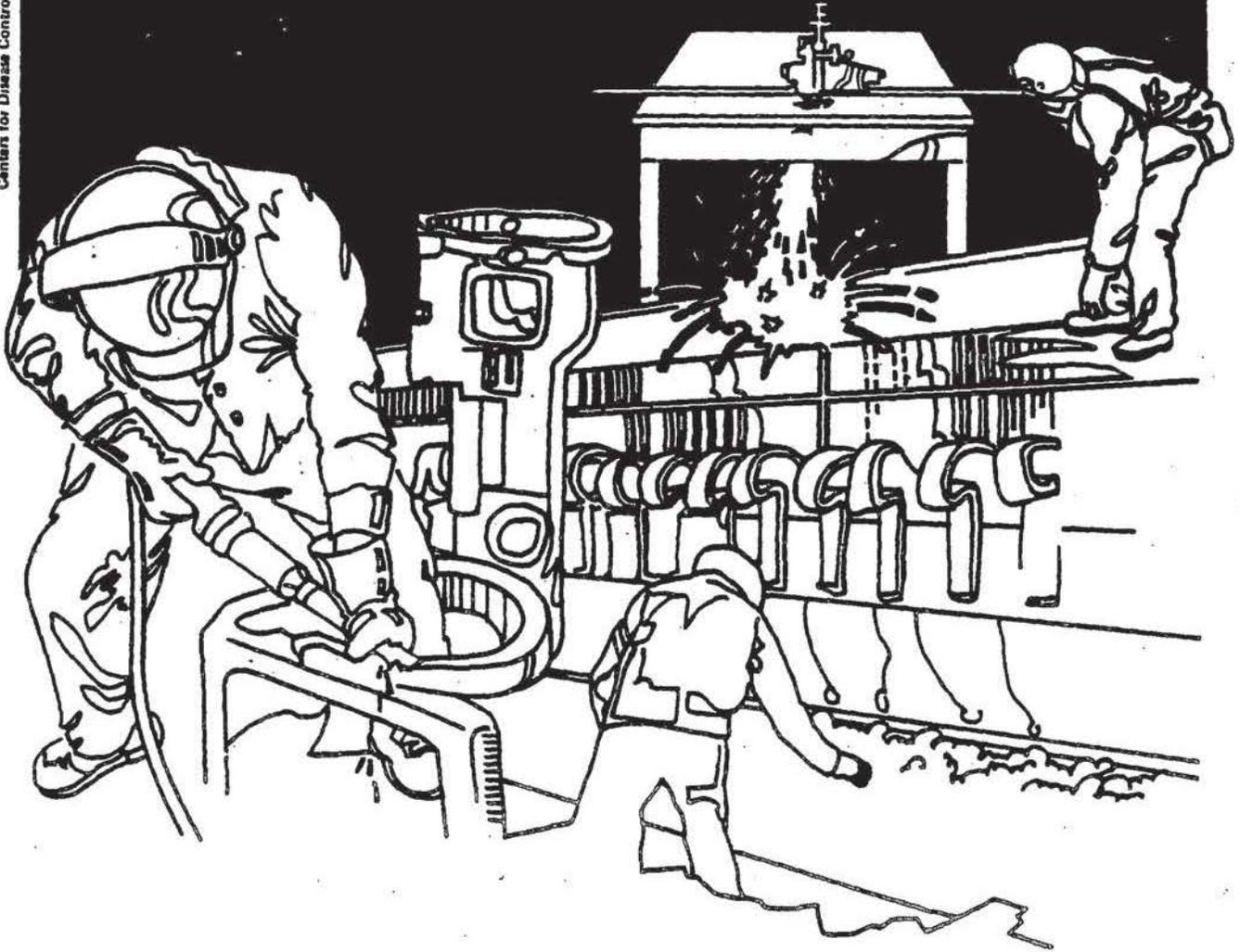


NIOSH



Health Hazard Evaluation Report

HETA 84-026-1599
U.S. PENITENTIARY
TERRE HAUTE, INDIANA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 84-026-1599
MAY 1985
U.S. PENITENTIARY
TERRE HAUTE, INDIANA

NIOSH INVESTIGATOR:
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I. SUMMARY

On October 17, 1983, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate exposures to formaldehyde for inmates manufacturing bed sheets at the U.S. Penitentiary in Terre Haute, Indiana. The fabric used to make the sheets is treated with a formaldehyde-containing resin which imparts wrinkle-resistant properties to the material.

On January 10, 1984, NIOSH investigators conducted environmental and medical evaluations. Full-shift breathing-zone and general area air monitoring for formaldehyde exposure was conducted at the UNICOR facility utilizing solid sorbent and liquid media techniques. Breathing-zone formaldehyde concentrations ranged from 0.80 to 1.25 ppm and averaged 1.07 ppm. The OSHA standard for an 8-hour workday is 3 ppm, but NIOSH considers formaldehyde a potential occupational carcinogen, and recommends that exposures be maintained at the lowest feasible level.

A questionnaire survey of 25 inmates was conducted to characterize the health complaints. The data showed the following results for specific symptoms: eye irritation, 84%; nose irritation, 60%; throat irritation, 36%; skin irritation, 20%; cough, 28%; and headache, 28%. These symptoms are consistent with the measured exposures.

NIOSH measured concentrations of formaldehyde averaging 1.07 ppm for full-shift personal exposures among the workers/inmates at the Federal Penitentiary in Terre Haute. There was a high prevalence of irritation symptoms. Since formaldehyde is a potential occupational carcinogen and has shown irritation properties at low levels, measures to reduce exposure to the lowest feasible level are recommended.

KEYWORDS: SIC 9223 (Correctional Institutions), SIC 2211 (Broad Woven Fabric Mills, Cotton), formaldehyde, irritation (eyes, nose, throat, skin)

II. INTRODUCTION

On October 17, 1983, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the safety manager at the United States Penitentiary, Terre Haute, Indiana, concerning formaldehyde exposure to inmates manufacturing permanent press bed sheets. NIOSH investigators conducted a walk-through survey at the UNICOR facility of the Federal Prison Camp Industries on November 8, 1983. A follow-up evaluation was conducted on January 9-10, 1984. Results from the environmental monitoring for formaldehyde and a brief health questionnaire administered during the follow-up, were forwarded to prison officials by letter on June 18, 1984. Recommendations to reduce formaldehyde exposure concentrations were made.

III. BACKGROUND

The UNICOR facility manufactures bed sheets from pre-cured, durable-press, cotton-polyester blend fabric. This plant previously made canvas mail pouches for the U.S. Post Office, as well as bed sheets for the General Services Administration. The plant employs 80 inmates, who cut, sew, fold, and package the sheets.

Durable-press characteristics are imparted to the fabric by treatment with a glyoxal-based resin system, dimethylol dihydroxyethylene urea (DMDHEU). Excess formaldehyde is generally used in the manufacture of these resins and eventually ends up in the treated fabric. At the time of the survey, bolts of fabric were being purchased solely from West Point Pepperill.

The UNICOR plant covers 13,000 square feet and is T-shaped. The base of the tee is an older section of building, and the crossed section is a recent addition. This addition has a modern heating, ventilation, and air-conditioning (HVAC) system. It provides a varying ratio of recirculated and fresh outside air, controlled by the outside air temperature. The older portion of the building is heated with two conventional propane furnaces, and cooled with attached air-conditioning equipment. The air through these units is totally recirculated.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

The environmental evaluation included personal breathing-zone, and general area air monitoring. Twenty-five personal samples were collected. Seven long-term (3- to 15-hour duration) area air samples were collected. Three of these were collected in a fashion to determine an increase or decline in formaldehyde concentration overnight. Seven short-term (30-minute duration), or peak concentration air samples were collected in three zones within the plant. One of these corresponded to the end of the overnight sampling.

The breathing-zone and long-term area air samples were collected using NIOSH Method 2502.¹ This is a solid sorbent sampling method. The sorbent is Chromosorb 102 (180 mg) coated with 2-(benzylamino)ethanol. Air is drawn through the sorbent tube, using a battery-powered sampling pump, at a nominal flow rate of 0.03 liters per minute (lpm). The formaldehyde reacts with the 2-(benzylamino)ethanol, at a known rate, to produce 3-benzylloxolidine. This is then desorbed from the sorbent tube with isooctane, and measured using a gas chromatograph equipped with a flame ionization detector. The limit of detection for this method is 1.0 microgram per sample (ug/sample).

General area peak formaldehyde concentrations were measured using NIOSH Method 3500.¹ These samples were collected in impingers containing 20 milliliters of 1% sodium bisulfite solution. Air was drawn through the impingers using battery-powered sampling pumps calibrated at 1.0 lpm. The impinger solution is analyzed by visible absorption spectrophotometry. Chromotropic and sulfuric acids are added, and the absorbance of light at a wavelength of 580 nanometers is measured. The limit of detection for this method was 0.5 ug/sample.

Ventilation measurements were taken using a Flow Hood® Model CFM-83, manufactured by Shortridge Instruments, Incorporated, Scottsdale, Arizona.

B. Medical

A questionnaire was administered by NIOSH investigators to the 25 inmates who participated in the environmental evaluation. We inquired whether the worker believed he had health problems related to his work. Subsequent to his reply, we probed for the presence of six irritative or constitutional symptoms which might be present during work. The symptoms were; eye, nose, throat, and skin irritation, headache, and cough.

V. EVALUATION CRITERIA

A. Environmental 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 recommendations, 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 recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is 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.

B. Formaldehyde - Toxicological Effects

Formaldehyde is a severe irritant to the eyes and upper respiratory tract. The threshold for mild eye irritation may be as low as 0.01 parts per million (ppm) in some individuals; 4 ppm and above usually produces lacrimation, although continued exposure may result in some acclimatization to the irritant effect on the eyes. Mild effects on the throat have been noted at 0.5 ppm, and marked irritant effects on the nose and throat at 10 ppm. Formaldehyde

vapor and dilute aqueous solutions can irritate the skin. Formaldehyde can produce skin sensitization and cases of allergic contact dermatitis have been reported both in persons occupationally and non-occupationally exposed to formaldehyde. In addition, there are reports of asthma-like symptoms occurring in persons occupationally exposed to formaldehyde.²

Formaldehyde has induced a rare form of nasal cancer in both Fischer 344 rats and in B6C3F1 mice, as reported in a study by the Chemical Industry Institute of Technology. In a second study by New York University, formaldehyde appears to have induced the same type of cancer in Sprague-Dawley rats. Although humans and animals may differ in their susceptibility to specific chemical compounds, any substance that produces cancer in experimental animals should be considered a cancer risk to humans. Formaldehyde has also demonstrated mutagenic activity in several test systems. Although a substance cannot as yet be designated a potential occupational carcinogen based solely on results of mutagenicity tests, positive results in mutagenicity tests should be used as supporting evidence for identifying a potential occupational carcinogen.³ In a recent study of workers exposed to formaldehyde at a large chemical plant, researchers reported increased risks for buccal and pharyngeal cancer.⁴

C. Exposure Criteria

The OSHA formaldehyde standard is based on a threshold for irritant and upper respiratory complaints. The current OSHA standard requires that formaldehyde exposures be limited to an 8-hour time-weighted average (TWA) of 3 ppm, a ceiling level of 5 ppm, and an acceptable maximum peak above the ceiling level of 10 ppm for no more than a total of 30 minutes during an 8-hour work shift.⁵ NIOSH recommends that formaldehyde be handled in the workplace as a potential occupational carcinogen. Safe levels of exposure to carcinogens have not been demonstrated, but the probability of developing cancer should be reduced by decreasing exposure. An estimate of the extent of the cancer risk to workers exposed to various levels of formaldehyde, at or below the current 3 ppm standard, has not yet been determined. NIOSH recommends that occupational exposure to formaldehyde be maintained at the lowest feasible level.³

VI. RESULTS

A. Environmental

Personal breathing-zone sample results are summarized in Table I. The average exposure for all 25 samples was 1.07 ppm (sd +0.11) and the results ranged from 0.80 to 1.22 ppm. Within the six job categories, the sheet cutters averaged the highest formaldehyde exposure, 1.15 ppm (sd +0.08). A sheet puller had the highest

measured personal formaldehyde exposure, 1.25 ppm. In general, exposures to formaldehyde for the various job categories were about the same. The results do show that average exposures increased with the freshness of the cloth. The sheet cutters handled cloth fresh off the bolt (1.15 ppm), next the sewing machine operators (1.10 ppm), then the folders (1.03 ppm), the inspectors (1.04), and finally the stencilors (0.82 ppm).

Overnight area sampling showed that formaldehyde concentrations decreased from the time the shift ended to the time that the next shift started (Table 2). For 4 hours after the end of the shift, the formaldehyde concentration averaged 1.31 ppm, for 8 hours 1.16 ppm, and for 15 hours 1.05 ppm. A short-term sample at the beginning of the next shift showed that the concentration was at 0.99 ppm. The area samples in Table 3 show that by the afternoon the formaldehyde concentration was back up to an average 1.28 ppm. The sample collected where the fabric bolts were stacked showed the highest concentration of 1.43 ppm. The morning and afternoon peak, area exposure samples showed this same trend of lower concentrations in the morning and an increase toward the end of the shift.

Medical

The worker health questionnaires administered to those whose personal exposure was monitored indicated the following prevalence of symptoms: eye irritation, 84% (21 of 25); nose irritation, 60% (15 of 25); throat irritation, 36% (9 of 25); skin irritation, 20% (5 of 25); cough 28% (7 of 25); and headache, 28%. Sixteen of those interviewed smoked cigarettes.

VII. DISCUSSION

The formaldehyde exposures found at this prison facility are less than the OSHA PEL, but certainly are higher than the lowest feasible limit as recommended by NIOSH. The personal exposure concentrations found here average higher than those found during other NIOSH studies at garment manufacturing plants where DMDHEU resin treated fabrics are used. Typical full-shift personal exposures averaged below 0.5 ppm at other facilities. A plant manufacturing robes did have average personal exposures close to those found at the UNICOR plant, at 1.0 ppm for 14 samples. In general, the levels of exposure are related to the freshness of the fabric, the surface area of the fabric exposed to the air during the manufacturing of the desired item, and the adequacy of the plant ventilation system. The health symptoms reported by the inmates were consistent with the exposure concentrations measured.

Elimination of fabrics treated with formaldehyde containing resins is the most effective remedy for this vocational exposure. However, until such time as textile manufacturers find a replacement for these types of treatments, the burden of controlling exposure to formaldehyde to prevent worker ill-health will be borne by those who use these fabrics. An alternative to purchasing fabric not containing formaldehyde is some form of pre-use treatment of the fabric to remove the latent formaldehyde. An example of such a pre-use treatment might involve aerating the fabric before it reaches the cutting tables in a chamber at elevated temperature and exhausted to the outside. The manufacturers of the fabric might have additional ideas on pre-treatment of reduce formaldehyde exposure potential.

Another important factor is the effectiveness of plant ventilation systems. This facility had two types of heating and cooling systems, one of a modern fuel efficient design, and the other a more convention design. Both systems used recirculated plant air, although the newer system used varying amounts, depending upon outside air temperature. Neither system was designed to ventilate the plant. The most practical type of ventilation for this plant is termed dilution ventilation. This refers to the dilution of contaminated air with uncontaminated air in a general area, room, or building for the purpose of health hazard control.

VIII. CONCLUSIONS

The data collected during this investigation showed that the inmates experienced irritative symptoms consistent with those expected from exposure to formaldehyde. The average formaldehyde exposures are at the high end of the range of exposures previously found in this sort of textile industry. This health hazard can be diminished by airing the formaldehyde containing fabric prior to use and the addition of dilution ventilation.

IX. RECOMMENDATIONS

1. Airing of fabrics, prior to used, is recommended. One treatment method would involve aerating the fabric in a ventilated chamber, while at the same time adding heat to drive the formaldehyde out of the cloth. This would mean unrolling the bolt of cloth at one end of the process, and rolling it back at the other end in order to use your current pattern cutting technology. Proper temperature, humidity, and airing time would need to be determined (perhaps in an empirical fashion).
2. A contractor specializing in industrial ventilation systems should be consulted to provide specifications for a dilution ventilation system optimized for the UNICOR facility. The specifications should clearly state that indoor air containing formaldehyde vapor should not be recirculated.

X. REFERENCES

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XII. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. U.S. Penitentiary, Terre Haute, Indiana
2. NIOSH, Region V
3. OSHA, Region V

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

Personal Exposure Summary
(Sorbent Tube)Federal Prison Camp Industries
Terre Haute, Indiana
HETA 84-026

January 10, 1984

Job Classification	No. Samples	Formaldehyde Concentration (ppm)		
		Range	Mean	S.D.
Sewing Machine Operator	12	1.03-1.16	1.10	<u>+0.05</u>
Sheet Folder	5	0.94-1.19	1.03	<u>+0.10</u>
Sheet Cutter	3	1.06-1.22	1.15	<u>+0.08</u>
Inspector	2	0.97-1.12	1.04	<u>+0.11</u>
Stenciler	2	0.80-0.85	0.82	<u>+0.04</u>
Sheet Puller	1	-	1.25	-
All	25	0.80-1.22	1.07	<u>+0.11</u>

Table 2

Overnight Area Sample Data*

Federal Prison Camp Industries
Terre Haute, Indiana
HETA 84-026

January 9-10, 1984

Sample Type	Sample No.	Duration	Formaldehyde Concentration (ppm)
Sorbent Tube	1	1539-1939	1.31
Sorbent Tube	2	1539-2339	1.16
Sorbent Tube	3	1539-0639	1.05
Impinger	I-1	0642-0715	0.99

* Samples located in center area of plant.

Table 3

Area Exposure Data
(Sorbent Tube)Federal Prison Camp Industries
Terre Haute, Indiana
HETA 84-026

January 10, 1984

Location	Sample No.	Duration	Formaldehyde Concentration (ppm)
North End New Addition	51	1213-1526	1.12
Between Cutting Tables	52	1212-1536	1.24
Central Old Building	53	1211-1538	1.33
Fabric Bolt Stack	54	1237-1537	1.43

Area Exposure Summary

Location	No. Samples	Range	Mean	S.D.
All	4	1.12-1.43	1.28	<u>+0.13</u>

Table 4

Short-Term Area Sample Data
(Impinger)

Federal Prison Camp Industries
Terre Haute, Indiana
HETA 84-026

January 10, 1984

Location	Sample No.	Duration	Formaldehyde Concentration (ppm)
East End	I-4	0906-0935	0.86
East End	I-5	1400-1430	1.26
Central	I-3	0900-0930	0.95
Central	I-6	1401-1431	1.22
West End	I-2	0903-0933	1.30
West End	I-7	1436-1506	1.30

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