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E. I. DuPont de Nemours and Co., Inc.
Richmond, Virginia

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PREFACE

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

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Highlights of the NIOSH Health Hazard Evaluation

Evaluation of Exposure to Sulfuric Acid Mist and Dust

In response to a request from the Ampthill Rayon Workers Inc., NIOSH conducted an evaluation of exposures to sulfuric acid mists and dusts/fibers in the Kevlar® fiber production areas, and of the health concerns reported by employees.

What NIOSH Did

- We measured exposures to dusts/fibers in the Finishing area.
- We measured exposures to sulfuric acid mist in the Spinning area.
- We looked at the ventilation systems in the Finishing and Spinning areas.
- We talked to employees about their health, and reviewed relevant medical records.

What NIOSH Found

- Exposures to dusts/fibers in the Finishing area were low, and below available occupational exposure limits.
- The exposures to acid mist in the Spinning area were low, and below occupational exposure limits.
- The ventilation in the Finishing area is good. The ventilation in the Spinning area should be better maintained.
- 27% (4 of 15) interviewed Finishing area employees reported work-related allergy-like symptoms.
- A majority of interviewed Spinning area employees reported work-related upper respiratory symptoms.

What DuPont Managers Can Do

- Better maintain the ventilation system in the Spinning area.
- Better educate employees about contamination and raise awareness about not touching skin with acid covered gloves or clothing.
- Monitor and follow up on health problems reported by employees.
- Evaluate the interlacing procedure in the Spinning area to find ways to reduce task-related exposures.

What the DuPont Employees Can Do

- Report exposure problems to management and health problems to DuPont's medical department .
- Avoid touching skin with contaminated gloves or clothing.

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National Institute for Occupational Safety and Health
NIOSH

Health Hazard Evaluation Report 2000-0291-2840
E. I. DuPont de Nemours and Co., Inc.
Richmond, Virginia
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SUMMARY

On May 10, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from members of the Ampthill Rayon Workers Inc. (ARWI) employed at the E. I. DuPont de Nemours and Co., Inc., (DuPont) facility in Richmond, Virginia. The request indicated that persons working in the para-aramid (Kevlar®) fiber production area were experiencing "infected gland, sore throats, and infections" that they believed may be a result of workplace exposures.

In response to the request, NIOSH investigators visited the facility on July 26-28, 2000. Environmental monitoring was conducted to characterize exposures in the Spinning and Finishing (Beaming and Roving) areas. Total dust exposures in the Beaming and Roving areas of the Finishing area were below 0.02 milligrams per cubic meter ($mg/m^{3)}$, the limit of detection for the sampling method used. Fiber exposures in the Roving and Beaming areas were 0.01 and 0.02 fibers per cubic centimeter (f/cc), below the exposure criterion of 0.5 f/cc we used for this evaluation.

Sulfuric acid mist exposures in the Kevlar Spinning area during routine activities ranged from less than 0.003 mg/m^3 to 0.082 mg/m^3. The NIOSH, American Conference of Governmental Industrial Hygienists (ACGIH), and U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) established an exposure limit for sulfuric acid of 1 mg/m^3 as a time-weighted average. The local exhaust systems in the Spinning area were examined for air flow and air speed. We identified "dead spots" and relatively slow air velocities across the face of the hoods.

NIOSH medical officers interviewed 46 DuPont employees: 25 systematically and 3 voluntarily selected of 50 Spinning area employees, 15 of 16 current Finishing area employees, and 3 former Finishing area workers. Medical records of 12 employees seen for potentially work-related health concerns were reviewed.

Fourteen (56%) of the twenty-five systematically selected, current Spinning area employees reported work-related episodes of upper respiratory symptoms, two reported brief work-related episodes of shortness of breath, and four reported symptoms mainly occurring during work with the interlacing part of the machine. Of the 15 interviewed Finishing employees, 4 (27%) reported work-related allergy symptoms and/or increased frequency of upper respiratory infections, including sinusitis, 1 reported the onset of episodes of wheeze, and

shortness of breath after beginning work in the area, and 1 current and 2 prior Finishing area employees reported symptom onset or worsening after installation of the interlace boxes.

Three of five medical records received for Spinning area workers documented findings of throat irritation and/or chronic hoarseness; two of these medical reports mentioned work-related sulfuric acid mist exposure as a potential cause and one documented a physician-recommended job transfer. No association between symptoms and work environment was reported in medical records of four current Finishing employees. Medical records of three former Finishing area workers revealed two with eye and/or throat irritation who had both been restricted at certain times from the Roving interlace area by the company physician, and one with new-onset asthma diagnosed one year after beginning work in the Finishing area, but with no documentation of a specific cause, including exposures in the workplace.

All measured concentrations of dust, fibers, and sulfuric acid in this evaluation were well below available guidelines or standards. The symptoms reported by DuPont employees evaluated in this HHE are non-specific and cannot be directly related to specific exposures in the areas evaluated, however, it is possible that elevated concentrations of workplace contaminants could have occurred in the past and contributed to reported symptoms. Recommendations are provided in this report to address health and safety issues identified during our evaluation.

Keywords: SIC 2824 (Organic Fibers, Noncellulosic), para-aramid fibers, sulfuric acid, particulates, respiratory symptoms

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INTRODUCTION

On May 10, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from members of the Ampthill Rayon Workers Inc. (ARWI) employed at the E. I. DuPont de Nemours and Co., Inc., (DuPont) facility in Richmond, Virginia. The request indicated that persons working in the para-aramid (Kevlar®) fiber production area were experiencing sore throats and infections that they believed may have been a result of workplace exposures.

In response to the request, NIOSH investigators visited the facility on July 26-28, 2000. During the visit, NIOSH investigators held an opening conference attended by management and employee representatives. Following the conference, environmental monitoring was conducted to characterize exposures occurring in the Spinning and Finishing (Beaming and Roving) areas, and confidential medical interviews were conducted with employees in these two areas. This report describes the methods, findings, and recommendations of our evaluation.

BACKGROUND

The DuPont facility in Richmond, Virginia, manufactures nonwoven and specialty fibers, including Kevlar, a synthetic fiber material that is a key component in many commercial products, including bulletproof vests, tires, and tennis rackets. The Kevlar production process operates continuously, seven days per week, with employees working one of four shifts. Much of the production process is considered by the company to be proprietary, but will be discussed in general terms. The operation consists of two areas, Spinning and Finishing. In the Spinning area, the fibrous yarn is synthesized and wound onto reels to make bobbins of yarn. There are numerous spinning machines in the Spinning department. The yarn is synthesized from a solution composed largely of sulfuric acid. Though the solution is quickly diluted with water, employees working near the machines may incur an exposure to the acid mist and vapor, e.g., when re-threading a broken thread onto the interlace part of the machine. Company safety policy requires employees to use personal protective equipment (PPE). Employees are required to wear safety glasses in the Spinning area. Employees are required to wear shoulder-length gloves, mid-calf rubber boots, full length rain coat, and face shield if they approach the machines and work with the plastic machine shield down. A total of 96 workers, 24 per shift, work in the Spinning area; all perform the same job activities.

Bobbins of Kevlar yarn produced in the Spinning area are moved to the Finishing area, which is made up of the operations of Packaging, Roving, and Beaming. A total of 40 to 48 workers, 10 to 12 per shift, work in the Finishing area. The bobbins of Kevlar yarn are either packaged, sent to the Beaming section where the yarn is wound onto large spools, or sent to the Roving section, where yarn is wound onto tow packages. The Beaming process generally involves the simultaneous unwinding of multiple bobbins, aligning the stands of yarn in parallel, and winding them onto a spool. Yarn in the Roving process is wound onto tow packages, and interlace boxes, installed in May 1999, are intermittently used to assist in this winding operation. Airborne dust and fibers can be generated during the Roving process due to the high degree of yarn movement against friction points. Local exhaust ventilation systems (or "air chambers") were installed in March 2000 to exhaust the additional dust created by the interlace boxes. However, employees have reported problems with these ventilation systems. Air is provided to the Roving/Beaming area by a single heating, ventilating, and air-conditioning (HVAC) unit, which supplies air at a rate of 100,000 cubic feet per minute (CFM). Employees

are required to wear safety glasses while working in this area, and disposable dust masks are provided on request.

METHODS

Environmental Evaluation

Process and personal breathing zone (PBZ) air samples for total dust and fibers analysis were collected over the first shift in the Beaming and Roving areas of the Finishing area. Process samples were collected in the work areas near sources of dust and fiber generation. Each employee was asked to wear two sampling pumps: one for collecting total dust samples, and the other for collecting samples to be analyzed for fibers. Three employees participated in the sampling; two wore both types of pumps, one wore only the total dust collection pump.

Total dust samples were collected in accordance with NIOSH Manual of Analytical Methods (NMAM) method 0500.[1] Samples were collected on 37 millimeter (mm) diameter polyvinyl chloride (PVC) filters. The filters were placed in two-piece polystyrene cassettes and connected via Tygon® tubing to sampling pumps operating at a flow rate of 2 liters per minute (Lpm). Three field blanks were submitted with the sample set for quality control purposes. Filters were pre- and post-weighed on an electrobalance. Total weights were reported.

Fiber samples were collected in accordance with NMAM method 7400.[1] Samples were collected on 25-mm mixed cellulose-ester (MCE) filters. The filters were placed in cassettes outfitted with a conductive cowl. The cassettes were connected via Tygon tubing to sampling pumps operating at a flow rate of 2 Lpm. For quality control purposes, three field blanks were submitted with the sample set. Fibers were counted using phase contrast microscopy.

Seven PBZ air samples were collected on workers in the Kevlar Spinning area to assess exposure to sulfuric acid mist. Air samples were drawn through washed silica gel tubes in accordance with NMAM method 7903.[1] Sorbent tubes were placed in plastic holders and connected via Tygon tubing to sampling pumps calibrated to a nominal flow rate of 0.2 Lpm. Two field blanks were submitted with the sample set for quality control purposes. Samples were analyzed by ion chromatography.

Measurements of face velocity were obtained at four arbitrarily selected hoods in the Spinning area using a VelociCalc® Plus, Model 8360 (TSI Inc., St. Paul, Minnesota). Ten face velocity measurements were obtained at each hood. Smoke tubes were used to qualitatively assess airflow patterns through the hoods.

Medical Interviews

NIOSH medical officers interviewed 40 employees over two shifts, 25 of 50 Spinning area employees who were selected systematically from an employee roster, and 15 of 16 Finishing area employees from Beaming, Roving, and Packaging. Six employees (including three Spinning area workers and three former Finishing area workers) with potentially work-related health concerns volunteered to be interviewed, but were not included in calculations of symptom prevalences. One of the two company physicians and the nurse from the DuPont health unit were also interviewed. Medical records of 12 employees, 8 who had seen private physicians and 4 seen in the DuPont health unit for potentially work-related health concerns, were reviewed. In addition, the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Log and Summary of Occupational Injuries and Illnesses, Form 200 (OSHA 200 log) for the years 1997 to July 2000 were reviewed.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime

without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increases the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[2] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[3] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[4] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criteria.

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

to protect their employees from hazards, even in the absence of a specific OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8-to-10-hour workday. Some substances have recommended STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short term.

Para-Aramid Fibers (Kevlar Fibers)

Para-aramid fibers are manufactured from long-chain synthetic polyamide and are spun into yarn and fabrics or incorporated into composites. The fibers have a high strength-to-weight ratio, heat resistance, and chemical resistance. Typical para-aramid fibers are 12-15 microns in diameter, but during processing, fibrils of <1 micron diameter can break off the core fiber and become airborne.[5] Several studies of animals exposed to airborne para-aramid fibrils have found that, unlike asbestos fibers, the para-aramid fibrils deposited in the lungs of the animals are broken down into even smaller fibrils that are more easily cleared from the body. Para-aramid fibrils have not been shown to cause chronic disease; however, no human data are available regarding Kevlar fibril exposure.[5,6] The World Health Organization's International Agency for Research on Cancer (IARC) has concluded that there is inadequate evidence of para-aramid fibril exposure causing cancer in humans.[5]

Sampling methods used for these fibers are similar to those used for inorganic fibers such as asbestos or man-made mineral fibers. During manufacturing and end use, fibril levels have been reported to range from 0.01 to 0.4 fibers per cubic centimeter (f/cc) for an 8-hour TWA.[6] Although there are no current recommended exposure levels for para-aramid fibrils, fibril concentrations maintained near the level typically found in current commercial operations (0.5 f/cc or less) are not known to pose a health risk to humans.[6]

Particulates

The chemical(s) comprising an airborne particulate often do not have an established occupational exposure limit. It has been the convention to apply a generic exposure criterion in such cases. Formerly referred to as nuisance dust, the current terminology for the nonspecific particulate ACGIH TLV is "particulates not otherwise classified (PNOC)," or "particulates not otherwise regulated" (PNOR) for the OSHA PEL. [3,4]

The OSHA PEL for total PNOR is 15.0 milligrams per cubic meter (mg/m^3) (5.0 mg/m^3 for the respirable fraction) determined as an 8-hour average.[4] The ACGIH TLVs for exposure to PNOC are 10.0 mg/m^3 (total dust, 8-hour TWA) and 3 mg/m^3 (respirable particulate, 8-hour TWA).[3] These are generic criteria for airborne dusts which do not produce significant organic disease or toxic effect when exposures are kept under reasonable control.[7] Excessive concentrations of PNOCs in the workroom air may seriously reduce visibility; may cause unpleasant deposits in the eyes, ears, and nasal passages; or can injure the skin or mucus membranes by chemical or mechanical action by the rigorous skin cleansing procedures necessary for their removal.[7] NIOSH does not have a REL for particulates.

Sulfuric Acid

Sulfuric acid (H_2SO_4) is a severe irritant to the eyes, mucous membranes, and skin. Concentrated sulfuric acid is a corrosive; it can cause severe burns on contact. Sulfuric acid mists can cause eye, nose, and throat irritation, respiratory irritation (manifested by cough and difficulty breathing), and dental erosion. The extent of respiratory irritation depends on factors such as air concentration, particle size, temperature, and humidity.[8] NIOSH,

ACGIH, and OSHA have established an exposure limit for sulfuric acid of 1 mg/m^3 as a TWA to prevent dental erosion and the irritant effects of exposure; ACGIH has recently published a notice of intended change to 0.1 mg/m^3 for TLV.[3,4,9]

Epidemiologic studies have indicated that exposure to sulfuric acid mist and other acid mists is associated with cancer. After review of these studies, the IARC determined that there is sufficient evidence that occupational exposure to strong inorganic acid mists containing sulfuric acid is carcinogenic.[10] This determination was based on the demonstration of epidemiologic associations between occupational exposures to strong acid mists (mostly sulfuric acid mists) and excess risks for laryngeal cancer[11,12,13,14] and lung cancer.[15,16,17] A study of cancer in the general population (not just workers) found that any exposure to sulfuric acid was associated with cancer of the esophagus, but an association between higher exposure and higher risk was not established.[17]

RESULTS

Environmental

Total dust exposures of workers in the Roving and Beaming area ranged from 0.03 to 0.1 mg/m^3 during the July 27th work shift. These data are shown in Table 1. These dust concentrations are below the OSHA PEL of 15 mg/m^3 and ACGIH TLV of 10 mg/m^3. The two area samples had no detectable particulate (limit of detection for the method was 0.2 mg/m^3).

Two PBZ and one area sample were collected for fibers in the Roving and Beaming areas. PBZ fiber exposures during the sampled period were 0.01 and 0.02 f/cc. These concentrations are below the level of 0.5 f/cc typically found in other commercial operations.[6] Fiber sampling results are shown in Table 2.

Eight PBZ samples for sulfuric acid mist concentrations were collected on persons working in the Spinning area. Six samples were collected during routine activities.Task-based samples were collected on two separate employees while they performed start-up and interlacing tasks. Exposures for the six individuals sampled during routine activities ranged from less than 0.003 mg/m^3 to 0.014 mg/m^3. Exposures during start-up and interlacing were 0.082 mg/m^3 and "trace," based on sample volume. Trace concentrations are semi- quantitative and fall between 0.06 and 0.20 mg/m^3 for this sample set. All measured concentrations were below the NIOSH REL of 1 mg/m^3. These data are shown in Table 3.

The local exhaust systems ventilating four machines in the Spinning area were examined qualitatively for smooth (laminar) vs. turbulent air flow, and air speed was measured at several locations across the face of each hood. Air flow was generally laminar into the hoods, but air speeds were not uniform. The evaluation identified "dead spots" across the face of the hood where air velocities were relatively slow. Average air velocities across the faces of the four hoods were 40, 51, 52, and 58 feet per minute (fpm).

Medical

Twenty-eight Spinning area employees were interviewed: three females and twenty-five males (average age =41 years, range: 27-62 years; average length of time working in Spinning area =7 years, range: 3 months to 21 years). Fourteen (56%) of the 25 systematically selected current Spinning area employees reported work-related episodes of upper respiratory symptoms (sinus problems, sore throat, dry throat, headache, cough, eye, nose, and throat irritation). One of the fourteen, along with another Spinning worker with no other upper respiratory symptoms, also reported brief work-related episodes of shortness of breath. Of the total 28 interviewed Spinning area employees, 7 had sought medical attention

because of the symptoms and 4 reported that their symptoms mainly occurred during work with the interlacing part of the machine. Medical records were requested for six of these employees and received for five; three of the five records for Spinning area workers documented reported symptoms of throat irritation and/or chronic hoarseness and objective findings of redness and swelling of the mucous membranes of the pharynx (throat). Of these three cases, two underwent fiberoptic examination of the larynx revealing redness and swelling of the mucous membranes near or on the vocal cords. Two of these medical reports mentioned chemical exposures in the workplace, particularly sulfuric acid mist, as a potential cause. Since the site visit, one employee has been transferred to a different job, based on his physician's recommendation, due to symptoms reportedly experienced from working in the Spinning area.

Fifteen current Finishing area employees were interviewed; seven females and eight males (average age =41 years, range: 38-59 years; average length of time in Finishing job =2.8 years, range: 1 month to 8 years). Of the 15, 4 (27%) reported work-related allergy symptoms (nasal congestion, nasal drainage, nasal and back of throat itching, watery eyes) and/or increased frequency of upper respiratory infections, including sinusitis. Another current Finishing area employee reported the onset of episodes of wheeze, and shortness of breath about three weeks after beginning work in the area, but had not sought medical attention at the time of the site visit. One current and two prior Finishing area employees reported that their eye, nose, and throat irritant symptoms either began or worsened after the interlace box was installed. Four current Finishing area employees had sought medical attention for upper respiratory symptoms. None of their medical records documented health effects that could directly be associated with their work environment. Medical records of the three former Finishing area workers interviewed revealed two with documented reports of eye and/or throat irritation, in addition to objective findings of eye inflammation, thought to be caused by dust exposure in the Kevlar Finishing area, particularly during work tasks involving the interlace box and air chamber; the company physician recommended that both of these employees be restricted from the Roving interlace area. The third former Finishing employee had been diagnosed with allergies and new-onset asthma after one year of working in the Finishing area, however, medical records did not support a work-related etiology.

The DuPont health unit provides new-hire physical examinations, drug screening, routine physical examinations such as those required for Hazmat and Respiratory programs, disability examinations, employee placement determinations, minor emergency care, and evaluations of potentially work-related health concerns. The health unit is staffed by nursing personnel Monday through Friday during the day shift and a physician is on-site 12 hours per week. The interviewed physician, who works four hours per week at the facility, reported having seen three employees with eye, nose, and/or throat irritation from their work area, one Spinning area and two Finishing area employees, in the preceding six months.

Review of OSHA 200 logs revealed 118 entries for Kevlar employees during the time period of 1997 until our site visit in July 2000. One entry from June 2000 involved a production machine operator from the Spinning area; the illness was described as "congestion and soreness in the throat." The remaining entries included 112 musculoskeletal disorders, two eye injuries, one laceration, one varicose vein, and one entry, in December 1998, for asbestosis in a maintenance employee working in the Kevlar department.

DISCUSSION AND CONCLUSIONS

The Beaming and Roving areas of the Finishing area were clean and did not show evidence of a dusty environment at the time of the NIOSH survey; there were signs of dust in some isolated friction points in the process. Based on current knowledge, the level of dust and fibers generated during the day of the NIOSH site visit would not be expected to cause adverse health effects among employees working in that area. Despite the low air concentrations of dust in the Finishing area during the NIOSH evaluation, it is conceivable that dust levels may have been elevated in the past, as was reported by employees, and potentially could have contributed to the upper respiratory and eye irritation that some Finishing employees experienced. Kevlar fiber and/or finishing dust exposure may cause irritant symptoms similar to other dust exposures (coughing, mucous membrane irritation, sneezing); chronic diseases such as asthma and chronic bronchitis have not been associated with Kevlar fiber exposure.[5]

Sulfuric acid exposures in the Spinning area appeared to be well controlled on the day of the NIOSH survey. The NIOSH team did, however, note a few opportunities for improvement. Employees performing tasks that require close interaction with the wet end of the machine were observed using proper PPE, as required by company policy. We observed, however, that employees performing these tasks tended to touch their face with the contaminated gloves. We observed them pushing up their glasses with their gloves and generally having their gloves in their face area. Touching the skin with contaminated PPE could lead to acute itching and mild acid burns at the point of contact. The upper respiratory and eye irritation experienced by some Spinning area employees are non-specific, but are consistent with sulfuric acid mist exposure. Although low concentrations of sulfuric acid mist were found during the NIOSH survey, the potential for intermittent higher exposures exists, and may occur with inadequate ventilation and/or containment of the acid mist. The frequency and duration of job-tasks with higher sulfuric acid mist exposure levels, such as re-threading the interlacer and machine start-up, may also be a factor.

Face velocities across the four randomly selected hoods were in the 40-60 fpm range. These velocities are less than recommended standards for good practice.[18] Although it is doubtful that a ventilation hood would capture large mist aerosols, fine mists and acid gasses emanating from the process should be contained if face velocities are maintained at a minimum of 100 fpm. Air velocities across the face of the hoods were also not well balanced, generally ranging from less than ten fpm in some places and exceeding 100 fpm in other areas of the plane. Both hourly and salaried employees reported an incident, not detected for a week, in which a portion of the ventilation system for machine 3108 had fallen into the machinery, affecting the functioning of the system. After the problem was fixed, employees indicated that they felt the ventilation worked better and that exposures to the acid mist were reduced.

On the day of the survey, a large fan was located near machine 3101. The fan was oriented to direct air back down the line toward a nearby doorway into the Spinning area. Reportedly, the fan was in use to help ventilate an area where employee training was in progress. Other floor fans were in place throughout the Spinning area. There was disagreement between union and management representatives with regard to how often the fans are used in the department. There did seem to be agreement among employees that the fans did improve the working environment.

RECOMMENDATIONS

1. Airflow into and through the Spinning area should be improved. Local exhaust ventilation for each machine in the Spinning area should be increased to maintain face velocities of 100 fpm at

the wet end of the machine. Face velocities should be evaluated annually or when there is a change in process or an increase in worker complaints, and adjusted as needed. Efforts should be made to improve the balance and laminar flow into the hood.[18]

2. Placing stationary fans in the Spinning area seems to improve employees' comfort with the work environment. It may be advantageous to keep fans in the area. Any supplemental fans in the Spinning area, however, should be placed a great enough distance from the process machinery so as not to disrupt airflow into the hood. This can be qualitatively observed using smoke tubes.

3. Employees should avoid touching their skin with any object (including PPE) that may be contaminated with sulfuric acid. This topic could be included in the annual Hazard Communication training.

4. As part of the safety and health program, DuPont should monitor reported health problems in a systematic manner designed to identify particular job duties, work materials, machines, or areas of the plant which may be associated with particular health effects. All workers should be protected from exposures to agents presumed to cause or exacerbate the health effects by using engineering (e.g., isolation and ventilation) and/or administrative (e.g., work and hygienic practices, and housekeeping) controls primarily if feasible, and PPE secondarily.

5. Employees with potential work-related health symptoms should notify DuPont's medical providers. When an employee is found to have a work-related health effect, the worksite should be evaluated and exposures of relevant agents should be monitored.

6. If a physician diagnoses an occupational health problem for which reassignment of the affected employee is necessary to avoid a causative or exacerbating exposure, the reassigned worker should retain wages, seniority, and other benefits that might otherwise be lost by such a job transfer.

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Table 1
Total Dust Concentrations Measured in the Roving/Beaming Areas
HETA 2000-0291-2840
July 27, 2000

Personal Exposure Samples			
Job Title	Sample Time[1]	Sample Volume[2]	Concentration[3]
Operator, Roving 3,4, and 5	0806-1547	922	.033
Material Transporter	0820-1550	900	.047
Operator, K-2 Beamer	0814-1549	910	.099
Area Samples			
Sample Location	Sample Time[1]	Sample Volume[2]	Concentration[3]
K-2 Beamer near Lindly	0827-1555	896	ND[4]
On top of Roving 4	0839-1554	870	ND

[1] Reported in military time

[2] Reported in liters of air

[3] Reported in milligrams of dust per cubic meter of air (mg/m^3)

[4] ND means none detected by the sampling and analytical methods used. The airborne dust concentrations for these samples are below the method's minimum detectable concentration of 0.02 mg/m^3

Table 2
Fiber Concentrations Measured in the Roving/Beaming Area
HETA 2000-0291-2840
July 27, 2000

Personal Exposure Samples			
Job Title	Sample Time[1]	Sample Volume[2]	Concentration[3]
Operator, Roving 3,4, and 5	0809-1547	916	.008
Operator, K-2 Beamer	0816-1549	906	.022
Area Samples			
Sample Location	Sample Time[1]	Sample Volume[2]	Concentration[3]
On top of Roving 4	0839-1554	868	.053

[1] Reported in military time
[2] Reported in liters of air
[3] Reported in fibers per cubic centimeter of air (f/cc)

Table 3
Sulfuric Acid Mist Concentrations in the Kevlar Spinning Department
HETA 2000-0291-2840
July 27, 2000

Location/Activity of Sampled Worker	Sample Time[1]	Sample Volume[2]	Concentration[3]
Spinning Machine 32, Modules 1-4/ routine	0823-1440	87	.014
Spinning Machine 31, Module 8/ routine	0825-1217[3]	46.4	ND[4]
Spinning Machine 32, Module 9/ routine	0834-1545	86.2	.008 (trace)[5]
Spinning Machine 32, Module 7/ routine	0831-1547	87.2	ND
Spinning Machine 31, Module 5/ routine	0815-1210	47.0	ND
Spinning Machine 31, Module 4/ routine	0814-1550	91.2	.011
Spinning Machine 31, Module 6/ interlacing	1214-1345	18.2	.082
Spinning Machine 31/ machine setup	1443-1506	4.6	.087 (trace)

[1] Reported in military time
[2] Reported in liters of air
[3] Reported in milligrams of sulfuric acid per cubic meter of air (mg/m^3)
[4] "ND" means no sulfuric acid was detected on this sample by the analytical techniques used. The limit of detection (LOD) for this sample set was 0.3 micrograms (µg) per sample, which corresponds to a minimum detectable concentration (MDC)of 0.003 mg/m^3 for the 87-liter air sample.
[5] "Trace" concentrations are those which are between the analytical MDC and the minimum quantifiable concentration (MQC). These concentrations are semi-quantitative.

For Information on Other

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