HEALTH HAZARD EVALUATION REPORT

HETA 94-0309-2514
HOMECREST INDUSTRIES INCORPORATED
WADENA, MINNESOTA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of the National Institute for Occupational Safety and Health conducts field investigations of possible health hazards in the work place. 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 an employer or authorized representative of the employees, to determine whether any substance normally found in the place of employment has potential 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 to federal, State, local agencies, labor, industry, and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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HOMECREST INDUSTRIES INC.
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SUMMARY

In June 1994 the National Institute for Occupational Safety and Health (NIOSH) received a request from the Teamsters Union, Local 346, to conduct a health hazard evaluation in the Soft Goods Department at Homecrest Industries Incorporated, Wadena, Minnesota. Homecrest Industries manufactures casual/outdoor furniture. The Soft Goods Department is where the furniture cushions and coverings are produced. The request was to investigate employee health complaints of respiratory problems, eye and nose irritation, headaches, skin irritation, and rashes. A site visit was made on September 20 and 21, 1994, during which time interviews with employees from the Soft Goods Department were conducted and personal breathing zone (PBZ) and area air samples were collected for aldehydes, and other volatile organic compounds (VOCs). Bulk samples of the cotton and cotton blended fabrics and polyvinylchloride coated polyester yarn backing were also collected and analyzed for releasable formaldehyde and VOCs.

The workers' health complaints, in the judgment of the investigator, were derived from emissions coming from the fabrics. Six of 12 fabric samples analyzed for releasable formaldehyde had detectable concentrations ranging from 140 to 540 micrograms of formaldehyde per gram of fabric sample. VOC emissions were collected by heating a weighed portion of the fabric to 60°C. Small amounts of phenol, formaldehyde, and bis(dimethyl)ethyl phenol were the only compounds detected at 60°C.
Eight area air samples were collected and analyzed qualitatively to identify VOCs. Four consecutive area air samples were collected in the fabric storage room, and the other four were collected in the Soft Goods Department near the fabric cutter. Only trace amounts of any contaminants were detected. Formaldehyde appeared to be present on most samples above blank levels. Formaldehyde levels were highest on samples collected from the fabric storage room, which was consistent with the air sample data presented below. Other compounds detected on some samples were a C_4H_8/C_4H_{10} aliphatics, methylene chloride, vinylidene chloride, toluene, acetone, and phenol. Two area air samples were collected for formaldehyde using impingers containing 1% sodium bisulfite solution. One area air sample was collected in the fabric storage room and the other was collected in the Soft Goods Department near the fabric cutter. The results for these two area air samples were 0.14 and 0.01 parts per million (ppm), respectively. Additional area air samples were collected using treated XAD-2 tubes for several different aldehydes. Detectable concentrations of formaldehyde (0.12 ppm), acetaldehyde (0.03 ppm), acrolein (trace), valeraldehyde (0.03 ppm), and hexanal (0.08 ppm) were found in the area air sample collected in the fabric storage room. No detectable aldehyde concentrations were found in the area air sample collected in the Soft Goods Department near the fabric cutter.

Six PBZ air samples were collected and analyzed for formaldehyde, acetaldehyde, acrolein, butyraldehyde, valeraldehyde, iso-valeraldehyde, hexanal, and heptanal. None of the PBZ air samples had detectable concentrations of formaldehyde, acetaldehyde, acrolein, butyraldehyde, hexanal, or heptanal. Trace concentrations (between 0.004 and 0.01 ppm) of valeraldehyde were found in four of the six PBZ air samples. The NIOSH recommended exposure limit (REL) for valeraldehyde is 50 ppm as an 8-hour time-weighted average (TWA). NIOSH has identified formaldehyde as a suspected human carcinogen and recommends that exposures be reduced to the lowest feasible concentration. The Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for formaldehyde is 0.75 ppm as an 8-hour TWA.

Formaldehyde, phenol, and other phenolic compounds were found in emissions from heated fabric samples. These substances, as well as other aldehydes, methylene chloride, and vinylidene chloride, were detected in area air samples but were not present, or were present in only trace concentrations, in the PBZ air samples. Although the concentrations of these contaminants were well below occupational exposure limits, it is possible that the irritative symptoms experienced by the employees are related to exposures, since people vary widely in their subjective responses and health complaints.

Keywords: SIC 2514 (metal furniture manufacture) casual/outdoor furniture, sewing, fabric, formaldehyde, acetaldehyde, acrolein, butyraldehyde, valeraldehyde, iso-valeraldehyde, hexanal, heptanal, methylene chloride, and vinylidene chloride.

INTRODUCTION

In June 1994 the National Institute for Occupational Safety and Health (NIOSH) received a request from the Teamsters Union Local 346, for a health hazard evaluation (HHE) to investigate exposures at Homecrest Industries Incorporated. The request concerned the Soft Goods Department where employees cut and sew fabrics and polyvinyl chloride coated (PVC) polyester yarn backing to make cushions and coverings for casual/outdoor furniture. Employees had complained of respiratory problems, eye and nose irritation, headaches, rashes, and dermatitis. A site visit was conducted on September 20 and 21, 1994, and included a walk-through survey, employee interviews, and an industrial hygiene survey.

BACKGROUND

At the time of the survey, there were approximately 45 employees working in the Soft Goods Department. Workers in this department have the job title of *Cutter*, *Sewer*, or *Cushion Finisher*. A *Cutter* rolls out fabric in layers on long tables and cuts the layered fabric using a Greber fabric cutter. A *Sewer* sews the cut fabric into cushions and coverings, sometimes using a PVC coated polyester yarn backing called Phifertex®. A *Cushion Finisher* cuts polyester filler, places the filler into the cushions, and then completes the sewing.

MATERIALS AND METHODS

Industrial hygiene sampling was conducted on September 21, 1994, in the Soft Goods Department and in the fabric storage room. Personal breathing zone (PBZ) air samples were collected on *Cutters, Sewers,* and *Cushion Finishers* for aldehydes and other volatile organic compounds (VOCs). Area air samples were collected in the Soft Goods Department near the Greber fabric cutter and in the fabric storage room for aldehydes and VOCs. Cotton-containing fabrics require chemical treatment to impart smooth-drying and durable-press properties, and also certain functional properties such as dimensional stability. These chemical treatments comprise cross-linking adjacent microstructural units of cellulose to improve the resiliency of the cotton fiber, and thus the fabric. Aldehydes and phenols are the most common chemicals used in these treatments.[1] Aldehydes and some phenolic compounds have been associated with irritation of the eyes, nose, and upper respiratory tract.

PBZ and area air samples for aldehydes were collected using XAD-2 tubes treated with 10% (2-hydroxymethyl) piperdine at an air flow rate of 50 milliliters of air per minute (ml/min). The PBZ and area air samples collected were full-shift samples. The aldehyde tubes were analyzed by gas chromatography according to NIOSH Methods 2539 with modifications.[2] Analytes measured included acetaldehyde, formaldehyde, valeraldehyde, hexanal, heptanal, butyraldehyde, acrolein, and iso-valeraldehyde.

Area air samples were also collected for formaldehyde using impingers containing a 1% sodium bisulfite solution at an air sampling flow rate of 500 ml/min. Analysis was performed in accordance with NIOSH Method 3500.[2]

Area air samples were collected for VOCs using thermal desorption tubes at an air flow rate of 20 ml/min. Each thermal desorption tube contained three beds of sorbent materials: 1) a front layer of Carbotrap C (≈350 milligrams [mg]); 2) a middle layer of Carbotrap (≈175 mg); and 3) a back section of Carboxen 569 (≈150 mg). Prior to sampling, the thermal desorption tubes were conditioned for 2-hours at 375°C. The samples were analyzed using the Perkin-Elmer ATD 400 automatic thermal desorption system. The thermal unit was interfaced directly to a gas chromatograph with a mass selective detector (GC-MSD). Samples were qualitatively analyzed separately by directly inserting each tube into the thermal desorber unit with no other sample preparation. Each sample tube was desorbed at 300°C for 10-minutes.

PBZ and area air samples for VOCs were collected using charcoal tubes at an air sampling flow rate of 100 ml/min. The charcoal tubes were analyzed for methylene chloride and vinylidene chloride based on the qualitative VOC results. These charcoal tube samples were analyzed by gas chromatography with flame ionization detection in accordance with NIOSH Methods 1005 and 1015 with modifications.[2]

Bulk samples of the fabric and backing were collected and stored separately in sealed plastic bags. Twelve different styles of fabric samples (cotton and cotton/synthetic blend) and the PVC coated yarn backing sample were analyzed for releasable formaldehyde using a method which employs the Hantzsch reaction.[3] Ten milliliters (ml) of high purity water were added to weighed portions of each of the bulk samples placed in glass vials with aluminum-lined screw caps. All vials were incubated in a 37°C water bath for 4-hours. Upon cooling to room temperature, the solution was filtered through a 0.45 µm PTFE filter into another glass vial with an aluminum-lined screw cap. A 2.0 ml aliquot of each filtered sample solution was transferred to a 5 ml glass screw cap vial. Two ml of 2,4-pentanedione (acetylacetone) reagent were added to each vial. Each vial was shaken thoroughly to mix, then placed in a 60°C water bath for 10-minutes. After cooling to room temperature, solutions were transferred to 1-cm pathlength cuvettes. The absorbance of the yellow-colored reaction product was measured at 412 nanometers.

The fabric and backing samples were also qualitatively analyzed for VOC emissions by GC-MSD. A small portion (13-15 mg) of each was weighed and placed in a glass thermal desorption tube. The samples were then warmed to 60°C for 10-minutes prior to analysis using the Perkin-Elmer ATD 400 automatic thermal desorption system. Elevated temperatures were used to simulate a worse case storage conditions by facilitating VOC emissions.

EVALUATION CRITERIA

To assess the hazards posed by workplace exposures, NIOSH investigators use a variety of environmental evaluation criteria. These criteria suggest exposure levels which most workers may be exposed to for a working lifetime without experiencing adverse health effects. However, because of wide variation in individual susceptibility, some workers may experience occupational illness even if exposures are maintained below these limits. The evaluation criteria do not take into account individual hypersensitivity, pre-existing medical conditions, or possible interactions with other work place agents, medications being taken by the worker, or environmental conditions.

The primary sources of evaluation criteria for the workplace are: NIOSH Criteria Documents and Recommended Exposure Limits (RELs),[4] the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs),[5] and the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs).[6] The objective of these criteria for chemical agents is to establish levels of inhalation exposure to which the vast majority may be exposed without experiencing adverse health effects.

Occupational health criteria are established based on the available scientific information provided by industrial experience, animal or human experimental data, and/or epidemiologic studies. Differences between the NIOSH RELs, OSHA PELs, and ACGIH TLVs may exist because of different philosophies and interpretations of technical information. It should be noted that RELs and TLVs are guidelines, whereas PELs are standards which are legally enforceable. The OSHA PELs are require to take into account the technical and economical feasibility of controlling exposures in various industries where the agents are present. The NIOSH RELs are primarily based upon the prevention of occupational disease without assessing the economic feasibility of the affected industries, and as such tend to be conservative. A Court of Appeals decision vacated the OSHA 1989 Air Contaminants Standard in AFL-CIO vs OSHA, 965F.2d 962 (11th cir., 1992); and OSHA is now enforcing the previous 1971 standards (listed as Transitional Limits in 29 CFR 1910.1000, Table Z-1-A).[5] However, some states which have OSHA-approved State Plans continue to enforce the more protective 1989 limits. Minnesota has their own state plan and has adopted the OSHA 1989 Air Contaminants Standard. Employers are encouraged by NIOSH to use the 1989 limits or the RELs, whichever are most protective.

Evaluation criteria for chemical substances are usually based on the average PBZ exposure to the airborne substance over an entire 8- to 10-hour workday, expressed as a time-weighted average (TWA). Personal exposures are usually expressed in parts per million (ppm), milligrams per cubic meter (mg/m^3), or micrograms per cubic meter (µg/m^3). To supplement the 8-hour TWA where there are recognized adverse effects from short-term exposures, some substance have a short-term exposure limit (STEL) for 15-minute peak periods; or a ceiling limit, which is not to be exceeded at any time. Additionally, some chemicals have a "skin" notation to indicate that the substance may be absorbed through direct contact of the material with the skin and mucous membranes.

It is important to note that not all workers will be protected from adverse effects if their exposures are maintained below these occupational health exposure criteria. A small percentage may experience adverse health effects because of individual susceptibility, a preexisting medical condition, pervious exposures, and/or a hypersensitivity (allergy). In addition, some hazardous substance may act in combination with other work place exposures, or with medications or personal habits of the worker (such as smoking, etc.) to produce health effects even if the occupational exposures are controlled to the limit set by the evaluation criterion. These combined effects are often not considered by the chemical specific evaluation criteria. Furthermore, many substance are appreciably absorbed by direct contact with the skin and thus potentially increase the overall exposure and biologic response beyond that expected from inhalation alone. Finally, evaluation criteria may change over time as new information on the toxic effects of an agent become available. Because of these reasons, it is prudent for an employer to maintain exposures well below established occupational health criteria.

Aldehydes

PBZ and area air samples were collected and analyzed for eight different aldehydes: formaldehyde; acetaldehyde; acrolein; butyraldehyde; valeraldehyde; iso-valeraldehyde, hexanal, and heptanal. Table 1 lists a summary of the occupational exposure limits for these substances.

Formaldehyde

Formaldehyde is a colorless gas with a strong odor. Exposure can occur through inhalation and skin absorption. The acute effects associated with formaldehyde are irritation of the eyes and respiratory tract, and sensitization of the skin. The first symptoms associated with formaldehyde exposure, at concentrations ranging from 0.1 to 5 ppm, are burning eyes, tearing, and general irritation of the upper respiratory tract. It is often difficult to ascribe specific health effects to specific concentrations of formaldehyde because people vary in their subjective responses and complaints. For example, irritation symptoms may occur in people exposed to formaldehyde at concentrations below 0.1 ppm, but more typically they begin at exposures of 1.0 ppm and greater. However, some children or elderly persons, those with pre-existing allergies or respiratory disease, and persons who have become sensitized from prior exposure may have symptoms from exposure concentrations of formaldehyde between 0.05 and 0.10 ppm. Cases of formaldehyde-induced asthma and bronchial hyperactivity developed specially to formaldehyde are uncommon.[7,8]

In two separate studies, formaldehyde has induced a rare form of nasal cancer in rodents.[7] Formaldehyde exposure has been identified as a possible causative factor in cancer of the upper respiratory tract in a proportionate mortality study of workers in the garment manufacturing industry.[9] NIOSH has identified formaldehyde as a suspected human carcinogen and recommends that exposures be reduced to the lowest feasible concentration. For this survey the minimum detectable concentration (MDC) of formaldehyde was 0.02 ppm, assuming an air volume of 24 liters. The OSHA PEL is 0.75 ppm as an 8-hour TWA, and 2 ppm as a STEL.[10] The ACGIH considers formaldehyde a suspected human carcinogen and therefore, recommends that worker exposures by all routes should be carefully controlled to levels "as low as reasonably achievable" below the TLV.[6] The ACGIH has set a ceiling concentration of 0.3 ppm.

Acetaldehyde

Acetaldehyde is a clear liquid at room temperature and has a pleasant fruity smell at dilute concentrations which becomes pungent and suffocating at high concentrations.[11] Acute exposure of humans to 50 ppm acetaldehyde vapor for 15-minutes produced mild eye irritation; 200 ppm for 15-minutes produced bloodshot eyes and reddened eyelids; and 135 ppm for 30-minutes produced mild irritation of the upper respiratory tract. Systemic effects resulting from chronic acetaldehyde exposure in the workplace have not been reported, but prolonged exposure to acetaldehyde may produce drowsiness. Exposure to acetaldehyde has produced nasal tumors in rats and laryngeal tumors in hamsters, therefore NIOSH recommends that acetaldehyde be considered a potential occupational carcinogen and recommends that exposures be reduced to the lowest feasible concentration. For this study the MDC for acetaldehyde was 0.02 ppm assuming an air sample volume of 24 liters. The OSHA PEL is 200 ppm as an 8-hour TWA. The ACGIH has designated acetaldehyde to be an animal carcinogen indicating that the agent will cause cancer in experimental animals at a relatively high dose. Available epidemiological studies do not confirm an increased risk of cancer in exposed humans.[6] The ACGIH has set a ceiling concentration for acetaldehyde of 25 ppm.

Other Aldehydes

The health effects associated with exposure to many aldehydes are predominantly eye irritation and irritation of the upper respiratory tract and skin. Irritancy is a property of nearly all aldehydes, but it occurs more commonly and is more pronounced in the case of those with lower molecular weights and those with unstaturation in the aliphatic chain. Testing has not been completed to determine the carcinogenicity of acrolein (CAS # 107-02-8), butyraldehyde (CAS #123-72-8), n-valeraldehyde (CAS # 110-62-3), iso-valeraldehyde (CAS# 590-86-3), hexanal (CAS # 66-25-1), and heptanal (CAS # 111-71-7). However the limited studies to date indicate that these substances have chemical reactivity and mutagenicity similar to acetaldehyde. Therefore, NIOSH recommends that careful consideration should be given to reducing exposure to these aldehydes. The NIOSH REL for acrolein is a 0.1 ppm TWA and a 0.3 ppm STEL. The OSHA PEL for acrolein is a 0.1 ppm TWA. The ACGIH TLVs for acrolein are the same as the NIOSH RELs. The NIOSH REL, the vacated 1989 OSHA PEL, and the ACGIH TLV for valeraldehyde are 50 ppm as a TWA. Minnesota has their own state OSHA plan and has adopted the revised 1989 OSHA PELs.

Methylene Chloride

Methylene chloride is a colorless liquid that has a detectable odor at about 200 ppm. It is present in many multipurpose solvents and paint strippers, and is used in the manufacture of photographic film, aerosol propellants, and urethane foam. Methylene chloride exposures can occur through inhalation and skin absorption. Methylene chloride is a mild central nervous system depressant and an eye, skin, and respiratory tract irritant. It is carcinogenic in experimental animals and is considered a suspected human carcinogen.[12] NIOSH considers methylene chloride a potential occupational carcinogen and recommends that exposures be reduced to the lowest feasible concentration. For this study the MDC of methylene chloride was 0.15 ppm, assuming an air sample volume of 48 liters. The OSHA PEL is 500 ppm as an 8-hour TWA, a 1000 ppm ceiling limit, and a 2000 ppm 5-minute maximum peak in any 2-hour period. The ACGIH considers methylene chloride to be a suspected human carcinogen and recommends that worker exposures by all routes be carefully controlled to levels "as low as reasonably achievable" below the TLV.[6] The ACGIH has set a TLV-TWA of 25 ppm.

Vinylidene Chloride

Vinylidene chloride is a clear liquid that is highly flammable and reactive, and in the presence of air can form complex peroxides in the absence of chemical inhibitors. Vinylidene chloride is used in the production of copolymers of high vinylidene chloride content, the other major monomer usually being vinyl chloride, as in Saran and Velon for films and coatings. Exposure to vinylidene chloride occurs through inhalation of vapors and causes central nervous system depression at high levels. Repeated exposure to lower concentrations results in liver and kidney damage in experimental animals. Vinylidene chloride affects several liver enzymes. It is carcinogenic in experimental animals and is considered a suspected human carcinogen. NIOSH considers vinylidene chloride a potential occupational carcinogen and recommends that exposures be reduced to the lowest feasible concentration. For this study the MDC for vinylidene chloride was 0.02 ppm, assuming an air sample volume of 48 liters. No OSHA PEL is currently being enforced for vinylidene chloride. The vacated 1989 OSHA PEL is 1 ppm as an 8-hour TWA. The ACGIH has designated methylene chloride to be a suspected human carcinogen, and recommends that worker exposure by all routes should be carefully controlled to levels "as low as reasonably achievable" below the TLV.[6] The ACGIH has set a TLV-TWA of 5 ppm and a 20 ppm STEL.

RESULTS AND DISCUSSION

Two area air samples were collected for formaldehyde using impingers as the collection media. These sample results are shown in Table 2. One area air sample was collected in the fabric storage room, and had a formaldehyde concentration of 0.14 ppm. The other air sample was collected in the Soft Goods Department sewing area on a railing next to the Greber fabric cutter, and had a formaldehyde concentration of 0.01 ppm.

Six PBZ and two area air samples were collected and analyzed for the following aldehydes: 1) formaldehyde; 2) acetaldehyde; 3) acrolein; 4) butyraldehyde; 5) n-valeraldehyde; 6) iso-valeraldehyde; 7) hexanal; and 8) heptanal. The results for these eight aldehyde air samples are listed in Table 3. The only air sample which had a detectable concentration of formaldehyde was the area air sample collected in the fabric storage room (0.12 ppm). This area air sample also had very low or trace concentrations of acetaldehyde, acrolein, valeraldehyde, and hexanal. Trace concentrations are those between the MDC and minimum quantifiable concentration (MQC). Trace concentrations of valeraldehyde were found in PBZ air samples collected from four of the five sewers sampled. The MDC and MQC for valeraldehyde are 0.004 and 0.01 ppm, respectively. One sewer's PBZ air sample contained a trace concentration of iso-valeraldehyde. The MDC and MQC for iso-valeraldehyde were 0.005 and 0.02 ppm, respectively.

Eight area air samples were collected with thermal desorption tubes for qualitative VOC analysis (Table 4). Four thermal desorption tubes samples were collected sequentially in the fabric storage room, and the other four tubes samples were collected sequentially in the Soft Goods Department sewing area on the railing next to the Greber fabric cutter. Only trace amounts of any contaminants were detected on the thermal desorption tubes. Formaldehyde was present on all of the samples above blank levels. The "highest" levels of formaldehyde were found on samples collected from the fabric storage room, which coincides with the impinger air sample results previously mentioned. Other compounds detected on samples from the fabric storage room were C_4H_8/C_4H_{10} aliphatics, methylene chloride, vinylidene chloride, toluene, acetone, a terpene, and phenol. Other compounds detected on samples from the Soft Goods Department samples were C_4H_8/C_4H_{10} aliphatics, acetone, and vinylidene chloride. The "highest" level of vinylidene chloride was detected from the railing samples next to the Greber fabric cutter in the Soft Goods Department.

Six full-shift PBZ and two area air samples were collected using charcoal tubes and analyzed for methylene chloride and vinylidene chloride. All results for methylene chloride and vinylidene chloride were non-detectable (ND) with the MDCs for methylene chloride and vinylidene chloride being 0.048 and 0.005 ppm, respectively, assuming an air sample volume of 48 liters. However, it should be noted that the air sample volumes exceeded the recommended sample volume for these analytes. The air sample volumes for these charcoal tubes samples ranged between 38 and 44 liters of air. The recommended maximum air sample volume for methylene chloride is 2.5 liters and for vinylidene chloride is 7 liters. In addition, two charcoal tubes in series should be used to collect the methylene chloride air samples. The large air sample volumes collected during this survey may have resulted in sample loss.

Twelve different styles of fabric (cotton and cotton/synthetic blends) and one PVC-coated polyester yarn backing sample were analyzed for releasable formaldehyde concentration. The results for these analyses are shown in Table 5. One bulk fabric sample, Wellington-Sears Callaway fabric, had a releasable formaldehyde concentration above the limit of quantitation (LOQ) at 540 micrograms of formaldehyde per gram of fabric (µg/g). The LOQ was 400 µg/g. Five bulk fabric samples had releasable formaldehyde concentrations between the LOQ and the limit of detection (LOD). These fabrics were Shenandoah Melody (170 µg/g), Amtex Lanai (290 µg/g), Artistic Design Cachet (350 µg/g), Dickson-Elberton Mills Hana (340 µg/g), and Dickson-Elberton Mills Nottingham (140 µg/g). The LOD was 120 µg/g. No releasable formaldehyde was detected in the Phifertex backing or in the other six bulk fabric samples.

The method used by the NIOSH chemists to measure concentrations of releasable formaldehyde from these fabric samples employed a relatively mild aqueous extraction procedure to remove unreacted finishing agents, water-soluble finish fragments, and unbound formaldehyde. The 37°C temperature was chosen to simulate the human body temperature. The method employed by NIOSH chemists is similar to the Japanese Test Method 112-1973[12] which uses an aqueous extraction at 40°C for 1-hour with a 100:1 liquor-to-fabric ratio. A more aggressive extraction procedure, the American Association of Textile Chemists and Colorist (AATCC) Test Method 112-1993,[13] is commonly used to measure releasable formaldehyde concentrations in fabrics. A comparison of the Japanese Test Method Law 112-1973 to the AATCC Test Method 112 showed that the AATCC test had greater releasable formaldehyde concentrations than did the Japanese test.[1] Since the method used by NIOSH was similar to the Japanese test, the releasable formaldehyde concentrations results listed in Table 5 may be lower than those that would have been obtained if the AATCC Test Method 112-1993 had been used.

The twelve fabric samples and the backing sample were also analyzed for VOC emissions at an elevated temperature of 60°C (140°F). Results of these analyses are listed in Table 6. Only trace amounts of any of the contaminants were detected. Eight of the 12 fabric samples analyzed had detectable levels of formaldehyde, ten of the 12 samples had detectable levels of phenol, and all 12 samples had detectable levels of bis(dimethylethyl) ethyl phenol. Other compounds detected from some of the fabric samples included a (dimethylethyl) phenol, 2,6-di-tert-butyl-quinone, a bis (dimethylethyl) phenol, a phenolic compound, and siloxane compounds. The PVC-coated backing sample had detectable levels of acetone, phenol, bis(dimethylethyl)ethyl phenol, a phenolic compound, and siloxane compounds. No other aldehydes were detected in the headspace samples.

The room where the Soft Goods Department is located and where the complaints arose was approximately 270 feet by 50 feet by 12 feet, as shown in Figure 1. Ventilation for this area consists of two blowers located at the filler cutting end of the room. In response to the health complaints made by the employees, two long cylindrical cloth socks were attached to the faces of the two blowers and extended the length of the room. Two inch holes were periodically put in the socks in an effort to better uniformly distribute the air being supplied to the room. There is no exhaust ventilation for the room, and the air flow through the room comes from the holes in the socks and exits through the three door ways located on the one side of the room, as shown in Figure 1. There is no ventilation in the fabric storage room, and all of the doors to the room were kept closed during the site visit. There is one employee who works in the fabric storage room almost all day.

During the site visit, interviews were conducted with six employees from the Soft Goods Department. All six employees reported burning eyes and runny, burning noses at various times during the last two years. Five of the six interviewed employees complained of itchy, reddening skin, and one employee was diagnosed by the family physician as having vasomotor rhinitis. All six of the interviewed employees said that their symptoms got better when they were away from work. Several of the employees indicated that their symptoms improved after the socks were installed on the blowers.

CONCLUSIONS

The burning eyes, burning and runny nose, upper respiratory irritation and rashes experienced by some of the employees from the Soft Goods Department may be related to exposure to low concentrations of formaldehyde, other aldehydes, or phenolic compounds. Six of the 12 fabric samples analyzed for releasable formaldehyde had detectable concentrations ranging from 170 to 540 µg/g, indicating that formaldehyde was off-gasing from the fabric. Formaldehyde concentrations measured in the fabric storage room were 0.12 and 0.14 ppm. Although these concentrations are well below the OSHA PEL, they are in the range where burning eyes, tearing, and general irritation of the upper respiratory tract have been reported. Trace concentrations of valeraldehyde were measured in four of the six PBZ air samples and phenol was measured in VOC emissions from the fabrics. Both of the these compounds have also been associated with eye and upper respiratory irritation and well as skin irritation. Prior to the addition of the socks to the blowers supplying fresh air to the Soft Goods Department, the supply air may not have been evenly distributed throughout the room allowing for the buildup of formaldehyde and other contaminants. With the addition of the socks, it was reported that air has been better distributed and the employees' symptoms have decreased.

RECOMMENDATIONS

1. The socks connected to the blowers should be replaced with permanent duct work. Permanent duck work would better distribute the air coming from the blowers to all parts of the Soft Goods Department.

2. An exhaust ventilation system installed in the fabric storage room would help to further reduce the concentrations of VOCs including formaldehyde, which are offgassing from the stored fabrics.

3. Employees who experience recurring rashes or dermal irritation should see a physician.

REFERENCES

1. Andrews BA, Reinhardt RM [1985]. Predicting release of formaldehyde from cellulosic textiles. In: Turoski V, ed. Formaldehyde: Analytical Chemistry and Toxicology. Washington, D.D.: American Chemical Society, Chicago, Ill, pp83-100.

2. NIOSH [1994]. NIOSH Manual of Analytical Methods. 4th ed. Cincinnati, OH: Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) publication No. 94-113.

3. Nash T [1953]. The calorimetric estimation of formaldehyde by means of the Hantzsch reaction. Biochem J 55:46.

4. NIOSH [1992]. Recommendation for occupational safety and health: compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

5. Code of Federal Regulations [1989]. 29 CFR 1910.1000. Washington, D.C.: U.S. Government Printing Office, Federal Register.

6. ACGIH [1994]. 1994-1995 threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienist.

7. NIOSH [1977]. Criteria for a recommended standard: occupational exposure to formaldehyde. Cincinnati, OH: U.S. Department of Health Education and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-126.

8. NRC [1981]. Formaldehyde and other aldehyde. National Academy Press. Washington, D.C., National Research Council.

9. Stayner L, Smith AB, Reeve G, Blade LM, Keenlyside R, Halprin W [1985]. Proportionate mortality study of workers exposed to formaldehyde. Am J Ind Med 7:229-240.

10. OSHA [1992]. Occupational exposure to formaldehyde: final rule. Occupational Safety and Health Administration, Washington, D.C.: U.S. Government Printing Office, Federal Register 57(102):22289-22328.

11. NIOSH [1991]. Current Intelligence Bulletin 55: carcinogenicity of acetaldehyde, malonaldehyde, and mutagenicity of related low-molecular-weight aldehydes. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 91-112.

12. Law for Control of Household Goods Containing Harmful Substances, Law No. 112, Welfare Ministry Ordinance: Japan, 1973; No. 34-1974.

13. American Association of Textile Chemist and Colorists Technical Manual; AATCC: Research Triangle Park, N.C. 1994; Vol. 58.

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Copies of this report have been sent to:

1. Vice President, Personnel, Homecrest Industries
2. Union Steward, Teamsters Union Local 346
3. Union Representative, Teamsters Union Local 346
4. 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
Occupational Exposure Criteria for Eight Different Aldehydes
Homecrest Industries Incorporated
Wadena, Minnesota
HETA 94-0309

Aldehyde	NIOSH REL	OSHA PEL	Vacated 1989 OSHA PEL*	ACGIH TLV
Formaldehyde	Ca; LFC	0.75 ppm TWA 2 ppm STEL	-----	0.3 ppm ceiling
Acetaldehyde	Ca; LFC	200 ppm TWA	100 ppm TWA 150 ppm STEL	25 ppm ceiling
Acrolein	0.1 ppm TWA; 0.3 ppm STEL	0.1 ppm TWA	0.1 ppm TWA 0.3 ppm STEL	0.1 ppm TWA 0.3 ppm STEL
Butyraldehyde	-----	-----	-----	-----
Valeraldehyde	50 ppm TWA	-----	50 ppm TWA	50 ppm TWA
iso-Valeraldehyde	-----	-----	-----	-----
Hexanal	-----	-----	-----	-----
Heptanal	-----	-----	-----	-----

REL = recommended exposure limit
PEL = permissible exposure limit
TLV = threshold limit value
----- = not available
Ca = agent considered by NIOSH to be a potential occupational carcinogen
* Note that Minnesota OSHA has adopted and is enforcing these standards.

TWA = time-weighted average
STEL = short-term exposure limit
LFC - lowest feasible concentration

Table 2
Formaldehyde Area Air Sample Results
NIOSH Method 3500[1]
Homecrest Industries Incorporated
Wadena, Minnesota
HETA 94-0309

Sample Date	Sample Site	Sampling Time (minutes)	Sample Volume (liters)	HCHO Conc. (ppm)
09/21/95	In Soft Goods Department on railing next to Greber fabric cutter	378	18.9	0.01
09/21/95	In fabric storage room	409	20.5	0.14

HCHO = Formaldehyde
ppm = parts per million
[1]NIOSH [1994]. NIOSH Manual of Analytical Methods. 4th ed. Cincinnati, OH: Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94-113.

Table 3

Aldehyde Air Sample Results
Homecrest Industries
Wadena, Minnesota
HETA 94-0309

Sample Date	Job Title/ Sample Site	Sample Time (min.)	Sample Volume (liters)	1 Conc. (ppm)	2 Conc. (ppm)	3 Conc. (ppm)	4 Conc. (ppm)	5A Conc. (ppm)	5B Conc. (ppm)	6 Conc. (ppm)	7 Conc. (ppm)
09/21/94	Sewer	437	21.9	ND	ND	ND	ND	trace	ND	ND	ND
09/21/94	Sewer	432	21.6	ND	ND	ND	ND	trace	ND	ND	ND
09/21/94	Sewer	440	22.0	ND	ND	ND	ND	ND	trace	ND	ND
09/21/94	Sewer	430	21.5	ND	ND	ND	ND	trace	ND	ND	ND
09/21/94	Cushion Finisher	431	21.6	ND	ND	ND	ND	ND	ND	ND	ND
09/21/94	Sewer	435	21.8	ND	ND	ND	ND	trace	ND	ND	ND
09/21/94	Next to Greber fabric cutter (area)	378	18.9	ND	ND	ND	ND	ND	ND	ND	ND
09/21/94	In fabric storage room (area)	409	20.5	0.12	0.03	trace	ND	0.03	ND	0.08	ND

1 = formaldehyde MDC = 0.02 ppm; MQC = 0.06 ppm
2 = acetaldehyde MDC = 0.01 ppm; MQC = 0.02 ppm
3 = acrolein (2-propanal) MDC = 0.04 ppm; MQC = 0.10 ppm
4 = butyraldehyde (butanal) MDC = 0.01 ppm; MQC = 0.03 ppm
5A = valeraldehyde (pentanal) MDC = 0.004 ppm; MQC = 0.01 ppm
5B = iso-valeraldehyde (3-methyl-butanal) MDC = 0.005 ppm; MQC = 0.02 ppm
6 = hexanal (caproic aldehyde) MDC = 0.004 ppm; MQC = 0.01 ppm
7 = ND = non-detectable concentration

ND = non-detectable concentration
trace = trace concentration, between MDC and MQC
ppm = parts per million
MDC = minimum detectable concentration, assuming a sample volume of 24 liters
MQC = minimum quantifiable concentration, assuming a sample volume of 24 liters

Table 4 Identification of Volatile Organic Compounds in Area Air Samples Using Thermal Desorption Tubes Homecrest Industries Incorporated HETA 94-0309		
Sample Number	Sample Description	Volatile Organic Compounds Identified
CX-25	In fabric storage room	1,2,3,6,7,9
CX-10	In fabric storage room	1,2,3,5,7,8,9
CX-2	In fabric storage room	1,2,5,7,8
CX-30	In fabric storage room	1,2,3,6,8
CX-17	In the Soft Goods Dept. on the rail next to Greber fabric cutter	1,2,3,4
CX-16	In the Soft Goods Dept. on the rail next to Greber fabric cutter	1,6
CX-33	In the Soft Goods Dept. on the rail next to Greber fabric cutter	1,4
CX-57	In the Soft Goods Dept. on the rail next to Greber fabric cutter	1,2,4

1 = Formaldehyde*
2 = C_4H_8/C_4H_{10} aliphatics
3 = Acetone
4 = Vinylidene chloride/trace methylene chloride*
5 = Methylene chloride*
6 = Methylene chloride*/trace vinylidene chloride
7 = Toluene
8 = $C_{10}H_{16}$ terpene
9 = Phenol
*Also present on some field and/or media blanks

Table 5
Analysis of Fabric for Releasable Formaldehyde
Homecrest Industries, Inc.
Wadena, Minnesota
HETA 94-0309

Company	Fabric Name	Releasable Formaldehyde Conc. (µg HCHO/gram fabric)
Shenandoah	Melody	(170)
Wellington-Sears	Callaway	540
Wellington-Sears	Savanna	ND
Covington Fabrics	Antique Rose	ND
Covington Fabrics	Calypso-Phlox	ND
Ametex	Lanai	(290)
Artisic Design	Cachet	(350)
Dickson-Elberton Mills	Nottingham	(140)
Dickson-Elberton Mills	Tapis	ND
Dickson-Elberton Mills	Queen Anne	ND
Dickson-Elberton Mills	Thames	ND
Dickson-Elberton Mills	Hana	(340)
Phifer	Phifertex backing	ND

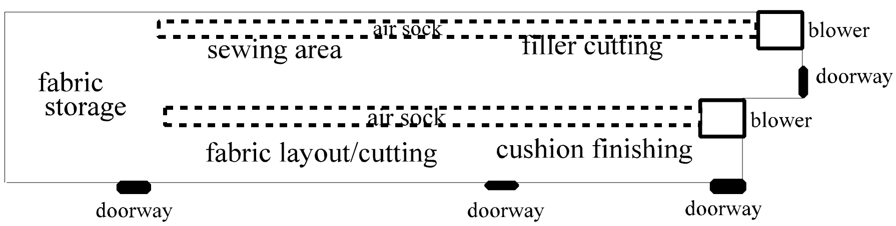
ND = non-detectable (below the limit of detection)
LOD = limit of detection = 120 µg/g
LOQ = limit of quantitation = 400 µg/g
Results between LOD and LOQ are listed in parentheses.

Table 6
Qualitative Analysis of Volatile Organic Compounds
Emission from Fabric Samples
Homecrest Industries Incorporated
Wadena, Minnesota
HETA 94-0309

Fabric Manufacture	Fabric Name	VOCs when fabric heated to 60°C (140°F)
Wellington-Sears	Callaway	1,3,5,7,8,9
Wellington-Sears	Savanna	3,4,5,6,7,8
Covington Fabric	Antique Rose	1,7
Covington Fabric	Calypso-Phlox	1,3,4,7,8
Shenandoah	Melody	1,3,7
Dickson-Elberton Mills	Nottingham	3,7
Dickson-Elberton Mills	Thames	1,3,7
Dickson-Elberton Mills	Hana	1,2,3,7
Dickson-Elberton Mills	Queen Anne	1,3,7
Dickson-Elberton Mills	Tapis	7
Amtex	Lanai	3,7,8,9
Artistic Design	Cachet	1,3,4,5,7,8,9
Phifer	Phifertex backing	2,3,7,8,9

VOCs = volatile organic compounds
MW = molecular weight
1 = Formaldehyde
2 = Acetone
3 = Phenol
4 = MW=150, a (dimethylethyl) phenol
5 = MW=220, 2,6-di-tert-butyl-quinone
6 = MW=206, a bis(dimethylethyl) phenol
7 = MW=234, $C_{16}H_{26}O_2$, bis(dimethylethyl)ethyl phenol
8 = MW=232, phenolic compound, $C_{16}H_{24}O$
9 = Siloxane compounds

Figure 1
Soft Goods Department Layout
Homecrest Industries Incorporated
Wadena, Minnesota
HETA 94-0309



1 inch ≈ 40 feet