U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 75-89-344

ROCK HILL PRINTING AND FINISHING COMPANY
ROCK HILL, SOUTH CAROLINA

NOVEMBER 1976

I. TOXICITY DETERMINATION

A combined environmental-medical study has been completed in the White Department of the Rock Hill Printing and Finishing Company, Rock Hill, South Carolina. Initial survey and follow-up studies were conducted during August 26-28, 1975 and February 24-25, 1976 respectively. Environmental assessment was conducted by obtaining measurements of acetaldehyde, acetic acid, acetone, butyraldehyde, iso-butyraldehyde, carbon dioxide, carbon monoxide, crotonaldehyde, formaldehyde, formic acid, methyl ethyl ketone, and oil mist. Medical evaluation of workers from the White Department was accomplished by obtaining medical histories and conducting preshift and postshift physical examinations and pulmonary function tests. Environmental measurements of substances were much less than the environmental criteria used in this evaluation with few exceptions. Carbon monoxide was the most significant contaminant identified in the work environment; other contaminants were identified in hygienically significant concentrations in only a few instances.

There is evidence that, although temporary in nature, employees experience headache and irritation of eyes and throat while working around the hot frames. Atmospheric levels approached (but were slightly below) the NIOSH recommended standard for carbon monoxide. Headaches may be associated at least in part with the environmental levels of carbon monoxide measured since individual susceptibility varies. The contribution of smoking as a cause of headache is considered negligible in this evaluation. In the judgment of the investigators, signs and symptoms of irritation are associated with substance(s) emitted from the hot frames. Although this study did not identify contaminants in sufficient concentration to be expected to cause irritation, it is possible that substance(s) not identified and measured in this evaluation may be associated with such irritation.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. Copies have been sent to:

a) Rock Hill Printing and Finishing Company, Rock Hill, South Carolina
b) Authorized Representative of Employees
c) U. S. Department of Labor - Region IV
d) NIOSH - Region IV

For the purpose of informing the approximately 90 "affected employees" (workers employed in the White Department), the employer shall post a copy of this determination report for a period of 30 calendar days at or near the workplace(s) of affected employees.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by an 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.

The National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of employees regarding employee exposure to smoke and "fumes" in the White Department of the Rock Hill Printing and Finishing Company, Rock Hill, South Carolina. The request stated that the dust, fumes and smoke from machinery and dirty air ducts were so bad at times that it was hard to breathe and workers felt it (the condition) was dangerous to their health.

IV. HEALTH HAZARD EVALUATION

A. Process Description and Evaluation Progress

1. Process Description

The subject plant is a large textile finishing plant which receives woven cloth made from various fibers: cotton, cotton-polyester blend, polyester-rayon blend, and 100% polyester. The materials are bleached, dryed, heat-set in the case of polyesters, dyed, and printed at this plant before selling to a plant where the end product might be the manufacture of clothing. This overall plant operation has existed at this site since 1929. The hourly employment totaled approximately 2575 which was down about 10% due to poor business conditions in the textile industry during the period of evaluation. The specific area of the request (White Department) employs 10 administrative, 86 production, and two maintenance workers. Normally three work shifts are employed on a 5-day per week basis with overtime worked on Saturday as business requires. Hours of work shifts are: 7-3, 3-11, and 11-7 with no shift rotation, i.e. workers remain assigned to a work shift and move to the more desirable work hours by seniority. For this reason the older and more experienced employees are concentrated on the 7-3 and 3-11 shifts.

The process operations in the White Department are relatively simple. The cloth is received in the White Department from the bleach plant in a wet condition although portions of the cloth may have dried out. The

cloth is first run over a roller and through a wet box to obtain fairly uniform moisture throughout the cloth. The wet cloth is then run over a series of steam heated dryer cans which predry the cloth to a moisture content of 15-18%. The cloth then travels through a series of three hot frames which are heated by natural gas to a temperature of 300-400°F. which completes the drying. The linear speed of the cloth through the frames is 100-200 meters/min. Adjustments are made of temperature and linear speed as necessary for the product which is being run. For polyester and polyester blends it is necessary to heat set the fabric to fix the width of the cloth which is very critical for the printing operation which is to follow. At the offtake end the dryed/heat set fabric is then wound onto a core to form a roll weighing several thousand pounds (approximately 3-4 feet in diameter). There are four lines in the White Department on which the fabrics are dryed and heat set as described above. One or two operators/shift work at the starting end of the hot frame lines tending the water boxes and dryer cans with an offtake operator working each of the lines or a total of four/shift. The emissions which are the source of employee complaints occur as the fabric leaves the hot frame dryer tunnel at the offtake end of the line.

Some dryer emissions were observed by the investigator at the time of the start of the physical inspection on August 26, 1975 although they were diminished to a great extent within about an hour's time. Other operations are conducted in the White Department in addition to drying and heat setting. These activities are concerned with straightening the filling of the fabric prior to the dyeing and printing and materials handling necessary to store or disburse cloth to the Print Shop. The rolls are moved to storage areas or to other departments using propane powered fork-lift trucks.

2. Initial Survey Evaluation - August 26-28, 1975

a. Results of Employee Interviews

Employees of the White Department were interviewed in a non-directed manner concerning any health effects they felt were related to their work. Employees were selected on the basis of their proximity to the source of emissions, i.e. the off take operators and straighteners who normally are those workers closest to the fabric exit from the hot frames. Workers were interviewed from the 7-3 and 3-11 shifts. The results of these interviews are tabulated in Table 1.

The symptoms related by workers were all of a past history nature. Most workers related the most recent episode resulting in their being symptomatic to have occurred the week before the initial survey visit. Symptoms reportedly clear fairly quickly (1-2 hours) after the smokey condition subsides according to most workers while a few related they had to go out into fresh air for a few minutes to obtain relief. Workers and company representatives seemed to agree that the worst offender for hot frame emission is a 50/50 blend of polyester and rayon. As might be expected a number of workers felt that cold weather aggravates the condition since the plant is obviously closed up tighter in cold weather. A brief interview was conducted with the plant nurse on duty, and it was revealed there were no visits to the clinic by White

Department employees during the six weeks preceding the initial survey visit. Symptoms would therefore appear to be relatively short lived and of a mild nature as workers have not sought medical treatment at the plant.

b. Environmental Results

An attempt was made to determine the concentration of particulate being produced from the hot frames by obtaining personal and area samples. These results were:

Sample Location	Type	Sample Time	Conc. (mg/M^3)*
#2 Hot Frame	Area	7 hours	0.09
#3 Hot Frame	Area	6 hours	0.14
#1 Hot Frame	Personal	4 hours	non-detected

* Results reported as concentration of total particulate per cubic meter of contaminated air. Results corrected by subtracting the average blank value.

The area samples were obtained as close to the source(s) of emissions as the location of machinery would allow (3-4 feet) while the operator was located approximately 10 feet from the source. There was a slight blue haze visible during the sampling which originated from the fabric exit from the hot frames. Particulate levels are obviously quite low on the area samples, and the personal sample result was less than the weight pickup of the average of four blank filters.

Detector tube measurements were made for possible gaseous contaminants associated with hot frame emissions. On August 27 four formaldehyde and one total hydrocarbon tubes were used with no detectable results. A carbon monoxide tube in an aisle of the storage area revealed a level of 0-10 ppm which was undoubtedly due to tow motor exhausts as it was some distance from the hot frames.

On August 28 a quite visible haze could be seen originating from the hot frames and a number of detector tubes were used as close to the source of emissions as possbile. Seven tubes for formaldehyde were all negative. Six detector tubes for total hydrocarbons were used; three tubes were negative and three indicated a slight color change below the detection limit of the tubes which is 2.9 mg/liter. During this period of most visible emissions the investigator did not notice any identifiable odor nor did he notice any irritation or other physical effects. Therefore, the environmental investigation did not reveal any definitive data implicating a specific substance(s) which could be associated with the widespread symptoms being reported by the workers.

An industrial hygienist from the State of South Carolina has investigated this problem at this plant.[1] Six charcoal tube samples were obtained by the State investigator to measure the presence of organic vapors. Analysis of these samples did not reveal the presence of any organic vapors. Samples for oil mist were also obtained with results $<< 1\ mg/M^3$. At a plant where a similar complaint action was initiated, the State investigator could not detect formaldehyde vapors in the area.

3. Potential Sources of Contaminants in the Work Environment

a. Size

Warp yarns are treated with a size which is usually either starch-based or more recently polyvinyl alcohol and carboxymethylcellulose. The fabric undergoes a desizing process prior to bleaching. It seems unlikely there would be sufficient residual size during the drying (heat setting) process in the White Department for the size or size pyrolysis products to be the etiological agent(s) resulting in the worker symptoms.

b. Oil Decomposition Products

Some yarns have an oil applied to them during processing. It would not seem very likely that there would be sufficient residual oil remaining on the fabric following desizing, scouring, and bleaching for this to be the source of emissions. However, the bluish haze being produced at the hot frames is suggestive of oil being the source of these emissions. It also is possible that the haze could be produced from heating of lubricating oils and greases used in the process machinery.

c. Polymer Pyrolysis Products

A paper has been reviewed in which the pyrolysis products produced from the decomposition of cellulosic polymers were studied.[2] The polymers of interest are the results reported for the products of pyrolysis for cotton and rayon polymers.

Cotton was evaluated over a temperature range of 250°C. (482°F.) to 379°C. and rayon over a range of 280°C. (536°F.) to 295°C. The results for the lower temperatures were considered most relevant to this study since they correspond more nearly to the hot frame temperature condition of 400°F.

The products of pyrolysis were divided into fractions: products condensed at 25°C. (V_{25}), at - 80°C. (V_{-80}), at - 190°C. (V_{-190}), and the residue or tar fraction (Vpyr).

Temp. °C.	Volatiles %	Volatile fractions, % of total volatilized part for step			
		Vpyr (tar)	V_{25} (H_2O)	V-80 (CO_2)	V-190 (CO)
(1) 250	2.7	26.3	53.9	12.0	7.8
(2) 280	3.3	19.6	61.7	11.7	7.0

(1) Cotton
(2) Rayon

The various fractions were analyzed by mass-spectrometry. Fraction V_{25} was found to be predominantly water with a small amount of acetaldehyde, V-80 was comprised of CO_2, and V-190 was predominantly CO.

Another study was reported in this paper in which pyrolysis products of cotton were identified by a gas chromatographic technique.[3] Substances which could be positively identified were: carbon dioxide, carbon monoxide, aldehydes (formaldehyde, acetaldehyde, acrolein, propionaldehyde, glyoxal, furfural, 5-hydroxymethyl furfural), acetone, MEK, acetic acid, lactic acid, and water.

An estimate of the initial rate of thermal degradation was 0.13% for cotton and 0.09% for rayon. These rates were considered the most appropriate for estimating a degradation rate for the hot frames where fabric is heated to 400°F. for only a few seconds.

In summary, the pyrolysis products for cotton and rayon are composed primarily (60-70%) of products which are quite innocuous, i.e. water and carbon dioxide unless the carbon dioxide attained very high levels which is considered unlikely. Some of the products identified, however, are consistent with symptoms reported by workers: headache and nausea (possibly carbon monoxide) and irritation (possibly aldehydes and organic acids).

A method for rapid identification of organic polymers by using a gas-liquid chromatography technique to qualitatively and quantitatively identify pyrolysis products has been described.[4] The resulting pyrograms offer a fingerprint of the polymer being analyzed. A polyester polymer was evaluated in this study and the primary small molecule pyrolysis products were acetaldehyde, carbon monoxide, and carbon dioxide. Methane, ethane, ethene, propene, and water also were found to be present. Large molecule pyrolysis products identified as present were pentene and possibly benzene and ethyl benzene.

It was concluded that a follow-up evaluation should be conducted in the White Department in view of the high incidence of reported symptoms by workers and the additional information obtained concerning potential emissions from cellulose and polyester polymers. Workers also stated that conditions were worse relative to hot frame emissions during the cold months (December -February) due to poorer ventilation in cold weather and the follow-up was planned for the cold weather period.

B. Evaluation Design

1. Environmental

The follow-up study protocol was designed to evaluate the potential work room concentrations of substances described earlier which might be associated with hot frame operation. Personal and area continuous sampling for time-weighted average exposures and detector tube sampling of peak concentrations were utilized in the White Department during three shifts of operation to evaluate exposures to workers. This sampling plan is outlined below:

Carbon dioxide - detector tube sampling in work areas using length of stain detector tubes.

Carbon monoxide - continuous area monitoring and detector tube sampling to evaluate exposure of hot frame take-up and straightener operators.

Aldehydes (C_1 through C_5) - personal and area sampling to evaluate exposure of hot frame take-up and straightener operators.

Acetic and formic acids - personal and area sampling to evaluate exposure of hot frame take-up and straightener operators and the relief operator.

Oil mist - personal sampling to evaluate exposure to hot frame take-up operator, scray loader helper, and small winder operator.

Organics (acetone and methyl ethyl ketone) - personal and area sampling to evaluate exposure to hot frame take-up and straightener operators.

2. Medical

Each of the three shifts is worked by 19 employees as follows:

Hot frame take-off operater	4
Mangle operator (tending the water boxes and dryer cans)	2
Straightener feed-in	2
Straightener take-off	3
Scray machine loader	2
Scray machine relief	1
Truck (fork-lift) operators	5

The day shift (7-3) and the swing shift (3-11) were chosen for study, and because of the small size of each group, it was decided that all workers on each shift would be asked to participate. However, 29 of the possible 38 employees reported for the evaluation.

No control group was established in this evaluation since employees in other departments in this plant were engaged in diversified operations, some of them being exposed to dyes, formaldehyde, ammonia, etc. Instead, by conducting pre- and post-shift testing, it was considered that each subject would serve as his own control.

C. Methods of Evaluation

1. Environmental Sampling and Analytical

Carbon monoxide - continuous area monitoring was conducted using Ecolyzer® CO monitors equipped with recorders, peak exposures were measured with length of stain detector tubes with an approximate detection limit of 10 ppm.

Aldehydes - continuous samples were obtained with midget impingers containing sodium bisulfite absorbing solution at a flow rate of 1.0 liter/minute. Aldehydes were identified and quantitated by a gas-chromatographic (GC) method.

Formic and acetic acids - continuous samples were obtained with midget impingers containing 0.1 N sodium hydroxide absorbing solution at a flow rate of 1.0 liter/minute. Formic and acetic acids were identified and quantiated by a GC method.

Oil mist - samples were collected on mixed esters of cellulose filters (0.8 u average pore size) which were held in a three piece closed-face cassette and sampled at a flow rate of 1.5 liter/minute and analyzed by a fluorometric method.

Organic vapors (Acetone and MEK) - samples were collected on charcoal tubes at a flow rate of 50 cubic centimeters/minute and analyzed by a GC method.

2. Method of Medical Survey

The workers were examined before and after the shift by physical examination, including inspection of eyes, nose and throat, and chest auscultation. Their subjective symptoms were reviewed with regard to the presence or absence of irritation or any problem of eye, nose, throat, head, chest, stomach, etc. Medical, occupational and smoking histories were obtained from each participant during the shift.

Using a Vitalograph® machine, pre- and post-shift tests were made for forced vital capacity (FVC), forced expiratory volume at 1 second, ($FEV_{1.0}$) and forced expiratory flow during 25%-75% of FVC (FEF 25-75). Three trials were made on each subject and the best performance was used for calculation. Both the individual and group results of the ventilatory tests were checked against the currently used standard[5] for these parameters. Where an individual was found to have a value below the normal range for his height and age, he and his personal physician were notified.

The pre- and post-shift results of the ventilatory test were analyzed using the paired Student's t-test and ANOVA method with regard to the shift (1st versus 2nd), smoking habit (smoker versus non-smoker), and work location (close-to versus away-from the source of smoke emission).

D. Evaluation Criteria

1. Environmental Criteria

The three primary sources of environmental evaluation criteria considered in the report are : (1) NIOSH Criteria Documents with recommended standards for occupational exposure, (2) American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's) with supporting documentation, and, (3) Federal occupational health standards, promulgated by the Occupational Safety and Health Administration, U.S. Department of Labor. For the substances evaluated during this study, the primary environmental criteria used were:

Substance	Standard or Guide ppm*	(mg/M^3)***
Acetaldehyde	100[2]**	(360)
Acetic acid	10[2,3]	(25)
Acetone	1000[2,3]	(2400)
Benzene	10[1,2,3]	(32)
Butyraldehyde	****	
Iso-butyraldehyde	****	
Carbon dioxide	5000[2,3]	(9000)
Carbon monoxide	35[1]	(40)
Crotonaldehyde	2[2,3]	(6)
Formaldehyde	2[2]C	(3)
Formic acid	5[2,3]	(9)
Methyl ethyl ketone	200[2,3]	(590)
Oil mist	-	(5)
Propionaldehyde	****	

C - Ceiling value which should not be exceeded at any time.
* Parts of vapor or gas per million parts of contaminated air by volume at 25°C and 760 mm Hg pressure.
** Reference numbers refer to the appropriate guide or standard from the above discussion.
*** Approximate milligrams of substance per cubic meter of air.
**** An occupational health guide or standard has not been adopted for this substance.

Occupational health exposure limits for individual substances are generally established at levels designed to protect workers occupationally exposed on an 8-hour per day, 40-hour per week basis over a working lifetime.

Although sources other than the Federal Standard were considered in this study for arriving at a Toxicity Determination, the only legal standard is the Federal Standard which is enforced by the Occupational Safety and Health Administration of the Department of Labor.

E. Results and Discussion

1. Environmental - Follow-up Study February 24-25, 1976

Three shifts of operation were monitored with personal and area continuous samples and detector tubes for potential contaminants which could be released into the work room due to hot frame and fork-lift truck operations during the follow-up evaluation. Operations were judged to be normal during the three shifts monitored. However, personal samples were not obtained on February 24 (7 am - 3 pm shift) since no medical evaluations were conducted during this shift.

February 24, 1976 (7am - 3pm shift)

The results of area continuous sampling conducted during this shift are contained in Table 2. All sample results were less than the detection limit of the analytical methods used with the exception of measurements of formaldehyde, formic acid and oil mist. The highest measured levels of formaldehyde and formic acid represent levels which are 7% and 2% respectively of the environmental criteria for these substances. Two oil mist measurements were 34% and 64% of the environmental criteria and the other two measurements of oil mist were below the detection limit of the analytical method.

Detector tube measurements made during this shift are contained in Table 3. Five detector tube measurements for carbon monoxide were made in the hot frame area (two detector tube measurements were made at the exit from hot frame hoods) and the Ecolyzer® reading of carbon monoxide observed at the same time; these readings agreed within the accuracy of the measurement methods indicating that emissions from the hot frames did not contribute significantly to carbon monoxide levels, rather that general room concentrations of carbon monoxide were measured with both the detector tubes and the Ecolyzer®.

The results of continuous monitoring for carbon monoxide during this shift are contained in Table 8. Both Ecolyzers were calibrated with span gas of a known concentration at the beginning of the shift, at midshift, and at the end of the shift; all calibrations during the study agreed within ± 1 ppm of the known concentration at midscale of the 0-100 ppm scale used. This procedure was followed during all three of the shifts monitored. For the 7am to 3pm shift on February 24, 1976 the 35.0 ppm recommended standard of the NIOSH Criteria Document was not exceeded in either location for the entire shift, however, at the No. 1 and No. 2 Hot Frame area this level was exceeded for three hours of the shift and the 32.0 ppm concentration for the shift did approach the 35.0 ppm recommended standard. The monitors were located in an area near the suspected source of the emissions (No. 1 and No. 2 Hot Frame area) or in the area where the blue haze emanating from the hot frames had been seen to drift (No. 9 and No. 10 Frame feed end). However, fork-lift trucks operate frequently in these areas, especially near the No. 1 and No. 2 Hot Frame location. By observing the upward response of the meter on the Ecolyzer® when fork-lift trucks passed, it was readily apparent that the source of carbon monoxide was the fork-lift trucks. This observation was confirmed on numerous occasions during this shift and the subsequent shifts evaluated.

February 24, 1976 (3pm - 11pm shift)

Continuous personal and area samples were obtained during this shift and the results are contained in Table 4. All sample results were below the detection limits of the analytical methods except the measurements of formaldehyde and formic acid; the highest levels measured for these two substances represent approximately 5% and 3% respectively of their environmental criteria. The results of formaldehyde and formic acid were both quite low and in fairly narrow concentration ranges indicating that levels of these substances were about the same levels throughout the work room.

Detector tube sampling was conducted during this shift and these results are contained in Table 5. All measurements of carbon dioxide and carbon monoxide were below the environmental criteria for these substances; the level of 5000 ppm for carbon dioxide is not a ceiling standard but it has been used for comparison purposes. Formaldehyde was below the detection limit of the detector tubes used for all measurements during this shift.

The results of continuous monitoring for carbon monoxide levels are contained in Table 8; levels were somewhat lower than the previous shift and were substantially below the 35.0 ppm level.

February 25, 1976 (7am - 3pm shift)

The results of area and personal continuous sampling during this shift are contained in Table 6; results were similar to the previous two shifts discussed in that low levels of formaldehyde and formic acid were measured. The highest levels of formaldehyde and formic acid measured represent levels which were 5% and 4% of their respective environmental criteria.

Acetic acid was measured at the operator's station of No. 10 and No. 11 Frames at a concentration which is 35% of the environmental criteria used for evaluation; the characteristic odor of acetic acid was not recognized at any time during the evaluation. This instance was the only time a significant level of acetic acid was measured during the evaluation.

Subjective observation classed this shift as the one during which the most smoke or haze was noted for any time the project officer was present in the White Department during either the August, 1975 or February, 1976 evaluations. The smokey condition was noted as early as 7:45am at the No. 4 Hot Frame, still quite smokey at 9:30am from No. 4 Hot Frame, was noted to be very smokey from 11:30am to 12:00 noon at No. 2 Hot Frame, and the area continued to be quite smokey until the end of the shift. A breakdown of the various products which were produced during the three shifts of the February 24-25, 1976 study, is contained in Table 9. The No. 2 and No. 4 Hot Frames were identified on Februay 25, 1976 as being the primary sources of smoke, and all production on both of these machines was either a polyester or polyester blend product. Polyester blends had been identified earlier by some workers as producing smoke. However, the No. 1 Hot Frame during the first shift of February 24 and the No. 2 Hot Frame during the second shift of February 24 had processed similar products and subjectively the smokey condition on these shifts was judged to be much less noticeable on these earlier shifts. A more comprehensive in-plant study which is outside the scope of a hazard evaluation would be necessary to determine if a correlation between product composition and process variables and the smokey condition does in fact exist.

The levels measured by continuous area and personal sampling and the detector tube measurements contained in Table 7 do not show results any different for this shift as compared to the two previous shifts. The results of continuous carbon monoxide monitoring contained in Table 8 for this shift are not unusual as compared to the other two shifts; a level of 29.4 ppm for the shift was measured at the No. 1 and No. 2 Hot Frame station and 23.1 ppm was measured at the No. 9 and No. 10 Frame Station.

Benzene was discussed as a potential contaminant which might be released as a decomposition product earlier in this report. However, benzene was not detected on any of the charcoal tube samples collected during any of the three shifts which were evaluated during this study.

Environmental Conclusions

Carbon monoxide was the most significant airborne contaminant which was quantitated during this evaluation. Although the NIOSH recommended standard of 35.0 ppm was not exceeded for an entire shift, there were periods of one hour or longer during the 7am - 3pm shifts on February 24 and February 25 when this value was exceeded. These shift averages do not represent levels which would be considered a health hazard, however symptoms such as headache in some workers may be related to carbon monoxide since no standard guarantees absolute protection to all workers. The source of the carbon monoxide was demonstrated to be from fork-lift trucks and not from hot frame emissions.

Very low but nevertheless detectable levels of formaldehyde and formic acid were measured during each of the three shifts. The source of these contaminants can not be positively identified, however, formaldehyde is present in other work areas of this plant and it is possible that the formaldehyde which is present has infiltrated into the White Department from these other areas. The generally uniform levels of formaldehyde measured in both personal and area samples with no apparent relation to the suspected source of emissions (the exits from the hot frames) suggests this may be the case. Another factor to support this theory is that no detectable levels of formaldehyde were measured at any time at the exit from the hot frames. The levels of formaldehyde and formic acid which were measured during the evaluation would not be expected to result in symptoms of irritation in exposed workers.

Oil mist was measured in two samples in significant quantities during the 7am - 3pm shift of February 24, 1976, but oil mist was not measured at levels above the detection limit of the analytical method during the subsequent two shifts. The source of the oil mist was from the lubricating oil used on the frame. Although oil mist itself would not be expected to be irritating at the levels measured, a decomposition product which was not evaluated cannot be completely discounted.

2. Medical

Initially, 29 workers were examined. However, three did not complete the study schedule and were excluded from the statistics. Therefore, the overall participation rate was 68% (26/38).

The average age of these 26 workers was 49.8 years (range = 23 to 75 years, median 51.5) and average length of RHPF employment was 25.8 years (range = 3 to 41 years, median 30).

Of these 26, 12 worked in the first shift (7am - 3pm) and 14 worked in the second shift (3 - 11pm). The latter included two female workers.

For the first shift group, the average age was 56.2 (range = 44 to 75, median 57.5) and the average length of RHPF work was 32.3 years (range = 7 to 41, median 35).

For the second shift group, the average age was 44.3 (range = 23 to 60, median 47) and average RHPF employment was 20.3 years (range = 3 to 37 years, median 25).

Since there was no shift rotation, workers tended to remain in one shift until they could move to more desirable work hours by seniority. This was probably the reason that the older and more experienced workers were found in the 7 - 3 shift.

a. Non-directed questions on health complaints which may be related to the job:

13 (50%) answered that they had no complaints (7 in the first shift and 6 in the second shift).

13 (50%) had health complaints which they thought were related to their work. Of this group, 9 answered that the smoke caused the following: headache (4), burning of eyes (4), irritation of throat (4), or nose (2), tight chest (2), and nausea (1). The remaining four felt that their health problem might be related to the smoke. They included retinal bleeding (because of eye irritation), chest pain of undetermined origin, asthamatic bronchitis and frequent colds. These are singular cases and this evaluation was not able to determine whether or not they were related to the exposure. One person had an inguinal hernia which might have been job related, but since it was unlikely related to the smokey condition, it is excluded from the count.

b. Responses to directed questions on symptoms which workers thought were related to the smokey condition are listed in Table 10.

More than two-thirds of the examined workers had experienced eye irritation. Headache, throat irritation, coughing, stuffy or runny nose, chest tightness or shortness of breath were reported by substantial percentage of examined workers as job-related.

c. Health complaints and physical findings before and after the shift.

As shown in Table 11, no one complained of eye or throat irritation or headache prior to the shift. However, at the end of the shift, workers complained of throat irritation (8), headache (6), eye irritation (4) and nose irritation (4).

One person who worked two consecutive shifts at the time of this study was excluded from this comparison.

Of eight workers who complained of throat irritation, seven were either non-smokers or did not smoke during the shift. Therefore, it may be considered that complaint of throat irritation was likely due to the smokey condition in the work area.

Of six workers who complained of headache, five worked in the first shift. None of these five smoked during the shift, although two of the five were occasional cigar smokers. In view of the fact that a significant level of carbon monoxide was detected during the first shift on February 25, it may be reasoned that carbon monoxide was probably responsible for their headache. In contrast, only one worker in the second shift on February 24 reported headache but he also smoked 10 cigarettes during the shift. In view of low levels of carbon monoxide reported in the second shift, his headache is more likely to be related to cigarette smoking than to environmental CO. Although carboxy hemoglobin (CO-Hb) levels were not measured in this study, it is a well established fact that symptom of headache is related to the elevated CO-Hb level[6], which is proportional to the inhaled CO, whether it is from the work environment or from cigarette smoking.[7]

Prior to the shift, three workers complained of either stuffy or runny nose, but these disappeared during the day. At the end of the shift, four different workers complained of nose irritation. Therefore, this was considered to be a possible reaction to the smoke in the work environment.

Physical Examination

Pre- and post-shift physical examinations were limited to the inspection of eyes, nose and throat, and auscultation of the chest. There were no persons who showed injected conjunctivae or pharynx before the shift. However, at the end of the shift, 5 (3 in the first shift and 2 in the second shift) showed conjunctival injection of slight to moderate degree and 7 (5 in the first shift and 2 in the second shift) showed pharyngeal injection of slight to moderate degree. In some, these objective signs corresponded to the complaints, but in others they did not.

The worker with a history of asthmatic bronchitis was found to have wheezes in his lung fields. Since they were heard at the time of both pre- and post-shift examinations, this was not considered to be related to the exposures during the shift.

Ventilatory Studies

Shown in Table 12 are means and standard deviations of actual values of FVC, FEV_1, and FEF25-75 for various groups. No significant difference was observed between any of pre- and post-shift values. Also, when the values are compared between the groups of Shift I vs Shift II, etc., there is again no statistical difference.

Not used in the statistical analyses of the ventilatory functions were one black male and two black female workers due to the fact that no standard values have been established for this ethnic group. One white worker who worked two consecutive shifts at the time of this study was also excluded from the statistical evaluation.

Listed in Table 13 is a comparison of ventilatory functions between our study group in the White Department and healthy, non-smoking population in Oregon studied by Morris, Koski and Johnson[5]. The result of the latter study has been widely quoted as a national standard. Since most of the RHPF workers who were studied fell into the age bracket of 40-49 and 50-59, only these groups were used for comparison. As seen on Table 13, their distribution in age and height are comparable to the population studied in Oregon. They have worked many years in RHPF, while the Oregon study was conducted among people living in a "pollution-free" area of that state. As seen from the Table, there is virtually no significant difference in any pair of comparison. In other words, ventilatory functions of the studied workers in the White Department are, on a group basis, not different from those of the referenced comparison population.

Discussion

Perhaps, no proof is required to the fact that smoke or smokey condition is a nuisance. Few people would prefer living or working in a smokey place, if they had a choice. Smokey condition in a work place is annoying (if not toxic) to the employees, and may affect their morale and productivity, and consequently, the quality of the finished material. In addition, this hazard evaluation is to answer the following questions:

1. Acute Effects of Smoke

From the data obtained, it is seen that a good number of employees are affected by the smoke, many in the form of eye, nose, and/or throat irritation. There is an indication that a complaint of headache may be related rather to CO in the exhaust from forklift trucks than to the smoke. It must be noted that these are subjective but specific complaints related to the job. Although they are temporary in duration and disappear shortly after the worker seeks a relief in a well ventilated area, their existence can not be denied.

As stated previously, finding of conjunctival or pharyngeal injection at the end of the shift did not necessarily match the complaints of eye irritation or throat irritation, respectively. It is the interpretation of NIOSH medical investigator that this fact does not indicate that employees are making false physical complaints. Rather, it is reflective of a great variability in individual perception of irritation. Some may feel little irritation while the mucous membrane is moderately injected; others may feel marked irritation despite a rather normal looking mucosa. Among the NIOSH investigators who visited the hot frame machine area at the time when the smoke condition was said to be mild, a medical officer felt a mild throat irritation which lasted several hours. On the other hand, a NIOSH engineer felt that he was not affected at all.

Another observation made during this survey was that workers in the first shift reported that they had a period of increased smoke levels for a few hours, while the workers in the second shift reported that the smoke was rather mild during their shift. As seen on Table 11, number of complaints and positive physical findings are increased at the end-shift examination, and the first shift group has, in general, more complaints or findings in comparison to the second shift group.

These differences are not statistically significant with the exception of headache (chi-square $P<0.05$). Even in this case, one could argue that the first shift group is about 6 years older than the second shift group and, therefore, may have more physical complaints. However, in view of the fact that there was a paucity of complaints before the shift, the NIOSH investigators feel that this increase in the number of complaints of headache is significant.

With regard to the possibility of acute lung effect caused by the smoke in the Hot Frame operation, this evaluation has detected no signs or symptoms that may indicate presence of such effect. There were no significant differences in ventilatory functions between the pre- and post-shift testings in any of the comparisons made. There were several individuals in the first shift whose forced expiratory volumes at the end-shift was larger than those measured at the pre-shift. This is considered to be due to the training effect of the testing, rather than to the effect of the work environment. In the second shift group, many workers showed a slight reduction in the forced expiratory volume at the end of the shift (Table 12). However, it was not to the degree of statistical significance.

2. Chronic Effects of Smoke

It is conceivable that a long term exposure to the smoke may lead to a chronic pulmonary disease such as chronic bronchitis. However, no such conclusion is formulated from the present study data. As shown in Table 13, our study group with many years of work in the White Department did not differ from the comparison group in their ventilatory performance. The spirometric machines used by Morris, et. al. in their Oregon study was of Stead-Wells type, while we used Vitalograph machines. Both of these types are widely used in ventilatory function testing and each set of equipment is well calibrated. We do not consider that there is a wide difference between these two types of instruments.

On an individual basis, workers studied in this evaluation showed a variety of responses; some with a relatively high age and long employment in the White Department plus a history of smoking performed rather well in the ventilatory testing. There were other cases to the contrary.

If there were any chronic effects by "the smoke on the job" or "tobacco smoking", it was not possible to separate them because the size of the study group was not large enough and it included 16 (61.5%) current smokers and 7 (27%) ex-smokers.

While the exact components of the smoke were unknown, the measured major components were all below the TLV. By definition of the TLV, under which, on the basis of current knowledge, nearly all workers may be repeatedly exposed day after day without adverse effect, it may be stated that the current smoke situation will not result in a chronic illness as far as the known and measured components are concerned.

3. Potential Heat Exposure

The NIOSH investigators noted that the hot frame machines create hot environment in the surrounding area. This follow-up study was done during the month of February and, although no measurements were taken on heat stress indices, it is expected that the hot condition may sometimes be severe during the hot months. Some employees admitted that workers would be overcome by heat during the hot season. Although NIOSH will not be conducting a heat stress survey, this observation is brought to the attention of both the management and employees so that proper precautionary measures may be taken to prevent occurrences of heat casualties (see Recommendation).

Conclusions

1. Smoke emission from the hot frame machine is responsible for acute irritation of eyes, nose, and throat which are experienced by employees in the White Department. Exhaust from fork-lift trucks may be responsible for headache experienced by some employees.

2. This study has not established that a long time exposure to the smoke emission from the hot frame machine will result in chronic disease of respiratory tract or other organs.

3. This study has failed to demonstrate any significant contaminant in the workplace which would have as its source,decomposition products from cotton, cotton-polyester, or polyester-rayon cloth which is processed in the hot frames in the White Department. Since the medical evaluation has demonstrated signs and symptoms of irritation, we can not exclude a possibility that a combination of several substances, while each is present in a minute quantity, may be responsible for the worker complaints of eye and throat irritation. The environmental study necessary to conclusively identify the substance(s) causing these effects is beyond the scope of a health hazard evaluation. An appropriate research effort to further study this problem should be considered.

V. RECOMMENDATIONS

A. Medical

1. Establish a program of preemployment and periodic medical examination for employees exposed to noxious dust or fumes. Such examination should include physical examination and ventilatory studies at a minimum. Periodicity of such examination may vary depending on employees' age, type of exposure, and other factors. For the White Department employees, a program of triennial examination is considered adequate.

2. In view of potential exposure to heat in the White Department during the hot season, a proper work practice be established in the White Department for prevention of heat stroke or heat exhaustion. Such work practices are listed in the "Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment" published by the American Conference of Governmental Industrial Hygienists, P.O. Box 1937, Cincinnati, Ohio 45201.

B. Environmental

1. A systematic study of smoke emission pattern be established as to the type of fabric, setting temperature and speed of fabric runs to determine ways to minimize smoke emission. If such controls are feasible without compromising the quality of the product, they should be implemented.

2. The smoke haze was observed escaping from the hot frame fabric exits on several occasions. The possibility of increasing the exhaust volume for the hot frame gas heaters should be investigated as a way to prevent hot frame emissions from entering the workroom. Curtains at the fabric exists might minimize the amount of air which would have to be exhausted from these points.

3. If the above recommendation is not feasible, local exhaust systems should be installed to capture the hot frame emissions.

4. Measures should be taken to minimize to the extent possible levels of carbon monoxide in the White Department. Fork lift trucks should not be allowed to idle when not in use, and operators should avoid racing truck engines.

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Table 1

Results of Non-Directed Questionnaires
Number of Workers Reporting Symptoms Indicated

Rock Hill Printing and Finishing Company
Rock Hill, South Carolina

August 27-28, 1975

Shift	No. of Workers	Headache	Nausea	Burning Eyes	Burning Nose or Throat	Difficulty Breathing	Wheezing
7-3	11	2	0	5	2*	3	1
3-11	9	3	1	3	1	7	1
Total	20	5	1	8	3	10	2

*One worker in addition reported nosebleeds attributed to lint.

Ten of eleven 1st shift workers and nine of nine 2nd shift workers reported one or more symptom associated with hot frame emissions.

Table 2

Results of Continuous Area Sampling

Rock Hill Printing and Finishing Company
Rock Hill, South Carolina

February 24, 1976 (7am - 3pm shift)

Location	Sample Period	Concentrations of Substances mg/M^3										
		Form-aldehyde	Acet-aldehyde	Butyr-aldehyde	Iso-butyr-aldehyde	Croton-aldehyde	Propion-aldehyde	Formic Acid	Acetic Acid	Oil Mist	Acetone	MEK
Operator's Station, No. 1 and No. 2 Hot Frame Take-up	7:57 am - 2:20 pm	0.21	<1.9	<1.3	<1.3	<1.3	<1.3	0.10	<0.03	1.7	<0.5	<0.5
Operator's Station, No. 3 and No. 4 Hot Frame Take-up	8:01 am - 2:23 pm	0.16	<1.9	<1.1	<1.1	<1.1	<1.1	0.18	<0.03	<0.02	<0.5	<0.5
Operator's Station, No. 9 and No. 10 Frames	8:07 am - 2:26 pm	0.18	<1.9	<1.1	<1.1	<1.1	<1.1	0.11	<0.02	3.2	<0.6	<0.6
No. 9 Frame at Feed End	8:10 am - 2:30 pm	0.16	<1.9	<1.1	<1.1	<1.1	<1.1	0.05	<0.03	<0.02	<1.1	<1.1
Environmental Criteria		3	360	-	-	6	-	9	25	5	2400	590

Table 3

Results of Detector Tube Sampling

Rock Hill Printing and Finishing Company
Rock Hill, South Carolina

February 24, 1976 (7am - 3pm shift)

Location	Time	Concentration of Substances (ppm)* Carbon Dioxide	Carbon Monoxide	Ecolyzer®**	Formaldehyde
Take-up Area, No. 1 and No. 2 Hot Frames	11:55 am	1000	20	20	<0.5
Exit from Hood, No 1 Hot Frame	12:07 pm	-	50	50	-
Exit from Hood, No. 3 Hot Frame	12:12 pm	1000	30	-	<0.5
Exit from Hood, No. 4 Hot Frame	12:20 pm	<1000	20	18	<0.5
General Area No. 11 Straightener Frame	12:22 pm	1000	15	15	-
Scram Loading Area	12:30 pm	<1000	10	12	-
Exit from Hood, No. 4 Hot Frame	12:46 pm	1000	12	-	<0.5
Environmental Criteria		5000	200	200	2

* Parts of vapor or gas per million parts of contaminated air by volume.

** The nearest Ecolyzer® carbon monoxide concentration at time of detector tube sampling.

Table 4

Results of Continuous Area and Personal Sampling

Rock Hill Printing and Finishing Company
Rock Hill, South Carolina

February 24, 1976 (3pm - 11pm shift)

Location/Job Description	Type* Sample	Sample Period	Concentration of Substances (mg/M^3)** Form-aldehyde	Acet-aldehyde	Butyr-aldehyde	Iso-butyr-aldehyde	Croton-aldehyde	Propion-aldehyde	Formic Acid	Acetic Acid	Oil Mist	Acetone	MEK
Operator's Station, No. 1 and No. 2 Hot Frame Take-up	A	4:37pm - 10:50pm	0.10	<1.4	<0.9	<0.9	<0.9	<0.9	0.23	<0.03	<0.02	<0.6	<0.6
No. 1 Hot Frame Take-up Operator	P	4:06pm 10:02pm	0.14	<1.2	<0.7	<0.7	<0.7	<0.7	-	-	-	-	-
No. 2 Hot Frame Take-Up Operator	P	4:32pm 10:15pm	0.09	<1.5	<0.9	<0.9	<0.9	<0.9	-	-	-	-	-
Operator's Station, No. 3 and No. 4 Hot Frames	A	4:46pm 10:50pm	0.09	<1.5	<0.9	<0.9	<0.9	<0.9	0.14	<0.03	<0.02	<0.6	<0.6
No. 3 Hot Frame Take-up Operator	P	5:00pm 9:20pm	-	-	-	-	-	-	-	-	-	<0.7	0.7
No. 4 Hot Frame Take-up Operator	P	4:11pm 10:05pm	-	-	-	-	-	-	0.18	<0.03	-	-	-
No. 7 - No. 11 Frames, Relief Operator	P	4:55pm 9:55pm	-	-	-	-	-	-	<0.03	<0.03	-	-	-
No. 7 Frame Operator	P	4:52pm 10:06pm	-	-	-	-	-	-	-	-	<0.02	-	-
No. 8 Frame Scray Loader/Helper	P	4:49pm 10:29pm	-	-	-	-	-	-	-	-	<0.02	-	-
Operator's Station, No. 9 and No. 10 Frames	A	4:48pm 10:50pm	0.10	<1.3	<0.8	<0.8	<0.8	<0.8	0.03	<0.03	<0.02	<0.6	<0.6
No. 9 Frame at Feed End	A	4:52pm 10:50pm	0.10	<1.2	<0.7	<0.7	<0.7	<0.7	0.20	<0.03	<0.02	<0.6	<0.6
No. 10 Frame Operator	P	4:19pm 10:00pm	0.09	<1.4	<0.8	<0.8	<0.8	<0.8	-	-	-	-	-
No. 11 Frame Operator	P	4:16pm 10:30pm	0.10	<1.8	<1.1	<1.1	<1.1	<1.1	-	-	-	-	-
Environmental Criteria	-	-	3	360	-	-	6	-	9	25	5	2400	590

* A - Area sample collected at the location in the White Department designated.
P - Personal sample collected in the breathing zone of the designated worker.

** Approximate milligrams of contaminant per cubic meter of contaminated air.

Table 5

Results of Detector Tube Sampling

Rock Hill Printing and Finishing Company
Rock Hill, South Carolina

February 24, 1976 (3pm - 11 pm shift)

Location	Time	Concentrations of Substances (ppm)* Carbon Dioxide	Carbon Monoxide	Formaldehyde
Operator's Station,	7:10 pm	1000	20	-
No. 1 and No. 2 Hot Frame Take-up	7:21 pm	1000	-	<0.5
Operator's Station,				
No. 3 and No. 4 Hot Frame Take-up	7:30 pm	1000	20	-
Exit from Hood,	7:38 pm	<5000	10	-
No. 2 Hot Frame	7:50 pm	-	10	<0.5
Operator's Station,				
No. 3 and No. 4 Hot Frame Take-up	8:07 pm	1000	-	<0.5
Walk-way Between				
Hot Frames No. 2 and No. 3	8:14 pm	-	10	-
Operator's Station,	9:10 pm	1000	>10	-
No. 10 and No. 11 Frames	9:30 pm	<1000	-	<0.5
Operator's Station,	9:35 pm	<1000	<10	-
No. 8 and No. 9 Frames	9:43 pm	<1000	-	<0.5
Environmental Criteria		5000	200	2

* Parts of vapor or gas per million parts of contaminated air by volume.

Table 6

Results of Continuous Area and Personal Sampling

Rock Hill Printing and Finishing Company
Rock Hill, South Carolina

February 25, 1976 (7am - 3pm shift)

Location/Job Description	Type* Sample	Sample Period	Concentration of Substances (mg/M^3) Form-aldehyde	Acet-aldehyde	Butyr-aldehyde	Iso-butyr-aldehyde	Croton-aldehyde	Propion-aldehyde	Formic Acid	Acetic Acid	Oil Mist	Acetone	MEK
Operator's Station, No. 1 and No. 2 Hot Frames	A	8:37am 2:05pm	0.12	<1.4	<0.9	<0.9	<0.9	<0.9	<0.03	<0.03	<0.02	<0.4	<0.4
No. 1 Hot Frame Take-up Operator	P	9:10am 1:26pm	0.09	<1.6	<1.0	<1.0	<1.0	<1.0	-	-	-	-	-
No. 2 Hot Frame Take-up Operator	P	7:50am 1:26pm	-	-	-	-	-	-	-	-	-	<0.7	<0.7
Operator's Station, No. 3 and No. 4 Hot Frames	A	8:40am 1:53pm	0.07	<1.4	<0.8	<0.8	<0.8	<0.8	0.13	<0.03	<0.02	<0.7	<0.7
No. 3 Hot Frame Take-up Operator	P	9:15am 1:28pm	0.16	<1.9	<1.2	<1.2	<1.2	<1.2	-	-	-	-	-
No. 4 Hot Frame Take-up Operator	P	7:38am 1:29pm	-	-	-	-	-	-	-	-	<0.02	-	-
No. 4 Hot Frame, Exit from Dryer	A	9:29am 1:55pm	-	-	-	-	-	-	0.04	<0.04	-	-	-
No. 8 and No. 9 Frames, Scray Loader	P	8:00am 1:30pm	-	-	-	-	-	-	-	-	-	<0.5	<0.5
No. 8 Frame on Machine	A	9:23am 1:59pm	-	-	-	-	-	-	0.36	<0.04	-	-	-
No. 9 Frame on Machine	A	8:45am 1:38pm	0.07	<1.8	<1.1	<1.1	<1.1	<1.1	0.07	0.13	<0.03	<0.6	<0.6
Operator's Station, No. 10 and No. 11 Frames	A	8:43am 1:36pm	0.09	<2.0	<1.2	<1.2	<1.2	<1.2	<0.4	8.7	<0.03		
No. 10 Frame Operator	P	9:19am 12:40pm	0.07	<3.4	<2.1	<2.1	<2.1	<2.1	-	-	-	-	-
No. 11 Frame Operator	P	7:44am 12:45pm	-	-	-	-	-	-	-	-	<0.02		
Environmental Criteria	-	-	3	360	-	-	6	-	9	25	5	2400	590

* A - Area sample collected at the location in the White Department designated.
P - Personal sample collected in the breathing zone of the designated worker.

Table 7

Results of Detector Tube Sampling

Rock Hill Printing and Finishing Company
Rock Hill, South Carolina

February 25, 1976 (7am - 3pm shift)

Location	Time	Concentration of Substances (ppm)* Carbon Dioxide	Carbon Monoxide	Ecolyzer®	Formaldehyde
Exit from Hood, No. 1 Hot Frame	12:25 pm	<1000	<10	10	<0.5
Exit from Hood, No. 3 Hot Frame	12:35 pm	1000	10	10-20	<0.5
Walk-way between No. 9 and No. 10 Frames	12:50 pm	<1000	<10	8-10	<0.5
Environmental Criteria		5000	200	200	2

* Parts of vapor or gas per million parts of contaminated air by volume.

Table 8

Results of Continuous Carbon Monoxide Monitoring

Rock Hill Printing and Finishing Company
Rock Hill, South Carolina

February 24-25, 1976

Date	Location	Time	Concentration of CO (ppm)*	Location	Time	Concentration of CO (ppm)
2/24	No. 1 and No. 2 Hot Frame Take-up Area	9:00am-10:00am	38.5	No. 9 and No. 10 Frames Area	8:50am- 9:50am	30.3
	"	10:00am-11:00am	41.6	"	9:50am-10:50am	41.8
	"	11:00am-12:00noon	29.7	"	10:50am-11:50am	34.5
	"	12noon - 1:00pm	32.0	"	11:50am-12:50pm	24.3
	"	1:00pm- 2:00pm	39.5	"	12:50pm- 1:50pm	30.9
	"	2:00pm- 3:07pm	12.9	"	1:50pm- 2:50pm	16.2
				"	2:50pm- 3:46pm	18.9
	Shift Average	9:00am- 3:07pm	32.0	Shift Average	8:50am- 3:46pm	28.1
2/24	No. 1 and No. 2 Hot Frame Take-up Area	3:40pm- 4:40pm	21.2	No. 9 and No. 10 Frames Area	3:47pm- 4:47pm	19.4
	"	4:40pm- 5:40pm	20.1	"	4:47pm- 5:47pm	19.9
	"	5:40pm- 6:40pm	16.8	"	5:47pm- 6:47pm	15.1
	"	6:40pm- 7:40pm	23.5	"	6:47pm- 7:47pm	16.5
	"	7:40pm- 8:40pm	29.2	"	7:47pm- 8:47pm	20.0
	"	8:40pm- 9:40pm	28.1	"	8:47pm- 9:47pm	19.9
	"	9:40pm-10:40pm	20.9	"	9:47pm-11:00pm	13.6
	Shift Average	3:40pm-10:40pm	20.0	Shift Average	3:47pm-11:00pm	17.6
2/25	No. 1 and No. 2 Hot Frame Take-up Area	7:45am- 8:45am	37.9	No. 9 and No. 10 Frames Area	7:35am- 8:35am	27.9
	"	8:45am- 9:45am	34.0	"	8:35am- 9:35am	49.6
	"	9:45am-10:45am	50.7	"	9:35am-10:35am	22.5
	"	10:45am-11:45am	27.9	"	10:35am-11:35am	20.3
	"	11:45am-12:45pm	13.7	"	11:35am-12:35pm	18.9
	"	12:45pm- 1:45pm	16.9	"	12:35pm- 1:35pm	17.1
	"	1:45pm- 2:30pm	23.0	"	1:35pm- 2:45pm	12.1
	Shift Average	7:45am- 2:30pm	29.4	Shift Average	7:35am- 2:45pm	23.1
Environmental Criteria (8 hour-time-weighted average)			35.0			35.0

* Parts of gas per million parts of contaminated air by volume.

Table 9

Type of Goods Processed as Percentage of
Shift Production for Each Hot Frame February 24-25, 1976

Rock Hill Printing and Finishing Company
Rock Hill, South Carolina

	Hot Frame Number							
	1			2		3		4	
1st Shift - 2/24	80.3*	50/50**	P/C***	49.1	50/50 P/C	36.4	50/50 P/R	60.4	50/50 P/C
	17.0	50/50	P/C HS	41.8	100 C	36.4	Wetout	39.6	100 C
	2.7	65/35	P/C	9.1	65/35 P/C HS	27.2	100 C		
2nd Shift - 2/24	60.0	100	C	86.7	50/50 P/C HS	50.0	100 C	66.6	100 C
	23.6	50/50	P/C	7.6	100 C	50.0	50/50 P/C HS	33.4	50/50 P/C HS
	16.4	50/50	P/C HS	5.7	65/35 P/C HS				
1st Shift - 2/25	100.0	100	C	60.6	50/50 P/C	55.0	50/50 P/C HS	55.9	50/50 P/C
				34.0	100 P	32.8	100 P	44.1	50/50 P/C HS
				5.4	50/50 P/C HS	12.2	100 C		

* Percent processed during shift.
** Blend as percent, e.g. 50/50 P/C - 50% polyester - 50% cotton
*** Composition of blend, P - polyester, C- cotton, R - rayon, HS - heat set.

Table 10

Rock Hill Printing and Finishing Company
Rock Hill, South Carolina

Frequency of symptoms which workers thought were related to the "smoky" condition in the White Department (Response to directed questions: listed in the order of frequency).

Rank	Symptom	Number of Examinees Answering "Yes"	%
1	Burning of Eyes	24	92
2	Watering of Eyes	18	69
3	Headache	17	65
4	Throat Irritation	12	46
5	Stuffy Nose	11	42
6	Coughing	10	38
7	Runny Nose	7	27
8	Chest Tightness	6	23
9	Shortness of Breath	6	23
10	Chest Wheezing	4	15
11	Nausea/Vomiting	2	8
12	Muscle Weakness	1	4
13	Weight Loss	0	0
14	Loss of Consciousness	0	0
15	Other	1	4

TABLE 11

Rock Hill Printing and Finishing Company
Rock Hill, South Carolina

Number of health complaints and physical findings before and at the end of the shift.

	Pre-shift Total (1st, 2nd)**	End-shift Total (1st, 2nd)**
Number of Workers	25 (12, 13)	25 (12, 13)
Complaint*		
Eye irritation	0 (0, 0)	4 (3, 1)
Stuffy or runny nose	3 (2, 1)	0 (0, 0)
Nose irritation	0 (0, 0)	4 (2, 2)
Throat irritation	0 (0, 0)	8 (4, 4)
Headache	0 (0, 0)	6 (5, 1)
Physical Exam*		
Conjunctival injection	0 (0, 0)	5 (3, 2)
Nasal mucosa injection	0 (0, 0)	0 (0, 0)
Pharyngeal injection	0 (0, 0)	7 (5, 2)

*Individuals' complaint and physical findings did not necessarily match in a few cases.

**The first shift group was studied on Fegruary 25, 7 a.m. - 3 p.m.
The second shift group was studied on February 24, 3 p.m. - 11 p.m.

TABLE 12

Rock Hill Printing and Finishing Company
Rock Hill, South Carolina

Ventilatory Functions of White Department Employees
Means and Standard Deviations of Actual Values*

Comparison	Number of Workers	FVC (Liter)		FEV_1 (Liter)		FEF (L/Sec)	
		Pre	Post	Pre	Post	Pre	Post
Shift I	12	4.4 ± 0.7	4.5 ± 0.7	3.2 ± 1.1	3.5 ± 0.5	2.7 ± 0.8	2.0 ± 1.0
Shift II	10	4.8 ± 1.1	4.6 ± 1.2	3.9 ± 0.9	3.7 ± 1.0	3.9 ± 1.7	3.6 ± 1.7
Smokers	12	4.7 ± 0.9	4.6 ± 0.9	3.7 ± 0.7	3.7 ± 0.8	3.2 ± 1.2	3.3 ± 1.3
Non Smokers	10	4.4 ± 1.0	4.4 ± 0.9	3.5 ± 0.9	3.5 ± 0.8	3.3 ± 1.7	3.1 ± 1.5
Close**	10	4.6 ± 1.0	4.5 ± 1.1	3.6 ± 0.8	3.5 ± 0.8	2.8 ± 0.8	2.9 ± 1.1
Far	12	4.6 ± 0.9	4.6 ± 0.8	3.7 ± 0.9	3.7 ± 0.7	3.6 ± 1.7	3.5 ± 1.6

*A similar comparison was made using the percent-predicted values (adjusted to age and height) but it yielded results which were not different from the above.

**Relative position of workers with regard to the source of smoke emission (take-off end).

Note: There is no significant statistical difference between the means in each pair, when they are compared horizontally (pre vs post) or vertically (Shift I vs Shift II, etc.).

TABLE 13

Rock Hill Printing and Finishing Company
Rock Hill, South Carolina

COMPARISON OF VENTILATORY FUNCTIONS

White Department Employees VS Oregon Standard[5]
Means and Standard Diviations

		Age Group 40 - 49	Age Group 50 - 59
Number of Men Studied (Smokers	RHPF	6(3)	11(4)
	Oregon	94(0)	67(0)
Age	RHPF	45.67 ± 1.97	55.45 ± 3.14
	Oregon	44.15 ± 2.64	53.82 ± 2.66
Years of RHPF Work		28.2 ± 3.1	32.2 ± 5.8
Height (inches)	RHPF	70.08 ± 3.41	69.95 ± 2.43
	Oregon	69.89 ± 2.70	69.86 ± 2.76
FVC (Liter)	RHPF	4.78 ± 0.49	4.69 ± 0.91
	Oregon	5.05 ± 0.67	4.88 ± 0.81
$FEV_{1.0}$ (Liter)	RHPF	3.85 ± 0.47	3.68 ± 0.77
	Oregon	3.79 ± 0.54	3.50 ± 0.59
FEF_{25-75} (L/sec)	RHPF	3.55 ± 1.50	3.17 ± 1.61
	Oregon	3.77 ± 0.95	3.45 ± 1.16

Note: Since the comparative means in each pair lie within one standard deviation of each other, there is obviously no signigicant difference in any of these comparisons.