# NIOSH HEALTH HAZARD EVALUATION REPORT:

# HETA 2003-0102-2921
# Bemis
# West Hazelton, Pennsylvania

# December 2003

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

# PREFACE

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

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

# ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Drs. Chandran Achutan and Daniel Rhodes of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Mr. Greg Burr of HETAB. Analytical support was provided by DataChem Laboratories (Salt Lake City, Utah) and the Division of Applied Research and Technology. Desktop publishing was performed by Shawna Watts. Review and preparation for printing were performed by Penny Arthur.

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# Health Hazard Evaluation Report 2003-0102-2921
# Bemis
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# December 2003

**Chandran Achutan, Ph.D.**
**Daniel W. Rhodes, M.D., M.P.H.**
**Greg Burr, C.I.H.**

## SUMMARY

On December 9, 2002, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Graphics Communications International Union to conduct a health hazard evaluation (HHE) at Bemis, in West Hazelton, Pennsylvania. Employees were concerned that work conditions in the bag, press, and extrusion departments were contributing to sinus infections, coughing, sneezing, sore throat, and eye irritation.

On March 24-25, 2003, NIOSH investigators conducted a site visit at Bemis. Following an opening conference with management and union representatives, NIOSH investigators toured the facility. On March 25, personal and area air sampling was conducted for ozone and volatile organic compounds (VOCs) in the extrusion department, VOCs in the press department, and VOCs, formaldehyde, acetaldehyde, acrolein, and particulates in the bag department.

Twenty one employees were interviewed from all areas of the plant. Every tenth employee was selected from a list of 290 employees who worked the day shift. Interviews covered employees' work history, past medical history, smoking history, and current symptoms, complaints, and concerns.

The concentration of formaldehyde ranged from 0.04 to 0.09 parts per million (ppm). This exceeds the NIOSH Recommended Exposure Limit (REL) of 0.016 ppm, but is below the Occupational Safety Health Administration (OSHA) and American Conference of Governmental Industrial Hygienists' (ACGIH) criteria. Concentrations of acrolein, acetaldehyde, ethanol, isopropanol, 1-propanol, ethyl acetate, propyl acetate, butyl acetate, and toluene were below all recommended and regulatory criteria. Particle size characterization indicated that 99.9% of the particles were in the respirable range, with a concentration of 0.32 milligram/cubic meter ($mg/m^3$). This is below the OSHA Permissible Exposure Limit (PEL) of 5 $mg/m^3$ and the ACGIH's recommended value of 3 $mg/m^3$ for respirable particulates. A majority (57%) of interviewed employees reported upper respiratory or mucous membrane irritation, which they associated with smoke in the bag department. The haze is a result of emissions during the bag manufacturing process. Chemicals used in the manufacturing process of the bags, such as formaldehyde, acrolein, acetaldehyde and VOCs, are likely to be found in the haze. It is possible that low levels of exposure to these chemicals can result in irritative effects.

Air sampling results indicate the presence of a variety of chemical substances in the press, bag, and extrusion departments. However, quantitative measurements of most of these substances indicate that airborne concentrations are below those believed to result in chronic health effects, though some irritative symptoms might occur with minimal exposure. The airborne concentration of formaldehyde exceeded the NIOSH REL. Recommendations are included in this report to further improve the air quality in the bag department by introducing dilution ventilation in addition to the local exhaust ventilation currently in place. Following the ventilation changes, the concentrations of formaldehyde and particulates should be monitored again.

Keywords: particulates, formaldehyde, VOCs, sinus irritation, bag making
SIC Code: 3081 (Manufacturing of Unsupported Plastics Film and Sheet)

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# INTRODUCTION

On December 9, 2002, the National Institute for Occupational Safety and Health (NIOSH) received a request to conduct a health hazard evaluation (HHE) at Bemis, in West Hazelton, Pennsylvania. The request stated that employees were concerned that sinus infections, coughing, sneezing, sore throat, and eye irritation were related to their work environment.

On March 24-25, 2003, NIOSH investigators conducted a survey at Bemis. On March 24, 2003, an opening conference was held between NIOSH representatives and the management and the Graphic Communications International Union Local 735S representatives. Following the opening conference, NIOSH investigators toured the facility with management and union representatives. On March 25, air monitoring was conducted in the extrusion, press, and bag departments. In addition, confidential interviews were conducted with serially selected employees concerning their health and work environment.

# BACKGROUND

Bemis was founded in 1858 in St. Louis, MO and is a manufacturer of flexible packaging and pressure sensitive materials. Roughly three-quarters of the company's sales are packaging related. The primary market for the company's products is the food industry, which accounts for 65% of sales. The Hazelton plant, a large, rectangular building, consisting of single-level, "high-bay"areas has been in operation since 1966, and employs approximately 600 people. It produces printed polyethylene film and bags for the bakery industry. The manufacturing process involves the extrusion of film, flexographic printing, and bag making. The facility operates 24 hours per day using a variety of shift schedules that generally differ between departments.

## Extrusion Department

Polyethylene and other ingredients are extruded together (forced under high pressure through a hot, metal die) continuously, and the resulting plastic film proceeds through an array of rollers to a cutter and onto large rollers or spools. This process produces a variety of chemicals such as alcohols, acetates, aliphatic hydrocarbons, and ozone, during the melting of the polyethylene pellets. The extrusion department operates 24 hours a day, for 7 days a week. The department employs approximately 50 people who are organized into four crews.

## Press Department

Mat boards are hardened in mold-making machines using a heated process. Once hardened, the molds can be used to make rubber printing plates, which are then affixed to the rollers of printing presses and used to print labels onto plastic films used in packaging. A varity of solvents are used in the printing process, including, alcohols, solvent blends, and solvent-based inks. There are 18 flexographic presses, operating 24 hours a day, seven days a week. The printing department employs approximately 230 people, who are organized into four crews.

## Bag Department

Plastic films are heat-sealed on 62 automated bag machines to make plastic bags for packaging. The thermal sealing and cutting of the bags releases smoke that contain formaldehyde and acrolein, various other organic vapors and particulates. The bag machines are equipped with local exhaust ventilation. The bag department employs 170 people, who work 5 days per week on three 8-hour shifts.

# METHODS

## Industrial Hygiene Evaluation

The industrial hygiene evaluation consisted of evaluating the ozone exposure in the extrusion department, evaluating volatile organic compounds (VOCs) in the printing and bag departments and evaluating VOCs, acetaldehyde, formaldehyde, acrolein, carbon monoxide, and particulates in the bag department.

Ozone was measured in the extrusion department using a colorimetric tube (Draeger, Sicherheitstechnik, Germany). One end of the tube is placed inside an hand-held air pump, and the other end, is exposed to the atmosphere. Air is drawn through the tube by squeezing the hand pump ten times, as specified by the manufacturer. The airborne concentration of ozone is determinded by the length of stain on the material inside the tube.

Side-by-side area samples (samples collected in fixed locations) for VOCs in the printing and bag departments were collected using thermal desorption tubes for qualitative analysis, and charcoal tubes for quantitative analysis. Thermal desorption and charcoal tubes were placed in the press, extrusion, and bag departments. Additional thermal desorption tubes were placed in the break rooms of the press and bag departments. Thermal desorption tubes were sampled and analyzed per NIOSH Manual of Analytical Methods (NMAM) 2549, at a flow rate of 50 mL/min[1]. The charcoal tubes were run at a flow rate of 100 mL/min.

One area and four personal breathing zone (PBZ) samples (samples collected in the breathing zone of individual employees) were collected for acetaldehyde and formaldehyde using silica gel tubes impregnated with 2,4-dinitrophenylhydrazine (Supelco, Bellefonte, PA), and for acrolein, using XAD-2 sorbent tubes (SKC Inc., Eighty-Four, PA) Acetaldehyde and formaldehyde were sampled at a flow rate of 100 mL/min, and analyzed by a combination of NMAM 2016 and NMAM 2018.[1] Acrolein was sampled at a flow rate of 100 mL/min, per NMAM 2539.[1] Particulate exposure was measured by a direct reading optical particle counter (GRIMM, Hamburg, Germany) with data logging capability. Carbon monoxide was measured using a direct reading electrochemical sensor (QTRAK, TSI, Minneapolis, MN). However, due to equipment malfunction, no data are available for carbon monoxide.

## Medical Evaluation

The medical evaluation consisted of confidential interviews with serially selected employees from an employee roster. Every tenth employee was selected from a list including only those who worked a day time shift. Selected employees represented all areas of the plant. The company leave of absence reports for approximately the past five years were reviewed as well as the Illness and Injury reports (OSHA 200/300 logs) for approximately the past three years.

## EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ 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 increases 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),[2] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[3] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[4] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criteria.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 91–596, sec. 5(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

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 STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term. Table 1 summarizes the exposure criteria used for the substances tested in this study.

## Formaldehyde

Formaldehyde is a colorless gas with a strong odor. Exposure can occur through inhalation and skin absorption. The acute effects associated with airborne exposure are irritation of the eyes and respiratory tract, and sensitization of the skin. The first acute symptoms associated with formaldehyde exposure, at concentrations ranging from 0.1 to 5 parts per million (ppm), are burning eyes, tearing, and general irritation of the upper respiratory tract. There is variation among individuals, in terms of their tolerance and susceptibility to acute exposures of the compound.[5]

In two separate studies, formaldehyde has induced a rare form of nasal cancer in rodents. Formaldehyde exposure has been identified as a possible causative factor in cancer of the upper respiratory tract in a proprotionate mortality study of workers in the garment industry.[6] NIOSH recommends treating formaldehyde as a potential carcinogen. The NIOSH REL is 0.016 ppm. The OSHA PEL is 0.75 ppm for an 8-hour TWA and 2 ppm for a STEL.[7] ACGIH has designated formaldehyde a suspected human carcinogen and therefore recommends that "worker exposure by all routes should be carefully controlled to levels as low as possible below the TLV", which is a ceiling limit of 0.3 ppm.[3]

## Particulates Not Otherwise Classified

Often the chemical composition of the airborne particulate does not have an established occupational health exposure criterion. It has been

the convention to apply a generic exposure criterion in such cases. Formerly referred to as nuisance dust, the preferred terminology for the non-specific particulate ACGIH TLV criterion is now *"particulates, not otherwise classified (n.o.c.),"* [or *"not otherwise regulated"* (n.o.r.) for the OSHA PEL]. The OSHA PEL for total particulate, n.o.r., is 15.0 milligram/cubic meter ($mg/m^{3)}$ and 5.0 $mg/m^3$ for the respirable fraction, determined as 8-hour averages. The ACGIH recommended TLV for exposure to a particulate, n.o.c., is 10.0 $mg/m^3$ (total dust, 8-hour TWA), and 3.0 $mg/m^3$ for respirable particles. These are generic criteria for airborne dusts which do not produce significant organic disease or toxic effect when exposures are kept under reasonable control.[8] There is no NIOSH REL for nuisance dust.

## Ozone

Ozone is a toxic gas consisting of three oxygen molecules. It is an oxidant air pollutant that irritates and damages mucous membranes and lung tissues.[9] Ozone is federally regulated in both the ambient and the occupational environments. To protect public health the Environmental Protection Agency National Ambient Air Quality Standard primary standard regulates $O_3$ in ambient air to 0.08 parts per million (ppm) as a maximum eight hour average, and 0.12 ppm as a one hour average.[10] The Occupational Safety and Health Administration regulates $O_3$ in the occupational environment as a time-weighted average of 0.10 ppm.[11] The National Institute for Occupational Safety and Health (NIOSH) recommends a ceiling concentration (not to be exceeded at any time) of 0.10 ppm.[2] The American conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) for full-shift occupational ozone exposures ranges from 0.1, 0.08, and 0.05 for light, moderate, and heavy work, respectively.[3]

## Volatile Organic Compounds

Volatile organic compounds describe a large class of chemicals which are organic (i.e., containing carbon) and have a sufficiently high vapor pressure to allow some of the compound to exist in the gaseous state at room temperature.

Research also suggests that the irritant potency of these VOC mixtures can vary. While in some instances it may be useful to identify some of the individual chemicals which may be present, the concept of *total volatile organic compounds (TVOC)* has been used in an attempt to predict certain types of health effects.[12] The use of this TVOC indicator, however, has never been standardized.

Some researchers have compared levels of TVOCs with human responses (such as headache and irritative symptoms of the eyes, nose, and throat). Research conducted in Europe suggests that complaints by building occupants may be more likely to occur when TVOC concentrations increase.[13] It should be emphasized that the highly variable nature of these complex VOC mixtures can greatly affect their irritancy potential. Considering the difficulty in interpreting TVOC measurements, caution should be used in attempting to associate health effects (beyond nonspecific sensory irritation) with specific TVOC levels.

## Toluene

Toluene is a colorless, aromatic organic liquid containing a six carbon ring (a benzene ring) with a methyl group ($CH_3$) substitution. It is a typical solvent found in paints and other coatings, and used as a raw material in the synthesis of organic chemicals, dyes, detergents, and pharmaceuticals. It is also an ingredient of gasoline, ranging from 5% to 22%.[1415] A previous NIOSH evaluation

found toluene content of gasoline ranging from 2.4% to 12%, with exposure levels from none detected to 0.56 ppm.[16]

Inhalation and skin absorption are the major occupational routes of entry. Toluene can cause acute irritation of the eyes, respiratory tract, and skin. Since it is a defatting solvent, repeated or prolonged skin contact will remove the natural lipids from the skin which can cause drying, fissuring, and dermatitis.[9,17]

The main effects reported with excessive (inhalation) exposure to toluene are CNS depression and neurotoxicity.[9] Studies have shown that subjects exposed to 100 ppm of toluene for six hours complained of eye and nose irritation, and in some cases, headache, dizziness, and a feeling of intoxication (narcosis).[18,19,20] No symptoms were noted below 100 ppm in these studies. There are a number of reports of neurological damage due to deliberate sniffing of toluene-based glues resulting in motor weakness, intention tremor, ataxia, as well as cerebellar and cerebral atrophy. Recovery is complete following infrequent episodes, however, permanent impairment may occur after repeated and prolonged glue-sniffing abuse. Exposure to extremely high concentrations of toluene may cause mental confusion, loss of coordination, and unconsciousness.[21,22]
Originally, there was a concern that toluene exposures produced hematopoietic toxicity because of the benzene ring present in the molecular structure of toluene. However, toluene does not produce the severe injury to bone marrow characteristic of benzene exposure as early reports suggested. It is now believed that simultaneous exposure to benzene (present as a contaminant in the toluene) was responsible for the observed toxicity.[8,17]

The NIOSH REL for toluene is 100 ppm for an 8-hour TWA. NIOSH has also set a recommended STEL of 150 ppm for a 15-minute sampling period. The OSHA PEL for toluene is 200 ppm for an 8-hour TWA. The ACGIH TLV® is 50 ppm for an 8-hour exposure level. It carries a skin notation, indicating that cutaneous exposure contributes to the overall absorbed inhalation dose and potential systemic effects.

## Isopropanol

Isopropanol is a colorless, volatile, flammable liquid of low toxicity that is used as a chemical intermediate, as a general purpose solvent, and is present in skin lotions, cosmetics, and pharmaceuticals.[8,9]

The vapor of isopropanol is irritating to the eyes and mucous membranes; inhalation of high concentrations can cause depression of the central nervous system.[9,23] The potential effects from dermal contact with the liquid are insignificant; cutaneous absorption should not contribute to systemic toxicity, and generally does not produce skin irritation, except with hypersensitive individuals.[8,24]

The inhalation exposure criteria established for isopropanol by NIOSH, OSHA, and ACGIH are equivalent to a full-shift TWA of 400 ppm, and a 15- minute STEL of 500 ppm.

## Ethanol

Upon inhalation, ethanol vapors cause slight symptoms of poisoning when air concentrations are about 1000 ppm, and strong stupor and morbid sleeplessness at 5000 ppm. According to ACGIH, "The inhalation of alcohol vapor causes local irritating effects on the eyes, headaches, sensation of heat, intraocular vision, stupor, fatigue, and a great need for sleep".[4] The NIOSH REL, OSHA PEL, and ACGIH TLV are all 1000 ppm for an 8-hour TWA exposure.

## n-Propanol

Vapors of n-propyl alcohol, or n-propanol, are irritating to the eyes and upper respiratory tract. Ingestion of the liquid has reportedly lead to one fatality. In animal studies, narcotic effects have been noted. In two small chronic animal studies, increased rates of malignant tumors were reported in rats directly injected with n-propanol, compared with control groups. The NIOSH REL, OSHA PEL, and ACGIH TLV are all 200 ppm for an 8-hour TWA exposure. NIOSH and ACGIH also recommend STELs of 250 ppm, and add the "skin" designation to their criteria to indicate the possibility of sufficient absorption through the skin, upon direct contact, to induce systemic effects.[2,3,4]

## Butyl Acetate

Exposure to butyl acetate vapors can cause irritation to the respiratory tract. Symptoms may include coughing, and shortness of breath. At high concentrations, butyl acetate possesses narcotic properties. Studies on humans have shown that butyl acetate vapors at a concentration of 200-300 ppm can cause eye and mucous membrane irritation, when exposures last from 3 to 20 minutes.[12] The NIOSH REL, OSHA PEL and ACGIH TLV are all 150 ppm for an 8-hour TWA. In addition, NIOSH and ACGIH have STELS of 200 ppm.

## Ethyl Acetate

Ethyl acetate vapor causes eye, skin, and respiratory tract irritation at concentrations above 400 ppm. Exposure to high concentrations may lead to headache, nausea, blurred vision, central nervous system depression, dizziness, drowsiness, and fatigue. Eye contact with the liquid can produce temporary irritation and lacrimation. Skin contact produces irritation.[12] The NIOSH REL, OSHA PEL and ACGIH TLV are all 400 ppm for an 8-hour TWA.

## Propyl Acetate

According to ACGIH, "there are few data upon which to base a TLV for n-propyl acetate. From the acute animal inhalation studies, n-propyl acetate appears to be more toxic than isopropyl acetate or ethyl acetate, but less toxic than n-butyl acetate". At high concentrations, animal studies show narcotic effects; salivation and eye irritation were also noted.[12] The NIOSH REL, OSHA PEL, and ACGIH TLV are all 200 ppm for an 8-hour TWA exposure. NIOSH and ACGIH recommend STELs of 250 ppm.

# RESULTS

## Industrial Hygiene Evaluation

A qualitative analysis of VOCs using thermal desorption tubes indicated the presence of a number of organic compounds (Table 2). Of these, seven analytes were chosen for quantitative analysis, based on the relative amount present in the environment, their relative toxicities compared to other organic compounds, and ability to separate them from the mixture. The results from the quantitative analysis are presented in Tables 3 and 4. The formaldehyde concentrations exceeded the NIOSH REL of 0.016 ppm, but did not exceed ACGIH's recommended value or OSHA's PEL. All other compounds were below the exposure criteria. In addition, the TLV for the VOC mixture, calculated per the ACGIH formula for mixtures,[3] was less than one, indicating no over exposure to these compounds.

The colorimetric indicator tubes used to measure ozone showed a slight discoloration (from yellow

to pink), and did not extend beyond the lowest concentration segment of 0.05 ppm. Thus, the ozone concentrations in the extrusion area were less than 0.05 ppm.

Particulate measurements indicate that 99.9% of the aerosols in the bag department are in the respirable range (Figure 1). When further broken down by particle size, 95% of the particulates were in the submicron range (1.0 micrometer [μm] or less). The concentration of particulates in the bag department was 0.32 $mg/m^3$, well below the PEL and TLV.

## Medical Evaluation

### Interviews

A total of 21 (4%) employees were serially selected for interviews from a list of 532 current employees. Employees either work on a 3 shift, 8-hour schedule, 5 days a week (bag department) or a 2 shift, 12-hour schedule, 3 days a week (all other departments). Employees selected worked either the 12-hour day shift (7:00 am to 7:00 pm) or the first (7:30 am to 3:30 pm) or second (3:30 pm to 11:30 pm) shifts. Every tenth employee was selected from these shifts to be interviewed. The average age of those interviewed was 44 years (range: 25 to 63 years). The average length of time these employees had worked at the plant was 19 years, 4 months (range: 7.5 months to 37 years), while the average length of time at their current position was 17 years 1 month (range: 6 months to 37 years). A total of 11 (52.4%) were from the bag department, 3 (14.3%) from press department, 2 (9.5%) from plate/ink department, 2 (9.5%) from extrusion department, and 3 (14.3%) from shipping department and maintenance. A higher percentage of those interviewed were from the bag department because more of them are working at any given time and two shifts were available for interviews. Of the 21 employees interviewed, 13 reported symptoms they associated with work; 9 reported eye irritation, 5 reported sinus problems, 4 reported trouble breathing, including one employee with diagnosed occupational asthma, 3 reported throat irritation, 3 reported headaches, 3 reported stuffy nose, and 2 reported musculoskeletal symptoms. A total of 9 of the 13 with current upper respiratory or mucous membrane symptoms worked in the bag department, and another 3, who did not work in this department, thought their symptoms were due to their proximity to the smoke from the bag department. Of those interviewed, 4 (19 %) had never smoked, 12 (57%) currently smoked, and 5 (24%) previously smoked. Of the 13 reporting current upper respiratory or mucous membrane irritation, 5 (39 %) were current smokers.

Concerns of the interviewed employees included the following: smoke in the bag department; ventilation in the bag department; musculoskeletal strains; solvent odors in the press department (especially near press 16 and 17); and heat/humidity in the summer. The concerns about smoke in the bag department were mentioned by employees from all areas of the plant, many of whom stated it was worse in the winter when all the windows were closed. At the time of our survey, the windows were opened. Some employees reported that smoke from the bag department would drift into other areas of the plant (i.e. the press department).

## Company leave of absence reports

Company leave of absence reports from January 1999 through March 2003 were reviewed. For each of the years 1999, 2000, and 2001, there were two personal leave of absence incidents relating to upper respiratory symptoms or mucous membrane irritation. These were for an average of 12, 18, and 11 days, respectively. All occurred in the bag department. For 2002 and 2003, there were no respiratory incidents.

## OSHA 200/300 Logs

The OSHA logs from January 2001 through March 2003 were reviewed. There were 49 and 34 recorded injury or illness entries in 2001 and 2002, respectively. The majority of these were for strains and contusions, with one recorded cumulative trauma strain (CTS) in 2001 and two CTS in 2002, all to the wrists. Through March 2003, there were five recorded illness and injury entries, all of which were for contusions and strains. There were no entries for upper respiratory or mucous membrane irritation in the OSHA logs.

# DISCUSSION

Evaluation of the bag department revealed an airborne particulate concentration of 0.32 mg/m$^3$, nearly all of which was in the submicron, respirable range. Acrolein was not detected in any of the air samples collected in the bag department. Acetaldehyde and formaldehyde were present in quantifiable amounts. The concentration of formaldehyde in air samples exceeded the NIOSH REL, but was below the OSHA PEL and ACGIH's recommended values. Organic compounds collected in the extrusion, press, and bag departments were below all regulatory and recommended standards.

The bag department consisted of approximately 60 bag machines that could manufacture bags at a rate of 300-500 bags a minute. During the survey, we observed a haze over the bag department. Each machine was enclosed within a canopy hood that captured some (but not all) of the smoke emitted into the work environment. A ventilation smoke tube was used, to verify that these hoods were not totally capturing the emissions from the bag machines. The ventilation specifications of the hoods were not available. An evaluation of the bag department revealed that the concentration of particulates was 0.32 mg/m$^3$. In addition, a size analysis of the particles showed that nearly all (99.9%) were in the respirable range (< 5 µm), with most of the particles (95%) in the submicron range (< 1 µm). On the day of sampling, the windows and doors were open; however, during the winter months, the concentration of particulates may be substantially higher with the doors closed and less outside air entering the work area.

Even though the particulate concentration is below recommended and regulatory standards, it is plausible that repeated exposure to particulates in the respirable range, coupled with low levels of contaminants such as formaldehyde, may cause some employees to experience respiratory difficulties. Studies have shown that chemicals can absorb onto the surface of ultra-fine particulates, and enter the body when the particles are inhaled.[2526] One possible solution to the problem would be to provide more general dilution ventilation in addition to the local exhaust ventilation provided by the canopy hoods currently in place. This additional dilution ventilation would dilute the haze in the bag department, prior to exhausting it out through the adjacent packaging department via exhaust fans. At the time of this survey there was an unused ventilation system with flexible ductwork on the ceiling of the bag department. We suggest consulting with ventilation engineers to make this unit operable again.

Bemis limits smoking to break rooms, which are located adjacent to the production floor. These rooms are used by smokers and non-smokers. It is possible that exposure to environmental tobacco smoke (ETS) or second hand smoke may result in some employees experiencing respiratory difficulties. Data from this survey shows that chemical markers specific to ETS, such as nicotine and vinyl pyridine, are confined to the break rooms. However, there is a chance that the ultra-fine particles that result from the combustion of

cigarette smoke may migrate to the production area if the break rooms are not maintained under negative pressure in relation to the production area.

## CONCLUSIONS

The results of industrial hygiene sampling did not indicate particulate matter levels above those shown to cause upper respiratory or mucous membrane irritation. Formaldehyde levels exceeded the NIOSH REL. Smoke, however, was visible in the bag department and there was the presence of smoke odor during the walk through. A majority of the 21 employees interviewed (57%) reported upper respiratory or mucous membrane symptoms they associated with exposure to smoke from the bag department operations.

Of the 21 interviewed, 11 (52%) voiced concerns over the amount of smoke in the bag department, especially in winter, regardless of their current department. There is the potential for aggravation of symptoms in those with underlying respiratory problems or in susceptible individuals. It is also possible that during the winter months, when the windows and doors are closed, that particulate matter and formaldehyde levels rise above the level needed to produce health symptoms.

## RECOMMENDATIONS

In order to improve the air quality in the bag department, we recommend the following:

1. general dilution ventilation be added to the bag department to dilute the smoke. This may be accomplished by utilizing a ventilation system with flexible duct work located on the ceiling of the bag department that was not operating during our visit. We suggest consulting with ventilation engineers to make this unit operable again.

2. Smoking be banned at the facility. We suggest that incentives be established to discourage smoking, smoking cessation classes be offered to employees, and literature on the harmful effects of cigarette smoke be provided to employees.[27]

3. additional air sampling for formaldehyde and for the respirable fraction particulates to better characterize employee exposure following these ventilation changes as well as to compare exposures during the summer and winter months.

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**Table 1:**
**Evaluation criteria for occupational exposures to air contaminants**

| Substance | NIOSH REL (ppm) | | | OSHA PEL (ppm) | | | ACGIH TLV (ppm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | TWA | STEL | Ceiling | TWA | STEL | Ceiling | TWA | STEL | Ceiling |
| Acetaldehyde | Lowest feasible conc. | | | 200 | NA | NA | NA | NA | 25 |
| Acrolein | 0.1 | 0.3 | NA | 0.1 | NA | NA | NA | NA | 0.1 |
| Butyl acetate | 150 | 200 | NA | 150 | NA | NA | 150 | 200 | NA |
| Ethanol | 1000 | NA | NA | 1000 | NA | NA | 1000 | NA | NA |
| Ethyl acetate | 400 | NA | NA | 400 | NA | NA | 400 | NA | NA |
| Formaldehyde | 0.016 | 0.1 | NA | 0.75 | 2 | NA | NA | NA | 0.3 |
| Isopropanol | 400 | 500 | NA | 400 | NA | NA | 200 | 400 | NA |
| Ozone | NA | NA | 0.1 | 0.1 | NA | NA | 0.05-0.2 | NA | NA |
| 1-propanol | 200 | 250 | NA | 200 | NA | NA | 200 | 250 | NA |
| Propyl acetate | 200 | 250 | NA | 200 | NA | NA | 200 | 250 | NA |
| Toluene | 100 | 150 | NA | 200 | NA | 300 | 50 | NA | NA |

“NA” Not applicable
“ppm” Parts per million

**Table 2:**
**Summary of qualitative results from analyses of air samples in the press, extrusion and bag departments. Compounds are listed based on the order in which they eluted from the analytical column**

| Compounds | Press department | Press department break room | Extrusion department | Bag department | Bag department breakroom |
|---|---|---|---|---|---|
| Formaldehyde | X | ND | ND | X | ND |
| Acetaldehyde/methanol | X | X | X | X | X |
| Ethanol | X | X | X | X | X |
| Acrolein | ND | ND | ND | X | X |
| Isopropanol | X | X | X | X | X |
| 1-Propanol | X | X | X | X | X |
| Ethyl acetate | X | X | X | X | X |
| Benzene | ND | X | ND | ND | X |
| Propyl acetate | X | X | X | X | X |
| Toluene | X | X | X | X | X |
| Butyl acetate | X | X | X | X | X |
| Vinyl Pyridine | ND | ND | ND | ND | X |
| Nicotine | ND | ND | ND | ND | X |
| Hexadecane | ND | ND | X | ND | X |

"X" denotes presence of chemicals in sample
"ND" denotes chemical was not detected

**Table 3:Full shift, area air samples collected in the press, extrusion and bag departments**

| Sample location | Sample no. | Flow rate (mL/min) | Time (min) | Airborne concentrations (ppm) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ethanol | Isopropanol | 1-propanol | Ethyl acetate | Propyl acetate | Butyl acetate | Toluene |
| Press #4 | CT-1 | 100.7 | 329 | 76.89 | 8.11 | 0.26 | 0.30 | 78.48 | 0.95 | 0.14 |
| Between extruders 2 and 3 | CT-2 | 100.6 | 355 | 10.55 | 0.69 | 4.56 | ND | 1.74 | 0.08 | 0.02 |
| Near bag machine #10 | CT-3 | 100.0 | 369 | 8.78 | 0.78 | 4.96 | ND | 1.88 | 0.07 | 0.03 |

**Table 3:**
**Full shift, area air samples collected in the press, extrusion and bag departments**

| Sample location | Sample no. | Flow rate (mL/min) | Time (min) | Airborne concentrations (ppm) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ethanol | Isopropanol | 1-propanol | Ethyl acetate | Propyl acetate | Butyl acetate | Toluene |
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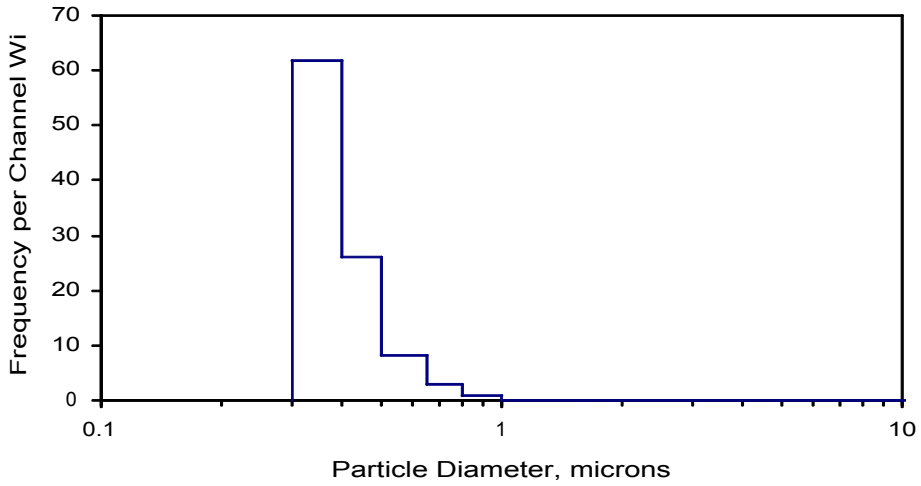
| Near bag machine #10 | CT-3 | 100.0 | 369 | 8.78 | 0.78 | 4.96 | ND | 1.88 | 0.07 | 0.03 |

**Table 4:**
**Full shift personal breathing zone and area air samples collected in the bag department**

| Bag department location | Sample type | Sample no. | Air sampling flow rate (mL/min) | Sampling time (min) | Airborne formaldehyde concentration (ppm) | Airborne acetaldehyde concentration (ppm) |
|---|---|---|---|---|---|---|
| Floater | Personal | SG-1 | 99.8 | 401 | 0.04 | 0.02 |
| Bag machine # 42 | Personal | SG-2 | 100.8 | 370 | 0.06 | 0.04 |
| Bag machine # 37 | Personal | SG-3 | 100.6 | 402 | 0.09 | 0.06 |
| Bag machine # 25 | Personal | SG-4 | 100.0 | 381 | 0.04 | 0.03 |
| Column 26, near Bag machine # 10 | Area | SG-5 | 100.5 | 368 | 0.06 | 0.03 |

**Figure 1:**
**Frequency of number of particles per channel width (particle size range) as a function of particle diameter**



**DEPARTMENT OF HEALTH AND HUMAN SERVICES**
**Centers for Disease Control and Prevention**
**National Institute for Occupational Safety and Health**
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