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BUSSMANN/COOPER INDUSTRIES
MPH
ELIZABETHTOWN, KENTUCKY

NIOSH INVESTIGATORS:
Aaron L. Sussell, MPH
Boris D. Lushniak, MD,

I. SUMMARY

On February 14, 1989, the National Institute for Occupational Safety and Health (NIOSH) received a request from Bussmann/Cooper Industries, Elizabethtown, Kentucky to evaluate employee exposures to emissions from heated polyvinyl chloride (PVC) film in a blister pack machine. Workers in adjacent areas had complained of skin rashes, respiratory irritation, and throat inflammation.

A walk-through survey, environmental sampling for selected PVC thermal decomposition products, and medical interviews were conducted on February 22, 1990. A bulk sample of the PVC film being used was collected for laboratory analysis to determine thermal decomposition products. Area air samples were collected at two locations, and a process sample was collected in the blister pack machine enclosure. Analytes for the air samples, which were determined by a review of previous studies, were: methyl methacrylate, volatile organic compounds, aldehydes, hydrogen chloride, and phthalates. In response to a report of skin irritation among box handlers during the survey, a sample of loose fibers from the bottom of a packaging box was collected for fiber identification in the laboratory.

PVC film thermal decomposition products detected in the laboratory included: hydrochloric acid, benzene, styrene, ethyl benzene, toluene, methyl methacrylate, naphthalene, xylenes, polyaromatic hydrocarbons, and numerous chlorinated alkanes. On the day of the survey, concentrations of hydrochloric acid, the primary decomposition product, measured in area samples 10 and 20 feet away from the blister pack machine were less than the analytical limit of detection (0.05 milligram per cubic meter (mg/m^3)), and 0.39 mg/m^3, respectively. Methyl methacrylate, aldehyde, and phthalate concentrations measured in the area and process air samples were below the respective limits of detection (0.02-0.74 mg/m^3). Volatile organic compounds detected in these samples were primarily solvents used in adjacent work areas for parts cleaning: 1,1,1 trichloroethylene, methylene chloride, perchloroethylene, and isopropanol; in concentrations of 4 to 24 mg/m^3. Fibers collected from the blister pack packaging boxes were found to be comprised of 90% teflon polymer fibers with jagged edges, with the remainder brown fibrous paper.

Ten of the 12 interviewed employees with health complaints (skin rashes, respiratory irritation, and throat inflammation) felt that their symptoms were worse when the blister pack machine had a melt-down of PVC, or was run at higher temperatures. The walk-through survey revealed a potential for entrainment of the

blister pack machine exhaust into an air-handling unit serving adjacent work areas. On the day of the survey, outside wind direction minimized potential entrainment, and no melt-down or higher temperature production run occurred.

On the basis of data obtained in this investigation, the NIOSH investigators determined that a potential health hazard existed among workers in areas adjacent to the blister pack machine, due to insufficient control of blister pack machine exhaust containing hydrogen chloride and the use of perchloroethylene and methylene chloride in areas without local exhaust ventilation. Recommendations for controlling exhaust emissions and for product substitution with less hazardous cleaning solvents in the adjacent work areas are presented in Section VII of this report.

Key Words: SIC 3613 (fuses, electric-manufacturing), fuses, blister-packaging, polyvinyl chloride film, PVC emissions

II. INTRODUCTION

On February 14, 1990, a management representative of Bussmann/Cooper Industries requested that NIOSH conduct a health hazard evaluation (HHE) of employee exposures to emissions from heated polyvinyl chloride (PVC) film in a blister pack machine. The request stated that workers in areas adjacent to this machine experienced chronic symptoms, including skin rashes, respiratory irritation, and throat inflammation.

On February 22, 1990, NIOSH investigators conducted an environmental evaluation to assess potential exposures and medical interviews to document employee symptoms.

III. BACKGROUND

Bussmann/Cooper Industries manufacturers fuses for automotive and other applications at the Elizabethtown facility, which has 226 employees. The blister pack machine in question, used for packaging fuses, was moved to the facility in early 1989 and began operations on March 9, 1989. This machine had been used 12 years at another location, reportedly without incident. An employee working in the "Buss-Pluss" area, about 20 feet from the blister pack machine, immediately began experiencing sinus and skin problems which became progressively worse with time. Since March 9, 1989, at least four other employees in nearby areas experienced chronic symptoms, including sinus problems, skin rashes, throat and respiratory irritation, numbness of face and lips, and nose bleeds.

The blister pack machine is used to package fuses by the following automatic process.

1. PVC plastic sheet material from a bulk roll (Genotherm Rigid PVC Film, Type 1002, 10 or 12 mil thickness) is fed into an electric oven where it resides for four to five seconds at 575 to 775°F (302 to 413°C), with the temperature varying with different production runs.

2. A sheet of blister packs is formed by applying a vacuum to the heated film, drawing it against a mold.

3. The molded plastic is air-cooled and cut into individual blister packs. Fuses are then loaded into the blister packs, and the plastic is adhered with heat (480°F for one to three seconds) and pressure, to teflon polymer-coated paper cards about 3 x 5 inches in size.

4. The completed blister packs are hand-loaded into cardboard boxes as they move down a conveyor.

During the survey on February 22, 1990, employees reported that loose fibers shed from the coated paper cards caused irritation of the skin on their hands and requested identification of the fibers.

During the blister pack process, PVC film occasionally became jammed in the machine, resulting in overheating of the plastic ("meltdown") and the release of irritating smoke to the work environment. A lesser, but still irritating, amount of emissions reportedly occurred during the normal operation of the machine. After employee health complaints were received, local exhaust ventilation was installed over the blister pack machine on March 18, 1989. During April and May 1989, the company installed an enclosure around the machine to improve emission capture, and a hydraulic lift on the oven heating element to prevent meltdowns.

Personal breathing zone and area air sampling were conducted during April, May, and June 1989, during investigations by a private consultant and Occupational Safety and Health Administration (OSHA) compliance officers. Trace amounts of hydrochloric acid (0.006 parts per million (ppm)) and organotin, and low concentrations of total particulate (0.21 mg/m^3) and total hydrocarbons (1.2 ppm) were measured. Subsequent air monitoring by Cooper Industries also detected low concentrations of methyl methacrylate monomer (0.65-1.73 ppm).

Several organic solvents were used near the blister pack machine or in adjacent areas of the plant for cleaning parts: perchloroethylene to remove flux from assembly wheel rings in the Coil-Winding area, methylene chloride to clean print rollers in an area between the Cleaning Room and the Coil-Winding area, 1,1,1-trichloroethane to clean rings on automatic wheels in Wheel areas, and isopropanol was used extensively in the Cleaning Room (which had local exhaust ventilation).

IV. EVALUATION DESIGN AND METHODS

Environmental

A. On February 22, 1990, a walk-through survey and environmental sampling were conducted in the blister pack machine area to assess exposures to airborne emissions from heated PVC film, and local exhaust and general ventilation. Three types of samples were collected: a) a bulk PVC film sample that was subsequently heated in the laboratory, with analysis of the resultant emissions; b) area air samples at two work locations, where most employee symptoms had been reported; and c) a process air sample as close as possible to the heating oven and mold inside the machine enclosure.

1. **Bulk PVC film sample**

   To determine constituents of emissions from the PVC film during a meltdown incident in the temperature range of normal production, the following technique was employed in the laboratory. A quartz tube furnace was heated to approximately 380°C, and small portions of the material were placed in a ceramic boat inside the hot furnace. The effluent from the sample was collected at a flow rate of 0.06 L/min using a critical orifice, with sampling times of 15-30 minutes, for subsequent analysis by GC/MS. The emissions were collected on both charcoal and Orbo® 23 tubes. The oven tubing was rinsed with acetone after air samples were collected, and this rinse solution was also analyzed.

2. **Area and process samples**

   Area and process air samples were collected with battery-powered pumps (Gillian®), connected with Tygon® tubing to the various collection media. The pumps were calibrated pre- and post-sampling, with periodic checks of the flow rates during the sampling period. The analytes, flow rates, collection media and methods of analysis for the area and process samples were as follows:

   a. **methyl methacrylate: flow rate of 0.05 liters per minute (L/min) through XAD-2 (Orbo® 42) sorbent tubes, analysis by gas chromatography/flame-ionization detector (GC/FID)--NIOSH Method 2537 [1].**

   b. **volatile organic compounds (VOCs): flow rate of 0.2 L/min through charcoal sorbent tubes, analysis by GC/FID--NIOSH Method 1500 [1].**

   c. **aldehydes: flow rate of 0.05 L/min through 10% 2-(hydroxymethyl) piperidine on XAD-2 (Orbo®3 23) sorbent tubes, analysis by GC/FID and mass spectrometry (MS)--NIOSH Method 2539 [1].**

   d. **hydrogen chloride (hydrochloric acid): flow rate of 0.5 L/min through silica gel sorbent tubes, analysis by ion chromatography--NIOSH Method 7903 [1].**

   e. **di-n-butyl phthalate and di(2-ethyhexyl)phthalate: flow rate of 2 L/min through glass fiber filters, analysis by GC/FID--NIOSH Method 5020 [1].**

3. Bulk fiber sample from packaging boxes

In response to an incidental report of skin irritation among box handlers, NIOSH investigators collected a sample of loose fibers from the bottom of a typical packaging box and submitted it to the laboratory for fiber identification. The sample components (yellow fibers and brown bundles) were isolated and analyzed individually. Each component was examined at 30X magnification on the stereomicroscope, with portions subsequently immersed in a Cargille liquid having a refractive index equal to 1.550 for examination by polarized light microscope (PLM) at 100X magnification.

B. Medical

The medical component of this investigation consisted of a plant walk-through survey, a review of OSHA 200 logs for 1989, personal interviews with 12 employees with medical complaints who work near the blister pack machine, observation of work practices, and review of medical records of individuals who had sought medical care from private physicians.

V. EVALUATION CRITERIA

A. General guidelines

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment 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/day, 40 hours/week for a working lifetime without experiencing adverse health effects. It is important to note, however, that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the levels set by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus the overall exposure may be increased above measured airborne concentrations. Evaluation criteria typically change over time as new information on the toxic effects of an agent become available. Studies which have

shown substances to cause cancer in animals are useful in identifying human carcinogens. Although humans and animals differ in their susceptibility to specific chemical compounds, any substance that produces cancer in experimental animals should be considered a potential cancer risk to humans. Absolutely safe levels of exposure to carcinogens have not been demonstrated, but lowered exposure to carcinogens decreases the risk of cancer.

The primary sources of evaluation criteria for the workplace are: NIOSH Criteria Documents and Recommended Exposure Limits (RELs) [2], the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs) [3], and the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs) [4]. These values are usually based on a time-weighted average (TWA) exposure, which refers to the average airborne concentration of a substance over the entire 8 to 10-hour workday. Concentrations are usually expressed in parts per million (ppm) or milligrams per cubic meter (mg/m^3). In addition, for some substances there are short-term exposure limits or ceiling limits which are intended to supplement the TWA limits where there are recognized toxic effects from short-term exposures.

The NIOSH recommendations and ACGIH TLVs may be lower than the corresponding OSHA standards, as both are usually based on more recent information. The OSHA standards also are required to take into account the feasibility of reducing exposures in various industries where the agents are used; whereas the NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. In evaluating worker exposure levels and NIOSH recommendations for reducing exposures, it should be noted that employers are legally required to meet the requirements of OSHA PELs and other OSHA standards.

B. Emissions from PVC films

Thermal decomposition products from flexible PVC film, which generally contains plasticizers and other additives, have been reported to be a function of temperature and the density of the material. Substances which have previously been identified in heated PVC film emissions include hydrochloric acid, benzene, toluene, and di-isooctyl adipate (di-2-ethylhexyl adipate) [5,6].

"Meat wrappers asthma" is a term used to describe acute respiratory symptoms, such as wheezing, shortness of breath, and chest tightness, occurring in some workers exposed to emissions from the cutting and sealing of PVC film with a hot wire or the application of labels to PVC film with a

heat-activated adhesive. A high prevalence of chronic respiratory symptoms in meat wrappers exposed

to PVC contaminants has also been reported, but allergic sensitization, although possible, has not been demonstrated [7].

C. Specific substances

1. Hydrogen chloride

Overexposure to hydrogen chloride (HCl) gas or hydrochloric acid mist can cause irritation of the respiratory tract, with burning, choking, and coughing. At high concentrations, severe breathing difficulties may occur, which may be delayed in onset. Repeated exposure of the skin to dilute solutions of hydrogen chloride may cause a rash. Most people can detect HCl at concentrations of 1-5 ppm [8]. The current OSHA PEL and ACGIH TLV-TWA for HCl are 7 and 7.5 mg/m^3, respectively; there is no NIOSH REL.

2. Di-n-butyl phthalate and di-2-ethyhexyl phthalate

Little data are available regarding the health effects from exposure to phthalates. Studies of phthalate esters, such as di-n-octyl and di-2-ethylhexyl phthalates show a very low acute toxicity, although there is evidence the latter substance is carcinogenic in rodents. There are currently no evaluation criteria for these phthalates.

3. Methylene chloride

Overexposure to the vapor, which is a mild central nervous system depressant, may cause mental confusion, light-headedness, nausea, and headache. Skin exposure to the liquid may cause irritation. Excessive carboxyhemoglobin levels in the bloodstream may follow exposure, putting persons with cardiac disease at increased risk [8]. This may make the symptoms of angina worse. NIOSH recommends treating methylene chloride as a potential human carcinogen and reducing exposure to the lowest feasible level; methylene chloride has produced tumors of the lung, liver, salivary, and mammary glands in animal studies [2]. The OSHA PEL and ACGIH TLV-TWA for methylene chloride are 174 mg/m^3, with a notation on the TLV that methylene chloride is a suspect human carcinogen and that exposure should be controlled to levels as low as reasonably achievable (ALARA) below the TLV.

4. Perchloroethylene (Tetrachloroethylene)

Overexposure to perchloroethylene may cause headache, nausea, drowsiness, dizziness, incoordination, and unconsciousness. It

may also cause irritation of the eyes, nose, and throat and flushing of the face and neck [8]. NIOSH recommends treating perchloroethylene as a potential human carcinogen and reducing exposure to the lowest feasible level; perchloroethylene has produced liver tumors in animal studies [2]. The OSHA PEL and ACGIH TLV-TWA for perchloroethylene are 339 and 170 mg/m^3, respectively, with a notation on the TLV that perchloroethylene has been identified by other sources as a suspect human carcinogen.

5. 1,1,1-Trichloroethane

Overexposure to 1,1,1-trichloroethane causes central nervous system depression, which may include drowsiness, dizziness, incoordination, and unconsciousness. Transient eye irritation for moderate exposures, and cardiac effects for high exposures have been reported among exposed workers [9]. The NIOSH REL for 1,1,1-trichloroethane is 1091 mg/m^3 as a TWA. The OSHA PEL and ACGIH TLV-TWA for 1,1,1-trichloroethane are 1900 and 1910 mg/m^3, respectively.

6. Isopropanol (isopropyl alcohol)

Overexposure to isopropanol may cause mild irritation of the eyes, nose, and throat. Drowsiness, headache, and incoordination may also occur [8]. The NIOSH REL for isopropanol is 984 mg/m^3 for a TWA, with a ceiling limit of 1,968 mg/m^3. The OSHA PEL and ACGIH TLV-TWA are 980 and 983 mg/m^3, respectively.

7. Methyl methacrylate

Overexposure to methyl methacrylate may cause irritation of the eyes, skin, and mucous membranes. Handlers of methyl methacrylate cement have developed paresthesia of the fingers. In one study, a high incidence of headache (78%) was reported among workers exposed to 0.5 to 50 ppm [9]. The OSHA PEL and ACGIH TLV-TWA are 100 ppm (410 mg/m^3). There is no NIOSH REL for this substance.

VI. RESULTS AND DISCUSSION

Environmental

A. Results from heated bulk PVC film sample

To determine compounds present in emissions from overheating the PVC film used at Bussmann/Cooper (i.e. a meltdown in the blister

pack machine), pieces of the film were heated to approximately 380°C in the laboratory, and the headspace was sampled using detector and solid sorbent tubes.

At this temperature, the plastic material immediately charred and evolved high levels of hydrochloric acid (confirmed with HCl detector tube and pH paper). The acidic vapors reacted with the reagent coating the sorbent in the Orbo 23 tubes used to sample for aldehydes, rendering them useless for determining the presence or absence of aldehydes, but still able to trap other VOCs. Subsequent analysis of the Orbo 23 tubes by GC/MS detected alkyl phenols, biphenyl compounds, and some polyaromatic hydrocarbons (PAHs). The acetone rinse of the oven tubing contained similar substances. Analysis of the charcoal tube sample of the headspace by GC/MS revealed that the following compounds were constituents of the emissions: benzene, styrene, ethyl benzene, toluene, methyl methacrylate, naphthalene, biphenyl, xylenes, alkyl phenols, 4-vinyl-1-cyclohexane, numerous chlorinated alkanes and chlorinated alkyl benzenes, and various nitrile compounds.

A wide variety of toxic or irritating compounds were detected in the emissions from overheating (meltdown) of the PVC film sample. These were thermal decomposition products of PVC, additives, and plasticizers added by the manufacturer of the film. Since thermal decomposition is a function of temperature, different ratios of similar compounds would be expected in the emissions during normal processing.

B. Results from Area and Process Samples

Sample results from the two area and one process sample locations are presented in Table 1. The locations were: (1) inside the local exhaust ventilation (LEV) enclosure above the blister pack machine (process sample); (2) the "Buss-Pluss" area on work table, 20 feet from machine; and (3) the coil-winding area near short-circuit wheel 10 feet from machine. The process sample for VOCs was qualitatively analyzed to determine which substances to quantitate in the area VOC samples.

The major VOCs detected in qualitative analysis of the process sample were isopropanol, 1,1,1-trichloroethane, perchloroethylene, and methylene chloride. Other organic compounds identified included various branched aliphatic hydrocarbons (C_9 to C_{12}) and aliphatic alcohols, methyl isobutyl ketone, butanol, butyl acetate, toluene, xylenes, ethanol, trichloroethylene, methyl methacrylate, pentanol,

hexane, and ethyl oxirane. The concentration of hydrogen chloride was 0.18 mg/m^3 in the process sample, as a 4-hour TWA it is not comparable to the OSHA and ACGIH ceiling limits of 7 mg/m^3. This TWA value does not exclude the possibility that hydrogen chloride levels exceeded the ceiling limits during the sampling period. No aldehydes, methyl methacrylate, or phthalates were detected in the process samples collected on the sample media specific for these compounds.

The two area VOC samples were analyzed quantitatively for isopropanol, 1,1,1-trichloroethane, perchloroethylene, and methylene chloride, the major compounds detected in qualitative analysis of the process sample. The concentrations of 1,1,1 trichloroethane (23.6 and 24.1 mg/m^3) and isopropanol (18.4 and 22.4 mg/m^3) in both samples were less than 3% of the NIOSH RELs of 1091 and 984 mg/m^3, respectively.

Both area air samples revealed detectable concentrations of methylene chloride (4.02 and 4.24 mg/m^3) and perchloroethylene (24.1 and 24.6 mg/m^3). NIOSH recommends that methylene chloride and perchloroethylene be treated as suspect human carcinogens, and that occupational exposures be reduced to the lowest feasible level (LFL).

The measured concentrations of hydrogen chloride were less than the limit of detection (0.05 mg/m^3) and 0.39 mg/m^3 at 20 feet and 10 feet from the blister pack machine, respectively. As 4-hour TWAs, these concentrations are not comparable to the OSHA and ACGIH ceiling limits of 7 mg/m^3. The TWA value at 10 feet from the machine does not exclude the possibility that the ceiling limits were exceeded during the sampling period--additional short-term sampling during high production periods would be necessary to establish maximum concentrations. No aldehydes, methyl methacrylate, or phthalates were detected in the area samples on the respective sample media specific for those compounds.

In summary, on the day of the survey low or less-than-detectable average concentrations of the irritant constituents (methyl methacrylate, hydrogen chloride, aldehydes, acrylonitrile, phthalates) of PVC film emissions were present in work areas near the blister pack machine. Since methylene chloride, perchloroethylene, isopropanol, and 1,1,1 trichloroethane were not detected in emissions from the bulk PVC film sample heated in the laboratory, but were present in all field samples taken, the likely source for those compounds in the air was the use of cleaning solvents in adjacent work areas.

C. Bulk Fiber Sample

What appeared to be yellow fibers collected from the blister pack packaging boxes were examined by PLM and found to be white fibers coated with a yellow resin. 100X magnification revealed that the fibers have jagged edges, are a teflon polymer, and comprise about 90% of the sample. The remaining 10% of the sample was brown fibrous paper derived from coniferous wood. The fibers described above could be a source of skin irritation among box handlers.

D. Local Exhaust and General Ventilation

An inspection of the general ventilation system serving the blister pack area revealed that there is a potential for entrainment of the blister pack machine exhaust into the air intake for air-handling unit #7, which serves the Buss-Pluss, and Coil-Winding areas. The local exhaust ventilation for the blister pack machine ends in a straight stack extending 8.5 feet above the roofline. The air intake for unit #7 is located 2-4 feet above the roofline approximately 50 feet SSE from the blister pack exhaust. With this arrangement, the flow patterns and turbulence of air passing over the building could cause recirculation of exhaust gases into the work areas, depending on wind direction and velocity. On the day of the survey a steady wind was blowing from the SSW, which would tend to minimize entrainment.

An evaluation of the local exhaust ventilation (LEV) on the blister pack machine using smoke tubes revealed that capture of emissions above the heating oven and molding processes was effective at the time of the survey. However, the exhaust from the vacuum pump located inside the machine enclosure near the floor was directed primarily into the work area, rather than into the LEV enclosure. Since the pump is used to create a partial vacuum which pulls the hot PVC film against the blister mold, the pump exhaust would be expected to contain PVC film emissions.

<u>Medical</u>

The 12 employees who were interviewed had a variety of complaints which they associated with emissions from heated PVC used in the blister pack machine. Their symptoms began occurring within weeks after the blister pack machine was installed in March 1989 and continued until November 1989, when ventilation changes were made on the machine. Symptoms began recurring on February 6, 1990. The predominant symptoms include: sinus problems/nasal irritation (5 individuals), headaches (5), skin irritation (4), breathing

difficulties (3), throat irritation/hoarseness (2), and eye irritation, metallic taste, and numbness (1 each). Eight individuals had sought medical care in the last year for these complaints. All 12 employees worked around or in the vicinity of the blister pack machine. There were, however, approximately 30 individuals who worked in the vicinity of this machine who did not complain of symptoms.

Review of medical records of four employees who had sought medical care were not helpful in determining a definitive diagnosis for these individuals.

The four individuals with skin complaints were examined at the time of the interview and found to have mild to moderate macular erythema (discrete areas of redness of the skin) on the inner forearms (2 individuals), on the upper chest (2), and on the flank, neck, and chin (1 each). The appearance of the rash was consistent with an irritant skin reaction.

Ten of the 12 employees felt that their symptoms were worse when the blister pack machine experienced a melt-down of PVC or when the machine was run at higher temperatures (such as during the production of larger PVC blisters or when the rate of production is increased on the machine).

The blister pack process can release hydrogen chloride, which is a known irritant and could cause eye, upper respiratory, and skin irritation. Hydrogen chloride can be detected by most persons at concentrations of 1 to 5 ppm. At slightly higher concentrations (5 to 10 ppm) it is immediately irritating. Previous industrial hygiene monitoring, however, showed only very low concentrations of this irritant. Our sampling also showed relatively low levels but could have missed a short-term higher exposure. Some other decomposition products that can cause similar irritant symptoms include: formaldehyde, phthalates, hydrogen sulfide, acrylonitrile, and diethylhexyl adipate.

VII. RECOMMENDATIONS

In view of the potential carcinogenicity of methylene chloride and perchloroethylene, and as a reasonable approach to reducing workers' exposures to hydrogen chloride and other compounds in the PVC film emissions which may at times reach irritant levels, we advise implementing the following recommendations:

1. **Substitute less hazardous cleaning solvents for perchloroethylene and methylene chloride in all areas served by general or dilution ventilation.**

2. Connect a hose to the blister pack machine vacuum pump to direct all of the exhaust into the LEV enclosure, and then to the exhaust stack outside.

3. To avoid entrainment of exhaust gases into air intakes, the exhaust stack(s) should be extended above the height of the recirculation zone on the roof of the building. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) recommends that the height of the zone of recirculation be considered to equal approximately:

   a. $0.3(A)^{0.5}$, where A=height (H) x width (W) facing the wind (where building width:height ratio is less than 8:1)

      or

   b. 0.85 x smaller of H or W (where building width:height ratio is greater than 8:1) [10].

4. Blister pack machine exhaust ducting that is under positive pressure (i.e. downstream of the fan) inside the building should be inspected for leaks and adequately sealed if necessary. Periodic evaluation of the ventilation system should be performed to insure that it is working effectively.

5. Continue to respond to worker complaints of symptoms by worksite monitoring and prompt medical evaluation at the time of the incidents. Further sampling for hydrogen chloride, to assess peak concentrations in work areas during short-term periods of expected maximum exposure, should be conducted.

6. Box handlers should be provided light cotton gloves to reduce skin exposure to paper and polymer fibers.

VIII. REFERENCES

1. NIOSH Manual of Analytical Methods, 3rd Edition, Vol. 1 and 2, with 1985, 1987, and 1989 supplements. Eller, P., Editor. DHHS (NIOSH) Publication No. 84-100.

2. Centers for Disease Control. NIOSH Recommendations for Occupational Safety and Health Standards 1988. MMWR 37 (S-7): 1-29 (1988).

3. ACGIH. Threshold Limit Values and Biological Exposure Indices for 1989-1990. ACGIH, Cincinnati, Ohio. 1989.

4. U.S. Department of Labor, OSHA. Air Contaminants-Permissible Exposure Limits. Title 29 Code of Federal Regulations, Part 1910.1000, OSHA 3112, 1989.

5. Vandervort, R.; Brooks, S.M.: Polyvinyl Chloride Film Thermal Decomposition Products as an Occupational Illness, 1. Environmental Exposures and Toxicology. Jour. of Occupational Medicine. 19(3):188-191 (1977).

6. NIOSH Health Hazard Evaluation Report HETA 84-239-1586, Ashland Super Valu, Ashland, Wisconsin. NIOSH (1985).

7. Vandervort, R.; Brooks, S.M.: Polyvinyl Chloride Film Thermal Decomposition Products as an Occupational Illness, 2. Clinical Studies. Jour. of Occupational Medicine. 19(3):192-196 (1977).

8. NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards, Volumes 1-3 and Supplement II-OHG. NIOSH Publications 81-123 and 89-104, 1981,1988.

9. Proctor, N.H., Hughes,J.P., and Fischman, M.L. Chemical Hazards of the Workplace, 2nd Ed. J.B. Lippincott, 1988.

10. ASHRAE Handbook 1985 Fundamentals Volume, Inch-Pound Ed. Air Flow Around Buildings. ASHRAE, Atlanta, Georgia. p 14.1-14.20 (1985).

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:
Aaron L. Sussell, M.P.H.
Industrial Hygienist
Industrial Hygiene Section

Boris D. Lushniak, M.D., M.P.H.
Medical Officer
Medical Section

Originating Office:
Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations and Field Studies

Report Typed By:
Sharon Jenkins
Clerk (Typing)
Industrial Hygiene Section

X. DISTRIBUTION AND AVAILABILITY OF REPORT

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

1. **Bussmann/Cooper Industries**
2. **International Union of Electronic, Electrical, Technical, Salaried, & Machine Workers, AFL-CIO Local 764**
3. **NIOSH Atlanta Region**
4. **OSHA, Region IV**

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.

Addresses:

David Day, Cooper Industries, First City Tower, Suite 4000, P.O. Box 4446, Houston, TX 77210

Ms. Helen Cundiff, 21300 South Har Spring Rd., Big Clifty, KY 42712

TABLE 1

BUSSMAN/COOPER INDUSTRIES
ELIZABETHTOWN, KY
FEBRUARY 22, 1990
HETA 90 - 172

Analyte	Location	Start (HH:MM)	Stop (HH:MM)	Volume liters	Conc. mg/m^3	LOD mg/m^3	ACGIH-TLV mg/m^3	OSHA-PEL mg/m^3	NIOSH-REL mg/m^3
1,1,1 TRICHLOROETHANE	3	11:21	15:50	53.8	23.6	0.06	1910	1900	1091
1,1,1 TRICHLOROETHANE	2	11:03	15:35	54.4	24.1	0.06			
ALDEHYDES	3	11:21	15:52	13.6	N.D.	0.07			
ALDEHYDES	2	11:03	15:30	13.4	N.D.	0.07			
ALDEHYDES	1	10:58	16:03	15.3	N.D.	0.07			
HYDROGEN CHLORIDE	3	11:23	15:55	136.1	0.39	0.05	7.5	7	
HYDROGEN CHLORIDE	2	11:05	15:55	145.1	N.D.	0.05			
HYDROGEN CHLORIDE	1	11:00	16:05	152.6	0.18	0.05			
ISOPROPANOL	3	11:21	15:50	53.8	18.4	0.09	983	980	984
ISOPROPANOL	2	11:03	15:35	54.4	22.4	0.09			
METHYL METHACRYLATE	3	11:21	15:50	13.5	N.D.	0.74	410	410	
METHYL METHACRYLATE	2	11:03	15:35	13.6	N.D.	0.73			
METHYL METHACRYLATE	1	10:58	16:06	15.4	N.D.	0.65			
METHYLENE CHLORIDE	3	11:21	15:50	53.8	4.24	0.06	174	1735	LFL
METHYLENE CHLORIDE	2	11:03	15:35	54.4	4.02	0.06			
PERCHLOROETHYLENE	3	11:21	15:50	53.8	24.1	0.06	339	170	LFL
PERCHLOROETHYLENE	2	11:03	15:35	54.4	24.6	0.06			
PHTHALATES	3	11:23	15:55	544.3	N.D.	0.02			
PHTHALATES	2	11:05	15:59	588.4	N.D.	0.02			
PHTHALATES	1	11:00	16:02	604.4	N.D.	0.02			
TOTAL HYDROCARBONS	3	11:21	15:50	53.8	2.2	0.02			
TOTAL HYDROCARBONS	2	11:03	15:35	54.4	1.9	0.02			

LOCATION: 1. Blister-pack machine
2. 20 feet from machine
3. 10 feet from machine

LOD: Limit Of Detection
LOQ: Limit Of Quantitation

LFL: Lowest Feasible Level (Potential for cancer in humans)
mg/m^3: milligrams per cubic meter
ppm: Parts Per Million
REL: Recommended Exposure Limit
N.D.: None Detectable, <LOD