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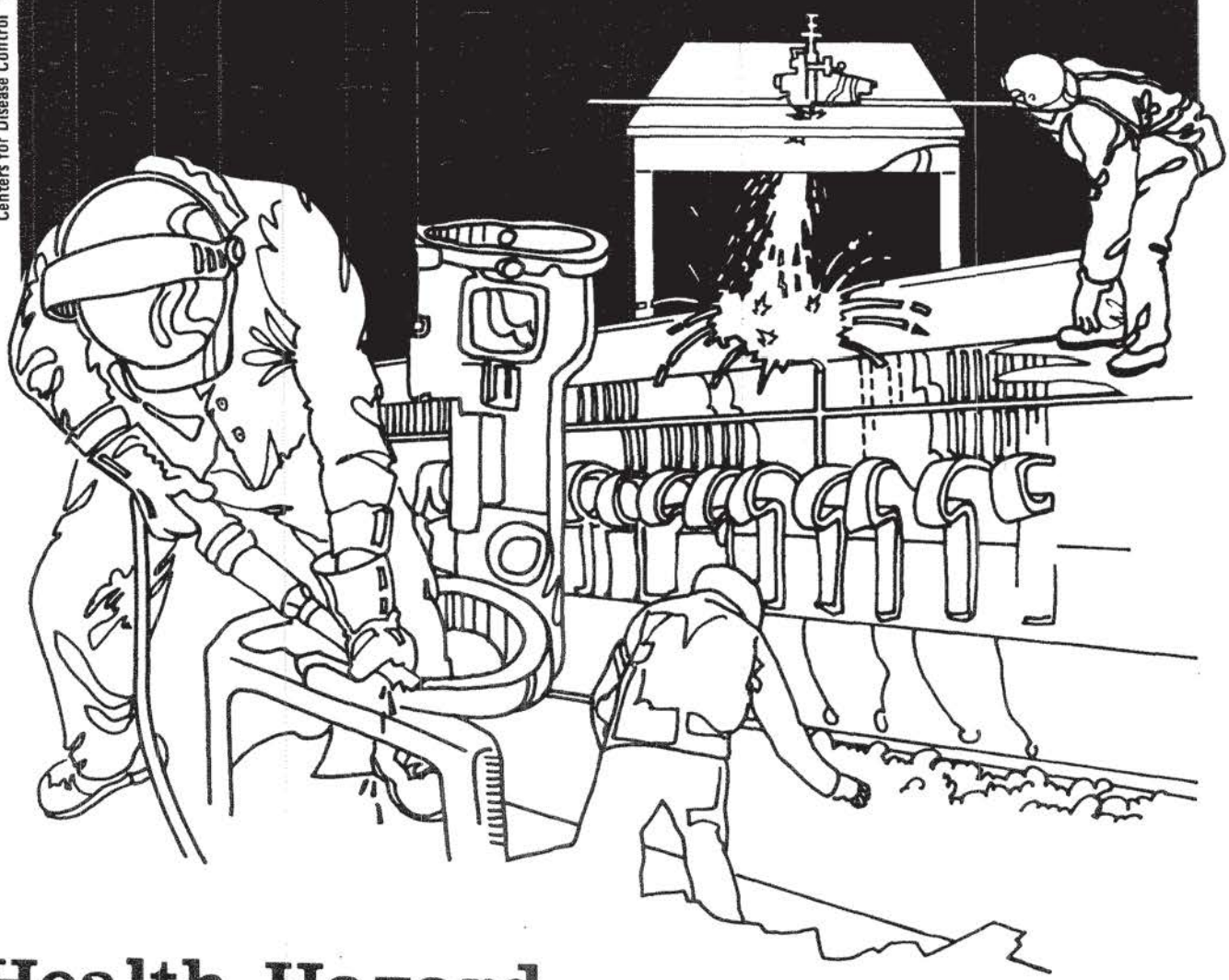

Health Hazard Evaluation Report

HHE 80-192-828
ROCK HILL PRINTING
& FINISHING COMPANY
ROCK HILL, NORTH CAROLINA

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. 699(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.

HE 80-192-828
MARCH, 1981
ROCK HILL PRINTING & FINISHING COMPANY
ROCK HILL, NORTH CAROLINA

NIOSH INVESTIGATORS:
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I. SUMMARY

On July 2, 1980 the National Institute for Occupational Safety and Health (NIOSH) received a request from the Amalgamated Clothing and Textile Workers Union (ACTWU) to evaluate workers' exposures to dust, dyestuffs, formaldehyde and chemical finishes at the Rock Hill Printing and Finishing Company, Rock Hill, North Carolina. NIOSH conducted a medical and industrial hygiene survey at the plant on August 4, 1980.

Measurements were made in several plant areas of total and respirable dust, formaldehyde, carbon monoxide, anisidine, o-toluidine and dimethylformamide. Exposures to formaldehyde in two areas (ager operation and chemical finishing) were close to the recommended NIOSH standard, a 30-minute ceiling concentration of 1 ppm based upon the irritative effects of formaldehyde. Levels of total dust were all less than 1 mg/m^3 in area samples. Carbon monoxide was detected at levels of 3.5 ppm. Anisidine, o-toluidine and dimethylformamide were not detected.

Workers handling solvents and those working in the roller print and ageing areas reported irritation of the eyes and upper respiratory tract. The workers commonly attributed these symptoms to exposure to these solvents and poor ventilation.

On the basis of the data obtained in this investigation NIOSH determined that formaldehyde exposure to the ager operators at the plant exceeded the NIOSH recommended standard. Furthermore, based upon animal studies showing formaldehyde to be a carcinogen, NIOSH has recently recommended[16] that occupational exposures be reduced to the lowest feasible limit. Dust exposure was not excessive at the time of the survey. Recommendations have been included in the body of this report for improved industrial hygiene monitoring, worker education, better ventilation in areas of solvent exposure and a modification of medical surveillance of workers following further studies of the plastic coating area.

Keywords: SIC 2260 - Dust, formaldehyde, carbon monoxide, anisidine, o-toluidine, dimethylformamide.

II. INTRODUCTION

On July 2, 1980 NIOSH received a health hazard evaluation request from the Amalgamated Clothing & Textile Workers Union for a health hazard evaluation at the Rock Hill Printing & Finishing Company, Rock Hill, North Carolina. There was concern about (1) dust exposure during rapid handling and sewing of unwashed broadwoven cotton fabric in the gray department, (2) exposures to dyestuffs and pigments in the color and dye room during weighing and mixing, (3) exposure to chemical finishes (especially formaldehyde) during finishing and drying of cloth, and (4) dust exposure during rapid handling and cutting of finished fabric.

III. BACKGROUND

NIOSH has conducted two health hazard evaluations at the Rock Hill plant in the past five years. The first was conducted on August 26, 1975, and February 24, 1976, to evaluate exposures to fumes from machines and dirty air ducts in the white department of the plant (HE 75-89-344, November 1976). Workers complained of headaches and irritation of the eyes and throat while working around the hot frames. Carbon monoxide was the most significant contaminant identified.

On January 25 - 27, 1978, a study was conducted in the screen print department following a request from employees for evaluation of emissions from the dyeing of polyester fabric (HE 77-70-515, August 1978). Workers had no complaints at that time but stated that symptoms had in the past been associated with a then discontinued flame retardant incorporated in the dye mixture. The concentrations of a number of substances were measured. These included benzene, xylene, decane, undecane, azo dyes, diazonium salts, formaldehyde, phenol phosphine, sulfur dioxide and methanol. None of the substances measured in either evaluation were at concentrations in excess of the NIOSH recommended evaluation criteria.

Process Description

The Rock Hill Printing and Finishing plant is a large textile finishing facility that has operated since 1929. Woven cloth made from fibers (cotton, cotton-polyester blend, rayon, etc.) is unpacked, bleached, dryed, heat set (in the case of polyesters), dyed and printed. The plant employs approximately 1700 workers over 3 shifts, 5 days per week.

The plant process begins with the unloading of loom-state fabric (gray goods) obtained from several countries. These include the United States, China, Japan, India, and Taiwan. Rolls of fabric are sewn together into a continuous length and mercerized in the griege department. Mercerizing is a continuous process in which fabric is treated under tension with hot caustic soda to make it stronger and more receptive to dyes. Following this, residual starch is removed by enzyme digestion. The fabric is then steamed, acid dipped, neutralized, washed, and bleached with sodium hypochlorite and hydrogen peroxide in the white department. It is then dried in frames at 300 - 400° C.

In the screen print department polyester fabric is disperse-dyed a solid color and then screen-or roller-printed. The dyestuffs may contain one or more dyes, a dye carrier, and antimigration and antifoaming agents. These are weighed and mixed by an operator on an elevated mixing platform and emptied into a vat.

After dyeing and printing, the fabric is pre-dried under infrared lamps and then passed into a hot house tenter frame which holds the fabric at a desired width to prevent shrinking.

Selected fabrics and patterns may be subjected to an "ageing" process, which involves treatment with acetic and formic acid. After ageing, the fabric is cleaned in a soaping process, which improves the absorbency of the fibers prior to chemical finishing.

In the chemical finishing process the cloth is treated with urea-formaldehyde resins, softeners and wetting agents. These give permanent press, durability, dimensional stability, spot resistance and water repellant qualities to the cloth. Following this the surface of the cloth may be finished (e.g. knapped) before being shipped to clothing manufacturers. (The fabrics used are pretreated with flame retardant when purchased.)

IV. EVALUATION CRITERIA

A. Environmental

Two primary sources of criteria for permissible exposure are used to assess the concentrations of the substances found: (1) NIOSH Criteria Documents on Recommended Occupational Health Standards; and (2) Recommended and Proposed Threshold Limit Values (TLV's) and Their Supporting Documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH), 1980. These criteria are based on the current state of knowledge concerning the toxicity of these substances for an 8-hour work day, 40 hour work week, over a normal working lifetime. A small percentage of workers may experience discomfort from some substances at concentrations at or below the evaluation criteria because of variation in individual susceptibility. The criteria given below are time-weighted averages for an 8-hour exposure (TWA) and ceiling values for a short interval (usually 30 minutes or less). The occupational health standards promulgated by the U.S. Department of Labor - OSHA applicable to the substances measured are also presented to indicate the compliance of the measured values with the federal regulations.

Environmental Criteria for substances measured

Recommended Criteria and Source		OSHA standard	HEALTH EFFECTS OF EXPOSURE
1) NIOSH			
Formaldehyde TWA*	--	3 ppm	Irritation of the eyes, throat, respiratory tract, asthma, skin sensitization, rash, allergy, animal carcinogen.
Ceiling	1 ppm**	5 PPM	
Carbon Monoxide TWA	35 ppm	50 ppm	Headaches, dizziness, vomiting, drowsiness, nausea, collapse, coma, brain damage.
Ceiling	200 ppm	--	
2) ACGIH+			
Respirable dust - TWA	5 mg/m^3	5 mg/m^3***	Asthma, bronchitis, allergic alveolitis, obstructive airway disease and irritation.
Total dust - TWA	10 mg/m^3	15 mg/m^3	
Anisidine - TWA	0.5 mg/m^3	0.5 mg/m^3	Headache, dizziness, cyanosis, kidney and liver damage.
O-Toluidine TWA	22 mg/m^3	5 ppm	Anoxia, headache, cyanosis weakness, dizziness, drowsiness eyeburns, dermatitis.
Dimethylformamide TWA Skin absorption	10 ppm	10 ppm	Nausea, vomiting, abdominal pain, facial flushing, liver damage, intolerance of alcohol, behavorial changes.

+American Conference of Government Industrial Hygienists
*TWA = 8-hour time weighted average
**ppm = parts of contaminant per million parts of air (30 minute sample)
***mgs/m^3 = milligrams of contaminant per cubic meter of air

V. METHODS AND RESULTS

A medical and industrial hygiene survey was conducted at the plant on August 4, 1980. Workers were interviewed in each area of concern and questioned about symptoms and health problems.

A. Environmental

Area and personal breathing zone air samples were obtained from employees working in departments throughout the plant and analyzed for respirable dust, total dust, anisidines, o-toluidine, formaldehyde, carbon monoxide, and dimethylformamide.

The following methods of collection and analysis for these substances were used:

1. Dust: Total and Respirable dust samples were collected using two-stage cyclone size-selective, samplers. The personal respirable samples were collected in the workers breathing zones on tared polyvinyl chloride (PVC) filters in 2-piece cassettes mounted on a 10 mm nylon cyclonic separators; air was pulled through the samplers at a rate of 1.7 lpm. A total of 7 samples were obtained from the unloading area, greige area, knapping room, and packing area. The PVC filters were analyzed for weight increase.

   The levels measured were all less than 0.5 mg/m^3 in respirable samples and less than 1 mg/m^3 in total dust area samples (Table I).

2. Formaldehyde: Thirteen area grab samples were measured using a CEA-555 Ambient Air monitor in the roller print shop, screen print shop, ageing process, chemical finishing, surface finishing, starch mezzanine, and finished goods storage areas. Only 2 measurements (1.2 and 1.05 ppm) were in excess of the NIOSH recommended ceiling of 1 ppm (Table II).

   Six personal breathing zone samples were obtained in solid sorbent tubes containing impregnated charcoal using Dupont P-200 sampling pumps set at a flow rate of 200 cc/min. The sampling time for each sample was approximately three hours. Exposures to formaldehyde during unsampled time periods were considered similar to exposures during sampled periods, for eight hour TWA calculations. The exposure for the ager operator exceeded the NIOSH recommended ceiling standard of 1 ppm in thirty minutes. The chemical finisher's exposure to formaldehyde approached the NIOSH standard (Table III).

   Six additional area samples were also obtained on the same media using Dupont P-4000 sampling pumps set at a flow rate of 0.5 liters per minute. The sampling time was approximately 90 minutes. All measured levels (apart from one in the ageing area of 1.04 ppm) were less than 1 ppm (Table IV).

   The charcoal tubes used for personal and area samples were analyzed by ion chromatography.[1]

3. Anisidine: Area and personal breathing zone samples for anisidine isomers were obtained in the drug room by drawing air, at a rate of 1 lpm, through XAD-2 porous polymer tubes. The approximate sample time was 180 minutes. The tubes were analyzed by high pressure liquid chromatography. Each isomer elutes separately and is quantitated individually.[2] No anisidine was detected in any sample (Table V).

4. O-Toluidine: Area and personal breathing zone samples for o-toluidine were obtained in the drug room by drawing air, at a rate of 1 lpm, through silica gel tubes. Sample time was approximately 60 minutes. The samples were analyzed separately by gas chromatography.[3] No o-toluidine was detected in any of the samples.

5. Dimethylformamide: A personal breathing zone sample for dimethylformamide was collected from one worker in the coating department by drawing air, at a rate of 1 lpm, through a silica gel tube. This sample was analyzed for

dimethylformamide by gas chromatography. The lower limit of detection using this method is 0.02 milligrams per cu m of methylformamide. None was detectable in the sample tube or in an unexposed control tube.

6. Carbon Monoxide: The concentration of carbon monoxide in several work areas was measured using a direct-reading Ecolyzer with a stripchart recorder. The instrument was calibrated to detect carbon monoxide in the ppm range. The highest level measured was 3.5 ppm in the chemical finishing area (Table II).

B. Medical

Twenty-two workers were interviewed and asked about symptoms and health problems. Three workers in the receiving and unpacking area complained of excessive dust from the opened rolls of cloth. (Cloth from Asia and the Far East was especially troublesome.) None had symptoms that suggested medically significant respiratory problems.

Two of the three workers in the starch mezzanine were interviewed. Their work involved weighing out starch softener and bleach, which were then mixed with solvents. Both complained of choking fumes from a resin (Resin 900) that is mixed with formaldehyde and used frequently in the area. They seemed generally ill-informed about the nature of the substances they were handling and were concerned about the inadequacy of their protective equipment (gloves, boots, goggles, etc.). The single conduit for fresh air in this area is a doorway that opens onto the roof of the building at one end of the mezzanine. A fan blowing inwards in the doorway provides a draft. Reportedly this occasionally blows smoke from the outside smoke stacks into the area.

One of the two workers employed in mixing color dyes for the screen printing shop attributed "bumps" on the skin of the fingers to contact with dyestuffs.

In the screen and roller print areas, where there is exposure to color mixtures, workers reported occasional mild eye irritation, upper respiratory irritation and a bitter taste in the mouth from Sitol, a dispersant and base which contains an ammonium compound.

Three workers in the ageing area were interviewed. They seemed poorly informed about the nature of the chemicals they were handling and reported shortness of breath, irritation of the eyes and throat, and difficulty in swallowing. These symptoms occurred infrequently but were more severe and more likely to occur with darker colored fabrics.

Two workers operating the finishing frames were troubled by heat, dust and fumes from the drying cloth. Their main symptoms were shortness of breath and burning eyes.

Workers in the napping and packing department stated that excessive heat and dust in the area had been a problem in the past. However, this had been reduced recently following a cleanup of the area and modification of the ventilation system. Dust had reportedly been a greater problem in this area during the winter months when the plant doors and windows were closed.

Three workers were interviewed in the plastic coating operation in a building adjacent to the plant. In this area they are potentially exposed to numerous solvents, including dimethylformamide. Their main complaints were of excessive heat and strong solvent fumes, to which one worker attributed fatigue and occasional lightheadedness.

Workers complained of inadequate ventilation and lack of protective clothing. The woman employed in the plastic coating area was not permitted to work on production stations involving contact with solvents, especially dimethylformamide. (It is a company policy that women of childbearing age do not work in areas with exposure to dimethylformamide).

Pre-employment physical examinations are required by the company, and a health screening program is available to employees on a voluntary basis. A questionnaire designed to identify the symptoms and signs of solvent toxicity is administered annually to workers in the plastic coating operation. They also have liver function tests and a urinalysis.

VI. DISCUSSION

This investigation was carried out when the weather was hot and the doors and windows of the plant were open to the outside air. Recent economic pressures had resulted in a reduction of the workforce of the plant and a curtailment of production. Most of the workers interviewed acknowledged these factors and stated that the conditions on the day of the investigation were not typical of the problems encountered 6 months previously. Therefore, the reports of excessive dust exposure earlier in the year could not be confirmed at this visit.

The industrial hygiene survey demonstrated that the concentrations of all contaminants measured (with the exception of formaldehyde) were below the NIOSH recommended criteria and OSHA standards. The measurements were taken at one point in time, however and may not reflect the variation of exposures over a period.

Formaldehyde concentrations in personal breathing zone samples were above the NIOSH recommended criteria. The ager operator was exposed to breathing zone concentrations of above the NIOSH recommended ceiling standard of 1 ppm.

There was general dissatisfaction among the workers about the provision of protective clothing in areas where workers handled chemicals, dyes and solvents, and workers lacked information about the nature of these substances.

No dimethylformamide (DMF) was detected in the personal breathing zone sample obtained from the coating line operator. The heat and excessive solvent vapors in this area were obvious to the investigators, who experienced upper respiratory irritation and headache. A variety of solvents are used in this area, but in-depth industrial hygiene survey of these exposures was not within the scope of this hazard evaluation.

The use of an annual questionnaire to elicit symptoms of DMF toxicity is not an appropriate screening device for protection of workers from its adverse health effects because symptoms asked about are those of serious toxic effects. Also the annual blood and urine tests will probably show no abnormalities in workers exposed to low levels. Occupational exposure occurs through inhalation of vapor and skin contact. In an acrylic fiber factory, skin absorption was found to be more important than inhalation in the overall exposure when no protective clothing was used.[9]

In man the liver and upper gastrointestinal tract may be affected after acute and chronic exposures. Workers exposed to DMF in textile plants have in the past experienced nausea, vomiting, abdominal pain, facial flushing, behavorial changes and liver damage.[10] Intolerance to alcohol is a well known effect of moderate exposure. The effects of low levels of exposure have not been well documented. Animals exposed to 23 ppm over an extended period showed no signs of clinical toxicity, but changes in the functional state of the liver were observed.[11] DMF has been shown to cross the placenta in rats, but no marked embryotoxic or teratogenic effects were reported.[12,13] It has not been established that DMF is toxic to the human embryo or that women are more susceptible than men to its effects. Its toxicity is probably intermediate with respect to other solvents in common use[14], and its effects must not be overemphasized at the expense of considering other potential hazards.

More appropriate protection of these workers would follow if the concentrations of solvents were monitored in area and personal breathing zone samples on a regular basis, and engineering controls introduced to ensure that workers are minimally exposed. Methylformamide, the metabolite of DMF, can be measured in the urine. Urine estimations have been reported to correlate well with exposure and may be used as an index of exposure to dimethylformamide (DMF).[15]

VII. RECOMMENDATIONS

1) The ventilation should be improved in the starch mezzanine area, and workers there should be supplied with adequate protective clothing (gloves, aprons, goggles.)

2) Regular industrial hygiene monitoring of levels of solvents and formaldehyde should be carried out in the ageing and finishing areas.

3) Engineering controls and stringent work practices should be used to limit employee exposure to formaldehyde to the lowest feasible level.

4) Detailed information about the chemical content of the substances handled should be made available to all workers.

5) An in-depth industrial hygiene survey of the coating operation should be carried out to characterize exposures to dimethylformamide and other solvents in the area. Following this an appropriate program of industrial hygiene monitoring, medical surveillance and personal protection for workers can be developed. There is no medical reason why women should be differentially excluded from jobs on the basis of exposure to DMF.

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IX. ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this report are currently available upon request from NIOSH, Division of Technical Services, Publications Dissemination, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161.

Copies of this report have been sent to:

1. Rock Hill Printing & Finishing Company, Rock Hill, North Carolina
2. Acting Director, Occupational Safety & Health, Amalgamated Clothing & Textile Workers Union, Union Square, New York, N. Y.
3. U.S. Department of Labor - OSHA - Region IV
4. NIOSH Regional Program Consultant - Region IV

For the purpose of informing the affected employees, the employer shall promptly post the determination report for a period of 30 days in a prominent place where exposed employees work.

TABLE I

HHE 80-192
Area and Personal breathing zone dust concentrations measured at
Rock Hill Printing & Finishing Company
August 5, 1980

	Personal breathing zone sample		Area Sample	
Job Title/Area	Sample Time	mg/m^3	Sample Time	mg/m^3
Greige Operator	360 min	0.01	360 min	0.82
Greige Operator	360 min	0.21	---	--
Knapping Roller Operator	230 min	0.02	---	--
Packing Attendant	80 min	0.04	---	--
Unloading Floor Person	360 min	0.02	369 min	0.25

TABLE II

Formaldehyde concentrations in grab samples (measured by a CEA ambient air monitor) and Carbon monoxide concentrations

Rock Hill Printing & Finishing Company
August 5, 1980

Area Sampled	Time of Day	ppm Formaldehyde	ppm Carbon Monoxide
Roller Print Shop	8:55 a.m.	.40	4
Screen Print Shop	9:25 a.m.	.30	1.5
Ageing Process			
No. 4 Ager	9:47 a.m.	.35	2
No. 17 Ager	9:55 a.m.	.15	3
No. 3 Ager	10:00 a.m.	.40	5
Chemical Finishing Area			
Start of No. 2 & 3 lines	10:17 a.m.	.20	3.5
Start of No. 10 & 12 lines	10:25 a.m.	1.05	5
End of No. 10 & 12 lines	10:35 a.m.	1.20	4
Start of No. 10 & 12 lines	2:15 a.m.	.55	4
End of No. 10 & 12 lines	2:25 p.m.	.70	3
Surface Finishing	11:15 a.m.	.50	2
Starch Mezzanine	1:00 p.m.	.70	1
Finished Storage	1:40 p.m.	.45	1

TABLE III

Personal Breathing Zone Sample Results
for Formaldehyde,

Rock Hill Printing & Finishing Company
August 5, 1980

	Time Period	Sample Volume liters	Concentration ppm	8-hour TWA* ppm
Ager Operator	A.M.	38	1.33	
	P.M.	37	0.97	
				1.15
Chemical Finisher	A.M.	31	0.81	
	P.M.	19	0.43	
				0.66
Starch Mixer	A.M.	81	0.11	
	P.M.	35	0.47	
				0.30

*TWA = time weighted average.

TABLE IV

Results of Area Environmental Sampling (90 minutes)
for Formaldehyde (charcoal tubes)

Rock Hill Printing & Finishing Company
August 5, 1980

Area	Time Period	Sample Volume liters	Concentration ppm
Chemical Finishing	A.M.	68	< 0.12*
	P.M.	47	0.29
	P.M.	47	< 0.17
Ageing Operation	A.M.	41	0.75
	A.M.	44	1.04
Starch Mezzanine	A.M.	54	0.18

*Limit of detection 10 ug per tube.

TABLE V

Results of Personal Sampling
for Dye Components

Rock Hill Printing & Finishing Company
August 5, 1980

Area or Job Title	Anisidines* mg/m3	o-Toluidine**
Druggist	N.D.***	N.D.
Drug Room	N.D.	N.D.
Roller Print Operator	N.D.	N.D.
Roller Print Shop	N.D.	N.D.
Color Shop Mixer	N.D.	N.D.
Screen Print Operator	N.D.	N.D.

*Samples were analyzed for Ortho-, para-, and meta-anisidines, The limit of Detection was 1 microgram per sample.

**The limit of Detection for o-toluidine was 0.01 milligrams per sample.

***N.D. - Not detectable.

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