HETA 96–0135–2612
Eagle Knitting Mills, Inc.
Shawano, Wisconsin

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PREFACE

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

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Health Hazard Evaluation Report 96–0135–2612
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Shawano, Wisconsin
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SUMMARY

In April 1996, the National Institute for Occupational Safety and Health (NIOSH) received a request from the UNITE Local 1567 union for a health hazard evaluation (HHE) at Eagle Knitting Mills, Inc., a garment manufacturer, in Shawano, Wisconsin. The requester expressed concern over exposures to formaldehyde, spot remover, silicone spray, and fabric softener; a lack of proper ventilation throughout the plant; and employee health problems such as asthma, wheezing, coughing, bronchial inflammation, rashes, boils, and skin inflammation. On June 25–26, 1996, NIOSH investigators conducted a walk–through survey of the facility; collected bulk material and environmental air samples for formaldehyde and organic solvents; reviewed past exposure monitoring reports, Occupational Safety and Health Administration (OSHA) 200 logs, company records of health claims, and Material Safety Data Sheets (MSDSs); and conducted voluntary, confidential medical interviews with 14 of 85 employees.

Trace airborne formaldehyde concentrations were detected in nine personal breathing zone air samples at a minimum detection level of 0.07 parts per million (ppm). Formaldehyde releases for the eleven fabric samples (measured by suspending the fabric sample over distilled water and heating at 49°C for 20 hours) ranged from non–detected to 920 micrograms per gram of fabric (μg/g). Formaldehyde concentrations on the dust/fiber samples were quite low, ranging non–detected to 0.002 ppm. Air concentrations of perchloroethylene, trichloroethylene, toluene, xylene, and n–hexane were well below current occupational exposure limits; acetone was not detected. Of the 14 individuals interviewed, all had respiratory or upper airway complaints, and half had concomitant dermatologic complaints. Most individuals complained about the same chemicals used at the facility and had similar symptoms.

The industrial hygiene sampling data indicate that workers were not overexposed to organic solvents at this facility. However, because formaldehyde, perchloroethylene, and trichloroethylene are considered to be potential human carcinogens, exposures should be minimized. Recommendations to reduce employee exposures to the chemicals used at this facility and to improve safety conditions are included in this report.

Keywords: SIC Code 2321 (Men's and Boy's Shirts, except Work Shirts), SIC Code 2331 (Women's, Misses', and Juniors' Blouses and Shirts), SIC Code 2361 (Girls', Children's, and Infants' Dresses, Blouses, and Shirts), garment manufacturing, formaldehyde, perchloroethylene, trichloroethylene, textile dyes, respiratory symptoms, skin irritation.

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INTRODUCTION

In April 1996, the National Institute for Occupational Safety and Health (NIOSH) received a request from the UNITE Local 1567 union for a health hazard evaluation (HHE) at the Eagle Knitting Mills, Inc. facility in Shawano, Wisconsin. The HHE request expressed concern over employees' exposures to formaldehyde, spot remover, silicone spray, and fabric softener; a lack of proper ventilation throughout the plant; and employee health problems such as asthma, wheezing, coughing, bronchial inflammation, rashes, boils, and skin inflammation which were thought to be associated with the workplace. In response, NIOSH personnel conducted a site visit at the plant on June 25 and 26, 1996, to evaluate these employee concerns. This report discusses the details of the site visit and presents our findings and recommendations.

BACKGROUND

Eagle Knitting Mills, Inc. manufactures a variety of garments such as sweat shirts, turtle–neck shirts, t–shirts, and pants for men, women, and children. The facility has approximately 85 employees including management (all full–time) and has been in operation at this site for more than 30 years. At the time of the site visit, the facility was operating six days (53 hours) per week. Smoking is allowed in the break area only. Separate areas are provided for smoking and eating; no smoking or eating is allowed in the production area.

The company is housed in a single–story building and has nine ceiling exhaust fans which are used in the summer. According to maintenance staff, there are 13 natural gas heating units for the building. Three of these units are set–up to provide 100 percent outside air from the roof. During the summer, the roof vents and windows are left open overnight to let in cool air. The maintenance department is staffed by two persons who do a wide variety of activities including machine repair and maintaining the ventilation systems.

Five types of fabric are used in the process — cotton, fleece, interlock, jersey, and lycra. According to the Material Safety Data Sheets (MSDSs), the majority of fabrics used at this facility have been treated with a resin containing formaldehyde. From the storage area, material is moved to the staging area where it is pulled out of its protective bag and allowed to sit for at least a half day before cutting. In the cutting department, the fabric is taken to either automatic spreading machines or to tables on which the fabric is hand–laid to match stripes. There are ten employees in the cutting department. Occasionally, solvent–based adhesives are used to glue the pattern pieces in place. A band saw or straight knife is used to cut fabric and a rotary saw is sometimes used to cut elastic pieces. The cut pieces go to the bundling area where they are sorted into buckets (20 to 50 pieces depending on the garment to be made). Tote carts are used to transport the buckets to the sewing area.

The sewing department employs about 50 individuals, who work in teams to make the clothing. The employees work on an incentive system. A variety of machines are used, including three–thread, single–needle, multi–needle, flat–bed hemmer, pocket setter, tacker, labels, button–holer, snap, and needle–nose. The machines used vary, depending on the garment being produced. To reduce the size of needle marks in the fabric, a solution of silicone lubricant, fabric softener, and water is used on the material.

The completed garments are taken to the finishing department, which has ten employees. Four employees inspect the garments for things such as stitching, loose threads, matching

stripes, spots, and stains. There are two spotting stations, used to remove stains from the garments, located adjacent to the sewing department. These spotting stations are used as needed. Spot removers containing trichlorethylene and perchloroethylene, and a rust stain remover containing hydrogen fluoride (8%) are used. There are local exhaust controls at each station. A heat press is used occasionally for fusible pellon fabric. Some employees in this area use Johnson & Johnson Germ filter masks as protection from organic vapors and dust. After inspection, the garments are folded and packed to ship to the customer.

METHODS

Industrial Hygiene Assessment

NIOSH investigators conducted a walk–through survey of the areas of concern and reviewed the facility's MSDSs. Smoke tubes were used to determine air flow patterns within the facility. Personal breathing zone (PBZ) and area air samples were collected for formaldehyde and organic solvents. NIOSH investigators also reviewed available industrial hygiene records. Two site visits had been made to this facility by a private consultant, on April 16 and 24, 1996. Personal and area exposures to dust/particles, methylene chloride, acetone, n–hexane, 1,1,1–trichloroethane, perchloroethylene, and formaldehyde were evaluated. Low levels of these compounds were detected; none of the concentrations exceeded current occupational exposure criteria. The consultant's report noted that the spotting stations had poor exhaust ventilation and that residue from over–spray was visible on the adjacent walls.

Formaldehyde

Formaldehyde exposure was a concern because formaldehyde–releasing resins are used on cellulosic fabrics to achieve durable press properties.[1] Three different analytical methods were used to evaluate potential formaldehyde exposures including: (1) analysis of the "source" fabric for "releasable formaldehyde;" (2) analysis of air samples for formaldehyde vapor; and (3) analysis of air samples for formaldehyde bound or adsorbed on particulates (i.e., dust, fibers, lint).

Eleven bulk fabric samples were analyzed for releasable formaldehyde in accordance with American Association of Textile Chemists and Colorists (AATCC) Test Method 112–1993.[2] This method utilizes a vapor extraction procedure to measure formaldehyde release from a weighed patch of fabric which has been suspended over water, in a sealed jar, and heated at 49°C for 20 hours. The conditions of the test are such that both free formaldehyde and formaldehyde from hydrolysis are measured. Individual fabric samples were stored in sealed, polyethylene bags until analyzed. The analytical limit of detection (LOD) for the method was 8 micrograms (μg) per gram of fabric.

To assess formaldehyde vapor exposures, PBZ air samples were collected on nine workers chosen to represent various job descriptions and locations within the plant. For comparison, an area air sample was collected in the sewing area adjacent to the finishing department. Full–shift air samples were collected using personal sampling pumps calibrated at 0.05 liters per minute (Lpm) with XAD–2 sorbent tubes. Analysis was performed in accordance with NIOSH Method 2541.[3] The LOD was 0.7 μg, which is equivalent to a minimum detectable concentration (MDC) of 0.02 parts per million (ppm), assuming a sample volume of 28.05 liters. The limit of quantification (LOQ) was 2.4 μg, which is equivalent to a minimum quantifiable concentration (MQC) of 0.07 ppm, assuming a sample volume of 28.05 liters.

Because formaldehyde may be bound or adsorbed on fibers, a potential inhalation hazard exists from deposition of fibers in the upper respiratory tract. To evaluate this potential hazard, five PBZ air samples were collected to estimate potential formaldehyde dose from inhalable dust/fibers. This method involves the collection of dust/fibers on Institute of Occupational Medicine (IOM) inhalable dust samplers (Air Quality Research, Berkeley, CA and SKC, Eighty Four, PA) using air sampling pumps calibrated at 2 Lpm. Aluminum filter holders were used with 25 mm, 5–micron pore size polyvinyl chloride filters. After sampling, the aluminum filter holders with filters were placed in 30–ml Nalgene® bottles and kept cool during shipment and prior to analysis. Samples were analyzed according to NIOSH Method 5700.[4] The analytical conditions of this method were designed to mimic the temperature and residence time of particles in the nasal and oropharyngeal passages, where the fibers would likely be deposited after inhalation.[5] The LOD and LOQ for this method were 0.09 µg per sample and 0.31 µg per sample, respectively.

Organic Solvents

Three thermal desorption tubes (two in the cleaning department and one in the cutting department [as a control]) were collected using personal sampling pumps calibrated at 0.05 Lpm for qualitative analysis of organic solvents. The thermal desorption tubes were analyzed using gas chromatography/mass spectrometry (GC/MS). Three PBZ and three area air samples were collected for quantitative analysis of organic solvents using personal sampling pumps calibrated at 0.05 Lpm with charcoal sorbent tubes. Based on the results of the qualitative analysis, the charcoal tubes were analyzed for perchloroethylene, trichloroethylene, toluene, xylene, n–hexane, and acetone using GC with a flame ionization detector. The LODs, MDCs, LOQs, and MQCs for these compounds, based on a sample volume of 22.15 liters, are listed in the table below.

Compound	LOD(mg /sample)*	MDC (ppm)**	LOQ(mg /sample)	MQC (ppm)
Perchloro-ethylene	0.004	0.03	0.012	0.08
Trichloro-ethylene	0.004	0.03	0.014	0.12
Toluene	0.002	0.02	0.0062	0.07
Xylene	0.002	0.02	0.0044	0.05
n–Hexane	0.002	0.02	0.005	0.06
Acetone	0.03	0.57	0.10	1.9

* – mg/sample = milligrams per sample.
** – ppm = parts per million.

Medical Assessment

Voluntary, confidential medical interviews were conducted with 14 workers, using a structured open–ended questionnaire (see Form 1). Information was obtained on respiratory and dermatologic symptoms, occupational exposures, symptom triggers, association with work, and medical interventions. The Occupational Safety and Health Administration Occupational Injuries and Illnesses records (OSHA 200 logs) and workers' compensation claims were reviewed.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff use 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),[6] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs®),[7] and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs).[8] In July 1992, the 11th Circuit Court of Appeals vacated the 1989 OSHA PEL Air Contaminants Standard. OSHA is currently enforcing the 1971 standards which are listed as transitional values in the current Code of Federal Regulations; however, some states operating their own OSHA approved job safety and health programs continue to enforce the 1989 limits. NIOSH encourages employers to follow the 1989 OSHA limits, the NIOSH RELs, the ACGIH TLVs®, or whichever are the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard and that the OSHA PELs included in this report reflect the 1971 values.

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 (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Formaldehyde

Certain fabrics are treated at textile–finishing plants with formaldehyde–based resins. The formaldehyde serves to provide shrink–resistance and crease characteristics (e.g., permanent press, wrinkle–resistant)[9] and dye fixation.[10] When a garment manufacturing facility receives pre–cured, finished fabric from textile–finishing plants, these treated fabrics contain some residual formaldehyde and off–gassing may occur during the cutting and assembly process. Besides off–gassing of free formaldehyde from the already cured resin–treated fabric, there may be exposure to formaldehyde bound or adsorbed on particulates. Upper airway and pulmonary complaints may arise by the inhalation route, and skin complaints may develop from dermal exposure.

NIOSH has investigated a number of clothing textile companies. These evaluations have involved assessment of formaldehyde exposure, ventilation system adequacy, and symptom prevalence. These NIOSH studies over the past 20 years,[11 — 26] plus other studies reported in the general medical literature,[27–31] consistently demonstrate that formaldehyde is an irritant, that there is variability among individuals in tolerance and susceptibility in reacting to treated clothing

textiles, and that there is a need for exposure control. Symptoms that can result from low level exposure to formaldehyde include eye, nose and throat irritation, nasal and sinus congestion, headaches, asthma, and skin rashes. Individuals vary in their tolerance and susceptibility to acute formaldehyde exposures.[32] Some individuals become sensitized (allergic) with allergic asthma and/or eczema[33] and may even require job relocation. To diagnose patients who have become occupationally sensitized to formaldehyde, patch testing can be used.[28,34]

A proportionate mortality study of workers in the garment industry identified formaldehyde exposure as a possible causative factor in cancers of the upper respiratory tract.[35,36] In–vitro laboratory studies have reported formaldehyde to be carcinogenic and geno–toxic.[37]

As established in the OSHA formaldehyde standard (29 CFR 1910.1048), the PEL for occupational exposure to free formaldehyde is 0.75 ppm as an 8–hour TWA, with an action level of 0.5 ppm, and a short–term exposure limit of 2 ppm.[38] OSHA has designated formaldehyde as a probable human carcinogen. NIOSH considers formaldehyde to be a potential occupational carcinogen and has set a REL of 0.016 ppm, as a 10–hour TWA, and a ceiling limit of 0.1 ppm.[39] ACGIH has established a TLV–ceiling limit of 0.3 ppm for formaldehyde and has designated formaldehyde as a suspected human carcinogen.[7] ACGIH recommends that exposures by all routes be carefully controlled to levels "as low as reasonably achievable."

There are no occupational exposure criteria for formaldehyde–releasing textiles. It has been hypothesized that the upper respiratory areas may be receiving formaldehyde exposure from particles which deposit in the upper respiratory tract.[40] Additional epidemiologic studies are needed, however, to better assess the effects of occupational exposure to formaldehyde–containing particulate material.

Organic Solvents and Textile Dyes

A list of organic solvents found in the products used at this facility, along with brief summaries of their primary health effects and respective evaluation criteria for occupational exposures, are presented in the following table.

Certain textile dyes may produce irritant non–allergic or allergic contact dermatitis.[41,42,43] Forty–nine different textile dyes have been associated with the development of allergic contact dermatitis.[44]

Substance	Primary Health Effects[6,33]	Occupational Exposure Criteria (ppm)		
		OSHA PEL*[8]	NIOSH REL[6]	ACGIH TLV[7]
Perchloroethylene	Central nervous depression (CNS) (symptoms such as headache, nausea, vomiting, dizziness, etc.). Carcinogenic (liver) in animal studies.	100 (25)	LCF–Ca**	25
Trichloroethylene	Skin, eye, and respiratory tract irritation. CNS depression (symptoms such as headache, nausea, vomiting, dizziness, etc.). Carcinogenic (liver) in some animal studies.	100 (50)	LCF–Ca	50
Toluene	Skin and eye irritation. CNS depression (symptoms such as headache, nausea, vomiting, dizziness, etc.).	200 (100)	100	50
Xylene	Skin, eye, and respiratory tract irritation. CNS depression (symptoms such as headache, nausea, vomiting, dizziness, etc.).	100	100	100
n–Hexane	Respiratory tract irritation. CNS depression (symptoms such as headache, nausea, vomiting, dizziness, etc.). Peripheral neuropathy.	500 (50)	50	50

Acetone	Skin, eye, and respiratory tract irritation. CNS depression (symptoms such as headache, nausea, vomiting, dizziness, etc.).	1000 (750)	250	750 [500]#

*–Parentheses indicate vacated 1989 OSHA PELs. **LFC– Ca–Potential carcinogen– lowest feasible concentration. # – Proposed change for 1996.

RESULTS/DISCUSSION

Industrial Hygiene Assessment

Formaldehyde

Table 1 presents the results of the formaldehyde air sampling. All PBZ and area airborne formaldehyde concentrations were between the MDC and MQC (trace levels), showing little variation among workers in different locations within the plant. These concentrations are well below the OSHA PEL of 0.75 ppm, but are above the NIOSH REL of 0.016 ppm. These results are consistent with the formaldehyde release values from the majority of fabric samples presented below.

Table 2 lists the formaldehyde release values for the eleven fabric samples collected at Eagle Knitting Mills, Inc. Ten of the fabric samples had formaldehyde release levels that are considered low by industry guidelines, with levels ranging from non–detected to 160 µg/g. One sample, the flat back rib (Copenhagen) fabric, had a much higher level of formaldehyde release (920 µg/g) than the other samples. This may be due to differences in formaldehyde resin formulation, fiber content, product handling, or manufacturing techniques.

The formaldehyde concentrations on dust/fibers (shown in Table 3) were also quite low, ranging from non–detectable to 0.002 ppm. As previously noted, there are no occupational exposure criteria for formaldehyde on particulates. Low levels of formaldehyde were detected on the field and media blanks indicating possible contamination in the laboratory.

Organic Solvents

Analysis of the thermal desorption tubes identified perchloroethylene and trichloroethylene as the major compounds in the three samples. Other compounds identified included 1,1,1–trichloroethane, propane, 1–propanol, C_4 alkanes, C_8–C_9 aliphatic hydrocarbons, toluene, and xylenes. Major peaks from the chromatographs for the GC/MS analysis of the thermal tubes are included in Appendix A.

Based on the results from the thermal tube analysis, the charcoal tubes were analyzed for perchloroethylene, trichloroethylene, toluene, xylene, n–hexane, and acetone (results are presented in Table 4). All of the PBZ and area air concentrations for perchloroethylene (range: non–detected to 1.03 ppm), trichloroethylene (range: non–detected to 7.05 ppm), toluene (range: 0.04 ppm to 0.11 ppm), xylene (range: non–detected to 0.41 ppm), n–hexane (range: non–detected to 0.04 ppm), were well below the OSHA PELs and ACGIH TLVs®, assuming that the activities in the facility were consistent throughout the day. NIOSH, however, considers perchloroethylene and trichloroethylene to be potential human carcinogens. Acetone was not detected in the samples at a MDC of 0.57 ppm. These environmental monitoring results do not address the issue of short–term exposures to these chemicals.

Observations

Use of the smoke tube showed that air moved from the maintenance shop, where welding and other repair work was done, into the rest of the

facility. There was no local exhaust ventilation control available for the portable welding station at the time of the survey. Use of the smoke tube also showed that the local exhaust ventilation controls for the spotting stations pulled air from about two inches from the units, which would not be adequate for capturing the spray. There was also spray residue visible on the walls adjacent to the spotting station as noted in the consultant's report. There was no general ventilation system for the facility. The windows and doors to the facility were open during the survey which provided some air movement. Review of the MSDS for the Electro–Kleen solvent product showed that it was meant to be used for electric motor part cleaning, not for fabric spot removal. The employees had concerns over possible carbon monoxide exposure during the cooler months from the use of a propane fork–lift and the furnaces. This issue could not be addressed during the site visit since the fork–lift and furnaces were not being used. The maintenance staff did report, however, that when the ceiling exhausts were used during the winter months, they have extinguished the pilot lights in the natural gas heating units.

Employees were using surgical masks, which are not protective for organic chemical vapors or dust. There was no respirator program, employees have not been trained or fit–tested, and the need for respirators has not been established. The employees were using Whink Rust Stain Remover, which contains approximately 8% hydrogen fluoride (HF), in the spotting stations without gloves or adequate local exhaust ventilation. Exposure to low concentrations of vapors of HF may cause chronic irritation and congestion of the nose, throat, and bronchial tubes.[33] Hydrogen fluoride liquid or vapor causes severe irritation and deep-seated burns of the eye and eye lids if it comes in contact with the eyes.[33] When lower concentrations (20% or less) come into contact with the skin, the resulting burns do not usually become apparent for several hours. There was no eye wash station available at the facility. The individual who cut the fabric did not use the machine guard on the band saw because fabric fibers collected on the guard in a very short period of time, obscuring the pattern lines.

Medical Assessment

Interviews

The age range of the survey participants was 19–59 years, with an average age of 41 years; the range of time on the job was 1/4 year to 35 years, with an average of 16 years. Most individuals complained about the same chemicals and had similar symptoms; all 14 workers had respiratory complaints and 6 (43%) of the 14 had concomitant skin complaints. None reported skin problems alone. Eleven (79%) of 14 had seen physicians and 4 were evaluated by specialists [2 by ENT (ear, nose and throat) specialists and 2 by pulmonologists] for a variety of work and non–work–related problems. Half of the workers interviewed were smokers or former smokers.

Based on the medical interviews, while many had health concerns that they thought were work–related, few had discussed these concerns with their private physicians or been evaluated (or treated) for these health complaints. In informal conversations on the work floor, some employees reported that the skin conditions they associated with work were aggravated when they worked with different color fabrics of the same type.

Record Review

Medical records of three workers were obtained for review. Two of the workers had been seen by pulmonologists, and one had been seen by an ENT specialist. One of the patients had a diagnosis of COPD (chronic obstructive lung disease) due to cigarette smoking. Another had been given a diagnosis of new–onset asthma caused by and exacerbated by work. The third has non–occupational chronic sinusitis.

The OSHA 200 logs review is summarized below. OSHA 200 Logs Entry Five Year Review

(1991–June 1996):

- 1996: 11 entries, 2 for "respiratory problems" and 1 for "inhalation of trichloroethylene." The other eight entries are injury–related.
- 1995: 13 entries, 1 illness (bee sting) and 12 injury–related.
- 1994: incomplete, but no reported illnesses.
- 1993: incomplete, but no reported illnesses.
- 1992: incomplete, with 2 reported (unknown type) illness occurrences.
- 1991: incomplete, with 1 reported (unknown type) illness occurrence.

The OSHA 200 Logs available for 1991 to 1994 were the posted annual summaries. The actual entries were not available and it was not possible to trace the recorded illnesses. Injury events were more common than illness events.

CONCLUSIONS

This investigation found that airborne formaldehyde exposures were low, at trace levels, but still above the NIOSH REL of 0.016 ppm. The air concentrations of perchloroethylene, trichloroethylene, toluene, xylene, n–hexane, and acetone (compounds which are components of the different products used in the facility) were below their current occupational health criteria. NIOSH considers formaldehyde, perchloroethylene, and trichloroethylene to be potential occupational carcinogens. These environmental monitoring results do not address the issue of short–term or dermal exposures to these chemicals (used as sprays) and reflect workplace conditions on the days of the survey. These sampling results probably do not reflect the conditions during the winter months, when the building is more enclosed. Some safety hazards, such as improper machine guarding and lack of an eye wash station, were identified. The masks that were being used in the spotting stations were not appropriate.

The most prevalent complaints among the workers interviewed were recurrent skin rashes and intermittent upper and lower airway symptoms. These problems appear to be more consistent with an irritant (non–immunologic) rather than allergic etiology in most workers. One employee has been diagnosed with new–onset asthma caused by and exacerbated by work. Due to the skin and pulmonary effects that may arise out of exposure to fabric dusts and lints, minimization of airborne dusts and reduction of worker exposure are to be strongly encouraged.

RECOMMENDATIONS

The NIOSH evaluation identified some areas which could be changed to improve the employee health and safety program at this facility. The following recommendations are offered to help reduce employee exposures to chemicals and improve safety conditions.

(1) To further reduce the employees' exposure to the organic solvents used at this facility, the local exhaust ventilation for the spotting stations could be modified to provide the appropriate capture velocity. Additional guidance in developing appropriate ventilation controls can be found in the American Conference of Governmental Industrial Hygienists' *Industrial Ventilation: A Manual of Recommended Practice*.[45] The portable welding station should have local exhaust ventilation (OSHA Part 1910 Subpart Q–Welding, Cutting, Brazing).[46]

(2) Other cleaning products which are designed to treat fabrics and contain less hazardous substances (not potential occupational carcinogens) could be substituted for the spot removers in use. If use of the rust spot remover with hydrogen fluoride is to be continued, Teflon gloves should be provided to the employees to protect their hands from exposure.[47]

(3) An eye wash station should be installed in the finishing department, where the spotting chemicals are being used, in case of accidental exposure to the eyes.

(4) The guard on the band saw in the cutting department should be used. Use of an anti–static spray may reduce the amount of fabric dust that accumulates on the machine guard.

(5) The OSHA 200 Log Entries must be completed in accordance with the OSHA record–keeping requirements, per 29 CFR Part 1904 (Reporting and Reporting Occupational Injuries and Illnesses).[48] A supplementary record for each recordable injury or illness should be completed and kept at the establishment. Records need to be retained for five years.

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Table 1
Formaldehyde Air Sampling Results
Eagle Knitting Mills, Inc.
Shawano, Wisconsin
HETA 96–0135
June 26, 1996

Job Description/Area	Sample Time	Sample Volume (liters)	Concentration (ppm)*
Personal			
Sewer	7:49 a.m. – 4:21 p.m.	25.6	Trace (0.03#)
Sewer/Dodge City	7:25 a.m. – 4 :27 p.m.	27.1	Trace (0.03#)
Supervisor/Cutting Room	8:02 a.m. – 8:24 p.m. 8:55 a.m. – 4:14 p.m.	23.05	Trace (0.04#)
Sewer/Musical Chairs	7:19 a.m. – 12:02 p.m. 1:04 a.m. – 4:30 p.m.	24.25	Trace (0.04#)
Bundler	7:58 a.m. – 4:15 p.m.	24.85	Trace (0.06#)
Inspector	7:51 a.m. – 4:17 p.m.	25.3	Trace (0.05#)
Sewer/Looney Tunes	7:43 a.m. – 4:25 p.m.	26.1	Trace (0.03#)
Cutter	7:57 a.m. – 4:15 p.m.	24.9	Trace (0.05#)
Sewer/Looney Tunes	7:45 a.m. – 2:26 p.m.	21.55	Trace (0.04#)
Area			
Sewing – Adjacent to Cleaning Station	6:48 a.m. – 4:09 p.m.	28.05	Trace (0.04#)
OSHA PEL (8–hr TWA)			0.75
NIOSH REL (10–hr TWA)			0.016
ACGIH® TLV® (Ceiling Value)			0.30
Minimum Detectable Concentration (MDC)**			0.02
Minimum Quantifiable Concentration (MQC)**			0.07

* – ppm = parts per million ** – Assuming a sample volume of 28.05 liters # – Between MDC and MQC

Table 2
Formaldehyde Released from Fabric
Eagle Knitting Mills, Inc.
Shawano, Wisconsin
HETA 96–0135
June 26, 1996

Type of Fabric (Color)	Formaldehyde (µg/g)*
Interlock (berry red)	110
Lycra (charcoal)	ND**
Flat Back Rib (Copenhagen)	920
Interlock (ivory maple leaf)	120
Interlock (red)	57
Fleece (gray)	89
Rib (navy)	160
Lycra (berry flora)	33
Jersey (banana)	68
Stripe (red and ivory 2x2)	160
Jersey (gray)	47
Limit of Detection	8
Limit of Quantitation	24

* – µg/gram – micrograms of formaldehyde per gram of fabric
** – ND – not detected at the analytical limit of detection of 8 micrograms of formaldehyde per gram of fabric

Table 3
Formaldehyde on Dust Air Sampling Results
Eagle Knitting Mills, Inc.
Shawano, Wisconsin
HETA 96–0135
June 26, 1996

Job Description/Team	Sample Time	Sample Volume (liters)	Formaldehyde (µg/sample)*	Sample Weight (mg)**	Formaldehyde (ppm)#	Inhalable Particulate (mg/m^3)##
Personal						
Sewer/Musical Chairs	7:17 a.m. – 4:20 p.m.	1086	1.2	0.18	0.001	0.17
Sewer/Mash	7:15 a.m. – 4:23 p.m.	1096	ND	0.11	——	0.1
Sewer/Little Haiti	7:34 a.m. – 4:25 p.m.	1062	0.9	0.06	0.001	0.06
Sewer/Looney Tunes	7:39 a.m. – 4:24 p.m.	1050	0.69	0.08	0.001	0.08
Sewer	6:50 a.m. – 4:10 p.m.	1120	2.1	0.21	0.002	0.19

* – µg – microgram
** – mg – milligram
# – ppm – parts per million
– mg/m^3 – milligram per cubic meter
+ – ND – not detected at limit of detection of 0.09 µg/sample

Table 4
Volatile Organic Compounds Sampling Results
Eagle Knitting Mills, Inc.
Shawano, Wisconsin
HETA 96–0135
June 26, 1996

Job Description/Area	Sample Time	Sample Volume (liters)	Concentration (ppm)*				
			Perchloroethylene	Trichloroethylene	Toluene	Xylene	n–Hexane
Personal							
Sewer	6:54 a.m. – 4:10 p.m.	27.8	0.03#	0.24	0.05#	ND^	0.02#
Spotter	6:58 a.m. – 12:17 p.m. 1:01 p.m. – 4:18 p.m.	25.45	0.17	1.24	0.04#	0.06	ND
Spotter/Repair Processor	7:06 a.m. – 2:29 p.m.	22.15	0.25	1.68	0.06	0.04	ND
Area							
Cutting–Bundling Table	9:01 a.m. – 4:28 p.m.	22.35	ND^	ND	0.06#	ND	0.07
Spotter Station	7:00 a.m. – 4:11 p.m.	27.55	0.1	1.01	0.05#	ND	0.03#
Spotter Station	7:08 a.m. – 4:12 p.m.	27.2	1.03	7.05	0.11	0.41	0.04#
OSHA PEL			100	100	200	100	500
ACGIH® TLV®			25	50	50	100	50
NIOSH REL			——	——	100	100	50
Minimum Detectable Conc. (MDC)**			0.03	0.03	0.02	0.02	0.03
Minimum Quantifiable Conc. (MQC)**			0.08	0.12	0.07	0.05	0.06

* – ppm – parts per million. ** – Assuming a sample volume of 22.15 liters. ^ND – not detected at MDC. # – Between MDC and MQC.

Form 1
HETA 96–0135: Eagle Knitting Mills, Inc, Shawano WI
Occupational Health Questionnaire

Name:_____ **Date:**_____
Address (H)_____
Telephone (H):_____ **DOB:**_____ **Age:**_____**Sex:**____**Race:**___
Current Job Classification (Job Title):_____ **Dept.:**_____
Time in Current Job Classification:____ **Time with Current Co:**_____
Shift Section:_____ **Job Duties:**_____
_____
Chemical Exposures:_____
Cigarette Smoking Hx:_____
Experiencing Health Problems: (Y / N ; Duration, Trigger, Work Assoc., Medical Eval., Rx):
_____
_____
Respiratory Sx: (cough, phlegm, dyspnea, wheezing, chronicity)
_____
_____
Skin Sx: (drying, fissuring, pruritus, erythema, infection, papules, pustules, vesicles)
_____
_____
PMD (Name, Address, Tel.#): _____
_____
Medical Diagnosis (inc.,tests, specialty referrals):_____
_____
_____
Any other potential health exposures of which we should be aware?
_____
_____
Aware of others with similar health problems?_____
Problems with formaldehyde, spot remover, silicone spray, softener?
(circle)_____
Specific Problems?_____
Other Problematic Chemicals & Processes:_____
PMH: (inc., FMH atopy/asthma/eczema)_____
PPE: (gloves,respirators,etc.)_____
Misc.:_____
_____
_____
_____
_____
_____
_____
_____
Agree to participate in possible F/U studies? (Y/N/NA)_____
Signed Medical Release Form (Y/N/NA):_____

Appendix A – Chromatographs from Thermal Tube Analysis

Thermal Desorption Tubes Peak Identification

(1) Air*
(2) CO_2*
(3) Formaldehyde*
(4) Propane
(5) Isobutane
(6) Butane
(7) Ethanol
(8) Acetone
(9) Dichloroethylene isomer
(10) 1–Propanol
(11) Butanal?
(12) Methyl ethyl ketone (MEK)
(13) Ethyl oxirane
(14) Acetic acid
(15) Hexane
(16) Chloroform
(17) 1,1,1–Trichloroethane
(18) Trichloroethylene
(19) C_8H_{18}/C_8H_{16} aliphatics
(20) 1,1,2–Trichloroethane
(21) Toluene
(22) 1–Chloro–2–butanol
(23) Perchloroethylene
(24) C_9H_{20}/C_9H_{18} aliphatics
(25) Ethyl benzene/xylene isomers
(26) Glycol ether acetate?
(27) Alkyl alcohol?
(28) Decane
(29) 2–Chlorohexanol?
(30) Undecane

* Also present on some media/field blanks.

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