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Shaw Industries
Stevenson, Alabama

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PREFACE

The Hazard Evaluations and Technical Assistance Branch of 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 Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Kevin C. Roegner, of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS) and Kevin Dunn, of the Engineering Control and Technology Branch, Division of Physical Sciences and Engineering (DPSE). Field assistance was provided by Calvin Cook of DSHEFS. Analytical support was provided by Ardith Grote of DPSE. Desktop publishing was performed by Nichole Herbert. Review and preparation for printing was performed by Penny Arthur.

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Health Hazard Evaluation Report 98–0053–2732
Shaw Industries
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SUMMARY

On December 5, 1997, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request from employees of Shaw Industries (Shaw), located in Stevenson, Alabama, to conduct a health hazard evaluation (HHE) in the Twisting department. Employees in the Twisting department reported skin and respiratory irritation, gastrointestinal effects, sinus infection, and nervous system effects which they believed to be work–related. Employees' concerns centered around skin contact with a lubricating oil and possible inhalation of the lubricating oil, dust, and fibers generated when a polyester polymer fiber is twisted.

In response to the request, NIOSH investigators visited the facility on March 2 and 3, and again on June 12, 1998, to conduct industrial hygiene and medical evaluations. Environmental monitoring was conducted to characterize exposures occurring in the Twisting department, and confidential medical interviews were conducted to identify symptoms. NIOSH investigators visited Shaw the second time to complete the medical interviews, better quantify exposures, and evaluate the ventilation system.

Employees on all shifts were interviewed. Twenty–seven (40%) reported sinus problems, 11 (16%) reported breathing difficulty, and 11 (16%) reported a rash. Twenty–four (36%) of the participants said that the polyester fiber was irritating. Fourteen (21%) said that the coning oil was irritating to the skin.

Analyses of samples collected on March 3 indicated that aerosols near the polyester polymer (PET) fiber twisting operation are 30–45% fibrous and 55–70% particulate. Airborne fiber concentrations ranged from 0.06 to 0.13 fibers per cubic centimeter (f/cc). Personal breathing zone (PBZ) samples had respirable particulate concentrations of 0.004 and 0.009 milligrams per cubic meter (mg/m^3), and total particulate concentrations of 0.302 mg/m^3. Total particulate concentrations in area and process samples ranged from 0.038 to 0.2.47 mg/m^3. These airborne dust concentrations are well below evaluation criteria for respirable and total dust exposures. The quantity of coning oil present on these samples ranged from 110 to 260 microgram per sample (µg/sample), corresponding to airborne oil concentrations ranging from 0.05 to 0.12 mg/m^3. Area samples obtained between twisting frames and near spindles collected consistently less oil in similar sample volumes than personal samples.

Relatively high air velocities were measured in the twisting area. While this level of air movement serves to thoroughly mix the air in the Twisting department and minimize pockets of stagnant air, it also stirs up dusts and fibers generated by the twisting process.

It was not determined if a health hazard exists in the Twisting department at Shaw. Employees reported respiratory and skin problems consistent with exposure to irritant fibers or chemicals, but there were insufficient data to document an association with any specific job or exposure. Airborne concentrations of environmental contaminants were below the evaluation criteria for dusts (as particulates, not otherwise classified [p.n.o.c].), and non–asbestos fibers (fibrous glass). It is difficult to ascertain, however, how these evaluation criteria should be applied to an oil adsorbed dust. The oil adsorbed onto the dust, and the large size fraction of the fibers, may contribute to the irritating properties reported by some employees. The scientific literature is not well developed in this area. Limited information about the oil's toxicity indicates that it is a mild irritant upon dermal contact, but no inhalation tests have been conducted on the toxicity of the aerosolized oil.

A few areas for improvement were identified. Namely, employees hands were contacting the lubricating oil during certain tasks, and personal protective equipment (PPE), though available for twister operators, was not readily accessible. Although the findings of evaluation do not support a recommendation for modifying the ventilation system, suggestions for a modified design configuration are provided in light of Shaw's plans to redesign the current system.

Keywords: SIC 2281 – Yarn Spinning Mills Textile, polyester yarn, twisting, dust, fibers, oil

TABLE OF CONTENTS

INTRODUCTION

On December 5, 1997, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request from employees of Shaw Industries (Shaw), located in Stevenson, Alabama, to conduct a health hazard evaluation (HHE) of exposures occurring in the Twisting department. Employees in the Twisting department reported skin and respiratory irritation, gastrointestinal effects, sinus infection, and nervous system effects which they believed to be work–related. The request was accompanied by a letter indicating that employees were specifically concerned about exposure to Stantex® 418 (a lubricating oil), dust, and fibers generated when Wellman (a polyester polymer [PET]) fiber is twisted.

In response to the request, NIOSH investigators visited the facility on March 2 and 3, and again on June 12, 1998, to conduct industrial hygiene and medical evaluations. During the first visit, NIOSH investigators held an opening conference attended by management and employee representatives. The day following the opening conference, environmental monitoring was conducted to characterize exposures occurring in the Twisting department, and confidential medical interviews were conducted. NIOSH investigators visited Shaw a second time to complete the medical interviews, better quantify exposures, and evaluate the ventilation system.

BACKGROUND

The Shaw facility was constructed in the early 1900s. Twisting operations have been in place since the 1960s. At the time of the initial survey, 660 employees were employed at the plant, 50 in the Twisting department. Typically about 13 persons work in the Twisting department at one time, with about eight operators assigned to frames twisting PET fiber. The Twisting department operates continuously, 24–hours per day, 7–days per week, and was staffed by four shifts. A given twister operator works 12 hour shifts, alternating between working three or four shifts per week. Twisting operators work either 36 or 48 hours in a given week depending on how many days the employees work, with the average work week being 42 hours.

The PET fiber is delivered to Shaw in bails and goes through a seven step process that manipulates the fiber into the final product, polyester yarn. The bails are first separated, then blended to assure uniformity. An "overspray" is then added to the fiber surface before the fibers move to the carding department, where the fibers are paralleled. In preparation for spinning, the fibers go through a drafting process to decrease their diameter. The fibers are then spun into a format suitable for twisting. Before reaching the Twisting department, the fiber is wound onto cones. In the Twisting department, two, one–ply strands of yarn are twisted into one, two–ply strand on Volkman two–for–one twisting frames. The two, one–ply yarn strands are routed through the oiler as they unwind from the two cones, located in the bucket of the twisting frame. A thin layer of oil is deposited onto the fiber, which is intended to help reduce dusting. Other types of synthetic fiber (nylon) are concurrently twisted in the department. Finally, the yarn is heat set in bake ovens.

The Twisting department has 18 twisting frames used to twist two, one–ply yarns into a two–ply yarn. A twisting frame consists of 120 spindles, 60 spindles on each side. A twisting operator typically is assigned to 180 spindles (1½ frames). The operator is responsible for doffing full two–ply cones, starting loose ends back up when a break occurs, replacing one–ply cones in the bucket when necessary, and maintaining a clean work area. Doffing requires the twisting operator to push the full cone onto the conveyor and replace an empty cone onto the spindle. The twisting operator then starts the loose ends back onto the spindle. Replacing the cones requires the twisting operators to remove the oiler and empty cone centers from the spindle, retrieve two new cones of one–ply yarn from the cart and place them in the bucket, then start the loose ends. All employees are required to wear ear plugs and safety glasses while in the plant. Filtering facepiece respirators (dust masks), latex or nitrile gloves, and barrier cream are also provided for twisting operators, but their use is not required.

The initial request was to address dust, fibers, and lubricating oil in the Twisting department. A lubricating oil, Stantex® 418, was used at the time employees requested the HHE. Prior to NIOSH's first site visit, the Stantex® 418 product was replaced with a different lubricating oil, Shawspin 128. Both oils are proprietory mixtures wholly classified as surfactant blend lubricating oils. Shaw indicated that they had been working with the suppliers to identify process, product, and environmental factors which contribute to the level of dust generated when the yarn is spun. Factors evaluated included process flow rate, temperature, humidity, oil, fiber age, and maud ratio (fiber shape). Twisting frames at Shaw are operated at speeds between 4500 and 5000 revolutions per minute (RPM). The company stated that they would like to operate twisting frames at 5000 RPM, but in an effort to limit the dusting, frames have been operating at 4500 RPM.

The plant ventilation in the twisting area is a uniform–distribution all–air system with supply air ducting overhead. The supply air diffusers are louvered with openings on both the side and the bottom of the duct facing the plant floor. The ducts run the length of the twisting area, with one run at each end of the ring twisting frames (see figure 1). Two service bays at either end of the plant provide the supply air for the spinning and twisting areas with a capacity of approximately 120,000 cubic feet per minute (cfm) per bay. A separate ventilated enclosure is provided for the spindle motors due to the high amount of heat generated by the motor. Return air is collected at either end of the plant and mixed with fresh make–up air introduced from the outside. The plant engineer and the heating, ventilating, and air–conditioning (HVAC) contractors indicated that the current air exchange rate is approximately 13 air changes per hour (ACH). The plant has a standard air conditioning system. It consists of a V–screen upstream of the air washer to remove flyoff or lint. The purpose of the V–screen is mainly for the protection of the air washer, not for efficient removal of dusts and fibers. The V–screens remove large lint particles that can foul or clog the air washer, which would then require shutdown and maintenance. The air washer is used to control humidity within the plant by the addition of water spray in the supply air (see figure 2).[1] There is no separate filtration system for the removal of fine particulates prior to recirculation of plant air. Management indicated that they had been considering a ventilation reconfiguration/upgrade for the Twisting department.

METHODS

Medical Evaluation

Private, open–ended interviews were conducted with workers on the two shifts working at the time of the first visit. Those on the two other shifts were interviewed during a second visit three months later. The latter visit was made because an attempt to solicit the remaining workers to participate in telephone interviews after the first visit resulted in a low response rate. To avoid identifying participants to management, all workers were supposed to report to the NIOSH interviewers, where they could then accept or decline an interview. The interview focused on respiratory and skin symptoms and work–related exposures. The Occupational Safety and Health Administration Log and Summary of Occupational Injuries and Illnesses (OSHA 200 log) for 1996 and for 1997 were reviewed, and a local physician identified by the requester as treating plant workers was interviewed by telephone.

Environmental Sampling

The sampling objective of the first site visit was to screen for air contaminants and generally characterize exposures occurring in the Twisting department. The following sampling strategy was employed: personal breathing zone (PBZ), area, and process air samples were collected for total dust and fibers, PBZ samples were also collected for respirable dust, and area samples were collected to screen for volatile organic compounds (VOCs). Bulk samples of the oil were also collected. During the second site visit, PBZ and area samples were collected to better quantify total dust and oil on dust exposures. Video exposure monitoring was conducted to identify specific tasks that may contribute to overall exposure.

Bulk Samples

Bulk samples of the virgin fiber, fiber with overspray, and fiber with overspray and coning oil were collected from their respective locations of the production process. Samples were placed in glass vials sealed with polyethylene–lined caps. Samples were extracted with methylene chloride and analyzed by gas chromatography–mass spectrometry (GC–MS) to determine which components of the extracted solute were most specific to the coning oil, and to assure that there were no extractable interferences in the virgin fiber or overspray. The coning oil–specific chemicals were then used to establish analytical standards for quantifying the oil collected in air samples.

Total Dust and Oil on Dust

PBZ, area, and process samples were collected to determine airborne dust concentrations, and estimate the portion of the total weight that is oil adsorbed onto the dust. Area samples were collected in the aisles between twisting frames at a height of 7 feet. Process samples were collected at the side of the spinning frames near buckets. Samples were collected on 37–millimeter (mm) diameter teflon filters in three piece filter cassettes connected via a length of Tygon® tubing to battery–powered air sampling pumps operating at a nominal flow rate of 2 liters/minute (L/min). The nominal flow rate was increased during the June 12 site visit to obtain a lower minimum detectable concentration (MDC). After sampling, the cassettes were allowed to equilibrate overnight. Two field blanks were submitted with the samples for quality control purposes. Filters from the March 3 sampling were weighed (pre and post sampling) on a Mettler AT–20 balance and a total weight was reported. Filters used in the June 12 sampling were inadvertently not pre–weighed, so total dust weights could not be obtained. Airborne oil concentrations for these samples were determined by desorbing the filters with methylene chloride and analyzed as follows. Per the bulk samples' analyses results, major compounds in the coning oil were chosen as representative compounds for quantification. Filter samples were extracted with two milliliters (mL) methylene chloride for one hour using a rotating mixer. A 1 mL aliquot of the solution was transferred to an auto sampler vial and analyzed by chromatography– mass specrometry (GC–MS) using a 30 meter DB–5 capillary column (splitless mode).

Stock solutions of standards were prepared by weighing portions of the bulk coning oil and diluting it with methylene chloride. Aliquots of 1 microliters (µL) to 200µL of stock solutions were spiked into 2mL methylene chloride and analyzed as the working standards. Blank filters were also spiked with aliquots of the stock solutions and analyzed with the field samples.

Respirable Dust

Respirable dust concentrations were measured during the March 3, 1998, evaluation. These samples were collected and analyzed in the same fashion as the total dust samples with the following exceptions: samples were collected at a nominal flow rate of 1.7 L/m and a 10 mm nylon cyclone was used for particle size discrimination.

Fibers

PBZ and area samples were collected to measure the airborne fiber concentration and characterize the fiber to particulate ratio. Samples were collected on 25–mm diameter cellulose–ester filters in a cassette outfitted with a conductive cowl in accordance with NIOSH Method 7400.[2] The cassettes were connected via a length of Tygon tubing to battery–powered air sampling pumps operating at a nominal flow rate of 2.0 L/min. After the sampling period, cassettes were capped and given to the laboratory for analysis by phase contrast microscopy.

Volatile Organic Compounds (VOCs)

Area samples were collected in the Twisting department (between twisting frames 6 and 7; and 8 and 9) on March 3, using thermal desorption tubes in accordance with NIOSH Method 2459 to screen for VOCs. Thermal desorption tubes contain three sorbent beds in consecutive layers from front to back (Carbopack Y, Carbopack B, and Carboxen 1003) which are used to capture organic compounds over a wide range of volatility. Substances such as acetone, toluene, pentane, and hexane will be trapped with this sorbent tube. This method is an extremely sensitive and a very specific screening technique; it will identify the compounds present on the sample in the parts per billion range.[2] The thermal desorption tubes were connected via Tygon tubing to battery–powered sampling pumps operating at a calibrated flow rate of 0.05 L/min. Samples were analyzed using an automatic thermal desorption (TD) system interfaced directly with a gas chromatograph (GC) and mass selective detector (MSD).

Ventilation

A limited number of air velocity measurements were made in the twisting area. Ventilation air velocity measurements were made along two aisles within the Wellman fiber twisting area. A TSI, Inc. VelociCalc® model 8360 thermal anemometer was used to measure air velocities in the twisting area. Representative air velocity measurements were taken across the width of the aisle between machine rows 4 and 5 at three locations along the length of the aisle. Ambient particle counts were also made using a TSI Aerodynamic Particle Sizer (APS) unit and the results are shown in Appendix A.

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 increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent becomes available.

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

(OSHA) Permissible Exposure Limits (PELs).[5] NIOSH encourages employers to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion. Exposure criteria used in this report are expressed as time–weighted average (TWA) values. A TWA exposure refers to the average airborne concentration of a substance during a normal 8– to 10–hour workday. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard.

Textile Coning Oil

The composition of the textile coning oil used by the company is considered proprietary; however, a review of the components (material safety data sheet [MSDS] and product composition) and possible adverse health effects revealed that inhalation of a mist or spray of this product can cause irritation of the respiratory tract. The manufacturer advised that the oil be used with adequate ventilation and that respiratory protection should be employed if a spray or mist is generated. Also, contact with the skin can lead to irritation, particularly from prolonged contact. No inhalation toxicological data were available, however, according to the MSDS.

Manmade Polyester Fiber (PET)

The biological reactivity of fibers is determined by their chemical composition, dimensions, and surface properties.[6] PET fiber is made from polyethylene terephthalate polymer and also contains one or more finishes. The MSDS noted that dust generated in high–speed spinning operations can be irritating to the skin and eyes. The irritation could be due to the finish, which is usually concentrated in the dust. Often, fiber particles are too large to reach areas in the lung where they could cause direct lung injury, and instead, settle out in the upper airway passages. To induce direct lung injury and disease, the fibers themselves must be able to reach the distal lung (e.g., alveoli or breathing sacs), and thus must have a specific size and geometry. A fiber with an aerodynamic diameter greater than 12 micrometers (µm) is unlikely to reach the distal lung; those fibers that have diameters of 3 µm or less are considered respirable and thus capable of reaching the distal bronchioles and alveoli[7,8,9] However, there are relatively few long–term inhalation studies which assess the pulmonary effects of fibers, either naturally occurring or man–made.[6]

Particulates

Often the chemical constituent of the airborne particulate does not have an established occupational health exposure criterion. It has been the convention to apply a generic exposure criterion in such cases. Formerly referred to as nuisance dust, the preferred terminology for the non–specific particulate ACGIH TLV criterion is now particulates, not otherwise classified (p.n.o.c.), or for the OSHA PEL, not otherwise regulated (p.n.o.r.).

The OSHA PEL–TWA is 15.0 mg/m^3 for total p.n.o.r. and 5.0 mg/m^3 for the respirable fraction, determined as 8–hour averages. The ACGIH recommended TLV–TWA for exposure to p.n.o.c., is 10.0 mg/m^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.[10]

RESULTS

Medical Results

Sixty–seven (78%) of the 86 eligible employees were interviewed. Twenty–six (39%) of the 67 participants reported no work–related medical problems. Twenty–seven (40%) reported sinus problems, 11 (16%) reported breathing difficulty, and 11 (16%) reported a rash. One person with a history of asthma denied any exacerbation of the condition related to work. Eight (53%) of 15 current smokers, and 14 (61%) of 23 never–smokers reported sinus problems. Three (20%) of the current smokers and 3 (13%) of the never–smokers reported difficulty breathing. Twenty–four (36%) of the participants said that the Wellman fiber was irritating. Fourteen (21%) said that the coning oil was irritating to the skin.

The OSHA 200 logs for 1996 and 1997 listed no respiratory or skin disorders. The interviewed physician treated many plant employees, but was not aware of any unusual prevalence of respiratory illness and had not referred anyone from the plant to a pulmonary specialist.

Environmental Sampling

Analyses of samples collected on March 3, 1998, indicated that aerosols near the PET twisting operation are 30–45% fibrous and 55–70% particulate. Airborne fiber concentrations ranged from 0.06 to 0.13 f/cc. Data are summarized in Table 1.

PBZ samples collected for particulates were 0.004 and 0.009 mg/m^3 for respirable samples, and 0.302 mg/m^3 for total particulates. Area and process samples ranged from 0.038 to 0.247 mg/m^3 (Table 2). These airborne dust concentrations are well below respective evaluation criteria for respirable and total dust exposures.

Four PBZ and five area samples were collected on June 12 to measure the amount of coning oil in the air. From PBZ sample volumes of roughly 2 cubic meters, oil content ranged from 110–260 µg/sample, corresponding to airborne oil concentrations ranging from 0.05–0.12 mg/m^3 (Table 3). Area samples obtained between twisting frames and near buckets collected consistently less oil in similar sample volumes than personal samples. The reason for this is unclear.

Observations

During the two site visits, NIOSH investigators spent several hours in the Twisting department and in other areas of the plant. Twister operators were observed performing their tasks, and were periodically asked why they did tasks in a certain manner. The observations made by NIOSH investigators were:

- Twister operators are required to periodically replace the winding packages in the bucket. This task requires the operator to remove the oiler in order to replace the cones. There is no convenient place to put the oiler during the task, and most of the twister operators lay the oiler on its side. Oil was observed leaking onto the twisting frame near the bucket. The twisting operator then came into contact with the oil while replacing the oiler atop the cones.

- Latex and nitrile gloves, particulate respirators, and barrier cream are provided for employees, but their use is not required. Management indicated that a few operators choose to wear the respirators. No operators were observed using the respirators during the NIOSH site visits. These safety items are stored in the nurses station, which is a two–minute walk from the Twisting department. Employees commented that the nitrile gloves do not afford enough manual dexterity for handling the fine strands of yarn. Additionally, the latex gloves are not durable enough for the required tasks, and break easily. All twister operators were wearing safety glasses and ear plugs as directed by plant policies.

- During the NIOSH site visits, an employee was observed sweeping the floors with a push broom. Additionally some twister operators were observed wiping dust from the twisting frames with rags, while others used compressed air to blow the dust from the twisting frame.

- Visibly, the dustiness near the frames twisting PET yarn was greater than near frames twisting nylon yarn. Dust was observed accumulating on the twisting frames during the work shift.

- Employees are permitted to smoke in the Twisting department. The smoking area is delineated by a small blue square painted on the floor. The smoking area is not isolated from the rest of the work space, nor is dedicated ventilation provided.

Ventilation

The ventilation air velocities measured from 90–400 feet per minute reveal very high levels of air motion consistent with thorough mixing throughout the twisting area. Good mixing results in minimal gradients in fiber or dust concentrations from row to row. However, these high velocities also serve to stir up the dusts and fibers generated by the mechanical processes in twisting and spinning. The placement of the air conditioning returns at either end of the facility also promotes the distribution of fibers and dusts throughout the work area. As the cool supply air is distributed from the ceiling, it meets the warm dust and fiber–laden air rising from the twisting machines. This air gets mixed and eventually is collected at the air returns placed at either end of the plant (see Figure 1).

DISCUSSION AND CONCLUSIONS

Medical/Environmental

Air concentrations of environmental contaminants were below the evaluation criteria for dusts (as p.n.o.c.), and airborne non–asbestos fibers (fibrous glass). Video exposure monitoring of a twister operator during a two–hour period of routine tasks did not identify any specific activities that contributed disproportionately to the overall daily exposure. It is difficult not clear how, or if these evaluation criteria should be applied to an oil adsorbed dust. The oil adsorbed onto the dust, and the large size fraction of the fibers, may contribute to the irritating properties reported by some employees. The medical interviews identified employees with respiratory and skin problems, and the PET fiber and coning oil were reported to be irritating. Although the health effects were consistent with exposure to irritants, there were insufficient data to document an association with any specific job or exposure. The scientific literature is not well developed in this area. Limited information about the oil's toxicity indicates that it is a mild irritant, but no tests were conducted to evaluate the inhalation toxicity of the aerosolized oil.

Reportedly, the concentration of airborne particulates increases when twisting frames are operated at a greater rate. Frames were operating at a rate of 4500 RPM during both NIOSH site visits. The impact of increased production rates on airborne dust concentrations was not measured in this study. One may presume, however, that the increased aerosol generation would likely lead to more employee concern, and possibly, to increases in respiratory/nasal irritation.

Though the oil is only mildly irritating, prolonged or repeated contact may lead to the skin conditions reported by employees. Oil leaking from the dispenser lead to skin contact, primarily on the hands. One employee was observed placing the oiler upright in the adjacent bucket. This approach seems equally convenient to laying the oiler on its side, and eliminates possible spillage and subsequent hand contact.

NIOSH–approved dust masks should be provided for employees who are experiencing symptoms related to exposure. Given that the exposures are relatively low and that the reported symptoms seem to affect only some employees, voluntary respirator use is appropriate. Voluntary use of respirators falls under paragraph (c)(2) of OSHA's respiratory protection standard. Under the direction of this paragraph, Shaw is not required to implement the elements of a respiratory protection program. Shaw must, however, provide employees with Appendix D of section 1910.134, "Information for Employees Using Respirators When Not Required under the Standard".[11] Current policy at Shaw is for the respirators and barrier cream to be stored at the nurses station, a two–minute walk from the Twisting department. The distance that employees must travel to get respirators and barrier cream may be a incumbrance to their use of these safeguards, particularly for barrier cream, which should be frequently reapplied.[12] Employee use of these safeguards may increase if they were stored in a more accessible location for twisting operators.

At the time of the second site visit, Shaw was providing 3M 8560/8710 dust masks. This is an obsolete respirator. After the current supply of respirators is exhausted, Shaw is encouraged to provide NIOSH–certified respirators for use in environments containing oil aerosols. Respirators meeting this requirement are classified as P or R series respirators as defined by 42 CFR part 84.[13]

Ventilation

A new ventilation system proposal has been submitted to Shaw Industries by Southeastern Mechanical Contractors, Inc. This system, as briefly described in meetings at the Stevenson site, involves the installation of a supplemental ventilation system that will distribute additional conditioned air along the spindle frames. This system will also provide some exhaust air terminals above the twisting machines. The primary purpose of this new design is to increase humidity in the twisting area to maximize production rates and product quality. The plant engineer commented that the spindle rotational speeds were adjusted downward due to excessive dustiness at higher speeds. This adjustment reduces productivity. The stated target temperature and humidity within the twisting area is 76^0 F and 53% relative humidity (RH) which is within the American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE) recommended RH range of 50–65% for the twisting process with man–made material. Humidity is an important parameter in controlling the process and generating the desired product. In the initial processes, such as carding, proper levels of humidity are necessary to suppress static electricity. In the twisting area, constant humidity allows for optimum frictional uniformity that results in desired yarn cross–sectional consistency.[14]

The contractors and plant engineer at Shaw stated that providing more localized exhaust and increasing humidity in the twisting area will reduce concentrations of fibers within the twisting area and allow for increased productivity. The proposed system would have the exhaust air terminals far above the process so that adequate overhead clearance is maintained. Also, the proposed exhaust would not enclose the working area but would collect hot air as it rises above the spindle frames. Supply air terminals with cooler air would be distributed across the spindle frames at a lower height than the exhaust terminals. The cool air would pick up heat from the spindles and rise to the overhead returns. The implementation of a more localized return system should provide better collection of the dust from the work area than the current system of wall returns at either end of the spinning/twisting room. However, the high volume and velocity of the air delivered to the area from the current overhead supply diffusers keeps the generated dust and lint stirred up and may result in dust moving through the breathing zone of the worker. The proposed design, while likely to increase relative humidity and uniformity in plant atmospheric conditions, will not likely decrease worker exposure to fibers and dust. Although this approach provides more localized pickup of lint and fiber flyoff, it is not a substitute for a local exhaust system. A local exhaust ventilation system is a dedicated system that is designed to collect the contaminant at or near the source. These systems are preferable to general exhaust systems for contaminant control because they are more effective at removing the contaminant while minimizing exhaust flowrates.[15] Enclosing the process is the optimum method of assuring contaminant capture and minimizing worker exposure. The open frame design of the twisting machines, however, provides a challenge to effectively collecting fiber flyoff and lint. Also, the practice of enclosing is not commonly used in twisting operations, and may not be necessary here due to the low level of measured total and respirable dust.

Alternate ventilation approaches within the spinning and twisting area, however, may be utilized to maintain good operating conditions while yielding a more favorable work environment. A 1996 ASHRAE Technology Award case study involved the development and implementation of an innovative ventilation system for an open end spinning frame. Two of the primary goals of the project were to maintain optimum temperature and RH levels while decreasing dust levels in the spinning room. The design delivered cool conditioned air under the spinning machine. The air became heated by the machine and rose to overhead collection return ducts. The air was then transported with the captured lint to a collection system with a 99.97% efficient automatic panel filter. Although specific numbers on the improvement in dust levels are not given, the author states that the spinning room exhibited one of the lowest dust levels ever recorded for the operation. The author also stated that the system was able to maintain average temperature and humidity levels to ±1 ^{0}F and ±1% RH respectively along the 120 foot spindle frame with good control during both the summer and winter seasons.[16] Another approach highlighted in the 1995 ASHRAE HVAC Applications handbook involves the use of a local waste capture device with intake orifices and a local collector fan at the end of the spindle frame. The system also uses this air to provide cooling for the spinning drive motor.[14]

The selection of good filtration is also key in providing clean air in a recirculation system. While V screens provide reasonable filtration to protect fouling of the air washer, they do not collect particles within the respirable range. Use of an improved filter mar help reduce airborne levels of fiber and dust which cause upper respiratory irritation. Also, the ASHRAE HVAC Applications Handbook briefly addresses the health considerations associated with the control of oil mist in textiles operations, stating: "Spinning operations that generate oil mist must be provided with a high percentage (30–75%) of outside air. In high speed spinning, 100% outside air is commonly used."[14] These are issues which should be addressed when evaluating a new ventilation system.

RECOMMENDATIONS

Based on the exposure measurements obtained and observations made during the two NIOSH site visits, and on the information provided by managers and twister operators, NIOSH offers the following recommendations for addressing employee concerns about airborne dusts, fibers, and oils in the Twisting department.

1. Although a new ventilation system does not seem to be required strictly for reducing worker exposure to dusts and fibers (based on the sampling results from this survey), consideration of the effect of a new system on worker exposure should be given. The ventilation system design should address issues such as air filtration and pickup points for return air that will be beneficial to worker health and safety while not adversely impacting process parameters. The proposed design with supply and return points overhead could possibly cause the air to form a loop (from the supply to the return registers) that may increase worker exposure to dusts and fibers. The implementation of local exhaust along with enclosing the operation to the extent possible will decrease worker exposure to dusts and fibers released from the process.

2. Continue to provide NIOSH–approved dust masks for persons in the Twisting department to use voluntarily. Respirators selected to replace the model currently used at Shaw should be suitable for use in an oil mist–containing environment. Depending on time–use patterns, either P or R–series respirators as identified by 42CFR part 82 would be appropriate. P–series respirators may be used for longer than one, 8–hour shift, whereas R series respirators should be disposed of at the end of each work shift. For a complete list of NIOSH–approved dust masks you may wish to visit the research portion of the NIOSH internet site at http://www.cdc.gov/niosh.

3. The stock of respirators and barrier cream should be moved to a location that is more accessible to twisters. The continuous nature of the twister operators' work limits their opportunity to leave their work station in search of a respirator, should they prefer to use one. The Twisting department supervisor's office may be a good location. The employees should be informed of any change in the storage location of respirators and barrier cream.

4. Twister operators should be encouraged to handle oilers in a manner which will limit the potential for skin contact with the oil. The oilers should not be laid on their side while the twister operators are replacing cones. Placing the oiler upright in the adjacent bucket appears to be a good solution. Any oil that is inadvertently spilled should be immediately wiped up before the twisting operator advances to the next bucket. This will help to limit the potential for employees' contact with the oil.

5. Shaw has been making efforts to identify and address factors that contribute to the dusting. Ideally, employees should be included in this process. Additionally, employees should periodically be informed as to the efforts that management is taking to address the problem and what outcomes are expected.

6. Good housekeeping practices are important in minimizing the re–entrainment of dust and fibers from the process. The use of compressed air to clean the spindles during working hours should be limited to avoid stirring up dusts and fibers in the workplace. Also, the use of dust masks is strongly encouraged when twisting frames and/or spindles are blown down.

7. NIOSH recommends that workers not be involuntarily exposed to ETS.[17] The best method for controlling worker exposure to ETS is to eliminate tobacco use from the workplace and to implement a smoking cessation program for employees. Until tobacco use can be completely eliminated from the facility, Shaw should make efforts to protect employees from ETS by limiting smoking to dedicated, enclosed and separately ventilated areas.

8. The company should have an arrangement for employees with potentially work–related health problems to be evaluated by a physician knowledgeable in occupational medicine. In some cases, appropriate medical management of a health problem related to a specific exposure or job may involve advising the worker to avoid further exposure, either temporarily or permanently. A worker transferred from a job because of work–related health problem, should retain whatever seniority, wages, and benefits to which he or she would have been entitled had the removal not occurred.

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Table 1
Shaw Industries
Stevenson, Alabama
Fiber Concentration and Percent of Fibrous Material
HETA 98–0053
March 3, 1998

Personal Breathing Zone Samples					
Job Title	Sample Number	Sample Time[1]	Sample Volume[2]	Fiber Concentration[3]	Percent Fibrous
Twisting Operator	F–1	0919–1449	660	.13	45%
Twisting Operator	F–2	0928–1437	618	.12	35%
Twisting Operator	F–4	0855–1431	790	.07	35%
Twisting Operator	F–7	0905–1423	636	.10	35%
Area Samples					
Sample Location					
Between Frames 11 and 12	F–3	0825–1442	735	.10	30%
Between Frames 9 and 10	F–5	0830–1440	740	.10	40%
Between Frames 7 and 8	F–6	0837–1423	692	.10	30%
Between Frames 5 and 6	F–8	0841–1407	652	.06	30%

[1] This is the start and stop time for the sampling device (reported in military time).
[2] Sample volumes are expressed in liters of air.
[3] Fiber concentrations are reported as number of fibers per cubic centimeter of air (f/cc)

Table 2
Shaw Industries
Stevenson, Alabama
Total and Respirable Dust Concentrations
HETA 98–0053
March 3, 1998

Personal Breathing Zone Samples					
Job Title	Sample Number	Sample Time[1]	Sample Volume[2]	Total Dust Concentration[3]	Respirable Dust Concentration
Twisting Operator	D–6	0916–16–15	704	–	.004
Twisting Operator	D–7	0922–1625	698	–	.009
Twisting Operator	D–3	0914–1618	848	.302	–
Area Samples					
Sample Location					
Between Frames 9 and 10	D–1	0830–1609	918	.105	–
Between Frames 11 and 12	D–2	0825–1612	934	.247	–
Left side of frame 8, near spindle	D–4	0835–1606	902	.068	–
Near spindle on frame 5	D–5	0845–1602	874	.038	–

[1] This is the start and stop time for the sampling device (reported in military time).
[2] Sample volumes are expressed in liters of air.
[3] Dust concentrations are reported in milligrams of dust per cubic meter of air (µg/m^3).

Table 3
Shaw Industries
Stevenson, Alabama
Extractable Oil from Dust
HETA 98–0053
June12, 1998

Personal Breathing Zone Samples					
Job Title	Sample Number	Sample Time[1]	Sample Volume[2]	µg of oil/sample	Concentration of oil in air[3]
Twisting Operator	A–1	0756–1615	1961	230	.12
Twisting Operator	A–2	0813–1620	1893	130	.07
Twisting Operator	A–3	0753–1629	2078	260	.12
Twisting Operator	A–8	0803–1632	2003	110	.05
Area Samples					
Sample Location					
Right side of frame 11, near bucket	A–5	0830–1622	2099	trace	<.01
Between frames 9 and 10	A–4	0834–1310	1537	trace	<.02
Between Frames 11 and 12	A–10	0826–1611	1871	trace	<.02
Between frames 7 and 8.	A–11	0845–1611	1803	trace	<.02
Right side of frame 10, near bucket	A–14	0840–1618	1756	34	.02

1 This is the start and stop time for the sampling device (reported in military time).
2 Sample volumes are expressed in liters of air.
3 Oil concentrations are reported as micrograms of oil per liter of air (mg/m^3).

APPENDIX A

Particle Size Sampling and Analysis

Introduction

Particle size analysis is an important tool for determining the effect of particulates and fibers on the respiratory system and on developing the appropriate filtration needed to remove these dusts. Particulate and fiber diameter are the primary determinants on the region of deposition in the respiratory system. Particles with aerodynamic diameters greater than 10 micrometers (µm) are generally deposited in the nasal mucosa while those with AEDs between 3 and 10 µm can be deposited in the tracheobronchial region. The smallest particles (AEDs ranging from 0.1 and 3 µm) are deposited in the aveolar region. Fibers are likewise deposited on the basis of aerodynamic diameter rather than length.[1] Particle size distribution is an important design parameter in selecting the appropriate filter for a collection system.

Methods

Particulate and Fiber Sizing

A TSI® model 3320 Aerodynamic Particle Sizer (APS) was used to measure particulate aerodynamic diameters and quantities. The APS is a precision time of flight spectrometer that provides count size distributions for particles with aerodynamic diameters from 0.3 to 20 µm. Time of flight spectrometry involves the determination of a particle's aerodynamic diameter by measuring the acceleration of particles or fibers through a nozzle. As the particle leaves the nozzle, the time it requires to travel between the paths of two laser beams is measured. The time of flight is used to calculate aerodynamic diameter based on a calibration curve. Larger particles require longer times to traverse the path and thus have longer time of flight.[2] The APS unit sampled for 10, one–minute sample intervals at each of ten locations in the fiber twisting area. Samples were collected from eight stations in the Wellman (PET) fiber twisting area, two areas in the nylon twisting area, and one location at the plant and front offices. Sampling was performed along the aisle between the ring twisters at sites on either end and in the middle of the machines.

Results

Particulate and Fiber Sizing

Ten, one–minute samples were taken at each of ten locations within the twisting area. For comparison, samples were also taken at the offices within the plant area and at the administrative offices. A graph of the count distributions for a single one–minute sample at representative locations in the Nylon and PET twisting areas, the Shaw Administrative front office, the Shaw Plant Office, and a typical office at NIOSH in Cincinnati (for comparison) are shown in Figures A–1 through A–5.

Discussion

Particulates and Fibers

In general, there was little difference in both the particle size distribution and calculated mass concentration between the twisting areas and office areas. However, the number of particles less than 0.5 µm in size was higher for the plant as compared to the office data. The APS sample results show a bimodal distribution which has the highest number of particles less than 0.5 µm in aerodynamic diameter and a second peak between 0.5 µm and 0.7 µm. The distributions in the twisting area are not significantly different in mass concentration from the front office. These concentrations however exclude any particles or fibers with an aerodynamic diameter greater than 20 µm (the upper range of the instrument). Also, the APS mass concentrations are calculated based on an assumption of spherical particles with the measured aerodynamic diameter. Fiber aerodynamic diameter is primarily a function of fiber diameter independent of length, therefore, the APS may inaccurately estimate mass concentration in conditions where fibers are present. The limitations of the upper particle size limit of the APS unit exclude the third mode of particles that consist of most of the fiber mass. These are the large billowy fibers that float throughout the plant atmosphere. These large fibers contribute to the total dust mass concentration but consist of fibers that will likely be removed by settling or (if inhaled) by the passages within the upper airways. Sample mass concentrations of total dust are greatly influenced by the existence of these larger aerosols frequently masking the larger number of smaller respirable particles.

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National Institute for Occupational Safety and Health (NIOSH) Study of Dust and Oil Exposure in the Twisting Department

What NIOSH Did

#NIOSH measured dust, fibers and oil getting into air.

#NIOSH asked twister operators about symptoms they were having.

#NIOSH looked at the ventilation in the Twisting Department.

#NIOSH looked at how the twister operators worked.

What NIOSH Found

#Low levels of dust, fibers, and oil are getting into the air where they may be breathed by twister operators.

#Some twister operators reported symptoms that may be caused by the dust, fibers, and oil.

#The ventilation may be blowing too hard and stirring up the dust that settles on the frames and floor.

#Shaw has been looking into possible causes of the dusting from the Wellman fiber so they can improve the air quality.

#Dust masks and barrier creams are provided for twister operators, but these items may be too far from the twisting area.

What SHAW Managers Can Do

#Continue to look at what causes the Wellman fiber to dust and how to make it less dusty.

#Move the dust mask and barrier cream supply closer to the Twisting Department.

#Consider how any ventilation redesign may affect dust levels in the Twisting Department.

#Send employees who may have breathing problems from the dust to see a doctor.

#Ask the employees what they believe causes the twisting operation to be more or less dusty.

What SHAW Employees Can Do

#Handle oilers without laying them on their side. If oilers are not laid on their side, they should not leak oil. This will help to keep the oil from getting on their hands.

#Use the dust masks that are provided if you feel throat or nose irritation.

#Keep area clean and limit the use of air to blow down twisting frames.

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

What To Do For More Information:
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 1–513–841–4382 and ask for HETA Report # 98–0053–2732

National Institute for Occupational Safety and Health
NIOSH

For Information on Other
Occupational Safety and Health Concerns

Call NIOSH at:
1–800–35–NIOSH (356–4676)
or visit the NIOSH Homepage at:
http://www.cdc.gov/niosh/homepage.html

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