NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2004-0013-2990
Hallmark Cards, Inc.
Lawrence, Kansas

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

PREFACE

The Respiratory Disease Hazard Evaluations and Technical Assistance Program (RDHETAP) 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 (OSH) Act of 1970, 29 U.S.C. 669(a)(6), or Section 501(a)(11) of the Federal Mine Safety and Health Act of 1977, 30 U.S.C. 951(a)(11), which authorizes the Secretary of Health and Human Services, following a written request from any employers 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.

RDHETAP 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.

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Copies of this report have been sent to employee and management representatives at Hallmark Cards, Inc. and the OSHA Regional Office. This report is not copyrighted and may be freely reproduced. The report may be viewed and printed from the following internet address: http://www.cdc.gov/niosh/hhe. Single copies of this report will be available for a period of three years from the date of this report. Requests for single copies should include a self-addressed mailing label and should be sent to:

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HIGHLIGHTS OF THE NIOSH HEALTH HAZARD EVALUATION AT HALLMARK CARDS, INC.

This evaluation was requested by plant workers because of concerns about health effects of flock-associated dust exposure. Environmental and health surveys were conducted at Hallmark Cards, Inc. in August and October 2004, respectively. NIOSH measured dust exposures and aspects of employee health in relation to work processes.

What NIOSH Did

- Measured airborne dust and fiber concentrations in several areas and for most jobs within the plant
- Invited 284 employees to participate in the medical survey in order to compare groups with exposure to flocked cards, unflocked cards, and ribbon manufacturing
- Interviewed employees about symptoms and medical, work, and smoking histories
- Measured employees' lung function with spirometry, diffusing capacity, and bronchodilator or methacholine challenge tests
- Analyzed measurements and interview results for associations between work exposures and health effects.

What NIOSH Found

- Most time-integrated airborne dust and fiber concentrations were too low to be measured accurately.
- Peak exposures to airborne particulate occurred during cleaning with compressed air and vacuuming with a compressed-air vacuum.
- Production-related sources of airborne particulate included the open top of a flock line cyclone, flock module card feed and discharge points, and small foil compressed-air card separators.
- Working with flock and cleaning with compressed air were associated with respiratory health effects in employees.
- Respirators were not used regularly and many employees who need respirators reported not being fit-tested.

What Hallmark Cards Managers Can Do

- Modify cleaning with compressed air to capture the dust
- Capture the open-top cyclone discharge
- Improve local exhaust ventilation at flock lines, especially at feed and discharge points
- Provide cleaning methods that reduce the need of reaching into the flock modules
- Provide local exhaust ventilation for the dust generated by the compressed air that separates flocked cards
- On compressed air vacuums, use bag filters that more effectively capture respirable particles
- Require that NIOSH-certified respirators be worn during compressed-air cleaning activities and that all respirator users are fit-tested under a written respiratory protection program
- Inform employees about work-related disease observed among flock workers and how to reduce disease risk.
- Require that employees use vacuums instead of compressed air for removing dust from their clothing.

What Employees Can Do

- Wear respirators when required by management
- Inform management and personal physicians of respiratory symptoms and associated flock exposures.

CDC Workplace Safety and Health

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We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #2004-0013-2990

NIOSH

Health Hazard Evaluation Report 2004-0013-2990
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SUMMARY

NIOSH has found evidence of interstitial lung disease among workers exposed to nylon flock (flock workers' lung) in various plants in the past. In November 2003, based on health complaints among several workers, employees from Hallmark Cards, Inc. requested a health hazard evaluation (HHE) to get a better understanding of the potential respiratory hazards associated with the use of rayon flock at this card-producing plant.

In order to characterize exposures, symptoms, and lung function of flock-exposed workers and appropriate internal comparison groups, NIOSH conducted environmental and medical surveys at this plant.

The environmental survey consisted of time-integrated sampling, including air samples for gravimetric concentration of respirable dust with side-by-side air samples for fiber concentration. We conducted real-time sampling with aerosol photometers to obtain real-time continuous relative levels of dust (approximately respirable) during some plant activities together with video taping, to record events that might be associated with any observed peaks in real-time readings.

For the cross-sectional medical survey, we invited 284 employees, divided into three groups according to their potential exposure, as follows: Group A, workers exposed to flock and paper dust; Group B, workers exposed to paper dust only; and Group C, workers from the ribbon production areas (without significant flock or paper dust exposure). Trained NIOSH interviewers administered computer-based questionnaires that focused on respiratory symptoms, systemic symptoms, physician diagnosis of respiratory illnesses, smoking, work history, respirator use, and whether fit-testing had been conducted. Each participant, unless medically contraindicated, was offered spirometry testing, carbon monoxide diffusing capacity (DL_{CO}) testing, and either a bronchodilator test or a methacholine challenge test (MCT).

The 8-hour time-weighted average airborne respirable dust and fiber concentrations were largely below or near the minimum detectable concentrations of 0.03 milligrams per cubic meter of air (mg/m^3) and 0.01 fibers per cubic centimeter (fibers/cc), respectively. Peak exposures to airborne particulate occurred during cleaning with compressed air and vacuuming with a compressed-air vacuum. Production-related sources of airborne particulate included the open top of a flock line cyclone, flock module card feed and discharge points, and small foil compressed-air card separators.

A total of 239 employees (participation rate = 84%) participated in the medical survey. The employees were predominantly female (54%), white (80%), and never-smokers (55%). Nearly

one-half of the employees had worked over 20 years at the Hallmark plant. A total of 146 participants (61%) reported working at least one hour per week in an area where flock-coated cards are processed. A total of 47 participants (20%) reported cleaning with compressed air for at least one hour per week. Overall, 41 workers (17%) reported wearing air-purifying respirators at the plant. Use of respirators while cleaning equipment with compressed air was reported by 26 participants; none of the 26 reported that they had been fit-tested. Use of respirators at other times besides cleaning was reported by 31 workers, only one of whom reported having been fit-tested.

Nasal irritation, sinus problems, and eye irritation were the most frequently recorded symptoms. In general, flock workers had higher prevalences of symptoms arising during employment at Hallmark than non-flock workers with paper dust exposures and ribbon workers. Workers who cleaned for one hour or more per week using compressed air generally had higher symptom prevalences than other workers.

Working in areas where flock-coated cards are processed and cleaning equipment with compressed air were both significantly associated with the development of nasal symptoms after hire at Hallmark. Cleaning with compressed air was also significantly associated with the development of chronic cough.

Spirometry tests showed that male flock workers were significantly more likely than male non-flock workers to have results indicating restrictive lung disease (low forced vital capacity), in which the lungs cannot expand normally. Also, employees who worked a higher number of years in areas where flock-coated cards are processed were more likely to have test findings of decreased volume in the air sacs (decreased alveolar volume) and decreased ability of the lung to transfer gases (low carbon monoxide diffusion capacity). This pattern of changes is not diagnostic by itself, but can indicate scarring and stiffness of the lung tissue which is found in interstitial lung disease (ILD), including “flock workers’ lung”.

We conclude that working with flock and cleaning with compressed air were associated with health effects in workers at this plant.

We recommend that the company take steps to prevent flock-associated dust exposures: by controlling the airborne particulate generated in compressed air cleaning and vacuuming, in the separation of cards at small foil machines processing flocked cards, and at card feed and discharge points at flock lines; by reducing the need to reach into modules; by capturing the open-top cyclone discharge, and by requiring that employees use vacuuming rather than compressed air to remove dust form their clothes. Since safe levels of flock-associated dust are unknown, we recommend that a written respiratory protection program be developed that requires NIOSH-certified respirators for compressed air cleaning and fit testing of all respirator users. We recommend informing employees about work-related disease observed among flock workers and providing informational materials to them to share during any physician consultation about concerns or actual health problems.

NIOSH investigators determined that a health hazard exists from occupational exposure to flock-associated dust at this plant. This risk is evidenced by upper and lower respiratory symptoms, such as nasal irritation and cough, and objective measurements of lung function suggesting a restrictive pattern, compatible with subclinical interstitial lung disease. These health outcomes are associated with work in areas where flock-coated cards are processed and equipment is cleaned with compressed air.

Keywords: NAICS 511191 (Greeting Cards), flock, fibers, rayon, flock workers’ lung, interstitial lung disease

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INTRODUCTION

In November 2003, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a health hazard evaluation from employees at the Hallmark Cards, Inc. Lawrence Production Center in Lawrence, Kansas. The requesters were concerned about respiratory problems, such as asthma and bronchitis in relation to exposure to flocking materials in the flock, foil stamp, and machine-fold departments during the production of greeting cards.

This request led to our site visit to Hallmark Cards on January 13, 2004. During this walk-through visit, we toured the facility and spoke privately with several employees who confirmed the occurrence of respiratory symptoms, such as cough, shortness of breath, and mucous membrane irritation in relation to exposures at work. The OSHA Form 300 logs from the past 5 years were reviewed. Except for a record of one employee with "Lung condition/possible inhalation" in 2002, no other records referred to respiratory diseases or respiratory symptoms. After this visit, and with Hallmark management staff concurrence, NIOSH investigators planned further investigation, including an environmental survey and a cross-sectional medical survey aimed to identify operations which may result in excessive dust exposures and to identify possible associations between workplace particulate exposures and respiratory health outcomes.

The environmental survey took place from August 23 to 26, 2004, when airborne dust and airborne fiber measurements were obtained. The medical survey took place from October 17 to 30, 2004, after NIOSH staff gave explanatory presentations to workers on October 10 and 11, 2004. The medical survey included the administration of a respiratory symptom and work history questionnaire, spirometry, bronchodilator or methacholine challenge tests, and lung diffusing capacity measurements. This report provides the findings from the surveys at this plant and serves to close out this health hazard evaluation.

BACKGROUND

Most flock is composed of synthetic fibers of about 1 millimeter (mm) in length, which have been cut from continuous filaments ("tow") of materials such as nylon, rayon, polyester, acrylic, or polypropylene with typical diameters of 10 to 15 micrometers (µm). These short fibers are applied to adhesive-coated surfaces of many materials, such as fabrics and paper, to create a velvet-like finish on a variety of products, including upholstery coverings, greeting cards, glove boxes for automobiles, etc. The only occupational exposure limits for the dust associated with flock operations are those for particulates not otherwise regulated (PNOR) — 5 milligrams per cubic meter of air (mg/m^3) for respirable dust and 15 mg/m^3 for total dust [CFR, 2005]; however, flock-associated dusts have been shown to have health effects below these standards [Daroowalla, 2005].

Plant and process description

The Hallmark Lawrence Production Center was built in 1958 to produce greeting card and ribbon products. Production of greeting cards and ribbons takes place in the 700,000 square-foot, two-story building. Multiple cards are produced on large card stock material and individual cards are made on small stock; many machines can only handle one of the sizes. Depending on the card design, production of a card can include any of the following stages: ink printing at screen printers or offset printers; thermographic powder printing; application of flitter (reflective polyethylene film glitter) or flock; die cutting, embossing, and/or foil application at the small or large presses; page insertion; folding; counting; and packaging. Operations in the plant are conducted around-the-clock over three 8-hour shifts on weekdays. Weekend production occurs only as necessary to meet seasonal demands.

For those cards that receive flock coverage, application of flock takes place at flock conveyor lines where it is dispersed in a flock machine onto adhesive-coated cards. The adhesive is applied via a silkscreen. Flock coverage on a card can vary from a very small patch to the entire exposed surface. The current supplier of flock has been used since 1998. The product they supply is "washed" (treated/dyed in an aqueous solution and then spun down) after being cut to minimize inclusion of small fragments. Only rayon flock is used, but of multiple colors and two sizes. Fineline flock is 0.02 inches (~1/2 mm) long and shag flock is 0.1 inches (~2.5 mm); both are 10 to 20 μm in diameter. Available Hallmark production records indicate that fineline flock usage at the plant went from 17,000 pounds in 1999 to 27,000 pounds in 2003. During that same time, shag flock usage fluctuated back and forth between 500 and 1300 pounds annually. Flocking operations were initiated in 1961 with 3 flocking line systems. Two of the systems were replaced, one in 1998 (Line 2) and the other in 2000 (Line 1), and are located together in an enclosed room. At the time of the NIOSH walk-through visit, one of those original flocking systems (Line 3) still existed, wrapped on three sides with plastic curtain walls. The line was moved into a fully-enclosed room by the time the NIOSH environmental survey was conducted, and a new room was being constructed in preparation for the addition of another flocking line. To remove excess flock from cards, card-cleaning modules and downdraft tables are located on the flock lines. The air from these systems is directed into a cyclone separator and then through a bag filter to remove entrained flock and other particulates. Room air is circulated through an air-conditioning system with HEPA filtration.

Other areas where flocked cards are handled on a daily basis include the small foil/die cutting, folding, and counter/packaging areas. In the small foil/die cutting area, a cluster of 4 machines known as the "Quad" processes the majority of the flocked cards (almost daily), and the remaining 3-machine clusters handle flocked cards less frequently. Another area, specialty packaging, only processes flocked cards approximately once every week or two. Other than occasionally in a couple areas, flocked cards are not processed elsewhere in the plant. There were approximately 186 employees in the flock-handling areas of the plant during our surveys, including 36 in the specialty packaging area. Other card production areas that don't handle flock-coated products employed about 500 workers. Ribbon production (involving extrusion of melted polypropylene pellets) employed another 75 workers, and administrative workers totaled nearly 80. Ribbon is not flocked at this plant.

Between production runs, remnant flock is blown with compressed air from all equipment on the flock conveyor lines in a process referred to at the plant as a "clean-out." This maintains uniform flock color for each card order. A central vacuum system is also utilized for cleaning the flock lines. Compressed-air cleaning is also required at the other card-processing machines in the plant to prevent contamination on card orders as well as to remove flock and/or paper dust debris that can jam the machinery or interfere with optical detection components of the equipment. During our survey, a new compressed-air vacuum device was being evaluated by the company for cleaning machines in the plant. The device comprised a vacuum tube, trigger, and a small bag. By connecting it to a compressed-air hose and pulling the trigger, the compressed air produced a vacuum to pull material through the tube and into the bag.

Past environmental sampling

Past environmental sampling data were available from the company for almost all years since 1995 and from OSHA in 2002. Company air sampling data indicate that in the *flocking areas*, total dust concentrations at Lines 1 and 2 ranged from 0.03 to 0.38 mg/m^3 in 7 personal and area samples. Two additional measurements were not detectable with approximate detection limits of 0.02 – 0.04 mg/m^3. The OSHA total dust sample collected on a Line 1 operator measured 0.53 mg/m^3. At Line 3, four of the five company total dust samples were detectable (0.86 mg/m^3 during cleaning of the module and between 0.18 and 0.42 mg/m^3 during production runs). Respirable dust samples measured only 1 detectable concentration (0.06 mg/m^3) in 5 samples collected during production, and between 0.03 and 0.07 mg/m^3 in 3 samples collected during cleaning operations at Lines 1 and 2. At Line 3, detectable measurements of 0.24 and 0.47 mg/m^3 respirable dust were obtained during production, and measurements of 0.07, 0.23, 0.44, 0.50 mg/m^3 were collected during clean-outs (2 additional measurements collected during each of these tasks were not detectable). These Line 3 data were all collected prior to moving Line 3 into an enclosed room.

Ten of the 13 company area and personal total dust samples collected in the *small foil/die cutting areas* were detectable from 0.11 to 29.93 mg/m^3. The three highest concentrations were at or above 5.85 mg/m^3 and were collected in 1995 at the "Quad" station. The other nine samples were below 1 mg/m^3. The three total dust samples collected by OSHA on small foil/die cutting press operators measured 0.18, 0.47 and 5.60 mg/m^3. Only 2 of the 7 company respirable dust samples collected in these areas were detectable and measured 0.03 and 0.37 mg/m^3.

Disease characteristics

In 1996, a group of employees from a Rhode Island plant that produces and applies nylon flock was identified as having work-related interstitial lung disease (ILD) [Kern 1997, Kern 1998]. In interstitial lung disease, inflammation of the air sacs and tiny airways and scarring of the lung tissue causes the lungs to become stiff, small, and less effective in transferring oxygen from the air and carbon dioxide from the blood. One year earlier, Canadian scientists had described five cases of ILD in a flock plant owned by the same company [Lougheed 1995]. Patients with this newly recognized disease had breathlessness and dry cough. The symptoms ranged from mild to very severe, and one subject required prolonged mechanical ventilation in a hospital intensive care unit due to respiratory failure. The usual latency between date of hire and onset of symptoms was 5 to 6 years. On chest radiograph, the earliest recognized cases had abnormal opacities described as diffuse reticulonodular infiltrates [Lougheed 1995, Kern 1997, Kern 1998]. Patchy areas of consolidation, ground-glass opacities, and micronodules were the main characteristics on high-resolution computed tomography (CT) of the chest [Weiland 2003]. Pulmonary function tests generally showed a pattern of not expanding normally (a restrictive pattern) and reduced gas transfer (low carbon monoxide diffusion capacity), in which oxygen does not cross the lung tissue into the blood stream normally. Some patients also had abnormal methacholine challenge tests, indicating very sensitive or "twitchy" airways called bronchial hyperresponsiveness. Usually months after leaving work, patients' symptoms, radiographs, and pulmonary function tests improved, but typically without complete recovery. Some cases were treated with high doses of corticosteroids; some with supplementary oxygen therapy [Kern 2000]. A unique pattern of lung damage (lymphocytic bronchiolitis and peribronchiolitis with lymphoid hyperplasia) is visible with a microscope in "flock workers' lung" [Eschenbacher 1999, Boag 1999]. While the initial case clusters and several sporadic cases of flock workers' lung have been reported in the nylon flock industry in North America, more recently reported cases in Europe have been associated with other types of flock. A case of flock workers' lung was described in a worker exposed to polyethylene flock in Spain [Barroso 2002]. In Turkey, a cross-sectional study in the polypropylene flock industry showed a 3.6-fold increase in respiratory symptoms in exposed workers compared to unexposed controls [Atis 2005].

Objectives

The main objectives of this evaluation were: (1) to characterize worker exposures to airborne particulates associated with rayon flocking operations at the Hallmark Lawrence Production Center; and (2) to assess health effects in relation to exposure to these particulates, by comparison of health status of exposed workers at the plant to national data and among subgroups within the plant with other exposures.

METHODS

Environmental Survey

Bulk sampling

Bulk samples of flock were obtained from boxes of the product. A small sample of the bulk flock was observed by scanning electron microscopy (SEM). In addition, a sample of the bulk flock material was agitated in a vibrating vial and blown into a test chamber where a respirable dust sampling cyclone collected the airborne particulate on a polycarbonate filter, which was examined by SEM.

Time-integrated sampling

Personal sampling in all areas in which the medical survey study population worked (described in next section) included air samples for gravimetric concentration of respirable dust (NIOSH Method 0600) with side-by-side air samples for fiber concentration (NIOSH Method 7400 with A-counting rules). A table of the sampling methods is included as Appendix A. We evaluated approximately 49 distinct job titles, representing over 370 workers at the plant, by collecting samples on about 40 workers throughout three 8:00 am to 4:30 pm morning shifts and one 4:00 pm to 12:30 am afternoon shift. Additionally, we collected personal respirable dust and fiber samples at both flocked and non-flocked card production areas during some clean-out activities to measure possible peak exposures during cleaning tasks. We recorded data regarding presence of flock on cards in areas we sampled.

To more fully characterize the dust in the different areas, we placed a basket with an array of samplers in each area during at least one of the sampling periods. Each basket included a respirable dust sampler, a total dust sampler, and a fiber sampler. Also included were dust samplers with polycarbonate filters for analysis with SEM to evaluate characteristics of the airborne particulate.

Real-time sampling

We used aerosol photometers (light-scattering aerosol monitors) to obtain real-time continuous relative levels of dust (approximately respirable – instrument optimized for detection of particles up to 10μm) during some plant activities. To record events that might be associated with any observed peaks in real-time readings, we utilized video cameras during those measurements.

Medical Survey

Study population

Company records were provided to NIOSH regarding job and work area of all employees as of September 2004. The study population for the cross-sectional medical survey consisted of 284 invited individuals of over 850 total employees at the plant, distributed in the following groups:

> Group A (n=150): All individuals who worked in the small foil/diecut, counter/packaging, flock, and cardboard folding departments (all shifts). (Although workers in the "specialty packaging" department are occasionally exposed to cards coated with flock, these were not included in the sample, because their exposure did not seem to be comparable to the others in group A).
>
> Group B (n=94): All individuals who worked in the large die-cut and manufacturing finishing departments, in the morning (8:00-4:30) and afternoon (4:00-12:30) shifts.
>
> Group C (n=40): All individuals who worked in the ribbon production area (extrusion, injection mold, specialty, converting, bow manufacturing and packaging, extruding and coating, and hand converting departments) in the morning (8:00-4:30) and afternoon (4:00-12:30) shifts.

The categorization into these 3 groups was intended to allow for comparisons among workers exposed to **flock and paper dust**

(Group A), **paper dust only** (Group B), and **no flock or paper dust** (Group C).

Questionnaire

After obtaining written informed consent, trained NIOSH interviewers administered a computer-based questionnaire to each participant. It included sections on upper and lower respiratory symptoms, systemic symptoms, physician diagnosis of respiratory illnesses, smoking and work history, respirator use, and whether fit-testing had been conducted (Appendix B). Questions about lower respiratory symptoms were taken from standard, validated questionnaires [Ferris 1978, NCHS 1994]. Questions on onset dates and work-related patterns were included for the respiratory, nasal, and sinus symptoms.

Pulmonary function tests

Each participant, unless medically contraindicated, was offered spirometry testing, carbon monoxide diffusing capacity (DL_{CO}) testing, and either a bronchodilator test or a methacholine challenge test (MCT). All tests were conducted by trained NIOSH technicians. Each worker tested was notified of his or her results by a letter sent to their home address with recommendations for follow-up evaluation by a physician if his or her pulmonary function tests were abnormal.

Spirometry: Spirometry measures the movement of air out of the lungs (i.e., ventilatory function). Spirometry was performed using dry rolling-seal spirometers interfaced to dedicated computers. Procedures conformed to American Thoracic Society (ATS) guidelines [ATS 1995]. Predicted values were calculated using published reference equations [Hankinson 1999]. Abnormal test results were defined and categorized as having an obstructive, restrictive, or mixed pattern, as follows, based on measurements of the forced expiratory volume in one second (FEV_1), the forced vital capacity (FVC), and their ratio (FEV_1/FVC) compared to lower limits of normal (LLN):

Obstruction: FEV_1/FVC% < lower limit of normal (LLN) and FVC ≥ LLN

- Obstruction occurs in airways diseases, such as asthma, chronic obstructive lung disease, and emphysema.

Restriction: FEV_1/FVC% > LLN and FVC < LLN

- Restriction occurs in scarring and inflammatory diseases of the lung tissue, such as flock workers' lung.

Mixed: FEV_1/FVC% < LLN and FVC < LLN

- A mixed pattern can be found when both airways and lung tissue are affected by a disease process, such as can occur in hypersensitivity pneumonitis. It is also found due to hyperinflation, which occurs with moderate to severe airways obstruction even in the absence of restriction.

Categories of severity for each pattern of lung function abnormality (obstructive, restrictive, or mixed):

Interpretation	FEV_1 (% predicted)
Mild	≥ 60% and < LLN
Moderate	≥ 40% and < 60%
Severe	< 40%

Bronchodilator test: Each participant with an FEV_1 less than 70% of the predicted value repeated spirometry 10-15 minutes after inhaling two "puffs" of albuterol 200 mg via a metered-dose inhaler attached to a spacer. Bronchodilator response was considered positive if a post-bronchodilator FEV_1 improvement of at least 12% and 200 ml occurred. Persons with reversible airways obstruction, such as those with asthma, often have positive bronchodilator test results.

MCT: Participants with an FEV_1 greater than 70% of the predicted values performed methacholine challenge tests (MCT) according to ATS guidelines [ATS 2000]. The MCT provides a measure of airways "twitchiness" (hyperresponsiveness) and is typically abnormal in persons with asthma. A Rosenthal dosimeter with a DeVilbiss air compressor was used to deliver the following concentrations of methacholine: 0.125, 0.5, 2.0, 8.0, and 32.0 mg/ml. (For individuals who did not report symptoms suggestive of asthma and who also had no indication of airways obstruction on baseline spirometry, the initial concentration of 0.125 mg/ml was skipped.) A diluent "dose" was not used. For each step, five inhalations of the testing dose were administered over no more than 2 minutes; 30 to 90 seconds after the 5th inhalation was completed, spirometry was performed. After each step, if the highest FEV_1 was greater than 80% of the highest baseline FEV_1, the next dose of methacholine was administered and the process was repeated until the last dose. If the highest FEV_1 after a dose was 80% or less than the highest baseline FEV_1, the test was terminated, and a bronchodilator was administered. Test results were expressed as the concentration (mg/ml) of inhaled methacholine administered and were categorized in terms of the provocative concentration required to achieve a 20% drop in FEV_1 (PC_{20}) as follows:

Interpretation	**PC_{20} (mg/ml)**
Normal bronchial responsiveness (BHR)	> 16
Borderline BHR	4.1 - 16
Mild BHR	1.0 - 4.0
Moderate to severe BHR	< 1.0

DL_{CO}: Diffusing capacity testing measures the lung's ability to exchange gases. The test also gives an estimate of the volume of the lung involved in exchanging oxygen and carbon dioxide (alveolar volume, V_A). Alveolar volume is a very good estimate of total lung capacity (TLC) in people without moderate to severe airway obstruction. Lung volumes such as TLC, V_A, and FVC decrease in scarring lung diseases. Measurements of DL_{CO} were performed using the single-breath technique in a Jaeger MasterScreen system. Procedures followed ATS recommendations [ATS 1995]. Predicted values for DL_{CO} were based on published prediction equations [Miller 1983]. DL_{CO} for an individual was considered <u>abnormal</u> if it was less than the LLN.

Data Analysis

To assess whether Hallmark employees had excess symptoms and spirometry abnormalities, we compared participant results to national data from the Third National Health and Nutrition Examination Survey (NHANES III). We calculated ratios of the observed number of cases among employees versus the expected number of cases for four symptoms and two spirometry abnormalities, using data from and pooling estimates across gender, race, age, and smoking categories [NCHS, 1996].

Statistical analyses of the questionnaire and pulmonary function data were conducted using SAS software [SAS, 2004]. The initial analysis of the data examined a number of factors, including the location of workers within the plant (e.g., the department or floor), the process with which workers were involved (e.g., administration, stock-handling, etc.), their flock tenure (i.e., the number of years of each worker's Hallmark tenure which involved flock work according to the work history), and cleaning status (e.g., the amount of time spent cleaning machines with compressed air each week). In order to make some comparisons as unambiguous as possible, data from subsets of workers were excluded from some preliminary analyses if, for instance, they had changed departments or positions during the previous year. These preliminary results were then used to determine a subset of factors which were further examined during the formal analysis involving data from all participants.

The original groups A, B, and C did not fully meet the expected categorization of flock work. Therefore, we made the major comparisons based on the number of hours of flock work reported in the questionnaire. We defined flock workers as those working at least 1 hour per week in areas where flock-coated cards are processed.

The modeling examined the effects of flock-work, flock-tenure, cleaning, and possible bivariate interactions between these factors or with the covariates. The initial models were assessed using stepwise selection or the C_p statistic [Mallows, 1973], along with examinations of collinearity, influence, and partial-regression plots. The covariates for the multivariate regression models and the logistic models included gender, race, height, body mass index (BMI), tenure, age, and smoking, the last factor being represented by the estimated pack-years (i.e., years-smoked * cigarettes-per-day / 20). An important limitation for the logistic models was the small number of cases for some outcomes. The work of Peduzzi et al. [1996] suggests that a stable estimate (e.g., an estimate which would not be expected to differ substantially for additional sampling) can be obtained by having 10 cases per variable, although some authors, such as Stokes et al. [1995], suggest a general rule of five observations per variable for valid estimation. Therefore, we attempted to limit the number of variables in the logistic models by first fitting the 'covariates only' model, and then adding the other predictors of interest. For the logistic models, the goodness-of-fit was assessed using the statistic from Hosmer and Lemeshow [2000]. An essential assumption for the modeling results was that there were no important but unmeasured covariates [Rosenbaum, 2002].

RESULTS

Environmental Survey

Bulk sampling

SEM images of the bulk flock material show the tendency for the rayon flock used at Hallmark to form shreds. Figures 1 and 2 show low magnification of the flock, revealing the cut ends of flock in both images as well as the smaller particles attached to the flock in Figure 2. Figure 3 shows an image of the cut end of a flock fiber at higher magnification. The airborne particles collected in a test chamber after vibratory agitation of a bulk sample are shown in Figure 4. The photomicrograph shows many compact particles in addition to several elongated particles. This image closely resembles airborne samples collected during previous NIOSH evaluations at flock plants (NIOSH, 2000a and 2000b).

Time-integrated sampling

During the four shifts sampled, 127 sets of personal samples (respirable dust and fibers) were collected over most of the shift (see Appendix C). Only 8 respirable dust samples had measurable concentrations, ranging from 0.03 to 0.06 mg/m^3. The minimum detectable concentration (MDC) was 0.03 mg/m^3 for respirable dust. One of the 8 samples (0.03 mg/m^3) was collected on a flock operator, while the remaining 7 were collected on workers who were neither working directly with nor near cards that were coated with flock. Measurable fiber concentrations were detected on 82 of the fiber samples, with 77 (94%) between 0.01 and 0.05 fibers per cubic centimeter (fibers/cc) and the remainder between 0.09 and 0.24 fibers/cc (MDC=0.01 fibers/cc). No trend was apparent between measurable fiber concentrations and working with or around flocked cards; however, the highest concentration was measured on a worker during a shift he cleaned a flock line. In the table in Appendix C, samples collected in an area (or on a person working in an area) where flocked cards were being handled, are denoted as such.

No respirable dust concentrations were detected among the 24 area samples collected. Measurements ranged from 0.03 to 0.06 mg/m^3 in the 4 of 16 area total dust samples with detectable concentrations. Six of 24 area fiber samples had detectable concentrations from 0.01 to 0.04 fibers/cc. The air samples subjected to SEM analysis revealed only small amounts of particulate. The predominant airborne particle appeared to be paper dust, which was likely the major contributor to the fiber counts.

Real-time sampling

Real-time personal and area air measurements obtained with aerosol photometer samplers are provided in Figures 5–9. Because of the low time-integrated respirable dust concentrations during our sampling, reliable calibration of the photometer instruments against simultaneously-collected gravimetric samples was not possible. Thus, these graphs show trends in dust levels (approximately respirable) over time as provided by the instrument (presented in the graphs as "photometric units") but cannot be used to determine mass concentrations in air. The most important information obtained from the graphs is the relative response of the instrument to the airborne particles at different points in time. Included in the figures are bars representing the duration of activities during collection of the measurements, as obtained from the video tapes.

Measurements from the instrument worn by a worker while cleaning a flock module (Figure 5) show elevated particle generation during cleaning compared to before and after cleaning. Peaks indicate that all cleaning activities are associated with increased airborne particulate, including vacuuming with a hose connected to a central vacuum system port. Based on review of the video, peaks appeared to occur when the worker reached into the flock module. One of the highest was generated at the end of the cleaning activity when the worker blew the dust from his clothes with compressed air.

Progressively lower measurements are revealed from an area sampler near the small foil machines (Figure 6) as the activity changes from cleaning to card production and finally to shutdown during lunch break. Notable on this graph are the long duration peaks produced during blowing of flock with compressed air. Short duration peaks arise during card production. No videotaping was conducted during this activity, so the specific source of these peaks is unknown.

An aerosol photometer was used to find sources of particle generation by placing the device near different parts of the production lines at the flock lines and one of the small foil stations (Figures 7-8). At the flock lines, elevated measurements were obtained at most of the points along the lines where the cards were fed into and discharged from the flock modules. The highest level was noted when the sampler was placed above a cyclone that served the flock module at Line 3. This cyclone discharged air with entrained small particles into the room rather than sending it to a bag filter as was done at all the other cyclones in the flock areas. At the small foil "Quad" station, elevated peaks arose at the machines when the device was placed above where the cards are pulled from the stack into the machine.

Figure 9 shows measurements obtained while a compressed-air vacuum device being evaluated by Hallmark was used to clean a flock module. While holding the sampler in the worker's breathing zone, peaks were associated with the activity cycles of vacuuming the module and emptying the bag into a nearby garbage can. With the sampler held next to the vacuum bag during vacuuming of the module, it became apparent that the vacuum device itself was probably contributing greatly to the exposure, likely a result of small particles escaping through the collection bag. We demonstrated this to a member of plant management who intended to inquire about the filtering capability of the bags from the vacuum manufacturer.

Medical Survey

Study population demographics

Of the 284 workers initially invited to participate, 11 were absent due to sick leave or vacation, resulting in a total of 273 eligible employees during the 2-week survey. A total of 239 of these invited workers completed the questionnaire, resulting in an overall participation rate of 84%. The participation rates of the 3 invited study groups were similar. (Four workers from departments not specified in the original protocol were also tested; they were excluded from all analyses.)

Table 1 shows the distributions of participating workers in terms of gender, age, race, smoking status, tenure, and shift. The majority of employees were female (54%), white (80%), and never-smokers (55%). Nearly one-half of the employees had worked over 20 years at the Hallmark plant, and only about 12% had changed jobs within the previous year.

Table 2 shows the distribution of participating workers according to seven groups of departments: (1) large die cut; (2) foil stamp; (3) manufacturing finishing; (4) flock; (5) ribbon and bow; (6) cardboard fold; and (7) counter packaging.

Work practices and respiratory protection

Flock workers (i.e., those workers who reported working at least one hour per week in areas where flock-coated cards are processed) represented 87% of Group A participants, 43% of Group B participants, and 11% of Group C participants.

Table 3 shows the frequency of work with flock and cleaning by department. A total of 146 participants (61%) reported working at least one hour per week in an area where flock-coated cards are processed. A total of 47 participants (20%) reported cleaning with compressed air for at least one hour per week. Of these, 35 reported working in an area where flock-coated cards are processed for at least one hour per week. A total of 189 participants reported ever cleaning equipment with compressed air, 142 for less than one hour per week.

The flock tenure (i.e., the number of years working in areas where flock-coated cards are processed) among participants was longer than 10 years in 90 (38%), 3 to 10 years in 93 (39%), and shorter than 3 years in 55 workers (23%).

Overall, 41 workers (17%) reported wearing air-purifying respirators at the plant, the use of which is voluntary at the plant. Use of respirators while cleaning equipment with compressed air was reported by 26 participants; none reported to be fit-tested. Use of respirators at other times besides cleaning was reported by 31 workers, only one of whom reported to be fit-tested. During the environmental study, a half-facepiece cartridge respirator was worn by the worker cleaning the flock module. At the small foil "Quad" station, some workers were wearing respiratory protection during production and cleaning. One wore an N95 disposable respirator; however, another was seen wearing a surgical-type mask, which is not a NIOSH-certified respiratory protective device.

Symptoms

Nasal irritation, sinus problems, and eye irritation were the most frequently recorded symptoms. When we compared symptom prevalence of participating workers to national data, the ratios for "wheeze apart from cold" and for "shortness of breath" were statistically significantly elevated (Table 4).

In general, with the exception of cough, phlegm, wheeze, and wheeze attacks, flock workers (i.e., those who work at least one hour/week with flock) had higher prevalence of symptoms arising during employment at Hallmark than non-flock workers with paper dust exposures (largely Group B) and ribbon workers (most of Group C). The prevalence of eye, nasal, and throat irritation and sinus and chest symptoms was higher for flock workers compared to paper workers and that of paper workers was higher than ribbon workers, with a statistically significant test for trend (Figure 10).

Workers who cleaned for one hour or more per week using compressed air generally had higher symptom prevalence. The test for trend was statistically significant for eye, nasal, throat irritation, sinus symptoms, chronic cough, and medically diagnosed asthma (Figure 11). When asked to describe which materials might be associated with their chest symptoms (Question 37 in Appendix B), workers cited flock and flitter most frequently.

Pulmonary function tests

Spirometry test results were available for 234 Hallmark workers. Five workers did not perform tests due to technical difficulties or refusal to participate. Table 5 shows spirometry results by type and severity of respiratory impairment. Of the 192 workers who underwent methacholine challenge testing, 10 had borderline bronchial hyperresponsiveness and 5 had mild hyperresponsiveness. Of the 10 workers who underwent bronchodilator testing, two experienced a significant increase in FEV_1. Of the 231 workers who underwent DL_{CO} testing, one had a non-interpretable test, 9 (3.9%) had DL_{CO} below the LLN, and 33 (14%) had alveolar volume (V_A) below LLN.

Analysis of categorical pulmonary function variables

No statistically-significant association was observed between flock exposures and spirometry results analyzed as categorical variables. However, table 6 demonstrates that employees with evidence of bronchial hyperresponsiveness ($PC_{20} \leq 16$ mg/ml) were somewhat more likely to have worked with flock for at least 1 hour per week, with an odds ratio of 4.2 (95% CI [0.9–19.1]). When bronchodilator response was analyzed together with methacholine challenge results, the trend persisted, with an odds ratio of 3.0 (95% CI [0.8–10.8]) (Table 7). Workers with DL_{CO} and V_A below the LLN also were somewhat more likely to have longer flock tenures (≥ 5 years), with odds ratios of 3.9 (95% CI [0.5–32.2]) and 1.8 (95% CI [0.8–4.2]), respectively (Tables 8 and 9).

Multivariate analysis

In multivariate models, working in areas where flock-coated cards are processed and cleaning equipment with compressed air were both significantly associated with the development of nasal symptoms after hire at Hallmark (Table 10). Cleaning with compressed air was also significantly associated with the development of chronic cough (Table 10). Models using other symptoms as the outcome did not produce statistically significant results.

The results for the logistic model for nasal irritation with onset after starting work showed highly statistically significant effects for both cleaning with compressed air and flock work. The predicted probabilities suggest that non-flock workers who do not clean machines at least one hour per week have an estimated probability of approximately 30% of having nasal symptoms. This probability increases to over 50% for workers if they were either flock workers or if they cleaned machines at least one hour per week. For those who both worked with flock and cleaned machines with compressed air at least one hour per week, the probability increases to about 75%.

The results for the logistic model for chronic cough also showed a statistically significant effect for cleaning. These results indicate that non-smoking workers who do not clean machines for at least one hour per week have an estimated probability of about 6% of having chronic cough, and this rises to about 14% for non-smoking workers who cleaned machines at least one hour per week.

The average adjusted FEV_1 and FVC values were both significantly lower for male flock workers compared with male non-flock workers (Table 11). The results for females were slightly higher among flock workers compared to non-flock workers, although no statistically significant difference was observed. The mean FEV_1/FVC ratio was not statistically different for the exposure groups.

Longer flock tenure (i.e., the number of years that an employee has worked in an area where flock-coated cards are processed) was significantly associated with abnormally low V_A and DL_{CO}, findings suggestive of interstitial lung disease. The predicted probabilities from the V_A model suggest that a worker who is 45 years old with 20 years of Hallmark tenure (i.e., the median age and tenure of participating workers), with a body mass index of 30 (median = 29), and with zero years of flock tenure had an estimated probability of about 5% of having an abnormally low V_A. This probability increases to about 11% for a corresponding worker with 10 years of flock tenure, and to about 24% with 20 years of flock tenure. The predicted increases with flock tenure are much smaller for the DL_{CO} outcome, and the small number of cases of workers with DL_{CO} below the LLN makes these results less reliable. The model suggested that a non-smoking worker had an estimated probability of about 1% of having a DL_{CO} below the lower limit of normal. The estimated probability increases to about 2% for a non-smoking worker with 10 years of flock tenure, and to about 4% with 20 years of flock tenure.

DISCUSSION

During our air sampling at Hallmark, flocked cards were produced almost continuously at all three flock lines. At the small foil area, production of flocked cards took place throughout most of our visit at the entire "Quad" cluster of machines, with additional production at a couple other clusters. Accordingly, our sampling is probably reasonably representative of typical conditions at the plant at this time.

Our air sampling at Hallmark found time-integrated respirable dust concentrations to be generally low or below the detectable concentration. Higher concentrations have been measured during previous air sampling conducted by Hallmark since 1995. Our respirable dust concentrations were also generally low at Hallmark compared to previous measurements we obtained at flock-production and flock-application facilities with a much larger use of flock. An overall average of 0.09 mg/m^3 was measured among several of the previously studied plants [Daroowalla 2005]. Even higher concentrations were found at the plant where we conducted our first flock health hazard evaluation, where there was a cluster of cases of flock workers' lung [Burkhart 1999].

Although time-integrated air sampling revealed low average concentrations, real-time sampling with aerosol photometers was useful in detecting tasks that can lead to short-term higher (peak) exposures, such as cleaning of machinery and workers' clothes with compressed air and even with vacuum equipment. The peaks during vacuuming appeared to be related to the worker reaching into the flock module. This sampling was also able to detect some equipment that were sources of airborne particulate, such as module card feed areas, the open-top cyclone, and small foil machines. On the last of these, air was used to separate the cards prior to being pulled into the machine. This air stream was likely responsible for peak exposures. Hallmark is currently in the process of installing a local exhaust ventilation system at the "Quad" small foil machines where the majority of flocked cards are processed.

Despite levels of airborne flock-associated dust largely below the limit of detection using time-weighted averages, we found evidence of work-related health effects among Hallmark employees. First, there is an excess of wheezing and shortness of breath among employees compared to national rates. Within the plant, flock workers had increased prevalences of most symptoms compared to other workers. Employees using compressed air for cleaning, which is associated with high peak dust exposures, also had more symptoms than other employees. The symptom findings are corroborated by medical tests results. Specifically, current flock work or years of flock work were associated with trends toward airway hyperresponsiveness and gas exchange and lung capacity abnormalities. In addition, current flock work was associated with decreased spirometry results among male employees. In models that attempted to control for factors that contribute to nasal irritation and cough, flock work and/or cleaning with compressed air remained significantly associated with these symptoms arising during employment.

The prevalence of work-related mucous membrane irritant symptoms (i.e., throat and eye irritation) was higher at Hallmark when compared with results of previous NIOSH investigations in plants where flock was produced/processed [Washko 2000, Daroowalla 2005]. In contrast, lower respiratory symptoms (i.e., shortness of breath, cough, and wheeze) were reported less frequently among Hallmark employees. The difference in prevalences may in part be explained by the fact that dust and fiber levels at Hallmark are much lower than levels measured at the previously studied plants [Burkhart 1999, Daroowala 2005]. Another difference is that the particulate exposure at Hallmark included paper dust, which was not present in the flock plants investigated previously.

The objective findings of low FVC, V_A, and DL_{CO} are suggestive of a mild interstitial lung disease process (possibly flock workers' lung). Eschenbacher et al. [1999] reported that half of the cases of diagnosed flock workers' lung reviewed by an expert panel had a restrictive pattern, and in several other patients in the same group, TLC and FVC were in the low normal range. Almost 70% of these cases also had reduced DL_{CO}. In a nylon flock plant, restriction was observed in 7% of production workers compared to 3% in office workers; the prevalences of low diffusing capacity were 13% and 5%, respectively [Washko 2000]. Among polypropylene flock workers in Turkey, 20% had restriction and 26% had low DL_{CO}, compared to 4.4% and 4.4%, respectively, of non-exposed controls [Atis 2005]. The proportion of restriction among Hallmark participants was 7.8%, and 3.9% had low DL_{CO}. The lower proportion of low DL_{CO} (a more specific marker of scarring lung disease) at Hallmark is consistent with no clinical cases having been recognized at Hallmark.

The typical findings of pulmonary function tests in interstitial diseases, such as flock workers' lung, are consistent with restrictive impairment. However, functional and pathologic alterations consistent with small airways disease have been described in patients with various interstitial pulmonary diseases, including interstitial pulmonary fibrosis [ATS 2000]. Although not studied systematically with methacholine challenge tests, the occurrence of airways hyperresponsiveness among flock-exposed workers may be implied by the presence of increased asthma-like symptoms in epidemiological studies [Daroowala 2005, Washko 2000]. Bronchial hyperresponsiveness (a positive MCT) has been found in some patients with flock workers' lung [Kern 2000]. We found that Hallmark employees with positive MCT were four times more likely to have worked with flock for at least one hour per week than other workers. Nevertheless, the prevalence of asthma-like symptoms, such as wheezing and chest tightness, was not increased in flock workers at Hallmark. It is possible that this reflects a so-called "healthy-worker effect" very commonly observed in occupational disease studies that include only workers employed at a particular point in time (i.e., cross-sectional studies). Such studies exclude workers who have left employment or transferred to less exposed jobs due to symptoms. Paper dust, regardless of the presence of flock dust, could be responsible for the observed airways hyperresponsiveness among Hallmark employees. Torén et al. [1994] reported an increased risk for respiratory symptoms among workers exposed to paper dust.

This workplace evaluation has limitations. The relatively small number of flock-exposed workers makes it difficult to perform more sophisticated statistical analyses that would take into account the influence of other possible variables on the associations between exposure and health effects. Misclassification of exposures may have occurred in using questionnaire responses. Finally, three subgroups invited to participate does not reflect the entire workforce at the plant. However, comparisons of all Hallmark participants with national data revealed symptom excesses similar in magnitude to those derived by comparisons limited to flock-exposed workers (data not shown).

In summary, the Hallmark plant environment is complex. Flock workers at the plant are exposed not only to flock-associated dust, but also to paper dust. Paper dust itself results in higher prevalences of many symptoms as shown by comparing paper-exposed workers with ribbon workers. Paper dust may account for a proportion of mucous membrane irritation and airways symptoms (cough, phlegm, and wheeze), as well as airways hyperresponsiveness. However, paper dust is not known to be associated with restrictive lung disease, whereas flock-associated dust exposure is associated with the restrictive disease of flock workers' lung. Indices of mild restrictive lung disease are elevated in Hallmark flock workers, in Hallmark workers who clean equipment with compressed air, and in Hallmark workers who have worked with flock for a period of five years. These health outcomes may reflect higher flock-associated dust exposures in the past, as suggested by historical measurements and the long average period of employment of participants. Nonetheless, the health abnormalities should not be ignored, as they may represent preclinical (mild) occupational lung disease in the current workplace.

Commitment to respiratory protection and engineering control improvements is likely to lower the symptom burden in the employees and may prevent progression or development of flock workers' lung.

Employees may well inquire whether medical surveillance is desirable. At a minimum, employees with medical test abnormalities such as abnormal spirometry, methacholine challenge, or diffusing capacity should take this report and their individual report of test results to their physicians for counsel regarding possible further diagnostic work, follow-up, and secondary prevention measures. Those with airways hyperresponsiveness can be evaluated for possible work-related exacerbation of airflow limitation. Respiratory protection is a must for all employees involved with "clean-outs", given the increased risk of symptoms associated with using compressed air. Surveillance for early restrictive disease (flock workers' lung) in individuals is difficult because standard chest radiographs are insensitive and workplace spirometry is often poor quality and requires repeated measurements over years to detect abnormal declines in lung volume. Accordingly, we suggest that employees with measured abnormalities be followed by their personal physicians. We suggest that company resources be devoted first to prevention of exposures with an enhanced respiratory protection program and engineering control of exposures, even if they are largely unquantifiable when measured over 8-hour shifts. In the flock industry, a safe level of flock-associated exposure is not established, and the workforce's health is the ultimate measure of safety. Our health hazard evaluation at Hallmark shows that there are excesses of symptoms and lung function effects in relation to flock work that provide opportunities for prevention. Peak levels measured by real-time monitors are useful for setting priorities for engineering interventions.

RECOMMENDATIONS

We recommend the following for this workplace:

1. **Prevent dust exposures with engineering controls and improved work practices**

   - Provide cleaning methods that reduce the need to reach into the flock modules.
   - Modify cleaning with compressed air to capture the dust.
   - On compressed-air vacuums, use bag filters that do not discharge respirable particles.
   - Capture the open-top cyclone discharge.
   - Improve local exhaust ventilation at the flock lines, especially at flock module card feed and discharge points.
   - Provide local exhaust ventilation for the dust generated by the compressed air that separates flocked cards.
   - Use vacuums instead of compressed air for removing dust from workers' clothing.

2. **Until engineering controls are in place, expand the use of respirators.**
   - Require that NIOSH-certified particulate respirators be worn during compressed air cleaning activities and that all respirator users are fit-tested under a written respiratory protection program that meets the requirements of the OSHA Respiratory Protection Standard (29 CFR 1910.134).

3. **Inform workers about work-related disease observed among flock workers and how to reduce or control their risk of disease.**
   - Provide information on flock-related lung disease to employees and encourage them to share the information with their physicians.

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TABLES AND FIGURES

Table 1. Demographics of the 239 participating workers in the survey at Hallmark Cards, 2004.

Characteristic	Number	%
Gender (Female)	128	54
Race (White)	191	80
Age (Median) [minimum-maximum])	45	[21-69]
Smoking status:		
Never smoker	131	55
Former smoker	51	21
Current smoker	57	24
Tenure:		
≤ 5 years	23	10
5-10 years	39	16
10-20 years	63	26
> 20 years	113	48
Change in job title in the last 12 months	28	12
Shift:		
Day	107	45
Afternoon	90	38
Night	42	17

Table 2. Distribution of the 239 participating workers by department, Hallmark Cards, 2004

Departments	Number	%
Foil Stamp	66	28
Large Die Cut	43	18
Ribbon and Bow	37	15
Manufacturing/Finishing	34	14
Counter Packaging	35	15
Flock	14	6
Cardboard Fold	10	4
TOTAL	239	100

Table 3. Frequency of work in an area where flock-coated cards are processed and of cleaning equipment with compressed air, by department, for the 239 participating workers, Hallmark Cards, 2004.

Department	Work with flock				Clean with compressed air			
	< 1hr/week		≥ 1 hr/week		< 1hr/week		≥ 1 hr/week	
	Number	%	Number	%	Number	%	Number	%
Foil Stamp	8	12	58	88	48	73	18	27
Large Die Cut	23	53	20	47	38	88	5	12
Ribbon/Bow	33	89	4	11	34	92	3	8
Manufacturing/Finishing	20	61	13	39	31	91	3	9
Counter Packaging	8	23	27	77	28	80	7	20
Flock	-	-	14	100	6	43	8	57
Cardboard Fold	-	-	10	100	7	70	3	30
TOTAL	92	38	146	61	192	80	47	20

Table 4. Ratios of observed to expected number of participants with selected symptoms and spirometry abnormalities in comparison with NHANES III data, adjusted for gender, race, age, and smoking categories, Hallmark Cards, 2004.

Symptom/Abnormality	N*	Observed Number	Expected Number	Ratio (95% C.I.)
Chronic cough†	230	29	21	1.4 (1.0 – 2.0)
Chronic phlegm‡	230	25	17	1.5 (1.0 – 2.1)
Wheeze apart from cold§	230	54	27	2.0 (1.5 – 2.6)††
Shortness of breath‖	230	70	44	1.6 (1.3 – 2.0)††
Obstruction¶	222	5	9	0.6 (0.3 – 1.4)
Restriction**	222	18	17	1.1 (0.7 – 1.7)

* Total number of workers with demographic characteristics comparable to NHANES data.
† Question 5c: "Do you usually cough like this on most days for 3 or more consecutive months during the year?"
‡ Question 6c: "Do you bring up phlegm like this on most days for 3 or more consecutive months during the year?"
§ Question 7a: "Apart from when you have a cold, does your chest ever sound wheezy or whistling?"
‖ Question 10a: "Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill?"
¶Forced expiratory volume in one second (FEV_1)/Forced vital capacity (FVC) ratio (FEV_1/FVC%) < lower limit of normal (LLN) and FVC ≥ LLN
**FEV_1/FVC% > LLN and FVC < LLN
††Statistically significant for $\alpha = 0.05$

Table 5. Respiratory impairment type and severity according to spirometry results for 234 participating workers, Hallmark Cards, 2004.

Spirometry pattern	Severity of respiratory impairment				TOTAL
	None	Mild	Moderate	Severe	
Normal	208	-	-	-	208
Obstructive	-	3	1	1	5
Restrictive	-	18	1	0	19
Mixed	-	2	0	0	2
TOTAL	208	23	2	1	234

Table 6. Cross-tabulation of flock exposure status with methacholine challenge test (MCT) outcome among 191 participating workers who underwent MCT, Hallmark Cards, 2004.

	MCT Result (PC_{20})		
	≤ 16 mg/ml	> 16 mg/ml	TOTAL
Flock worker	13	107	120
Non flock worker	2	69	71
TOTAL	15	176	191

Unadjusted Odds Ratio = 4.2 95% C.I. = 0.9 – 19.1

Table 7. Cross-tabulation of flock exposure status with combined methacholine/brochodilator outcome among 201 participating workers who underwent one of these tests, Hallmark Cards, 2004.

	Methacholine/Bronchodilator Test Result		
	Positive	Negative	TOTAL
Flock worker	14	112	126
Non flock worker	3	72	75
TOTAL	17	184	201

Unadjusted Odds Ratio = 3.0 95% C.I. = 0.8 – 10.8

Table 8. Cross-tabulation of flock tenure with lung diffusing capacity (DL_{CO}) test outcome for 229 particiapting workers who underwent DL_{CO} testing, Hallmark Cards, 2004.

Flock tenure		DL_{CO} < LLN	DL_{CO} Normal	TOTAL
Flock tenure	≥ 5 years	7	142	149
	< 5 years	1	79	80
	TOTAL	8	221	229

Unadjusted Odds Ratio = 3.9* 95% C.I. = 0.5 - 32.2

Note: One participant who underwent DL_{CO} testing had an uninterpretable result.

* See Results Section for estimated adjusted odds ratio. Due to few cases of low DL_{CO}, this result may not be stable.

Table 9. Cross-tabulation of flock tenure with alveolar volume (V_A) based on DL_{CO} testing among 230 participating workers who underwent DL_{CO} testing, Hallmark Cards, 2004.

Flock tenure		V_A < LLN	V_A Normal	TOTAL
Flock tenure	≥ 5 years	25	125	150
	< 5 years	8	72	80
	TOTAL	33	197	230

Unadjusted Odds Ratio = 1.8* 95% C.I. = 0.8 - 4.2

* See Table 10 for an estimate of an adjusted odds ratio.

Table 10. Summary of selected results for the multivariate logistic modeling of symptoms and pulmonary function test results, Hallmark Cards, 2004.

Outcome	Predictors	Covariates	Odds Ratios (95% C.I.)	Model Predictions & Interpretations
nasal irritation with onset after employment	flock-work* cleaning*	none	2.6 (1.5 – 4.5) 2.5 (1.2 – 5.1)	A 31% occurrence of nasal irritation for non-flock workers who do not clean machines at least one hour per week; a 75% occurrence of nasal irritation for flock workers who clean machines at least one hour per week.
chronic cough with onset after employment	cleaning†	smoking	2.6 (1.0 – 6.5)	A 6% occurrence of chronic cough for non-smokers who do not clean machines at least one hour per week; a 14% occurrence of chronic cough for non-smokers who clean machines at least one hour per week. This 14% is similar to the occurrence of cough predicted for workers who do not clean machines at least one hour per week, but who have smoked one pack of cigarettes per day for over 25 years.
V_A (alveolar volume) < lower limit of normal	flock tenure* (10 years)	BMI‡ tenure age	2.6 (1.5 – 5.2)	A 5% occurrence of V_A below lower limit of normal for 45-year old workers with 20 years of Hallmark tenure and zero years of flock tenure; an 11% or 24% occurrence for corresponding workers with 10 or 20 years of flock tenure, respectively.

* Statistically significant for $\alpha = 0.01$
† Statistically significant for $\alpha = 0.05$
‡ Body mass index

Table 11. Summary of results for the multivariate logistic modeling of FEV_1 and FVC, Hallmark Cards, 2004.

Outcome	Group	Adjusted Means*	Model Predictions & Interpretations
FEV_1 (forced expiratory volume in one second)	Males / Non-Flock Males / Flock	3.723 liters† 3.534 liters†	The average FEV_1 among male flock-workers is about 190 milliliters smaller than the average FEV_1 among male non-flock-workers.
FVC (forced vital capacity)	Males / Non-Flock Males / Flock	4.761 liters‡ 4.467 liters‡	The average FVC among male flock-workers is about 300 milliliters smaller than the average FVC among male non-flock-workers.

*Adjusted for body mass index (BMI), height, smoking, age, tenure, and race

† Statistically different for $\alpha = 0.06$
‡ Statistically different for $\alpha = 0.02$

Figure 1: Scanning electron microscope image of bulk flock material, Hallmark Cards, 2004.

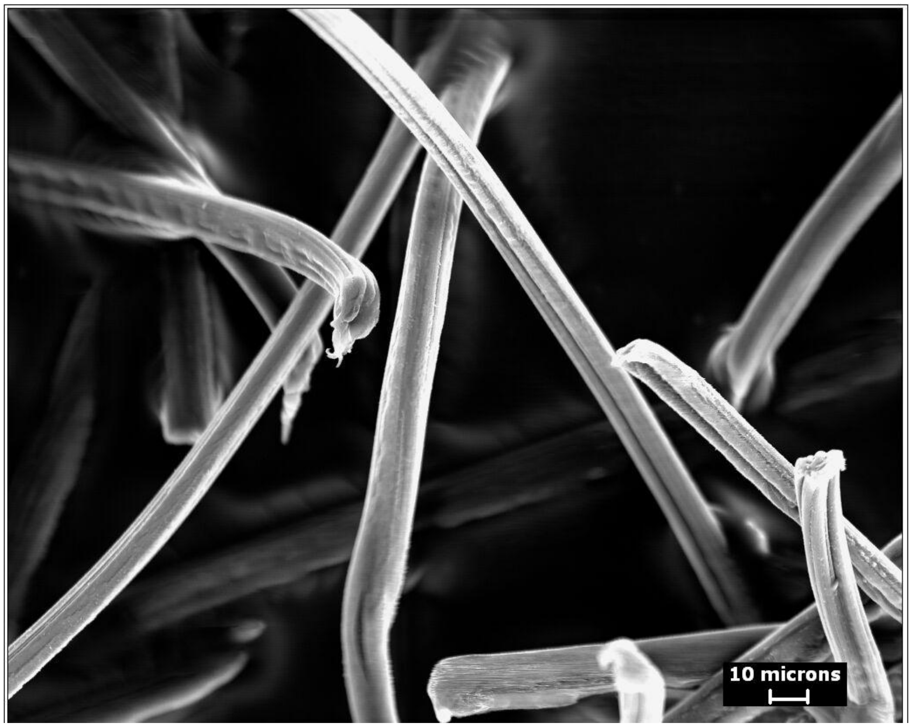


Figure 2: Scanning electron microscope image of bulk flock material, Hallmark Cards, 2004.

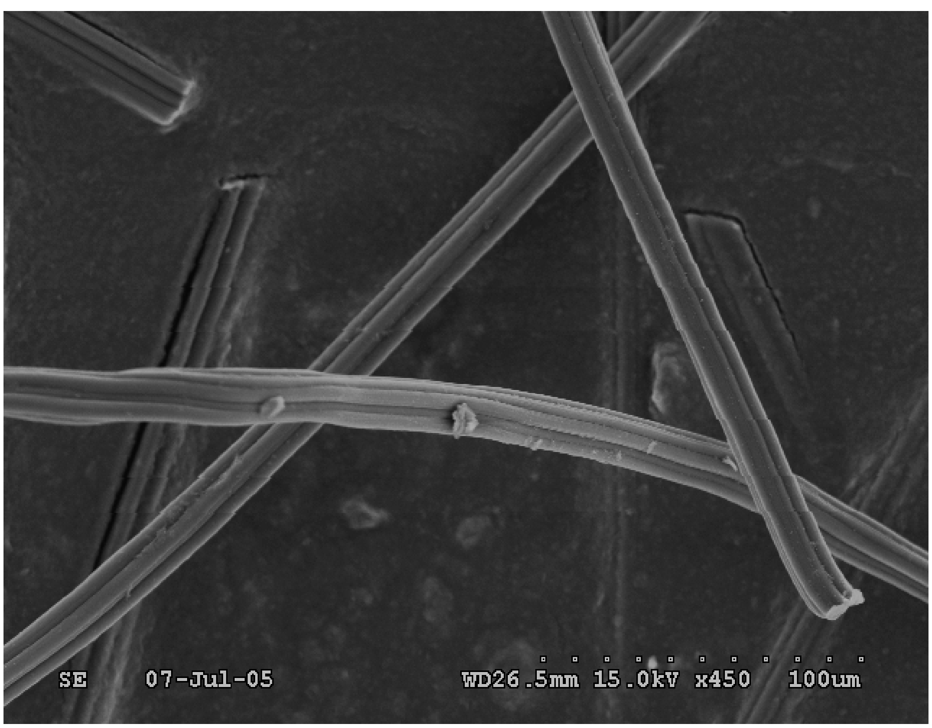


Figure 3: Scanning electron microscope image of the end of a flock fiber in bulk sample, Hallmark Cards, 2004.

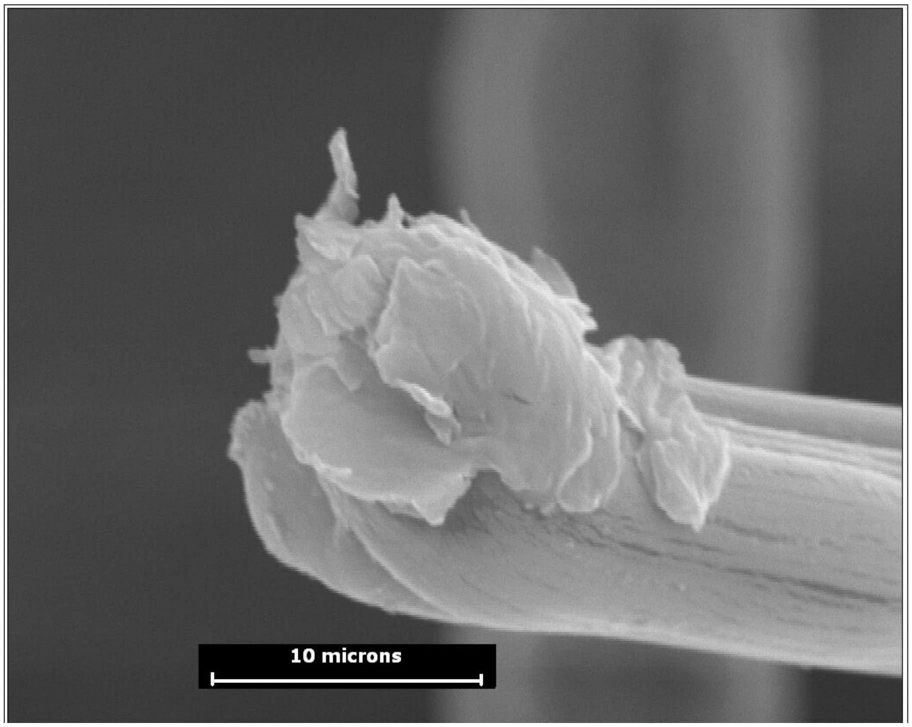


Figure 4: Scanning electron microscope image of airborne sample collected in test chamber after agitating a bulk flock sample, Hallmark Cards, 2004.

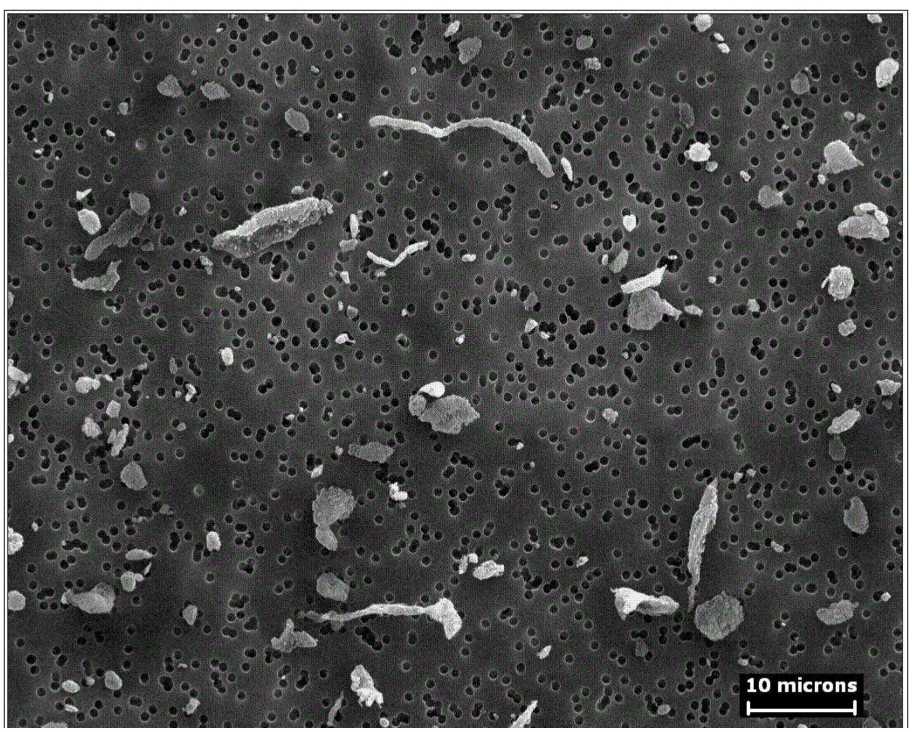
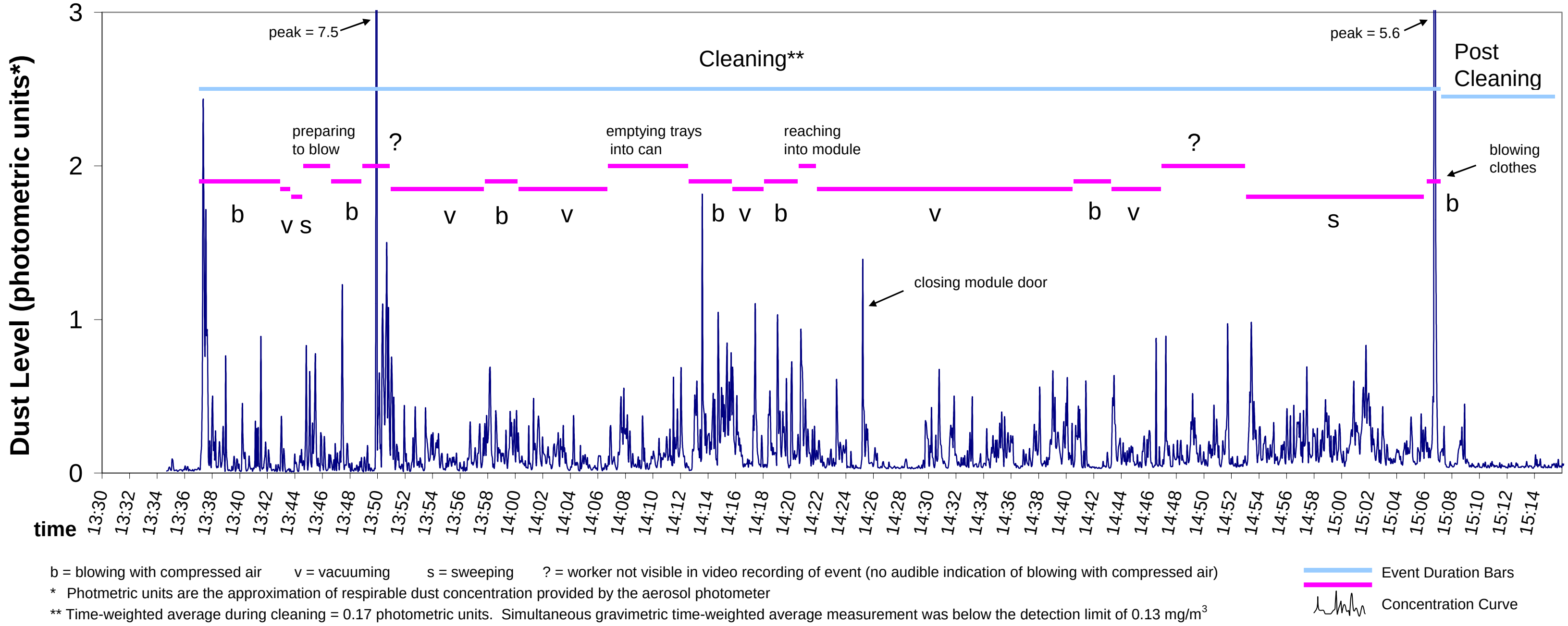


Figure 5: Real-time personal dust measurements during cleaning of Flock Module 2, Hallmark Cards, 2004.

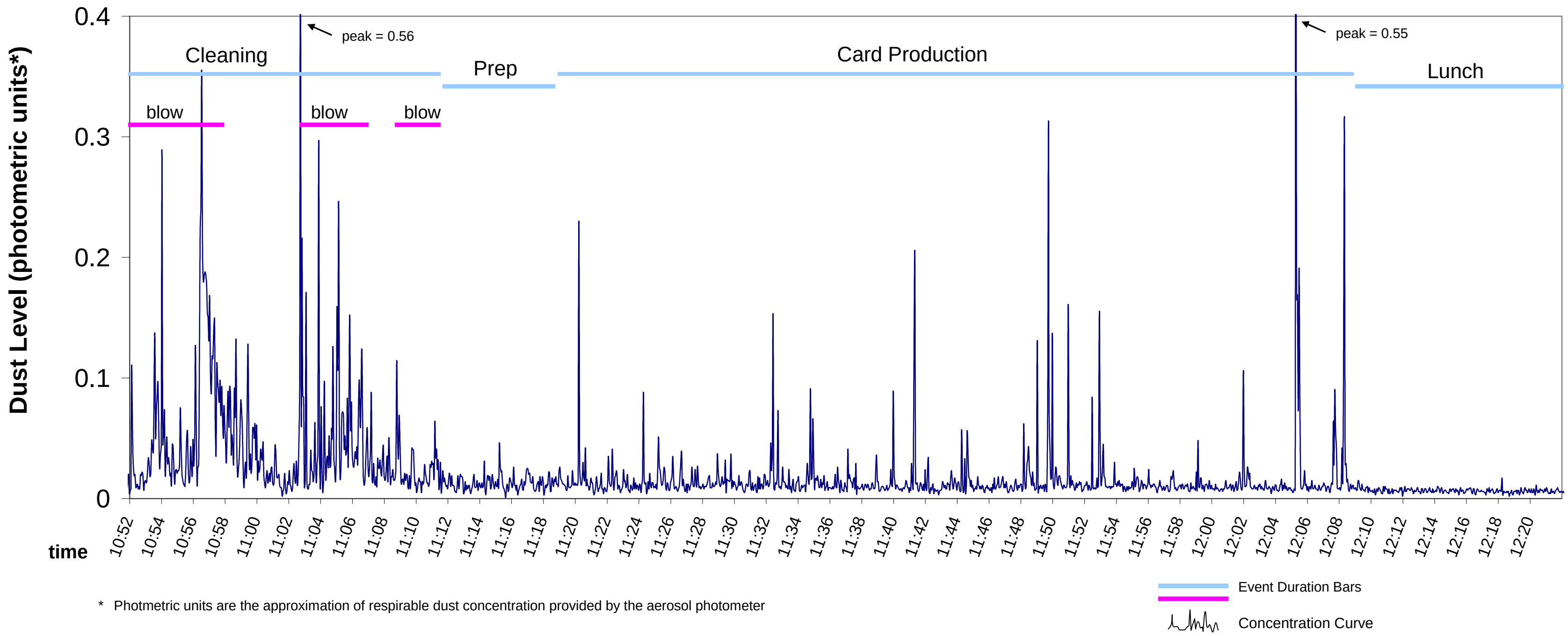


b = blowing with compressed air v = vacuuming s = sweeping ? = worker not visible in video recording of event (no audible indication of blowing with compressed air)

* Photmetric units are the approximation of respirable dust concentration provided by the aerosol photometer

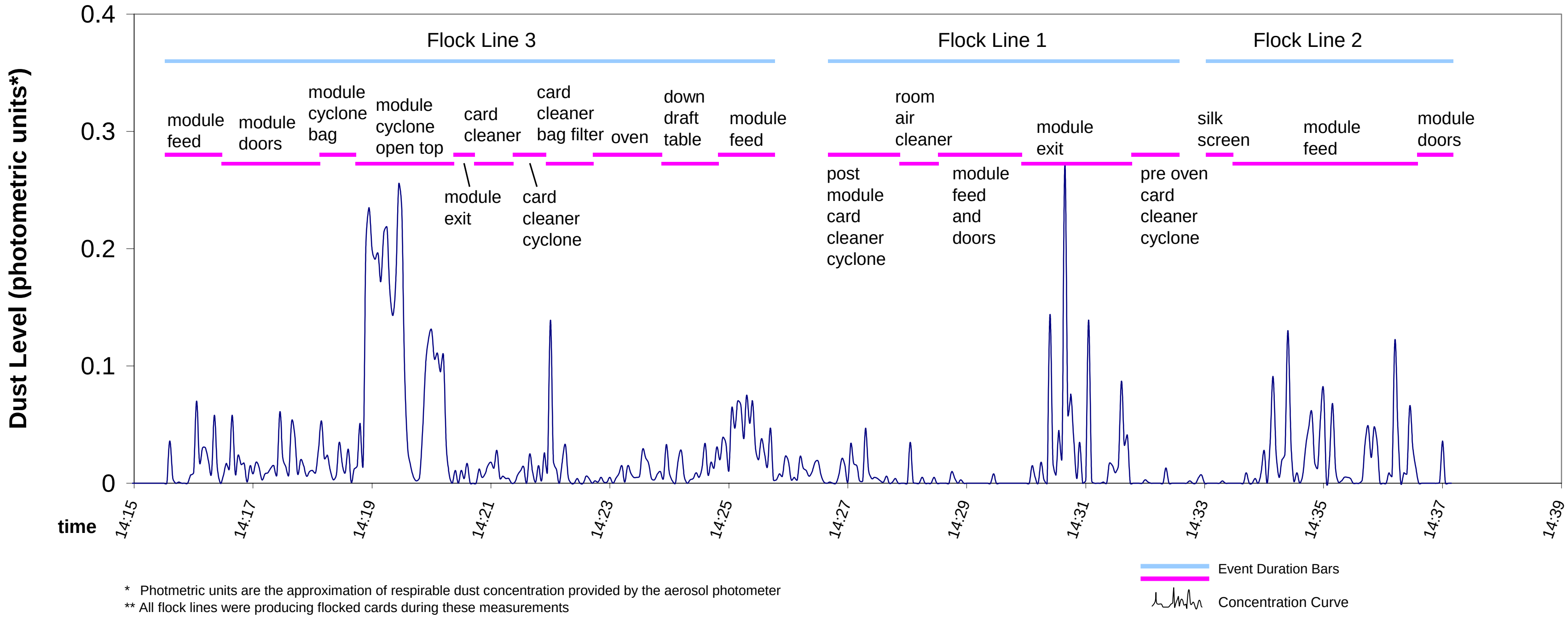
** Time-weighted average during cleaning = 0.17 photometric units. Simultaneous gravimetric time-weighted average measurement was below the detection limit of 0.13 mg/m^3

Figure 6: Real-time area dust measurements between Small Foil Machines T4 & T5, Hallmark Cards, 2004.



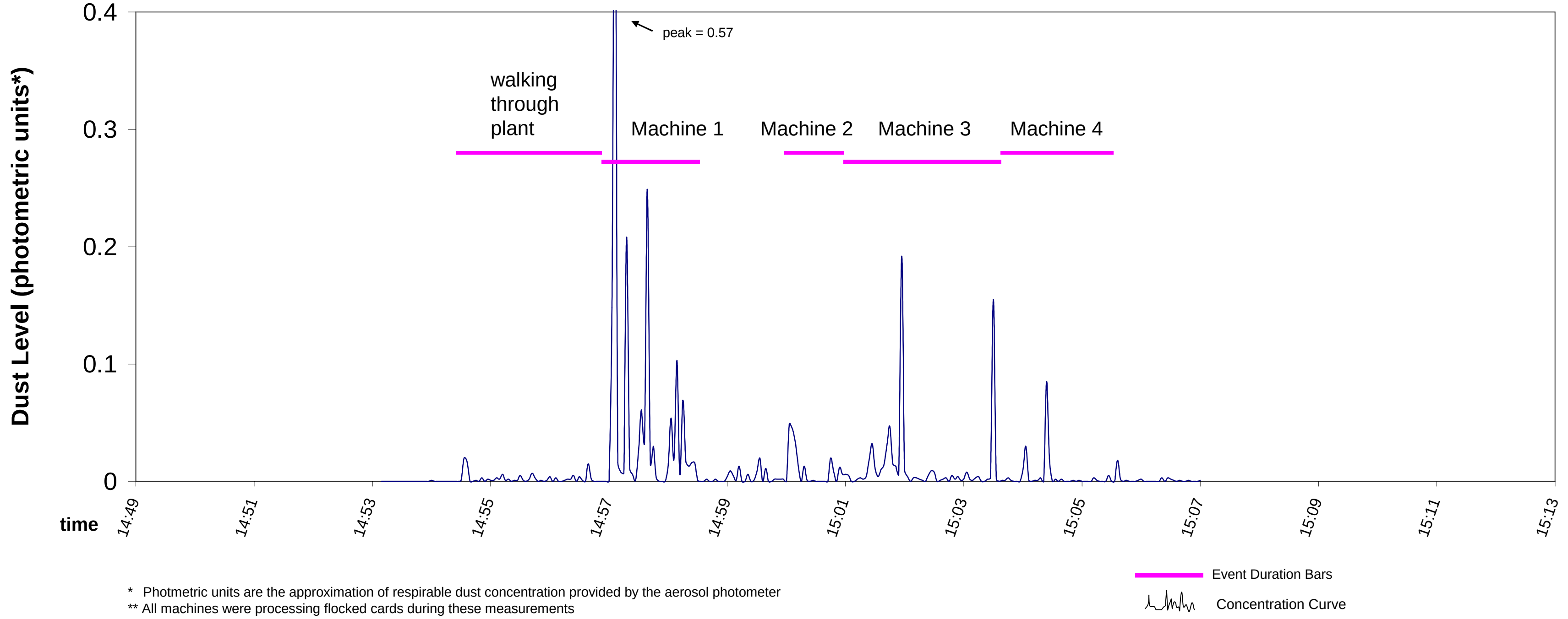
* Photmetric units are the approximation of respirable dust concentration provided by the aerosol photometer

Figure 7: Real-time dust measurements during walk-around in flock line areas,** Hallmark Cards, 2004.



* Photometric units are the approximation of respirable dust concentration provided by the aerosol photometer
** All flock lines were producing flocked cards during these measurements

Figure 8 Real-time dust measurements during walk-around in Small Foil Quad area**, Hallmark Cards, 2004.



* Photometric units are the approximation of respirable dust concentration provided by the aerosol photometer
** All machines were processing flocked cards during these measurements

Figure 9: Real-time dust measurements during flock module cleaning with compressed-air vacuum, Hallmark Cards, 2004.

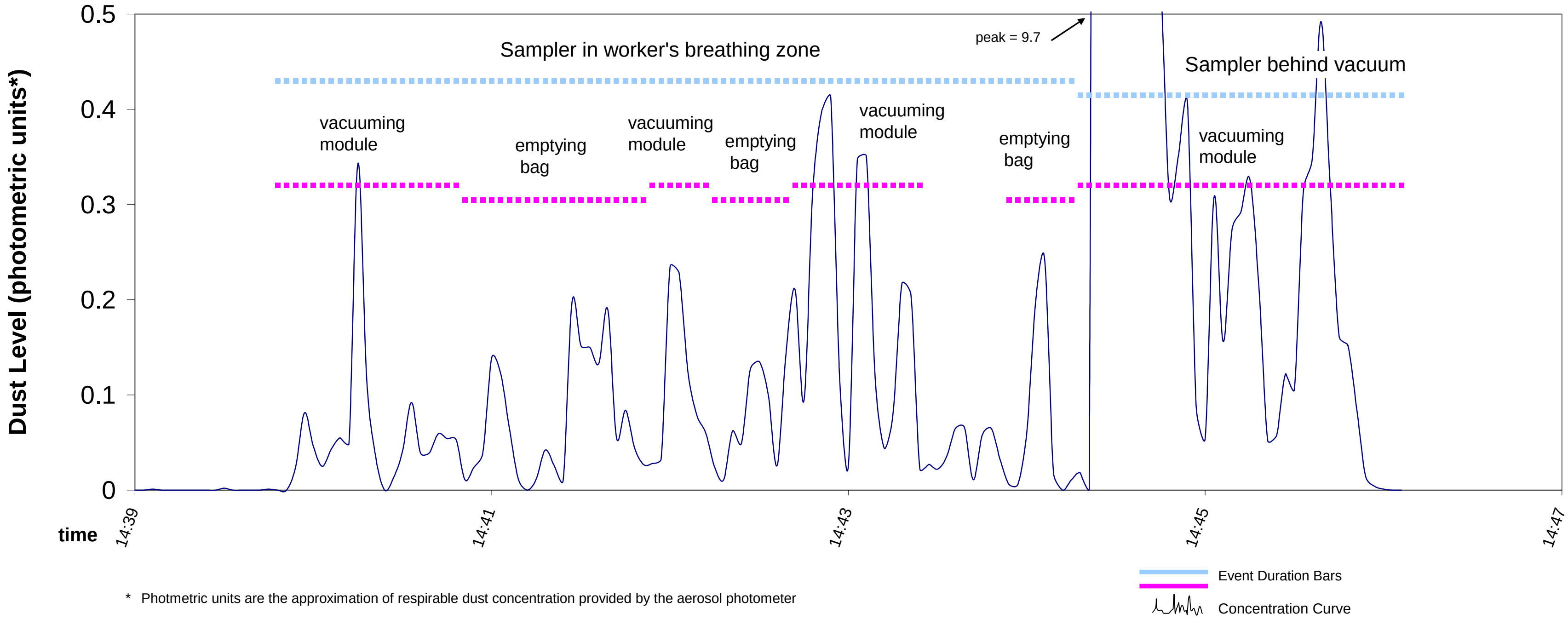
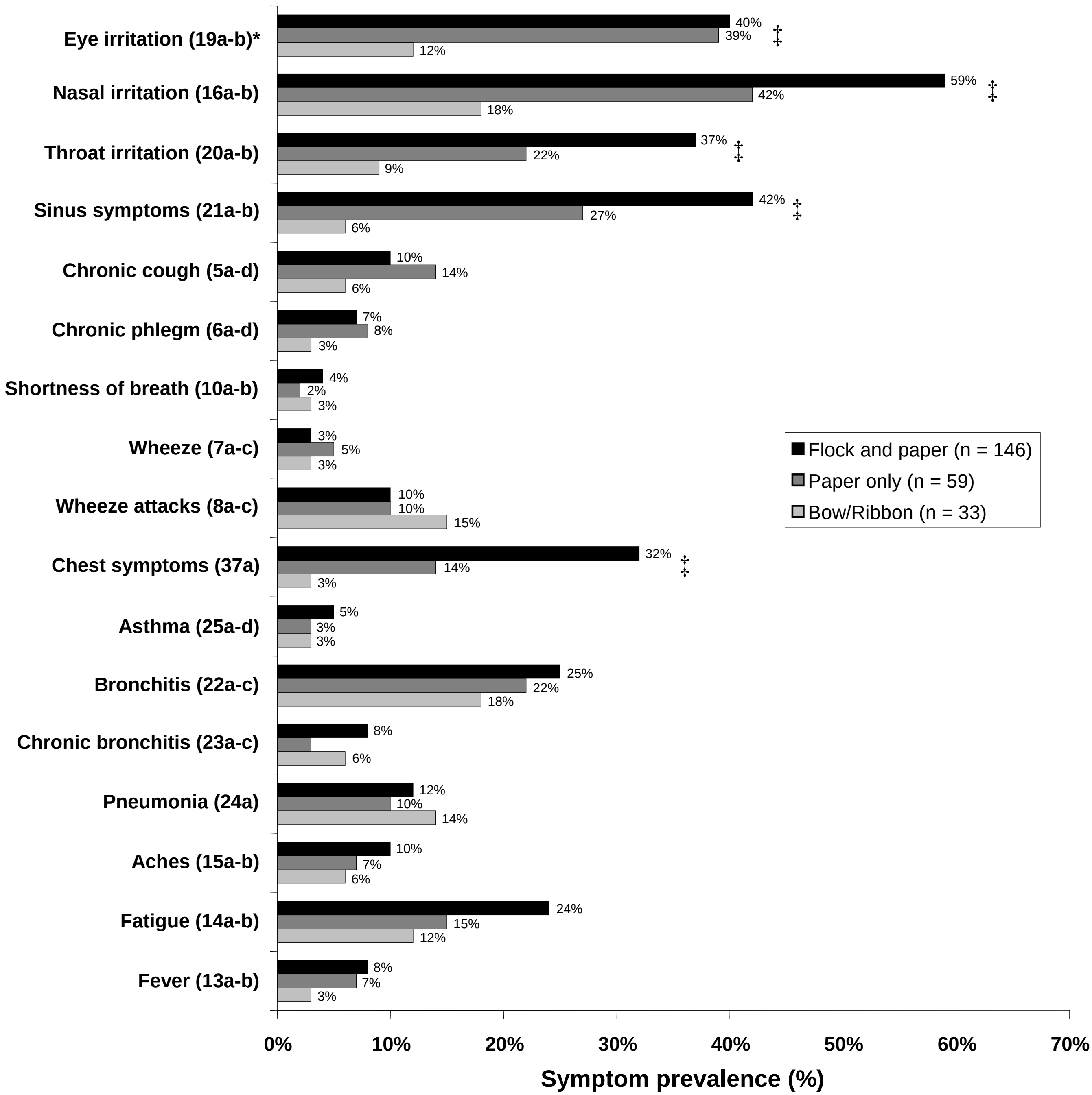
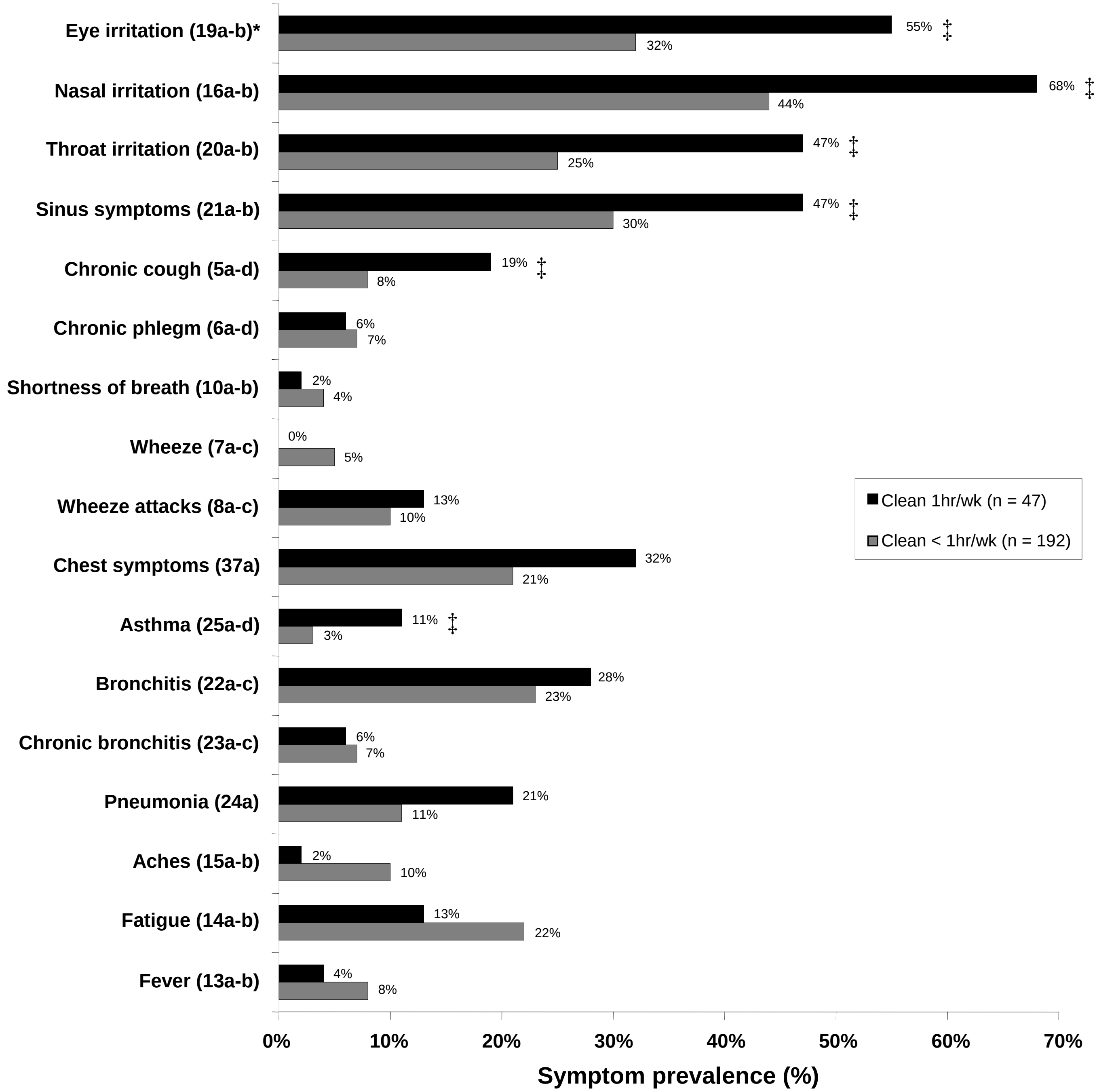


Figure 10: Prevalences of symptoms arising during employment among 238 participating workers[†], by exposure group, Hallmark Cards, 2004.



*The question numbers from the questionnaire (Appendix B), used to define each symptom, appear in parentheses.
[†] One worker was excluded due to not reporting hours of work with flock.
[‡] Chi-square for trend statistically significant for $\alpha = 0.01$.

Figure 11: Prevalences of symptoms arising during employment, among 239 participating workers, by cleaning status, Hallmark Cards, 2004.



*The questions from the original questionnaire (Appendix B), used to define each symptom, appear in parentheses.
‡ Chi-square statistically significant for $\alpha = 0.05$.

APPENDICES

Appendix A
Air Sampling Methods

Analyte	Location	Airflow	Sampling Equipment	Analytical Method
Respirable Dust	Personal and Area	1.7 LPM	37-mm, 5-µm, tared polyvinyl chloride filter, 2-piece cassette, 10-mm cyclone, battery-powered pump	Gravimetric via NIOSH Method 0600[1]
	Area	1.7 LPM	25-mm, 0.8-µm polycarbonate filter, 2-piece cassette, 10-mm cyclone, battery-powered pump	Scanning electron microscopy
Total Dust	Area	1.7 LPM	37-mm, 5-µm, tared polyvinyl chloride filter, 2-piece cassette, battery-powered pump	Gravimetric via NIOSH Method 0500[1]
	Area	1.7 LPM	25-mm, 0.8-µm polycarbonate filter, 2-piece cassette, battery-powered pump	Scanning electron microscopy
Fibers	Personal and Area	0.5 LPM	25-mm, 0.8 µm cellulose ester membrane filter, conductive cowl cassette, battery-powered pump	Fiber counting via NIOSH Method 7400[1] using A-rules
Dust (direct-reading)	Personal and Area	not applicable	MIE personal DataRam™	Aerosol photometer[1] (light-scattering aerosol monitor)

LPM = liters of air per minute
mm = millimeter
µm = micrometer

Reference:
1. NIOSH [2003] NIOSH manual of analytical methods. Vol. 4, with supplements. Cincinnati, OH: U.S. 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 2003-154.

Appendix B - Questionnaire

ID Number: _________

HETA 2004 – 0013

Interviewer: ____________ Interview Date: __ __ / __ __ / __ __ __ __
(Month) (Day) (Year)

Section I: Identification and Demographic Information

Name: ____________________________ ______________________ ____
(Last name) (First name) (MI)

Address:____
(Number, Street, and/or Rural Route)

_____________________ ______________ __________
(City) (State) (Zip Code)

Home Telephone Number: ( ) _______ - __________

If you were to move, is there someone who would know how to contact you?

Name: ____________________________ ______________________ ____
(Last name) (First name) (MI)

Relationship to you:____________________

Address:____
(Number, Street, and/or Rural Route)

_____________________ ______________ __________
(City) (State) (Zip Code)

Home Telephone Number: ( ) _______ - __________

~~~~~~

1. Date of Birth: __ __ / __ __ / __ __ __ __
(Month) (Day) (Year)

2. Sex: 1. ____ Male 2. ____ Female

3. Are you Spanish, Hispanic, or Latino? 1.____Yes 0.____No.
~~~~~~

4. Select <u>one or more</u> of the following categories to describe your race:

1. ___ White
2. ___ African-American or Black
3. ___ Asian
4. ___ American Indian or Alaska Native
5. ___ Native Hawaiian or Other Pacific Islander

Section II: Health Information

I'm going to ask you some questions about your health. The answer to many of these questions will be "Yes" or "No." If you are in doubt about whether to answer "Yes" or "No," then please answer "No."

COUGH

5a. Do you usually have a cough? (*This includes a cough with first smoke or on first going out-of-doors, but does not include clearing of throat*.) 1. ___ Yes 0. ___ No

IF YES:

5b. Do you usually cough as much as 4 to 6 times a day, for 4 or more days out of the week? 1. ___ Yes 0. ___ No

5c. Do you usually cough like this on most days for 3 or more consecutive months during the year? 1. ___ Yes 0. ___ No

5d. In what year did you first notice this cough? __ __ __ __

PHLEGM

6a. Do you usually bring up phlegm from your chest? (*This includes phlegm with a first smoke, on first going out-of-doors, and swallowed phlegm; but does not count phlegm from the nose.*) 1. ___ Yes 0. ___ No

IF YES:

6b. Do you usually bring up phlegm like this as much as twice a day, 4 or more days out the week? 1. ___ Yes 0. ___ No

6c. Do you bring up phlegm like this on most days for 3 or more consecutive months during the year? 1. ___ Yes 0. ___ No

6d. In what year did you first notice this phlegm? __ __ __ __

WHEEZING

7a. Apart from when you have a cold, does your chest ever sound wheezy or whistling? 1. ___ Yes 0. ___ No

IF YES:

7b. Does your chest sound wheezy or whistling most of the time?	1. ___ Yes	0. ___ No
7c. In what year did you start wheezing like this?	__ __ __ __	

ATTACKS OF WHEEZING

8a. Have you ever had an attack of wheezing that has made you feel short of breath? 1. ___ Yes 0. ___ No

IF YES:

8b. In what year did you first have an attack of wheezing with shortness of breath?	__ __ __ __	
8c. Have you ever required medicine or treatment for the(se) attack(s)?	1. ___ Yes	0. ___ No

BREATHLESSNESS

9a. Do you have any nerve, muscle, bone problems or heart trouble that makes walking difficult for you? 1. ___ Yes 0. ___ No

IF YES, ask for description of difficulty:

9b.____

10a. Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill? 1. ___ Yes 0. ___ No

IF YES:

10a. Do you have to walk slower than people of your own age on the level because of shortness of breath?	1. ___ Yes	0. ___ No
10b In what year did you first notice this shortness of breath?	__ __ __ __	

CHEST TIGHTNESS

11a. Have you ever woken up with a feeling of tightness in your chest? 1. ___ Yes 0. ___ No

IF YES:

11b. During the last 12 months, have you woken up with a feeling of chest tightness?	1. ___ Yes	0. ___ No

12a. Have you ever had to change your job, job duties, or work area at this plant because of breathing difficulties? 1. ___ Yes 0. ___ No

IF YES:

12b. What month and year did you change your job, job duties, or work area? __ __ / __ __ __ __ (Month) (Year)

12c. Describe your job, job duties, and/or work area before the change:

____

____

12d. Describe your job, job duties, and/or work area after the change:

____

____

12e. Were your breathing problems after the change:

1. ___ Better
2. ___ The Same
3. ___ Worse

SYSTEMIC SYMPTOMS

13a. Since you began working at this plant, have you had fever, chills or night-sweats? 1. ___ Yes 0. ___ No

IF YES:

13b. How often have you had the fever, chills, or night-sweats?

1. ___ Rarely
2. ___ Monthly
3. ___ Weekly
4. ___ Daily

14a. Since you began working at this plant, have you had unusual tiredness or fatigue? 1. ___ Yes 0. ___ No

IF YES:

14b. How often have you had the unusual tiredness or fatigue?

1. ___ Rarely
2. ___ Monthly
3. ___ Weekly
4. ___ Daily

15a. Since you began working at this plant, have you had flu-like achiness or aches all over your body? 1. ___ Yes 0. ___ No

IF YES:

15b. How often have you had these aches?

1. ___ Rarely
2. ___ Monthly
3. ___ Weekly
4. ___ Daily

EYE, NOSE, THROAT, and SINUS SYMPTOMS

16a. Since you began working at this plant, have you had symptoms of nasal irritation such as a stuffy or blocked nose, an itchy nose, a stinging or burning nose, or a runny nose? (A*part from a cold*) 1. ___ Yes 0. ___ No

IF YES:

16b. Is there an exposure at work that aggravates these nose symptoms? 1. ___ Yes 0. ___ No

IF YES:
16c. Please describe the exposure(s) that aggravate your nose symptoms:

____

____

17. Since you began working at this plant, have you had nose bleeds more than once a month? 1. ___ Yes 0. ___ No

18. Since you began working at this plant, have you ever coughed up blood? 1. ___ Yes 0. ___ No

19. Since you began working at this plant, have you had symptoms of eye irritation such as watering or tearing eyes, red or burning eyes, itching eyes, or dry eyes? 1. ___ Yes 0. ___ No

IF YES:

19b. Is there an exposure at work that aggravates your eye symptoms? 1. ___ Yes 0. ___ No

IFYES:
19c. Please describe the exposure(s) that aggravate your eye symptoms:

____

____

20a. Since you began working at this plant, have you had any symptoms of throat irritation, soreness, or tickle? 1. ___ Yes 0. ___ No

IF YES:

20b. Is there an exposure at work that aggravates your throat symptoms? 1. ___ Yes 0. ___ No

IF YES:
20c. Please describe the exposure(s) that aggravate your throat symptoms:

____

____

21a. Since working at this plant, have you had any symptoms of of sinus fullness, drainage, or sinus pain? 1. ___ Yes 0. ___ No

IF YES:

21b. Is there an exposure at work that aggravates your sinus symptoms? 1. ___ Yes 0. ___ No

IF YES:
21c. Please describe the exposure(s) that aggravate your sinus symptoms:

____

____

RESPIRATORY ILLNESSES

22a. Since you began working at this plant, have you ever had attacks of bronchitis? 1. ___ Yes 0. ___ No

IF YES:

22b. Was it confirmed by a doctor? 1. ___ Yes 0. ___ No

22c. While working at this plant, how many times have you had bronchitis? ______ Times

23a. Have you ever had chronic bronchitis? 1. ___ Yes 0. ___ No

IF YES:

23b. Was it confirmed by a doctor? 1. ___ Yes 0. ___ No

23c. How old were you when it began? ______ Years old

24a. Since you began working at this plant have you ever had pneumonia? (*Include bronchopneumonia*) 1. ___ Yes 0. ___ No

IF YES:

24b. How many times have you had pneumonia since you began working at this plant?	______ Times

25a. Have you ever had asthma? 1. ___ Yes 0. ___ No

IF YES:

25b. How old were you when it began?	______ Years old	
25c. Was it confirmed by a doctor?	1. ___ Yes	0. ___ No
25d. Do you still have asthma?	1. ___ Yes	0. ___ No

Section III: Work History at Hallmark Cards Inc.

I am now going to ask you questions about your current job at Hallmark Cards.

26. What is your current department?

____

27. What is your current job title?

____

28. What shift do you usually work? 1. ___ Day 2. ___ Afternoon 3. ___ Night

29. During an average week, how many hours do you usually work? ______ Hours per week

30. During an average week, how many days do you usually work? ______ Days per week

31a. Do you ever work in an area where flock-coated cards are processed? 1. ___ Yes 0. ___ No

IF YES:

31b. During an average week, how many hours do you work in areas where flock-coated cards are processed? ______ Hours per week

32. Does flock accumulate on surfaces where you work? 1. ___ Yes 0. ___ No

33a. Do you ever clean equipment with compressed air? 1. ___ Yes 0. ___ No

IF YES:

33b. During an average week, how many times do you clean equipment with compressed air? ______ Times per week

33c. During an average cleaning session, how long do you spend cleaning equipment with compressed air? ______ Minutes Per cleaning session

33d. Do you wear a mask or respirator when cleaning equipment with compressed air? 1. ___ Yes 0. ___ No

IF YES:

33e. Do you wear a mask or respirator:

1. ___ During all cleanings?
2. ___ During most cleanings?
3. ___ During some cleanings?

33f. Which type of mask or respirator do you wear? (See Diagram)	1. ___ Single strap 2. ___ 2-strap 3. ___ Half face piece 4. ___ Full face piece 5. ___ PAPR 6. ___ SCBA 7. ___ Other
*Describe:*__________________________	
33g. Were you fit tested for this respirator?	1. ___ Yes 0. ___ No

34. Do you ever clean equipment with a vacuum cleaner? 1. ___ Yes 0. ___ No

35. Do you ever clean your clothes with compressed air at work? 1. ___ Yes 0. ___ No

36a. Do you ever wear a mask or respirator during your regular work activities, other than when cleaning with compressed air? 1. ___ Yes 0. ___ No

IF YES:

36b. What percent of the time do you wear a mask or respirator when performing your regular work activities?	______ Percent
36c. Which type of mask or respirator do you wear? (See Diagram)	1. ___ Single strap 2. ___ 2-strap 3. ___ Half face piece 4. ___ Full face piece 5. ___ PAPR 6. ___ SCBA 7. ___ Other
*Describe:*__________________________	
36d. Were you fit tested for this respirator?	1. ___ Yes 0. ___ No

37a. Have you noticed material(s) at work that cause you to have chest symptoms such as cough, phlegm, wheezing, attacks of wheezing, or shortness of breath? 1. ___ Yes 0. ___ No

IF YES, describe the material(s) and associated chest symptom(s):

	MATERIAL	CHEST SYMPTOM
37b.	______________________	______________________
37c.	______________________	______________________
37d.	______________________	______________________
37e.	______________________	______________________

I'm now going to ask you to list all the jobs that you have held at Hallmark Cards, Inc. We will begin with your current job and work back through time.

	Job Title	Department	Start Date Month/Year	End Date Month/Year	Were flock-coated cards processed in your work area?
A					1. ___ Yes 0. ___ No
B					1. ___ Yes 0. ___ No
C					1. ___ Yes 0. ___ No
D					1. ___ Yes 0. ___ No
E					1. ___ Yes 0. ___ No
F					1. ___ Yes 0. ___ No
G					1. ___ Yes 0. ___ No
H					1. ___ Yes 0. ___ No
I					1. ___ Yes 0. ___ No
J					1. ___ Yes 0. ___ No
K					
L					1. ___ Yes 0. ___ No

Section IV - Past Work and Exposure History

Have you ever:			*IF YES:* Year Started	Year Ended
38a. Worked in mining?	1. ___ Yes	0. ___ No	__________	__________
38b. Worked in farming?	1. ___ Yes	0. ___ No	__________	__________
38c. Worked in chemical manufacturing like explosives, dyes, lacquers, and celluloid?	1. ___ Yes	0. ___ No	__________	__________
38d. Been exposed to irritant gases such as chlorine, sulfur dioxide, ammonia, and phosgene?	1. ___ Yes	0. ___ No	__________	__________
38e. Been exposed to mineral dusts including coal, silica, or talc?	1. ___ Yes	0. ___ No	__________	__________
38f. Been exposed to grain dusts?	1. ___ Yes	0. ___ No	__________	__________
38g. Been exposed to asbestos?	1. ___ Yes	0. ___ No	__________	__________
38h. Been exposed to any chemical or substance that affected your breathing?	1. ___ Yes	0. ___ No	__________	__________
IF YES to Question 38h, describe the exposure(s) that affected your breathing: ______________________________ ______________________________				

Section V - Cigarette Smoking History

I'm now going to ask you a few questions about tobacco use.

39. Have you ever smoked cigarettes regularly? (*YES if smoked 100 cigarettes or more in your entire life; 100 cigarettes = 5 packs*.) — 1. ___ Yes 0. ___ No

If YES:

39b. How old were you when you first started smoking cigarettes regularly? — _______ Years old

39c. On average, for the entire time that you smoked, how many cigarettes did you smoke per day? (*20 cigarettes = 1 pack*) — _______ Cigarettes per day

39d. Do you still smoke cigarettes (as of 1 month ago)? — 1. ___ Yes 0. ___ No

If NO:

39e. How old were you when you stopped smoking cigarettes regularly? — _______ Years old

Thank you for participating in this survey!

Appendix C
Hallmark Cards, Inc.
Air Sampling Results

Date	Sample Group *	Job Department	Job Title or Area Location	Sample Time (mins) Respirable Dust	Sample Time (mins) Fibers	Sample Time (mins) Total Dust	Respirable Dust** (mg/m^3)	A-Rules Fibers** (fibers/cc)	Total Dust** (mg/m^3)	Direct Flock Work?	Number Cleans Included	Total Time Cleaning (minutes)	Note
AREA SAMPLES													
8/23/2004	A	CARDBOARD FOLD	FOLDING MACHINES	395	395	395	< 0.03	< 0.02	< 0.03	flock	---	---	
8/23/2004	A	FLOCK	FLOCK LINE	395	395	395	< 0.03	< 0.02	**0.03**	flock	1	90	
8/23/2004	A	FLOCK	FLOCK LINE	90	90	90	< 0.13	< 0.07	< 0.13	flock	1	90	Sampled during cleaning only
8/26/2004	A	FLOCK	FLOCK LINE	445	445	---	< 0.03	**0.02**	---	flock	1	4	
8/26/2004	A	FLOCK	FLOCK LINE	425	425	---	< 0.03	**0.04**	---	flock	---	---	
8/26/2004	A	FOIL STAMP	FOIL CUTTING ROOM	416	416	---	< 0.03	< 0.01	---	---	---	---	
8/24/2004	A	FOIL STAMP	FOIL STAMP PRESSES	480	480	480	< 0.03	< 0.01	< 0.03	---	---	---	
8/24/2004	A	FOIL STAMP	FOIL STAMP PRESSES	477	477	269	< 0.03	**0.01**	< 0.04	---	---	---	
8/24/2004	A	FOIL STAMP	FOIL STAMP PRESSES	394	394	394	< 0.03	< 0.02	< 0.03	flock	---	---	
8/25/2004	A	FOIL STAMP	FOIL STAMP PRESSES	418	418	---	< 0.03	< 0.01	---	---	1	20	
8/25/2004	A	FOIL STAMP	FOIL STAMP PRESSES	438	438	438	< 0.03	< 0.01	< 0.03	---	---	---	
8/25/2004	A	FOIL STAMP	FOIL STAMP PRESSES	428	428	428	< 0.03	< 0.01	**0.06**	flock	1	5	
8/24/2004	A	FOIL STAMP	STOCKHANDLING LIFT	344	344	---	< 0.03	< 0.02	---	---	---	---	
8/26/2004	A	FOIL STAMP	STOCKHANDLING LIFT	442	442	---	< 0.03	< 0.01	---	---	---	---	
8/25/2004	B	LARGE DIE CUT	FABRICATION SHOP	452	452	452	< 0.03	**0.01**	**0.06**	---	---	---	
8/26/2004	B	LARGE DIE CUT	LARGE DIE CUT EMBOSSING	435	435	---	< 0.03	< 0.01	---	---	---	---	
8/24/2004	B	LARGE DIE CUT	LARGE DIE CUT MACHINES	414	414	414	< 0.03	< 0.01	< 0.03	---	---	---	
8/25/2004	B	LARGE DIE CUT	LARGE DIE CUT MACHINES	426	426	426	< 0.03	< 0.01	< 0.03	---	---	---	
8/24/2004	B	MANUFACTURING FINISHING	HIGH SPEED PAGE INSERT MACHINES	411	411	411	< 0.03	**0.01**	< 0.03	---	---	---	
8/25/2004	B	MANUFACTURING FINISHING	HIGH SPEED PAGE INSERT MACHINES	325	325	325	< 0.04	< 0.02	< 0.03	---	---	---	
8/23/2004	C	EXTRUDING	EXTRUSION MACHINE	418	418	418	< 0.03	< 0.01	< 0.03	---	---	---	
8/25/2004	X	MACHINE FOLD	FOLDING MACHINES	430	430	430	< 0.03	< 0.01	**0.04**	flock	2	6	
8/26/2004	X	MACHINE FOLD	FOLDING MACHINES	428	428	---	< 0.03	< 0.01	---	flock	3	16	
8/23/2004	X	STICKER CELL	STICKER CELL	407	407	407	< 0.03	**0.01**	< 0.03	---	---	---	
PERSONAL SAMPLES													
8/24/2004	A	CARDBOARD FOLD	CARDBOARD FOLD OPERATOR	438	438	---	< 0.03	**0.02**	---	---	---	---	
8/26/2004	A	CARDBOARD FOLD	CARDBOARD FOLD OPERATOR	185	185	---	< 0.06	**0.03**	---	flock	---	---	
8/26/2004	A	CARDBOARD FOLD	PACKAGER	312	312	---	< 0.04	**0.02**	---	flock	---	---	
8/26/2004	A	CARDBOARD FOLD	PACKAGER	357	357	---	< 0.03	**0.02**	---	---	---	---	
8/24/2004	A	CARDBOARD FOLD	STOCKHANDLER	363	363	---	< 0.03	< 0.02	---	---	---	---	
8/23/2004	A	COUNTER PACKAGING	BATCH COUNTER OPERATOR	402	402	---	< 0.03	**0.10**	---	---	---	---	
8/23/2004	A	COUNTER PACKAGING	BATCH COUNTER OPERATOR	fault	425	---	fault	**0.03**	---	---	---	---	
8/23/2004	A	COUNTER PACKAGING	BATCH COUNTER OPERATOR	415	415	---	< 0.03	**0.03**	---	---	---	---	
8/24/2004	A	COUNTER PACKAGING	BATCH COUNTER OPERATOR	425	425	---	< 0.03	< 0.01	---	---	---	---	
8/25/2004	A	COUNTER PACKAGING	BATCH COUNTER OPERATOR	423	423	---	< 0.03	**0.03**	---	---	---	---	
8/25/2004	A	COUNTER PACKAGING	BATCH COUNTER OPERATOR	424	424	---	< 0.03	**0.05**	---	---	---	---	
8/26/2004	A	COUNTER PACKAGING	BATCH COUNTER OPERATOR	417	417	---	< 0.03	**0.02**	---	---	---	---	
8/26/2004	A	COUNTER PACKAGING	BATCH COUNTER OPERATOR	348	348	---	< 0.03	**0.02**	---	---	---	---	
8/25/2004	A	COUNTER PACKAGING	CARDBOARD FOLD OPERATOR	433	433	---	< 0.03	**0.03**	---	---	---	---	
8/24/2004	A	COUNTER PACKAGING	COORDINATOR	368	368	---	< 0.03	**0.02**	---	---	---	---	
8/23/2004	A	COUNTER PACKAGING	FILM OVERWRAP OPERATOR	416	416	---	< 0.03	**0.03**	---	---	---	---	
8/24/2004	A	COUNTER PACKAGING	FILM OVERWRAP OPERATOR	377	377	---	**0.03**	**0.03**	---	---	---	---	
8/24/2004	A	COUNTER PACKAGING	FILM OVERWRAP OPERATOR	345	345	---	< 0.03	**0.03**	---	---	---	---	
8/25/2004	A	COUNTER PACKAGING	FILM OVERWRAP OPERATOR	420	420	---	< 0.03	**0.01**	---	---	---	---	
8/25/2004	A	COUNTER PACKAGING	FILM OVERWRAP OPERATOR	350	350	---	< 0.03	**0.03**	---	---	---	---	
8/26/2004	A	COUNTER PACKAGING	FILM OVERWRAP OPERATOR	357	357	---	< 0.03	< 0.02	---	---	---	---	
8/23/2004	A	COUNTER PACKAGING	LEAD WORK COORDINATOR	410	410	---	< 0.03	**0.04**	---	---	---	---	
8/23/2004	A	COUNTER PACKAGING	PACKAGER	352	352	---	< 0.03	**0.03**	---	---	---	---	
8/24/2004	A	COUNTER PACKAGING	PACKAGER	381	381	---	< 0.03	< 0.02	---	---	---	---	
8/24/2004	A	COUNTER PACKAGING	PACKAGER	450	450	---	< 0.03	**0.01**	---	flock	---	---	
8/24/2004	A	COUNTER PACKAGING	POWERED TRANSPORTER OPERATOR	458	458	---	< 0.03	< 0.01	---	---	---	---	

Date	Sample Group *	Job Department	Job Title or Area Location	Sample Time (mins) Respirable Dust	Sample Time (mins) Fibers	Sample Time (mins) Total Dust	Respirable Dust** (mg/m^3)	A-Rules Fibers** (fibers/cc)	Total Dust** (mg/m^3)	Direct Flock Work?	Number Cleans Included	Total Time Cleaning (minutes)	Note
8/23/2004	A	COUNTER PACKAGING	STOCKHANDLER	409	409	---	< 0.03	**0.02**	---	---	---	---	
8/25/2004	A	COUNTER PACKAGING	STOCKHANDLER	424	424	---	< 0.03	**0.02**	---	---	---	---	
8/25/2004	A	COUNTER PACKAGING	STOCKHANDLER	441	441	---	< 0.03	< 0.01	---	---	---	---	
8/26/2004	A	COUNTER PACKAGING	STOCKHANDLER	416	416	---	< 0.03	< 0.01	---	---	---	---	
8/26/2004	A	COUNTER PACKAGING	STOCKHANDLER	424	424	---	< 0.03	**0.01**	---	---	---	---	
8/23/2004	A	FLOCK	FLOCK OPERATOR	446	446	---	< 0.03	**0.02**	---	flock	1	90	not cleaning (adjacent in same room)
8/23/2004	A	FLOCK	FLOCK OPERATOR	390	390	---	< 0.03	< 0.02	---	flock	1	90	
8/24/2004	A	FLOCK	FLOCK OPERATOR	364	364	---	< 0.03	**0.05**	---	flock	---	---	
8/24/2004	A	FLOCK	FLOCK OPERATOR	423	423	---	< 0.03	**0.04**	---	flock	---	---	
8/25/2004	A	FLOCK	FLOCK OPERATOR	420	420	---	< 0.03	< 0.01	---	flock	---	---	
8/25/2004	A	FLOCK	FLOCK OPERATOR	424	424	---	< 0.03	**0.05**	---	flock	---	---	
8/26/2004	A	FLOCK	FLOCK OPERATOR	447	447	---	**0.03**	< 0.01	---	flock	---	---	
8/23/2004	A	FLOCK	STOCKHANDLER	436	436	---	< 0.03	**0.24**	---	flock	1	90	
8/24/2004	A	FLOCK	STOCKHANDLER	417	417	---	< 0.03	**0.01**	---	flock	---	---	
8/25/2004	A	FLOCK	STOCKHANDLER	404	404	---	< 0.03	**0.02**	---	flock	---	---	
8/24/2004	A	FOIL STAMP	CARD SCRAP SEPARATOR	432	432	---	< 0.03	**0.01**	---	flock	---	---	
8/23/2004	A	FOIL STAMP	COORDINATOR	402	402	---	< 0.03	< 0.02	---	---	---	---	
8/23/2004	A	FOIL STAMP	FOIL STAMP MULTI PRESS OPERATOR	379	379	---	< 0.03	**0.02**	---	---	---	---	
8/23/2004	A	FOIL STAMP	FOIL STAMP MULTI PRESS OPERATOR	435	435	---	< 0.03	**0.03**	---	flock	1	10	
8/23/2004	A	FOIL STAMP	FOIL STAMP MULTI PRESS OPERATOR	433	433	---	< 0.03	< 0.01	---	flock	1	10	
8/24/2004	A	FOIL STAMP	FOIL STAMP MULTI PRESS OPERATOR	428	428	---	< 0.03	**0.01**	---	---	1	5	
8/24/2004	A	FOIL STAMP	FOIL STAMP MULTI PRESS OPERATOR	418	418	---	< 0.03	< 0.01	---	---	1	5	
8/24/2004	A	FOIL STAMP	FOIL STAMP MULTI PRESS OPERATOR	368	368	---	< 0.03	< 0.02	---	---	1	3	
8/25/2004	A	FOIL STAMP	FOIL STAMP MULTI PRESS OPERATOR	430	430	---	< 0.03	**0.01**	---	---	2	6	
8/25/2004	A	FOIL STAMP	FOIL STAMP MULTI PRESS OPERATOR	444	444	---	< 0.03	**0.09**	---	flock	1	5	
8/26/2004	A	FOIL STAMP	FOIL STAMP MULTI PRESS OPERATOR	376	376	---	< 0.03	**0.02**	---	---	---	---	
8/26/2004	A	FOIL STAMP	FOIL STAMP MULTI PRESS OPERATOR	380	380	---	< 0.03	**0.03**	---	---	---	---	
8/26/2004	A	FOIL STAMP	FOIL STAMP MULTI PRESS OPERATOR	484	484	---	< 0.02	**0.02**	---	flock	1	33	
8/24/2004	A	FOIL STAMP	FOIL STAMP PRESS OPERATOR	434	434	---	< 0.03	< 0.01	---	---	1	4	
8/25/2004	A	FOIL STAMP	LEAD WORK COORDINATOR	401	401	---	< 0.03	**0.02**	---	---	---	---	
8/23/2004	A	FOIL STAMP	THOMSON TRI PRESS OPERATOR	388	388	---	< 0.03	**0.04**	---	---	---	---	
8/23/2004	A	FOIL STAMP	THOMSON TRI PRESS OPERATOR	443	443	---	< 0.03	< 0.01	---	---	---	---	
8/23/2004	A	FOIL STAMP	THOMSON TRI PRESS OPERATOR	423	438	---	< 0.03	< 0.01	---	flock	---	---	
8/24/2004	A	FOIL STAMP	THOMSON TRI PRESS OPERATOR	439	439	---	< 0.03	**0.02**	---	---	---	---	
8/24/2004	A	FOIL STAMP	THOMSON TRI PRESS OPERATOR	431	431	---	< 0.03	**0.02**	---	---	---	---	
8/25/2004	A	FOIL STAMP	THOMSON TRI PRESS OPERATOR	356	356	---	< 0.03	**0.03**	---	flock	---	---	
8/26/2004	A	FOIL STAMP	THOMSON TRI PRESS OPERATOR	fault	435	---	fault	< 0.01	---	---	1	180	
8/26/2004	A	FOIL STAMP	THOMSON TRI PRESS OPERATOR	471	471	---	< 0.03	< 0.01	---	flock	1	150	
8/23/2004	B	LARGE DIE CUT	AUTO SCRAP OPERATOR	398	398	---	**0.03**	**0.05**	---	---	---	---	
8/24/2004	B	LARGE DIE CUT	AUTO SCRAP OPERATOR	365	365	---	< 0.03	**0.02**	---	---	1	2	
8/25/2004	B	LARGE DIE CUT	AUTO SCRAP OPERATOR	423	423	---	**0.03**	< 0.01	---	---	---	---	
8/24/2004	B	LARGE DIE CUT	CARD SCRAP SEPARATOR	356	356	---	< 0.03	< 0.02	---	---	---	---	
8/25/2004	B	LARGE DIE CUT	CARD SCRAP SEPARATOR	444	444	---	< 0.03	**0.05**	---	---	---	---	
8/25/2004	B	LARGE DIE CUT	CARD SCRAP SEPARATOR	423	423	---	< 0.03	**0.02**	---	---	---	---	
8/23/2004	B	LARGE DIE CUT	COORDINATOR	424	424	---	< 0.03	**0.03**	---	---	---	---	
8/25/2004	B	LARGE DIE CUT	COORDINATOR	398	333	---	< 0.03	**0.04**	---	---	---	---	
8/23/2004	B	LARGE DIE CUT	LARGE DIE CUT EMBOSS OPERATOR	395	395	---	< 0.03	**0.03**	---	---	---	---	
8/23/2004	B	LARGE DIE CUT	LARGE DIE CUT EMBOSS OPERATOR	390	390	---	< 0.03	**0.02**	---	---	2	0.5	
8/23/2004	B	LARGE DIE CUT	LARGE DIE CUT EMBOSS OPERATOR	336	336	---	< 0.04	< 0.02	---	---	---	---	
8/24/2004	B	LARGE DIE CUT	LARGE DIE CUT EMBOSS OPERATOR	379	378	---	< 0.03	< 0.02	---	---	---	---	
8/24/2004	B	LARGE DIE CUT	LARGE DIE CUT EMBOSS OPERATOR	393	393	---	**0.06**	< 0.02	---	---	---	---	
8/25/2004	B	LARGE DIE CUT	LARGE DIE CUT EMBOSS OPERATOR	433	433	---	**0.03**	**0.01**	---	---	1	10	
8/25/2004	B	LARGE DIE CUT	LARGE DIE CUT EMBOSS OPERATOR	417	417	---	< 0.03	< 0.01	---	---	---	---	
8/26/2004	B	LARGE DIE CUT	LARGE DIE CUT EMBOSS OPERATOR	433	433	---	< 0.03	< 0.01	---	---	---	---	
8/25/2004	B	LARGE DIE CUT	MAKE READY SPECIALIST	447	447	---	< 0.03	**0.03**	---	---	---	---	
8/25/2004	B	LARGE DIE CUT	POWERED TRANSPORTER OPERATOR	407	407	---	< 0.03	< 0.02	---	---	---	---	
8/24/2004	B	MANUFACTURING FINISHING	COORDINATOR	428	428	---	< 0.03	< 0.01	---	---	---	---	
8/23/2004	B	MANUFACTURING FINISHING	DUAL GLUE LINE MACHINE OPERATOR	437	437	---	< 0.03	**0.02**	---	---	1	0.05	

Date	Sample Group *	Job Department	Job Title or Area Location	Sample Time (mins) Respirable Dust	Sample Time (mins) Fibers	Sample Time (mins) Total Dust	Respirable Dust** (mg/m^3)	A-Rules Fibers** (fibers/cc)	Total Dust** (mg/m^3)	Direct Flock Work?	Number Cleans Included	Total Time Cleaning (minutes)	Note
8/24/2004	B	MANUFACTURING FINISHING	DUAL GLUE LINE MACHINE OPERATOR	423	423	---	< 0.03	**0.05**	---	---	---	---	
8/24/2004	B	MANUFACTURING FINISHING	DUAL GLUE LINE MACHINE OPERATOR	412	412	---	< 0.03	**0.03**	---	---	---	---	
8/26/2004	B	MANUFACTURING FINISHING	DUAL GLUE LINE MACHINE OPERATOR	455	455	---	< 0.03	< 0.01	---	---	---	---	
8/23/2004	B	MANUFACTURING FINISHING	HIGH SPEED PAGE INSERT OPERATOR	436	436	---	< 0.03	**0.09**	---	---	1	3	
8/23/2004	B	MANUFACTURING FINISHING	HIGH SPEED PAGE INSERT OPERATOR	409	398	---	**0.03**	< 0.02	---	---	1	10	
8/24/2004	B	MANUFACTURING FINISHING	HIGH SPEED PAGE INSERT OPERATOR	421	421	---	< 0.03	< 0.01	---	---	---	---	
8/25/2004	B	MANUFACTURING FINISHING	HIGH SPEED PAGE INSERT OPERATOR	387	387	---	< 0.03	**0.05**	---	---	---	---	
8/26/2004	B	MANUFACTURING FINISHING	HIGH SPEED PAGE INSERT OPERATOR	437	437	---	**0.04**	**0.03**	---	---	1	0.03	
8/26/2004	B	MANUFACTURING FINISHING	HIGH SPEED PAGE INSERT OPERATOR	451	451	---	< 0.03	**0.01**	---	---	---	---	
8/24/2004	B	MANUFACTURING FINISHING	PACKAGER	420	420	---	< 0.03	**0.02**	---	---	---	---	
8/26/2004	B	MANUFACTURING FINISHING	POWERED TRANSPORTER OPERATOR	429	429	---	< 0.03	< 0.01	---	---	---	---	
8/23/2004	B	MANUFACTURING FINISHING	STOCKHANDLER	420	420	---	< 0.03	**0.01**	---	---	---	---	
8/26/2004	B	MANUFACTURING FINISHING	STOCKHANDLER	521	521	---	< 0.02	**0.02**	---	---	---	---	
8/23/2004	C	BOW MAKING	BOW MACHINE OPERATOR	423	423	---	< 0.03	**0.02**	---	---	---	---	
8/23/2004	C	BOW MAKING	BOW MACHINE OPERATOR	413	413	---	< 0.03	< 0.02	---	---	---	---	
8/24/2004	C	BOW MAKING	BOW MACHINE OPERATOR	468	468	---	< 0.03	**0.02**	---	---	---	---	
8/25/2004	C	BOW MAKING	BOW MACHINE OPERATOR	469	469	---	< 0.03	**0.02**	---	---	---	---	
8/26/2004	C	BOW MAKING	BOW MACHINE OPERATOR	287	467	---	< 0.04	< 0.01	---	---	---	---	
8/25/2004	C	BOW MAKING	COORDINATOR	390	390	---	< 0.03	< 0.02	---	---	---	---	
8/26/2004	C	BOW MAKING	COORDINATOR	374	374	---	< 0.03	< 0.02	---	---	---	---	
8/25/2004	C	BOW MAKING	RIBBON PRODUCTION COORDINATOR	445	445	---	< 0.03	< 0.01	---	---	---	---	
8/26/2004	C	BOW MAKING	SECTION MANAGER MANUFACTURING II	458	458	---	< 0.03	< 0.01	---	---	---	---	
8/24/2004	C	BOW MAKING	STOCKHANDLER	466	466	---	< 0.03	**0.03**	---	---	---	---	
8/26/2004	C	BOW MAKING	STOCKHANDLER	467	467	---	< 0.03	**0.03**	---	---	---	---	
8/23/2004	C	BOW MAKING	THERMAL PRINT OPERATOR	434	434	---	< 0.03	**0.01**	---	---	---	---	
8/23/2004	C	EXTRUDING	MATERIALS ANALYST I	427	427	---	< 0.03	**0.01**	---	---	---	---	
8/24/2004	C	EXTRUDING	RIBBON EXTRUDER ASSISTANT	439	439	---	< 0.03	< 0.01	---	---	---	---	
8/26/2004	C	EXTRUDING	RIBBON EXTRUDER ASSISTANT	457	457	---	< 0.03	**0.02**	---	---	---	---	
8/23/2004	C	EXTRUDING	RIBBON EXTRUDER OPERATOR	414	414	---	< 0.03	**0.02**	---	---	---	---	
8/25/2004	C	INJECTION MOLD	INJECTION MOLDNG OPERATOR	427	427	---	< 0.03	< 0.01	---	---	---	---	
8/26/2004	C	INJECTION MOLD	INJECTION MOLDNG OPERATOR	443	443	---	< 0.03	**0.02**	---	---	---	---	
8/23/2004	C	RIBBON CONVERT	COORDINATOR	422	422	---	< 0.03	< 0.01	---	---	---	---	
8/23/2004	C	RIBBON CONVERT	DUAL RIBBON WINDER OPERATOR	379	379	---	< 0.03	**0.05**	---	---	---	---	
8/24/2004	C	RIBBON CONVERT	DUAL RIBBON WINDER OPERATOR	468	468	---	< 0.03	**0.01**	---	---	---	---	
8/24/2004	C	RIBBON CONVERT	DUAL RIBBON WINDER OPERATOR	455	455	---	< 0.03	**0.02**	---	---	---	---	
8/25/2004	C	RIBBON CONVERT	DUAL RIBBON WINDER OPERATOR	443	443	---	< 0.03	**0.01**	---	---	---	---	
8/25/2004	C	RIBBON CONVERT	SECTION MANAGER MANUFACTURING III	435	435	---	< 0.03	**0.02**	---	---	---	---	
8/25/2004	C	RIBBON HAND CONVERT	RIBBON SPOOLER	446	446	---	< 0.03	< 0.01	---	---	---	---	
8/25/2004	X	MACHINE FOLD	DUAL FOLD MACH OPERATOR	423	423	---	< 0.03	**0.09**	---	flock	2	6	
8/25/2004	X	MACHINE FOLD	FOLD MACHINE OPERATOR	350	350	---	< 0.03	< 0.02	---	flock	---	---	
8/23/2004	X	UNIVERSAL QUEEN	PACKAGER	447	447	---	< 0.03	**0.02**	---	---	1	1	
8/24/2004	X	WAREHOUSE	POWERED TRANSPORTER OPERATOR	392	392	---	< 0.03	< 0.02	---	---	---	---	
8/24/2004	X	WAREHOUSE	POWERED TRANSPORTER OPERATOR	392	392	---	< 0.03	< 0.02	---	---	---	---	

* Sample groups selected prior to sampling based on information regarding potential flock exposure:
Group A: Individuals who work in areas where **cards with flock** are processed
Group B: Individuals who work in areas where **cards without flock** are processed
Group C: Individuals who work in the **ribbon production** area
Group X: Individuals not selected in original groups, but included in air sampling

** Sample concentrations denoted with " < " were not detectable, so the minimum concentration required for detection is presented. Detectable concentrations are shown in bold.

mg/m^3 = milligrams per cubic meter of air sampled
fibers/cc = fibers per cubic centimeter of air sampled
fault = sampling pump failed so no measurement obtained

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