U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health

NIOSH

Health Hazard Evaluation Report

MHETA 88-269-1993
MEYERSDALE MANUFACTURING CO.
MEYERSDALE, PENNSYLVANIA

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.

MHETA 88-269-1993
MEYERSDALE MANUFACTURING COMPANY
MEYERSDALE, PA
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NIOSH INVESTIGATOR:
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I. SUMMARY

In May of 1988 the Amalgamated Clothing and Textile Workers Union (ACTWU), Local 393, requested that the National Institute for Occupational Safety and Health (NIOSH) investigate potential occupational health hazards from formaldehyde exposures at Meyersdale Manufacturing Company (MMC), Meyersdale, Pennsylvania. NIOSH was also asked to evaluate worker exposure to lead from plant drinking water. Three industrial hygiene surveys were conducted at MMC in response to this request. Survey dates were August 8-9, 1988, January 31-February 1, 1989, and May 31, 1989.

Industrial hygiene sampling was done at MMC to evaluate worker exposure to formaldehyde and other organic chemicals. Water samples were collected to measure exposure to lead from plant drinking water. Some of the textile fabrics and all of the adhesive materials collected at MMC had detectable formaldehyde content. Time-weighted average formaldehyde concentrations from area impinger samples of plant air ranged from 0.03 parts per million parts air (ppm) to a high of 0.23 ppm. None of these area formaldehyde concentrations exceeded the personal exposure limits enforced by the Occupational Safety and Health Administration (OSHA), 1 ppm as a TWA, or recommended by the American Conference of Governmental Industrial Hygienists (ACGIH), 1 ppm - TWA and 2 ppm - short term exposure limit. Some of the formaldehyde concentrations in air were above the NIOSH recommendation to reduce potential carcinogen exposures to the lowest feasible limit. These formaldehyde concentrations at MMC were in a range that has been associated with irritation of the eyes/upper respiratory tract.

Other organic compounds including dioxane, methylene chloride, perchloroethylene, and trichloroethane were detected in factory air and attributed to dry cleaning solvents from the shirt cleaning area. Worker exposures to these solvents were all below the OSHA PELs and ACGIH TLVs as calculated to reflect the additive effects of exposure to these solvents. Personal exposures to methylene chloride, perchloroethylene and dioxane in the cleaning area, measured during winter operating conditions, exceeded NIOSH recommended exposure levels based on the potential carcinogenic effects of these compounds.

The results of the analysis for lead in water were inconclusive due to an unidentified source of lead contamination in the sampling materials.

Formaldehyde air concentrations were in a range that has been associated with irritations of the eyes and upper respiratory tract. These formaldehyde concentrations from MMC did not exceed the personal exposure limits enforced by OSHA or recommended by ACGIH; although, some of the formaldehyde concentrations exceeded NIOSH recommendations for lowest feasible limit (LFL) exposures to potential carcinogens. Exposure to dry cleaning solvents (dioxane, methylene chloride, and perchloroethylene) in the shirt cleaning area exceeded NIOSH RELs for LFL exposure to potential carcinogens. Recommendations for reducing worker exposures to formaldehyde and dry cleaning solvents are contained in section VIII of this report.

KEYWORDS: (SIC 2321) formaldehyde, shirt manufacturing, dry cleaning solvents, dioxane, methylene chloride, perchloroethylene, and trichloroethane.

II. INTRODUCTION

In May of 1988, the Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from the Amalgamated Clothing and Textile Workers Union (ACTWU), Local 393. NIOSH was asked to evaluate potential occupational health hazards from formaldehyde exposures from the fabrics used in shirt manufacture at Meyersdale Manufacturing Company (MMC), Meyersdale, Pennsylvania. NIOSH was also asked to evaluate worker exposures to lead from plant drinking water. On August 8-9, 1988, a NIOSH investigator conducted an industrial hygiene survey at MMC; a second industrial hygiene survey was conducted per union request on January 31 and February 1, 1989 to evaluate occupational exposures during winter operating conditions. On May 31, 1989, a NIOSH investigator made a third trip to MMC to take additional lead in water samples to replace samples from the January survey which were voided due to lead contamination in the control (blank) samples.

III. BACKGROUND

The MMC facility receives pre-cured, finished fabric from a textile-finishing plant. The shirt fabric is treated at the textile-finishing plant with formaldehyde-based resins, which give the fabric crease-resistant characteristics (permanent press). The resin treated fabric is cured before it is received by the Meyersdale plant.

The first step in the shirt manufacturing process is the cutting of shirt parts from the fabric (cutting area). Many layers of fabric must first be spread out on a long table. All of the layers are then cut simultaneously with hand-held saws ("cutters") or with dies. When a hand-held cutter is used to perform this step, a pattern is first laid over the top layer and the operator cuts according to this pattern. Cutting operations were done at MMC during the first industrial hygiene survey (August, 1988); at the time of the second industrial hygiene survey (January/February, 1989) cutting operations were no longer done at this factory.

After the cutting operations, the shirt parts are assembled. Parts of the cuffs, collars, and fronts are assembled into complete pieces (small parts area), then the major pieces, such as yokes, sleeves, collars, cuffs, and fronts, are assembled into complete shirts (assembly area). Most of the various assembly operations require sewing with sewing machines appropriately modified for each type of operation. Some assembly operations (collar and cuff making) make use of heat to form or fuse together (in conjunction with a heat-sensitive adhesive) various parts (fusing area).

The finished shirts are inspected (trim/inspect area) and moved to the apparel pressing operations where conventional hand irons are used to press the shirts (pressing area). The shirts are then folded (folding area) and packaged in bags and boxes for shipping (boxing area).

Finished shirts that become soiled during manufacturing are taken to the cleaning area where the dirt/stains are treated manually with a chlorinated dry-cleaning solvent.

Shirt manufacturing operations at MMC are done in a two-story, rectangular building with an open bay design. The second level of this building is occupied by employees in small parts and assembly operations; approximately 130 employees work in these two areas. The first level of this building houses a warehouse (2 employees), fusing operations (2-3 employees), spreading/cutting operations (prior to 1989 - 5 employees), shirt cleaning operations (1-2 employees), trim/inspect operations (10 employees), pressing operations (8 employees), folding operations (8 employees), and bagging/boxing operations (5 employees).

The facility is not air-conditioned; heating is accomplished by gas-fired heaters suspended from the ceiling. General ventilation, for comfort and exposure control, is accomplished by large free-standing floor fans and by smaller fans positioned throughout the factory on stands attached to the building support columns. During the summer months, windows and doors are kept open to provide outside air; however, during the winter months these windows and doors are generally kept closed. There is no mechanical source of outside air supply for this factory.

IV. METHODS

Industrial hygiene surveys were done at MMC to evaluate worker exposure to formaldehyde and other organic chemicals that may off-gas from materials processed during shirt manufacture. Samples were also collected to evaluate chlorinated hydrocarbon exposures from shirt dry cleaning and lead exposures from factory drinking water. Industrial hygiene evaluations at MMC were done over a period of four working shifts. Following a two day survey in August of 1988, a second industrial hygiene survey was done in January/February of 1989 in response to union concerns that occupational exposures and worker complaints were worse during winter operating conditions.

Formaldehyde samples were collected using a midget impinger with 20 milliliters (ml) of one percent sodium bisulfite solution. Portable sampling pumps calibrated at a flow rate of 1 liter per minute (LPM) were used to collect full shift, time-weighted average (TWA) samples. A portion of the formaldehyde samples were collected with a glass fiber filter ahead of the impinger to remove airborne particulates. These filter/impinger samples were taken in a side-by-side manner with other formaldehyde impinger samples, containing no prefilter in an attempt to determine if the formaldehyde collected in the impinger solutions was absorbed from air as a gas or leached from textile particulates that may be collected in the impinger media. Most of the formaldehyde samples were collected by attaching the samples to the employee's work station/sewing machine and positioning the sampling orifice in the worker's breathing zone. Some samples were collected by attaching the sampling device to the worker. The samples were analyzed by visible absorption spectrophotometry according to NIOSH Analytical Method 3500.[1]

The organic gas and vapor samples were collected on a solid charcoal media in a sorbent tube.[1] These samples were collected using portable sampling pumps calibrated at a flow rate of 50 cubic centimeters per minute (cc/min). Personal and area samples were taken as TWAs over a full shift. Bulk airborne gas/vapor samples were also collected using similar charcoal tubes at a sampling rate of approximately 200 cc/min. These bulk samples were analyzed qualitatively for organic compounds by gas chromatography (GC).[1] Charcoal tube samples were then analyzed quantitatively by GC for those organic gases and vapors detected in the bulk samples.[1]

Bulk samples of the textiles processed at MMC were collected and analyzed for latent formaldehyde content. Samples of textile material were suspended on a wire above distilled water in a sealed container heated to approximately 49° centigrade (°C) in a drying oven. Aliquots of the distilled water from each container were then analyzed for formaldehyde by visible spectroscopy according to NIOSH Method 9001.[1]

Bulk samples of water (approximately 100 ml) were collected in polyethylene containers for lead in water analysis; one ml of nitric acid was added to each sample as a stabilizing agent. These bulk water samples were analyzed for lead by atomic absorption spectroscopy according to NIOSH Method 239.1 (Environmental Protection Agency Method 600/4-79-020).[2]

V. EVALUATION CRITERIA

Evaluation criteria are used as guidelines to assess the potential health effects of occupational exposures to substances and conditions found in the work environment. These criteria consist of exposure levels for substances and conditions to which most workers can be exposed day after day for a working lifetime without adverse health effects. Because of variation in individual susceptibility, a small percentage of workers may experience health problems or discomfort at exposure levels below these existing criteria. Consequently, it is important to understand that these evaluation criteria are guidelines, not absolute limits between safe and dangerous levels of exposure.

Several sources of evaluation criteria exist and are commonly used by NIOSH investigators to assess occupational exposures. These include:

1. The U.S. Department of Labor (OSHA) permissible exposure limits (PELs);[3,4]
2. The American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs);[5]
3. NIOSH recommended exposure limits (RELs).[6,7]

These criteria have been derived from industrial experience, from human and animal studies, and, when possible, from a combination of the three. Consequently, due to differences in scientific interpretation of these data, there is some variability in exposure recommendations for certain substances. Additionally, OSHA considers economic feasibility in establishing occupational exposure standards; NIOSH and ACGIH do not consider economic feasibility in developing their criteria.

The exposure criteria described in this report are: Time weighted average (TWA) exposure recommendations averaged over the full work shift; short term exposure limit (STEL) recommendations for a brief (10-15 minute) exposure period; and ceiling levels (C) not to be exceeded for any amount of time. These exposure criteria and standards are commonly reported as parts contaminant per million parts air (ppm), or milligrams of contaminant per cubic meter of air (mg/m^3). Occupational criteria for the air contaminants measured during this study are as follows:[3-7]

SUBSTANCES	NIOSH (REL)	ACGIH (TLV)	OSHA (PEL)* TRANSITIONAL LIMITS	OSHA (PEL)* FINAL RULE LIMITS
Formaldehyde	Lowest Feasible Limit (LFL)	1 ppm - TWA 2 ppm - STEL	No Transitional Limit	1 ppm - TWA 2 ppm (15 min ceiling)
Methylene Chloride	LFL	50 ppm - TWA	500 ppm - TWA 1000 ppm - C	In rulemaking process - no final rule limi
Perchloroethylene (Tetrachloroethylene)	LFL	50 ppm - TWA 200 ppm - STEL	100 ppm - TWA 200 ppm - C	25 ppm - TWA
1,1,1-Trichloroethane (Methyl Chloroform)	200 ppm - TWA 350 ppm - C	350 ppm - TWA 450 ppm - STEL	350 ppm - TWA	350 ppm - TWA 450 ppm - STEL
P-Dioxane	1 ppm - C	25 ppm - TWA	100 ppm - TWA	25 ppm - TWA

* On March 1, 1989, OSHA amended its existing air contaminants standard, 29 Code of Federal Regulations (CFR) 1910.1000. These modifications included the addition of PELs for 164 previously unregulated substances and adoption of more protective PELs for 212 substances. September 1, 1989 is the date for compliance with the new OSHA PELs listed above as the Final Rule Limits, by any compliance method. The OSHA Transitional Limits are enforced until this time.(3)

VI. RESULTS/DISCUSSION

Most of the employees at MMC reported periodic irritation of the eyes and upper respiratory tract and skin rash and skin irritation believed related to work. Headache and breathing problems were also reported as common work association complaints by MMC employees on a self-administered health survey form distributed by ACTWU Union. These health complaints and symptoms were reported to be more severe during winter operating conditions and during work with certain textile materials (especially long sleeve, postal blue shirts).

One MMC employee developed medical problems for which she sought medical treatment; medical diagnosis (by her physician) was reported as acute allergic, contact dermatitis related to work activities. Following a several week absence from work, this employee was able to return to work at MMC and continue shirt manufacturing activities with the use of barrier creams.

Formaldehyde

Formaldehyde exposure was listed as the primary occupational health concern at MMC. As discussed earlier, formaldehyde-based resins are commonly used to impart crease-resistant properties to permanent press fabrics.(8-10) Formaldehyde was detected in all but one of the fabrics/materials processed at MMC. As indicated in Table 1, the formaldehyde content in the materials used during our survey ranged from below detectable levels (LOD = 5 parts per million parts by weight) to 24,000 ppm by weight. The highest formaldehyde content was detected in the adhesive materials from the fusing area; these materials had a mean formaldehyde content of 10,200 ppm by weight. Formaldehyde content of the textile fabrics used in shirt manufacture ranged from 160 ppm by weight to 890 ppm by weight (MacDonalds blue-brown stripe from the Dan River Mill). The mean formaldehyde content in the textile materials was 470 ppm by weight. The lining material sample did not contain detectable levels of formaldehyde. Different samples of the textile material used to manufacture blue post office uniform shirts ranged from 400 to 760 ppm by weight.

Formaldehyde, and other chemical constituents (eg. dyes) found in textiles are recognized to be skin irritants and sensitizers. There are many reports in the literature of contact dermatitis among textile workers attributed to formaldehyde-based resins or other chemical agents present in the textile fabrics.(8-10) Formaldehyde is also an intense irritant of the eyes and upper respiratory tract. The first symptoms noticed on formaldehyde exposure at concentrations ranging from 0.1 to 5 ppm in air are burning of the eyes, tearing, headache, and irritation of the upper respiratory tract. Formaldehyde exposures of 10 to 20 ppm in air are associated with coughing, tightness of the chest, a feeling of pressure in the head, and palpitation of the heart.(11) NIOSH studies of the textile industry suggest airborne levels of formaldehyde less than 1 ppm and cloth containing less than 750 ppm by weight formaldehyde were associated with occupational dermatitis. These NIOSH studies suggest that airborne formaldehyde concentrations below 0.2 ppm may be needed to prevent dermal effects in the apparel industry.(10-12)

Formaldehyde is also considered to be a potential occupational carcinogen based on studies where laboratory rats, exposed to formaldehyde vapor, developed nasal cancer. Based on these studies and additional mutagenicity tests, NIOSH recommends that formaldehyde be handled as a potential occupational carcinogen and exposures reduced to the lowest feasible level.(6,7,11) The ACGIH recommends a 1 ppm TWA and a 2 ppm STEL. ACGIH also considers formaldehyde a suspected human carcinogen.(5) The OSHA standard for formaldehyde is 1 ppm as a TWA.(4)

The post office blue material was described by many workers at MMC as being the most irritating, although the formaldehyde content in this material was similar to other textile materials used at MMC. It is possible that textile properties (eg. presence of dyes, abrasive nature of the material) in addition to formaldehyde content may contribute to irritation and dermatitis complaints. Long sleeve shirts were described by some workers to be more irritating to produce than short sleeve shirts. For some job categories, the manufacture of long sleeve shirts requires more handling and greater potential for skin contact with the shirt materials. This may account for any differences in irritant effects between long and short sleeve shirt manufacture.

Airborne formaldehyde concentrations are reported in Table 2 as time-weighted averages collected throughout the work shift. The forty airborne formaldehyde samples collected from manufacturing areas ranged from 0.03 ppm to 0.23 ppm. The formaldehyde concentrations collected with a prefilter ahead of the impinger were similar to adjacent sample concentrations collected with no prefilter. This suggests that the formaldehyde was present in air as a gas, and not leached from airborne cloth particulates or threads collected in the impinger media.

Geometric mean (GM) formaldehyde concentrations by manufacturing area (Table 3) ranged from 0.05 ppm (folding area) to a high of 0.18 ppm in the fusing area. The GM formaldehyde concentrations from the assembly and small parts areas were 0.12 ppm and 0.11 ppm respectively. Ambient (outside) formaldehyde concentrations with a GM concentration of 0.003 ppm were significantly lower than the levels from the manufacturing areas.

None of the TWA formaldehyde concentrations from MMC exceeded the personal exposure standards enforced by OSHA (1 ppm - TWA) or ACGIH (1 ppm - TWA and 2 ppm - STEL).[4,5] However, some of the TWA formaldehyde concentrations at MMC were in a range associated with irritation of the eyes/upper respiratory tract; the threshold for irritant effects from formaldehyde exposure is reported to be approximately 0.1 ppm depending on individual susceptibility.[11] None of the formaldehyde samples collected during summer operating conditions exceeded 0.1 ppm. Formaldehyde concentrations were higher during winter operating conditions, a time when employee complaints were reported to be more frequent; 15 of the 21 TWA formaldehyde samples collected from manufacturing areas during the winter industrial hygiene survey exceeded 0.1 ppm.

Organic Vapors

Other organic compounds detected in factory air at MMC included dioxane, methylene chloride, perchloroethylene, and trichloroethane (Table 5). The source of these compounds was dry cleaning solvents used in the shirt cleaning area on the first level of the factory. Dioxane and perchloroethylene were detected only during the winter survey in the cleaning area while methylene chloride and trichloroethane were detected in other manufacturing areas. These organic vapor concentrations were highest during the winter survey when the doors and windows were kept closed during part of the work shift.

Dioxane:

Dioxane concentrations in the cleaning area ranged from 0.1 ppm to 0.5 ppm (Table 5); the two personal exposure measurements from the cleaner (winter survey) had a GM of 0.3 ppm. The personal exposure measurements collected from the cleaner during summer operating conditions were below detectable limits (LOD = approximately 0.04 ppm).

Overexposure to dioxane can cause central nervous system problems with symptoms including drowsiness, dizziness, loss of appetite, headache, nausea, vomiting, and stomach pain. Overexposure to dioxane has been shown to cause liver and kidney damage in humans. Irritation of the skin, eyes, nose, and throat can also occur on overexposure and by direct contact. Exposure to dioxane can occur by inhalation or by absorption through the skin.[6,7,13,14]

Dioxane has been reported to cause liver, lung, and sinus cancer in experimental animals. Consequently, NIOSH considers dioxane to be a potential human carcinogen and recommends that exposures be reduced to the lowest feasible limit.[7] ACGIH considers dioxane to be an animal tumorigen of such low potential as to be of no practical significance as an occupational carcinogen at exposure levels near the TLV, 25 ppm as a TWA; the ACGIH TLV for dioxane is derived from data on hepatotoxic and neprotoxic effects which have occurred in workers.(5,13) The OSHA Final Rule Limit for dioxane exposure is 25 ppm as a TWA; the OSHA Transitional Limit for dioxane, in effect until September 1, 1989, is 100 ppm as a TWA.(13)

Perchloroethylene (Tetrachloroethylene):

Perchloroethylene concentrations in the cleaning area ranged from 0.6 ppm to 2.2 ppm (Table 5); the two personal exposure measurements from the cleaning job category (winter survey) had a GM of 2 ppm. The two personal exposure measurements collected from the cleaner during summer operating conditions were below the limit of detection (LOD = approximately 0.03 ppm).

Perchloroethylene (PCE) is a central nervous system depressant and can cause symptoms of headache, dizziness, vertigo, tremors, nausea, irregular heartbeat, sleepiness, fatigue, blurred vision, and intoxication (similar to that from alcohol). PCE overexposure can cause both liver and kidney damage; it may also cause irritation of the eyes, nose, and throat, with flushing of the face and neck; repeated contact may cause dermatitis.(6,7,13,14) Exposure to PCE can occur from inhalation of vapors or by skin absorption.

NIOSH considers PCE to be a potential human carcinogen and recommends that exposures be reduced to the lowest feasible limit.(7) ACGIH recommends a TWA exposure limit of 50 ppm with a STEL of 200 ppm to prevent anesthetic effects; these levels are expected to provide a wide safety margin in preventing liver/kidney injury.(5,13) The OSHA Final Rule Limit for PCE exposure is 25 ppm as a TWA. The OSHA Transitional Limit, in effect until September 1, 1989, is 100 ppm as a TWA with a ceiling concentration of 200 ppm.(3)

Methylene Chloride:

Methylene chloride was detected only during the winter survey at MMC; concentrations ranged from 0.3 ppm to 7.2 ppm (Table 5). The highest methylene chloride concentrations were measured in the cleaning area. The two personal exposure measurements collected from the cleaner during the winter survey had a GM of 4.6 ppm; exposure measurements collected from the cleaner during summer operating conditions were all below the limit of detection (approximately 0.08 ppm depending on sample volume).

Methylene chloride is a central nervous system depressant. Symptoms of overexposure can include headache, giddiness, stupor, nausea, irritability, numbness and tingling in the limbs. As with most halogenated hydrocarbons, methylene chloride can cause skin and eye irritation on direct contact and will produce serious burns if not promptly washed. The vapors are also irritating to the eyes and upper respiratory tract. Exposure to methylene chloride can occur from inhalation of vapors or by skin absorption.(6,7,13,14)

Following exposure, methylene chloride can be metabolized to carbon monoxide with subsequent carboxyhemoglobin formation. Consequently, persons with cardiac disease may be at increased risk from methylene chloride exposure and, concurrent carbon monoxide exposure would produce additive health effects. Methylene chloride has been shown to cause liver and kidney damage in experimental animals; consequently, workers with liver or kidney impairment may be at increased health risk from methylene chloride overexposure.[6,7,13,14] Both NIOSH and ACGIH consider methylene chloride to be a potential human carcinogen based on research from experimental animals. NIOSH recommends that methylene chloride exposures be reduced to the lowest feasible limit to prevent excess cancer risks.[7] ACGIH recommends a TWA exposure limit of 50 ppm.[5,13] The OSHA Transitional Limit for methylene chloride is 500 ppm as a TWA, and 1000 ppm as a ceiling concentration; the OSHA Final Rule Limit is currently in additional rule making processes and has not been established at this time.[3]

1,1,1-Trichloroethane:

1,1,1-Trichloroethane (TCE) concentrations ranged from below detectable limits (LOD = approximately 0.04 ppm) to 23 ppm (Table 5). The highest TCE concentrations were detected in the cleaning area. The geometric mean personal exposure measurements collected from the cleaner were 14.7 ppm (winter) and 1.4 ppm (summer).

TCE is generally considered to be one of the least toxic of the chlorinated hydrocarbons. TCE, like the other chlorinated hydrocarbons, can cause central nervous system effects on overexposure with symptoms of dizziness, incoordination, drowsiness. Hypotension, liver damage, and cardiac arrhythmia have been reported from TCE exposure. Both liquid and vapor are irritating to the eyes and repeated skin contact often causes dermatitis. Exposure to TCE can occur from inhalation of vapors or by skin absorption.[6,7,13,14]

NIOSH recommends a TWA exposure limit of 200 ppm with a ceiling REL of 350 ppm for TCE.[7] The ACGIH TLV for TCE is 350 ppm as a TWA and 450 ppm as a STEL.[5] The OSHA PEL for TCE is 350 ppm as a TWA (both as Final and Transitional Rule Limits); additionally, the OSHA Final Rule Limit for TCE includes a STEL of 450 ppm.[3]

Airborne concentrations of formaldehyde and other organic vapors were higher during the winter survey due primarily to a difference in ventilation practices. During summer operating conditions, factory doors and windows are opened to provide outside air to cool employees. This provides dilution of process generated contaminants. The factory has no mechanical source of outside air intake; consequently, during winter operating conditions (doors and windows closed) there is almost no outside air intake. Environmental conditions during the NIOSH "winter" survey in January/February were unseasonably warm; some of the factory door/windows were opened during sampling in the afternoon. Consequently, our sampling was not done during "typical" winter conditions with all doors/windows closed for the full shift. More of the factory fans were observed in use during summer operating conditions than during winter operations; this provided better air mixing and in conjunction with increased outdoor air intake during summer operation, more effective dilution of formaldehyde and other organic vapors.

Lead in Water

The water samples collected for lead analysis from the first floor drinking fountain and spigot were inconclusive. Lead was detected in these samples; however lead was also detected in the control (blank) samples of distilled water at equivalent concentrations indicating contamination of some component of the sampling or analytical system.

VII. CONCLUSIONS

1. The irritant/dermatitis symptoms reported at MMC are consistent with formaldehyde exposures from textile materials containing formaldehyde-based resins as permanent press agents. Some of the textile fabrics and all of the adhesive materials collected from MMC had latent formaldehyde concentrations in a range which have been associated with dermatitis problems in other textile manufacturing operations.[8-10]

2. None of the airborne formaldehyde concentrations from MMC exceeded the permissible exposure limits enforced by OSHA (1 ppm as a TWA) or recommended by ACGIH (1 ppm - TWA and 2 ppm - STEL).[3-5] Some of the formaldehyde concentrations were above the NIOSH recommendation to reduce potential carcinogen exposures to the lowest feasible limit.[6,7,11] The formaldehyde concentrations at MMC were in a range that has been associated with some irritation of the eyes and upper respiratory tract.[11] The fusing area had the highest formaldehyde concentrations from the heating of adhesive materials.

3. Dioxane, methylene chloride, perchloroethylene, and 1,1,1-trichloroethane were also detected in factory air and attributed to dry cleaning solvents used in the shirt cleaning area. Exposures to these solvents were all below the OSHA PELs and ACGIH TLVs as calculated to reflect the additive effects of these solvents. Personal exposures to methylene chloride, perchloroethylene, and dioxane during winter operating conditions in the cleaning area exceeded the NIOSH recommended exposure level based on potential carcinogenic effects of these compounds.

4. Airborne concentrations of formaldehyde and other organic vapors were higher during the winter survey due primarily to a difference in ventilation practices during the winter months.

5. The lead in water samples from MMC were invalid due to an unidentified source of lead contamination in the sampling materials.

VIII. RECOMMENDATIONS

1. Efforts should be made to obtain fabrics with the lowest formaldehyde concentrations possible; textile mills should be asked to supply information on the formaldehyde content for all materials received.

2. Airing of the textile fabrics treated with formaldehyde-containing resins over a three week period is recommended to allow off-gassing of the more volatile formaldehyde. This should be done in an area closed off from other manufacturing activities.

3. A dilution ventilation system should be added to provide tempered outside air during the winter months when factory doors and windows are closed. All the floor and wall support fans should be used during winter operations, as they were during the summer, to provide better air mixing. Additional fans should be operated in the fusing area to provide better air mixing and dilution to reduce formaldehyde exposures.

4. Workers could reduce skin contact with the formaldehyde treated fabrics processed at MMC by wearing loose fitting (formaldehyde free), long sleeve apparel. This should help reduce any contact dermatitis on the forearms from formaldehyde, other chemical agents in the treated cloth, or the abrasive nature of certain heavier fabrics. This long sleeve apparel should be laundered frequently.

5. Natural rubber (surgeons') gloves <u>may</u> be an effective control to reduce hand contact with formaldehyde-treated fabrics without compromising dexterity. However, these gloves may prove uncomfortable or unacceptable during warmer weather. The use of barrier creams may be effective for some workers in preventing or reducing any dermatitis from textile materials.

6. A local exhaust ventilation system should be added to the cleaning area to reduce workers exposure to dry-cleaning solvents.

7. Contact the Pennsylvania State Health Department or any other certified laboratory to obtain lead analyses of plant drinking water.

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TABLE 1

Formaldehyde Concentration in Fabric

Meyersdale Manufacturing Co.
Meyersdale, Pennsylvania
MHETA 88-269

Date of Collection	Fabric/Material	Formaldehyde Concentration PPM*
August 10, 1988	Post Office (Blue)	400
	Post Office (White)	370
	MacDonalds (Tatersall)	520
	MacDonalds (Blue/Brown Stripe)	890
	Unitog (Blue/Dark Blue Stripe)	180
	Metro Bus (Blue)	160
	Goodyear (Blue)	350
	Dan River	300
	Adhesive Material 1 (White)	810
	Adhesive Material 2 (White)	24000
	Adhesive Material 3 (White)	5800
	Lining Material (Federal Express)	ND
February 2, 1989	Post Office (Blue)	700
	Post Office (Blue)	760
	MacDonalds (Blue/Brown Stripe)	560

* Parts formaldehyde per million parts cloth by weight (PPM)
ND - non detectable, less than 5 ppm by weight

TABLE 2

Airborne Formaldehyde Concentration by Area

Meyersdale Manufacturing Co.
Meyersdale, Pennsylvania
MHETA 88-269

Sampling Date	Area	Job	TWA Concentration[1] (PPM)
08/09/88	Assembly	Joining	0.08
08/10/88	Assembly	Felling	0.10
08/10/88	Assembly	Joining	0.09
01/31/89	Assembly	Felling	0.16
01/31/89	Assembly	Felling	0.12
01/31/89	Assembly	Joining	0.13
02/01/89	Assembly	Joining	0.13
02/01/89	Assembly	Joining	0.13
02/01/89	Assembly	Felling	0.15
08/09/88	Small Parts	Darts	0.06
08/09/88	Small Parts	Collars	0.07
08/09/88	Small Parts	Auto Band Creaser	0.10
08/10/88	Small Parts		0.07
01/31/89	Small Parts	Auto Band Creaser	0.17
01/31/89	Small Parts	Darts	0.14
01/31/89	Small Parts	Darts	0.15
02/01/89	Small Parts	Auto Band Creaser	0.17
02/01/89	Small Parts	Darts	0.14
01/31/89	Fusing	Collars	0.16
01/31/89	Fusing	Collars	0.23
02/01/89	Fusing	Creasing	0.14
08/09/88	Spreading/Cutting	Cutter	0.07
08/09/88	Spreading/Cutting	Spreader	0.03
08/10/88	Spreading/Cutting	Spreader	0.07
08/10/88	Spreading/Cutting	Spreader	0.09
08/09/88	Folding	Folder	0.04
08/10/88	Folding	Folder	0.04
01/31/89	Folding	Folder	0.10
08/09/88	Pressing	Presser	0.05
08/10/88	Pressing	Presser	0.04

[1] Time-weighted average concentrations in parts per million parts air (ppm) by volume from 6-8 hour samples.

TABLE 2 (continued)

Airborne Formaldehyde Concentration by Area

Meyersdale Manufacturing Co.
Meyersdale, Pennsylvania
MHETA 88-269

Sampling Date	Area	Job	TWA Concentration[1] (PPM)
01/31/89	Pressing	Presser	0.12
02/01/89	Pressing	Presser	0.10
08/09/88	Trim/Inspect	Trim/Inspect	0.08
08/10/88	Trim/Inspect	Trim/Inspect	0.04
08/10/88	Trim/Inspect	Trim/Inspect	0.05
01/31/89	Trim/Inspect	Trim/Inspect	0.09
02/01/89	Trim/Inspect	Trim/Inspect	0.09
02/01/89	Trim/Inspect	Trim/Inspect	0.08
08/09/88	Boxing	Boxer	0.07
02/01/89	Receiving	Bundle Boy	0.03
01/31/89	Ambient	--	0.005
02/01/89	Ambient	--	0.002

[1] Time-weighted average concentrations in parts per million parts air (ppm) by volume from 6-8 hour samples.

TABLE 3

Airborne Geometric Mean Formaldehyde Concentrations[1] by Area

Meyersdale Manufacturing Co.
Meyersdale, Pennsylvania
MHETA 88-269

Area	Samples	GM	GSD	Range Low	Range High
Assembly	9	0.12	1.3	0.08	0.16
Small Parts	9	0.11	0.15	0.06	0.17
Fusing*	3	0.18	1.3	0.14	0.24
Spreading/Cutting°	4	0.06	1.6	0.03	0.09
Folding	3	0.05	1.7	0.04	0.05
Pressing	4	0.07	1.6	0.04	0.12
Trim/Inspect	6	0.07	1.4	0.04	0.09
Boxing°	1	0.07	-	-	-
Receiving*	1	0.07	-	-	-
Ambient	2	0.003	1.7	0.002	0.005

[1] Time-weighted average concentrations in parts per million parts air (PPM) by volume from 6-8 hour samples.
GM - Geometric mean, GSD - Geometric standard deviation.
* Samples collected only during winter operation.
° Samples collected only during summer operation.

TABLE 4

Airborne Geometric Mean Formaldehyde Concentrations[1] by Area and Season

Meyersdale Manufacturing Co.
Meyersdale, Pennsylvania
MHETA 88-269

Area	Season[2]	Samples	GM	GSD	Range Low	Range High
Assembly	Summer	3	0.09	1.1	0.08	0.10
	Winter	6	0.14	1.1	0.12	0.16
Small Parts	Summer	4	0.08	1.2	0.06	0.10
	Winter	5	0.15	1.1	0.14	0.17
Fusing	Summer	0	–	–	–	–
	Winter	3	0.18	1.3	0.14	0.24
Spreading/Cutting	Summer	4	0.06	1.6	0.03	0.09
	Winter	0	–	–	–	–
Folding	Summer	2	0.04	1.0	0.04	0.04
	Winter	1	0.10	–	–	–
Pressing	Summer	2	0.05	1.1	0.04	0.05
	Winter	2	0.11	1.1	0.10	0.12
Trim/Inspect	Summer	3	0.05	1.4	0.04	0.08
	Winter	3	0.09	1.1	0.08	0.09
Boxing	Summer	1	0.07	–	–	–
	Winter	0	–	–	–	–
Receiving	Summer	0	–	–	–	–
	Winter	1	0.07	–	–	–
Ambient	Summer	0	–	–	–	–
	Winter	2	0.003	1.7	0.002	0.005

[1] Time-weighted average concentrations in parts per million parts air (ppm) by volume from 6-8 hour samples.
[2] Season = summer - measurements collected during August, winter - measurements collected during January/February.

TABLE 5

Organic Vapor Concentrations by Area

Meyersdale Manufacturing Co.
Meyersdale, Pennsylvania
MHETA 88-269

Sample	Date	Area	Type[2]	Concentration (ppm)[1] Methylene Chloride	Perchloroethylene	1,1,1-Trichloroethane	Dioxane
5	08/10/88	Assembly	A	N	N	N	N
50	02/01/89	Assembly	A	0.6	N	0.6	N
2	08/09/88	Small Parts	A	N	N	N	N
100	01/31/89	Small Parts	A	0.5	N	1.3	N
6	08/10/88	Fusing	A	N	N	0.2	N
200	01/31/89	Fusing	A	0.3	N	1.1	N
600	02/01/89	Fusing	A	0.4	N	0.9	N
10	08/09/88	Spreading	A	N	N	N	N
3	08/09/88	Trim/Inspect	P	N	N	N	N
1	08/09/88	Cleaning	P	N	N	1.0	N
7	08/10/88	Cleaning	P	N	N	1.9	N
300	01/31/89	Cleaning	P	2.9	0.9	9.4	0.2
700	02/01/89	Cleaning	P	7.2	2.2	23.0	0.5
800	02/01/89	Cleaning	A	1.8	0.6	5.5	0.1

1 Time-weighted average concentrations in parts per million parts air (ppm) by volume from 6-8 hour samples.
2 Type: A - area sample, P - personal exposure measurement.
N - Below detectable limits.