IN-DEPTH SURVEY REPORT:

CONTROL TECHNOLOGY FOR MANUAL DYE WEIGH-OUT OPERATIONS

at

Uni-Trade Company, Inc.
Newark, New Jersey

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PLANT SURVEYED:	Uni-Trade Company, Inc. 815 Frelinghuysen Avenue Newark, New Jersey 07114
SIC CODE:	2261
SURVEY DATE:	March 8-12, 1993
SURVEY CONDUCTED BY:	Marjorie A. Edmonds William A. Heitbrink
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EMPLOYEE REPRESENTATIVE CONTACTED:	No Union
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SUMMARY

This survey was conducted to evaluate the manual dye weigh-out operations in a small dye house. In these operations, powder dye is quantitatively transferred from drums and boxes to small buckets. The weigh-out operator may be exposed to dye dust during the scooping, transferring, and weighing tasks. The data gathered from this study showed the scooping task generated the highest exposure to the worker. This is in accordance with the findings of several previous studies of manual weigh-out operations. Color-fly (the unwanted adherence of airborne dye dust to finished goods) also was found to be a significant problem at this plant, particularly when dusty dyes were handled. The need for several controls was apparent. First, the scooping task must be redesigned to eliminate the worker's inclination to place his head in the drum where the dust exposure cannot be controlled. Second, the distance the dye is transferred should be minimized in order to reduce dust exposures as well as potential spills. Finally, the entire manual weigh-out operation should occur within a ventilated booth to further reduce worker exposure to dust and to help prevent the occurrence of color-fly in the plant. From the observations and conclusions of this and other studies, the manual weigh-out operation at this plant will be redesigned with the appropriate engineering controls. A follow-up study will then be conducted to determine the effectiveness of the controls. Control recommendations will then be disseminated throughout the textile and dye industries, with the help of the Ecological and Toxicological Association of Dyes and Organic Pigments Manufacturers (ETAD).

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is the primary federal organization engaged in occupational safety and health research. Located in the Department of Health and Human Services, it was established by the Occupational Safety and Health Act of 1970. This legislation mandated NIOSH to conduct a number of research and education programs separate from the standard setting and enforcement functions conducted by the Occupational Safety and Health Administration (OSHA) in the Department of Labor. An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards. The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering has been given the lead within NIOSH to study the engineering aspects of health hazards prevention and control.

Since 1976, ECTB has conducted several assessments of health hazard control technology based on industry, common industrial process, or specific control techniques. The objective of each of these studies has been to document and evaluate effective techniques for the control of potential health hazards in the industry or process of interest, and to create a more general awareness of the need for, or availability of, effective hazard control measures.

A study of manual dye weigh-out operations is being undertaken by the Engineering Control Technology Branch to provide control technology information for the prevention of occupational disease in this industry. ECTB has been working on this project with the U.S. Operating Committee of the Ecological and Toxicological Association of Dyes and Organic Pigments Manufacturers (ETAD). ETAD is an international organization comprised of representatives from various dye manufacturing companies. Two of the goals of ETAD are "to coordinate and unify the efforts of manufacturers of synthetic organic colorants to minimize possible impacts of these products on health and the environment" and "to achieve these ends in the most economic fashion without reducing the level of protection of health and the environment."[1] ETAD recognizes the potential risks associated with the use of dyes and it is their belief that the best method to reduce these risks is to concentrate on reducing dye exposures. To achieve this goal, ETAD organized a steering committee which included members from ETAD, NIOSH, the U.S. Environmental Protection Agency (EPA), and the American Textile Manufacturer's Institute (ATMI). This steering committee identified dye weighing operations as requiring research to develop improved techniques to reduce worker exposure to dye dust. NIOSH researchers were specifically asked to assist in projects to improve existing work practices and identify/develop local exhaust ventilation controls for the manual dye weigh-out process.

The objective of the manual dye weigh-out study is to provide dye and textile shops with information about practical, effective engineering control methods that control worker exposure to air contaminants (dust). To develop this information, the actual dye weigh-out process was observed to determine which aspects of the operation contribute the most to worker exposures, and how the tasks and other parameters such as drum height can be modified to reduce the exposures. A survey site was selected by NIOSH, ETAD, and ATMI based upon the following considerations: plant size (preferably a small business), high frequency of performing the manual dye weigh-out operation, ability to reproduce data collection conditions (i.e., amounts and types of dyes weighed being fairly constant), predominant use of powder dyes rather than liquid dyes, lack of engineering controls for the task, and willingness of plant management to participate and allow installation of controls at their site.

Once the survey site was selected, the manual dye weigh-out operation was observed and air sampling was performed to obtain a better understanding of the process and its potential hazards, as well as to obtain baseline exposure data. The data collected from this survey and previous surveys[2] will be instrumental in the development of engineering controls by the NIOSH researchers for the manual dye weigh-out process. ETAD will implement the proposed controls at this survey site and NIOSH will test their effectiveness and ability to control worker exposure to dye dust.

PLANT DESCRIPTION AND PROCESS DESCRIPTION

The survey site is a small dye house which only has been in business for a few years. The dye house receives finished articles of clothing from manufacturers who want the items dyed specific colors. The clothes are usually received at the site in white or natural colors. A batch of clothing is placed in one of the six dye machines. The color desired by the manufacturer is weighed out and added to the dye machine. Once the batch has been dyed, the dye operator spot dries an item and holds it up to a test swatch of the desired color. If the color is off, the on-site laboratory must adjust the original dye recipe accordingly and redye the batch. If the color is satisfactory, the batch can be transferred to one of the four dryers. The plant operates in three shifts, often operates seven days a week, and has a total of 40 employees.

There was only one designated weigh-out operator, and he worked the first shift. If dye had to be weighed out during the other shifts, any of the plant personnel could perform the work. The weigh-out operation was conducted in a corner room of the dye house. The dye room was approximately 40 feet long and 12 feet wide. A plastic sheet acted as a curtain between the room and the rest of the plant (see Figure 1). Cartons and drums of powder and liquid dyes were set up in specific locations along the inside walls of the dye room. This study did not evaluate the liquid dyes as they did not appear to contribute to the worker's dye dust exposure. The dye drums ranged from 17-23 inches in diameter and 20-40 inches in height. The weigh-out procedure was conducted using a small scale set on a 34-inch high stainless steel table. No ventilation controls were used.

The weigh-out operator received a dye recipe listing the specific amounts and types of dyes needed for a particular batch of clothing. An 18-inch high bucket was placed on the weigh scale. The operator walked to the storage location of the first dye listed on the recipe and scooped out material from the container (each container had a designated scoop which was kept inside the container). The operator then walked a distance of up to 27 feet back to the scale, being careful not to spill the material. The dye was then poured from the scoop into the bucket. If the correct weight was reached, the operator returned the scoop to the dye container. If the weight was too light, more

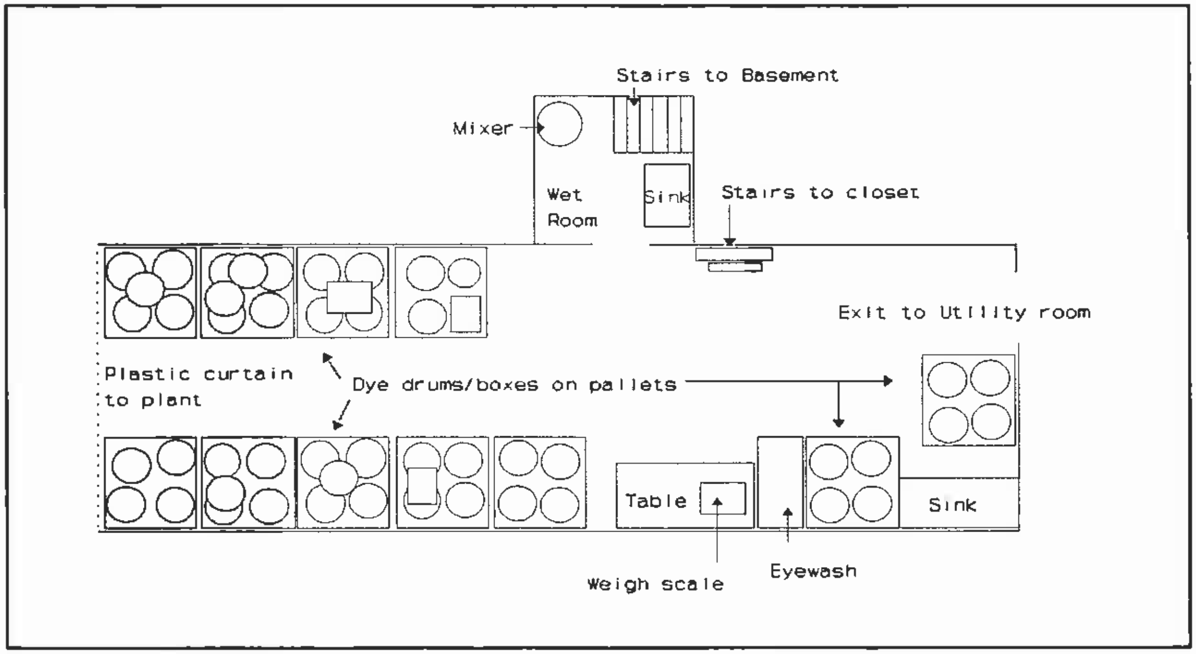

Figure 1: Schematic of Dye Weigh-Out Room

dye was transferred from its container to the bucket. Once the first dye was weighed, the operator thoroughly washed his gloved hands in the sink which was adjacent to the weigh table. The remaining dyes in the recipe were then weighed accordingly, into the same bucket.

Once all the dyes in the recipe had been weighed, the operator transported the bucket to the sink in the wet room. Steaming, hot water was added to the bucket while the operator constantly stirred the mixture. The bucket was then set on the floor of the dye room and covered with a lid. The recipe was placed on top of the bucket. Periodically, the weigh-out operator carried finished buckets of dyes out to the plant area where they were added to dye machines. The weigh-out operation was performed on an intermittent basis throughout the day.

POTENTIAL HAZARDS OF MANUAL POWDER WEIGH-OUT OPERATIONS

Workers who manually weigh out powders are exposed to airborne dust. Previous studies[3,4,5] have documented potential exposure levels and hazards of workers during weigh-out operations in various industries. One study at a rubber plant evaluated the dust exposure of workers who weighed and transferred powdered materials from bags and bins to smaller containers. During the sampling period, the majority of personal respirable dust concentration measurements were below 2 mg/m^3. During weigh-out activities, however, dust concentrations increased, peaking at 40 mg/m^3, suggesting an average respirable dust exposure of 15-20 mg/m^3.[3] A similar study of manual weigh-out of powders in a plastic plant found that most breathing zone samples exceeded 10 mg/m^3.[4] A third study, performed in an actual textile drug room, found that TLVs (and subsequently, the PELs) were not exceeded for total or respirable dust during the weigh-out operations.[5] However, the author of this study stressed that there may still be potential inhalation hazards from these dyes since their constituents may have established PELs which cannot be ignored.

Exposure to powders or dyes can be through three primary routes: inhalation, ingestion, and dermal contact. The main route of entry for dye dusts is through inhalation. The inhaled particles can irritate the respiratory system producing symptoms such as coughing, runny nose, or an irritated throat. The particles can also be absorbed from the lungs, or cleared from the lungs, swallowed, and absorbed from the gastrointestinal tract. This can lead to potential systemic effects arising from the metabolism of the dye into a more toxic substance than the original dye.[6]

EXPOSURE EVALUATION CRITERIA

As a guide when evaluating hazards posed by workplace exposures such as those from manual weigh-out operations, NIOSH field staff employ environmental evaluation criteria. These criteria assess several chemical and physical agents and 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 if their exposures are maintained below these levels. A small percentage may experience adverse health effects due to individual susceptibility, a preexisting 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 evaluation criteria. 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 become available.

The primary sources of environmental evaluation criteria in the United States that can be used for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs); (2) the American Conference of Governmental Industrial Hygienists's (ACGIH) Threshold Limit Values (TLVs); and (3) the U.S. Department of Labor (OSHA) Permissible Exposure Limits (PELs). The OSHA PELs are required to consider the feasibility of controlling exposures in various industries where the agents are used; the NIOSH RELs, by contrast, are based primarily on concerns relating to the prevention of occupational disease. ACGIH Threshold Limit Values (TLVs) refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. ACGIH states that the TLVs are guidelines. The ACGIH is a private, professional society. It should be noted that industry is legally required to meet only those levels specified by OSHA PELs.

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 short-term exposure limits (STEL) or ceiling values that are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

The overall objective of this study is to control worker exposure to dust generated by manual powder weigh-out activities. Therefore, the exposure evaluation criteria is based primarily on controlling total and respirable dust. The PELs established by OSHA require industry to control the 8-hour time-weighted average (TWA) of total dust to 15 mg/m^3 and respirable dust to 5 mg/m^3.[7] The PELs for respirable and total dust were not changed by the 1989 amendment of OSHA's existing Air Contaminants Standard, 29 CFR 1910.1000, which has since been vacated by the courts. Therefore, the PELs listed above continue to be enforceable by OSHA. The TLVs suggested by ACGIH are set at a 10 mg/m^3 TWA for total dust and 5 mg/m^3 TWA for respirable dust.[8] There are no RELs recommended by NIOSH for total or respirable dust; however, NIOSH does list benzidine-, o-tolidine-, and o-dianisidine-based dyes as potential occupational carcinogens, and sets the RELs at the lowest feasible concentration.[9] It is the goal of the overall study to control both the total and respirable dust exposure to as far below the PEL and TLV as possible for the textile dye weigh-out process.

EVALUATION PROCEDURES

The objective of this study was to obtain an appreciation of the typical dye weigh-out operation and to provide baseline data for the associated worker exposures to airborne contaminants at this site. To aid in evaluation, air sampling and video exposure monitoring techniques were performed. Ventilation measurements were not taken other than to verify that the air in the room was relatively stagnant. The instrument used to measure the air flow was a hot wire anemometer (Model 1040 Digital Air Velocity Meter, Kurz, Carmel Valley, California). Smoke tubes were used to test for room pressure and any airflow patterns.

AIR CONTAMINANT EXPOSURE MONITORING

The worker's exposure to total particulate (dust) was measured using NIOSH Method 0500.[10] In this method, a known volume of air is drawn through a preweighed PVC filter. The flow rate used for collecting personal breathing zone samples was 13 L/min. A carbon vane pump was used to draw air through a critical flow orifice. The pressure downstream of the critical orifice was less than 0.5 atmospheres. The weight gain of the filter was then used to compute the milligrams of particulate per cubic meter of air.

In addition to collecting personal samples in the worker's breathing zone, area samples were collected to obtain the background level of air contaminants. A personal sampling pump (SKC Inc., Eighty Four, Pennsylvania) with a flow rate of 5 L/min was used to collect the area samples. The pump was positioned directly outside the plastic curtain, in the general plant area.

VIDEO EXPOSURE MONITORING

Video exposure monitoring was used to study in greater detail how specific tasks affected the worker's exposure to air contaminants.[4,11] An aerosol photometer, the Hand-held Aerosol Monitor (HAM) (PPM Inc., Knoxville, Tennessee), was positioned on the worker's chest using a belt and harness. A battery-operated pump was used to draw air through the HAM's sensing chamber. In the HAM, light from a light-emitting diode is scattered by the aerosol, and forward-scattered light is detected by the HAM. The amount of scattered light is proportional to the analog output of the HAM. However, the calibration of the HAM varies with aerosol properties such as refractive index and particle size. Therefore, the analog output of the HAM is expressed as relative concentrations which has units of volts. A personal sampling pump (MSA Model G, Mine Safety Appliance Co., Pittsburgh, Pennsylvania) was used to draw the air in the worker's breathing zone through the HAM's sensing chamber. The pump operated at a flow rate of 2 L/min.

The analog output of the HAM was recorded by a data logger (Rustrak Ranger, Gulton, Inc., East Greenwich, Rhode Island) attached to the worker's belt. When the data collection was completed, the data logger was downloaded to a personal computer (Compaq Portable III, Compaq Computer Corp., Houston, Texas) for storage and analysis. The worker's activities were simultaneously recorded on video (Video Camera Recorder Hi8 Handycam, CCD-V701, Sony Corp.) for use in a detailed task analysis of the weigh-out operation. Data were collected during three trials lasting approximately 90 total minutes.

RESULTS

VENTILATION MEASUREMENTS

The air in the dye room was stagnant with no more than a 20-30 fpm measured air flow towards the entrance of the room. The room was under a slight positive pressure with air from the dye room drifting into the plant area, despite the plastic curtain.

AIR CONTAMINANT EXPOSURE MONITORING

Table 1 summarizes the concentration data measured for the weigh-out operation. The results of individual air samples are presented in Appendix A. The mass of each filter was calculated by subtracting the mean weight change of the blank filters from the analyzed total weight of the sample filter. Concentration data were then computed by dividing the mass of each filter by the sample volume. None of the exposures exceeded the OSHA PEL of 15 mg/m^3 for total dust.

Table 1
Total Dust Concentration Data Summary

Sample Location	N	Geometric Mean (mg/m^3)	Geometric Standard Deviation
Personal Breathing Zone	6	1.54	3.4
Area	4	0.13	1.7

VIDEO EXPOSURE MONITORING

The first observed task was approximately 42 minutes in length. During this time, the operator weighed out three buckets of powdered dyes. The first bucket consisted of two dyes weighing a total of 2048 grams. The dyes were stored in standard size drums (55-gallon); one located near the weigh-out scale, the other near the plastic curtain. The operator made five total trips to the two drums. The second bucket consisted of an increased proportion of the same two dyes in Bucket 1, for a total weight of 2118 grams. The operator again made five total trips to the two drums. The third bucket consisted of two dyes weighing a total of 1531 grams. One dye was contained in a half-height drum located near the weigh-out table. The other dye was contained in a medium-height drum (about 30 inches tall), located towards the plastic curtain. The operator carried this drum to the weigh-out table and scooped the powder from there. He returned the drum to its location when he finished scooping. The operator made five total trips to the two drums.

The total amount of dye weighed during this first task was 5697 grams, and 15 trips were made by the operator to the dye containers.

The second observed task was approximately 34 minutes in length during which the operator weighed out five buckets. Each bucket contained the same powdered dye, but in different amounts (ranging from 2210-3169 grams). The dye was contained in a standard-sized drum located towards the weigh-out table. Due to the low level of dye in the drum, the operator stood on the pallet and leaned his whole body into the drum. The total amount of dye weighed during this time was 13,186 grams. The operator made 17 trips to the drum.

The third observed task was approximately 17 minutes in length, during which the operator weighed out three dyes into one bucket. One dye was contained in a half-height drum located towards the plastic curtain. The second dye was contained in a small cardboard box (about 2' x 1'), located towards the weigh-out table. The third dye was contained in a standard-sized drum located towards the plastic curtain. This dye was a turquoise powder which the weigh-out operator had previously indicated was the dustiest material in the dye room. The total amount of dye weighed during this task was 5052 grams. Over 80 percent of this weight was from the turquoise component. The operator made 11 trips to the three dye containers.

DISCUSSION

The video exposure monitoring was useful in identifying activities which led to the weigh-out operator's highest aerosol exposures. Many of the high exposure peaks were found to occur at times when hot water was being added to the bucket of dye or when the worker was washing up in-between weigh-out sessions. The steam generated by the hot water was identified by the HAM as an aerosol, thereby causing the HAM to register a high exposure. The steam was believed to be free of dye particulate; however, no tests were performed to verify whether this was a correct assumption. Assuming the steam is not detrimental to the worker, the remaining high exposures during the weigh-out operation could be attributed to scooping from the drums, walking with a scoop full of powdered dye, and weighing the dye.

This was verified by coding the data set of all three monitored periods (see Figures 2-4). By viewing the videotape of the actual work, each data point was assigned a corresponding task description. After adjusting for transportation delays associated with the data collection technique,[12] the exposure was shown to gradually decrease as the worker finished scooping and walked away from the drum. This indicated that the highest exposures to the worker occurred during the scooping task. In fact, when analyzing the second monitoring period during which the most dye was weighed out, the scooping task exposure was found to be 5-6 times greater than the exposures associated with carrying the scoop of dye and weighing the dye.

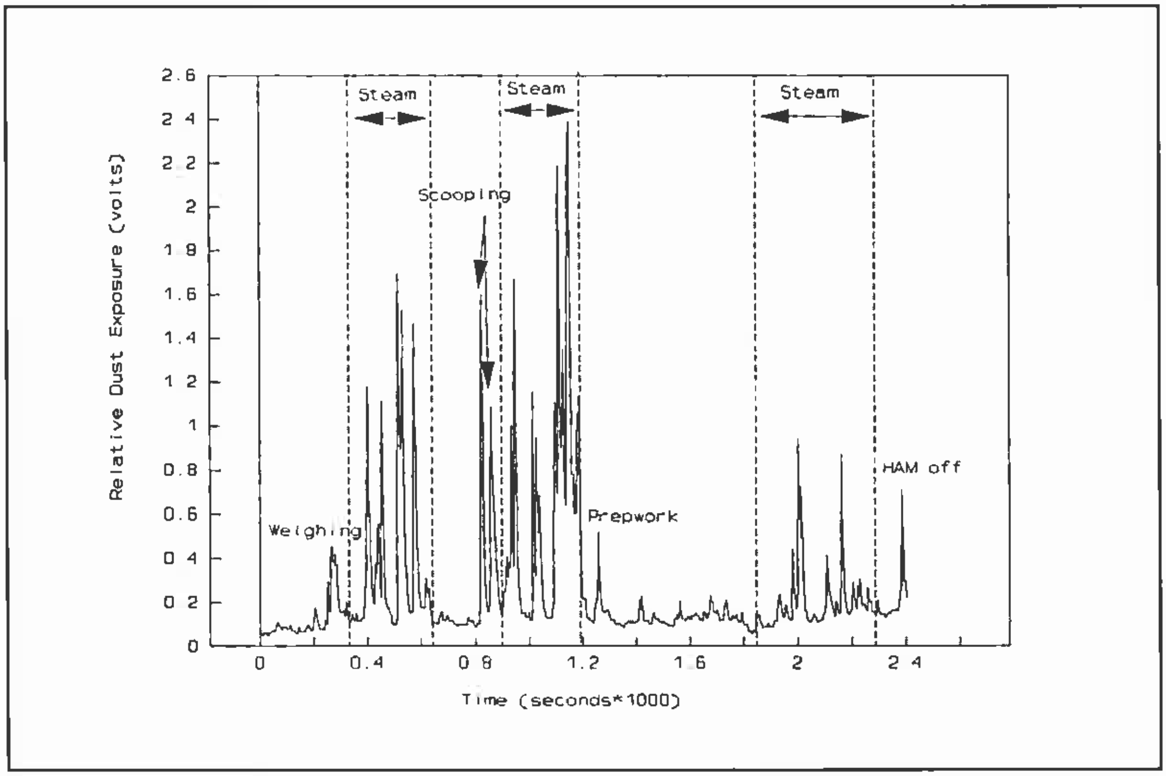

Figure 2: Video Exposure Monitoring Data for Task #1

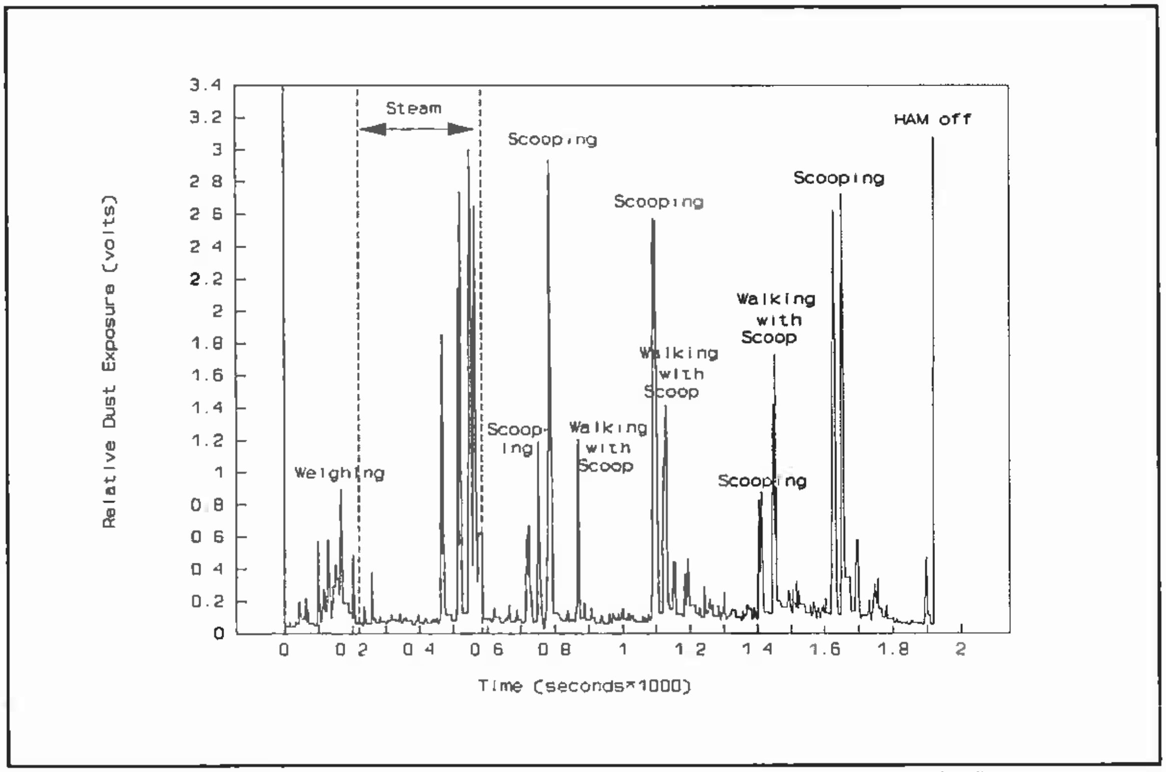

Figure 3: Video Exposure Monitoring Data for Weigh-out Task #2

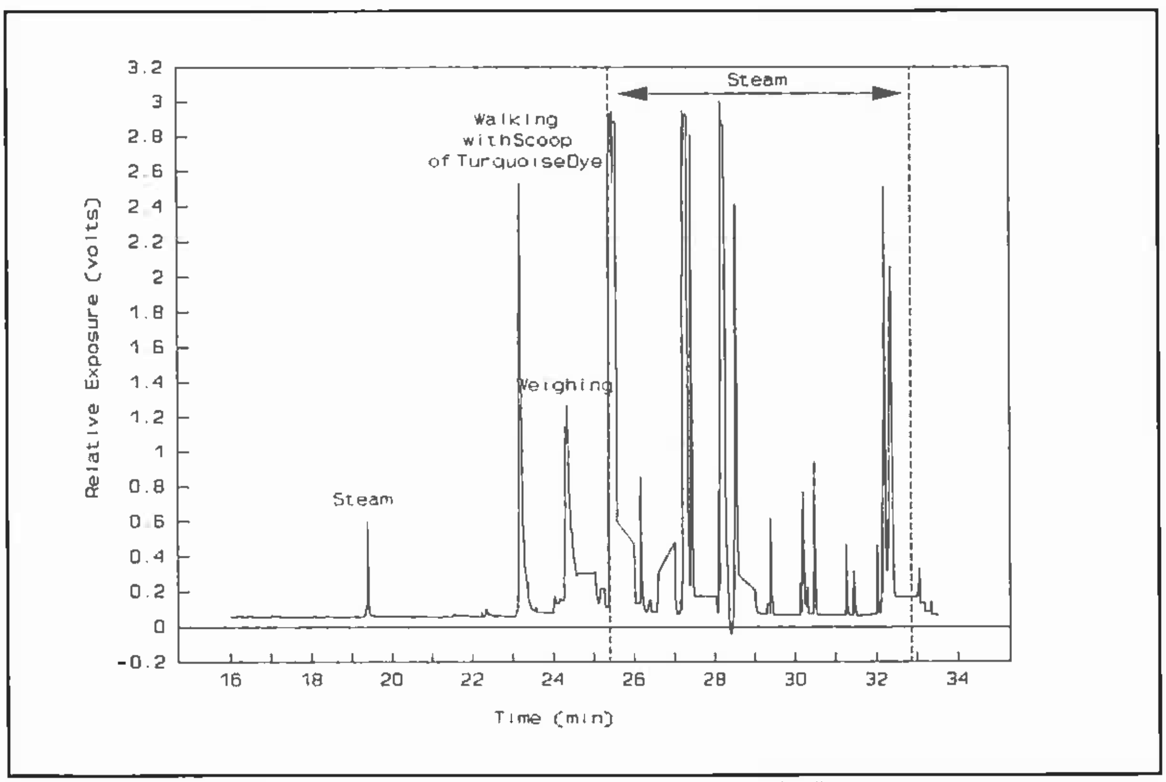

Figure 4: Video Exposure Monitoring Data for Task #3

One of the main problems of this plant was color-fly, which occurred when a dye was dispersed into the air after being handled in the weigh-out room. This dye would then drift out into the plant area and contaminant finished goods by adhering to them; causing small color flecks on the clothes. The turquoise dye which was weighed several times during this study was the dustiest dye handled at this plant. When this dye was handled, the area sample which was set up outside the weigh-out room showed traces of the turquoise color on the filter. This implied that color-fly was indeed a problem.

The personal and area total dust concentrations were all below OSHA's permissible levels (PELs). Several variables can affect the concentrations measured during the weigh-out procedure: the dustiness of the dye weighed, the actual amount of material weighed, the height of the drum, the height of the material inside the drum, the body measurements of the individual worker, and the work practices of the worker. The fact that the breathing zone samples were within OSHA's permissible levels does not automatically mean that there is an absence of hazards during this operation. As was pointed out earlier, the powder constituents may still exceed their established TLVs or PELs even if the total or respirable dust concentrations do not.

CONCLUSIONS

The main objective of this study was to observe the manual dye weigh-out operation and determine what controls are needed to reduce or eliminate the worker's exposure to dye dust. A side benefit of engineering controls would be the end of color-fly in the plant, saving the company time and money by eliminating the need to redye batches of finished goods.

Before recommending a setup for the dye weigh-out operation, tests need to be performed in a controlled laboratory setting at NIOSH to see how the positioning of the worker, the drum, and the weigh-out equipment affects exposure. In addition, the real-time data shows that unless the depth of scooping is restricted, there cannot be improvement in the worker's dust exposure. Once the scooping task is controlled, a ventilated booth and improved work practices can reduce exposure to the worker even further. After the appropriate engineering controls are designed and implemented at this plant, a follow-up study can be conducted to determine their effectiveness. Results of the overall manual dye weigh-out study can then be disseminated throughout the dye and textile industries to provide technical information on controlling worker dye dust exposure during these operations.

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APPENDIX A

Particulate Concentration Data During Weigh-out Operation

Date	Type	Task Description	Amount Weighed	Time (min)	Mass (mg)	Concentration (mg/m^3)
Mar 8	P*	Recipe: 2 dyes (2561 g). Repeated same recipe for 3 buckets. Recipe: 2 dyes (688 g). One bucket.	8371 grams	38	0.45	0.91
Mar 8	P	Recipe: 2 dyes (553 g). Repeated same recipe for 3 buckets. Needed as additions. Recipe: 3 liquid dyes. Amount unknown. Recipe: 2 dyes (2561 g). Repeated same recipe for 7 buckets. Eighth bucket: same dyes, different amounts (1817 g).	> 21,343 grams	131	1.60	0.94
Mar 8	A	Area sample.	N/A	171	0.05	0.06
Mar 9	P	Recipe: 3 dyes (5052 g). One bucket. This recipe contained 4210 g of the dusty turquoise dye.	5052 grams	26	2.09	6.18
Mar 9	A	Area sample.	N/A	187	0.14	0.15
Mar 10	P	Recipe: 2 dyes (629 g). One bucket. Recipe: 2 dyes (1044 g). One bucket. Second bucket: same dyes, different amounts (1008 g). Recipe: 2 dyes (2048 g). One bucket. Second bucket: same dyes, different amounts (2118 g). (VEM 1)** Recipe: 2 dyes (1531 g). One bucket. (VEM 1)	8378 grams	75	0.41	0.42
Mar 10	P	Recipe: 1 dye, 5 buckets of different amounts (2548 g), (3169 g), (2967 g), (2210 g), (2292 g). (VEM 2)	13,186 grams	34	0.33	0.75
Mar 10	A	Area sample.	N/A	480	0.45	0.19
Mar 11	P	Recipe: 3 dyes (5052 g). One bucket. This recipe contained 4210 g of the dusty turquoise dye. (VEM 3)	5052 grams	17	1.79	8.10
Mar 11	A	Area sample.	N/A	221	0.17	0.15
Mean Weight Change of Field Blanks					0.04	
Standard Deviation of Weight Change for Field Blanks					0.10	

* P: Personal Sample
A: Area Sample

** VEM 1: Video Exposure Monitoring Trial 1
VEM 2: Video Exposure Monitoring Trial 2
VEM 3: Video Exposure Monitoring Trial 3