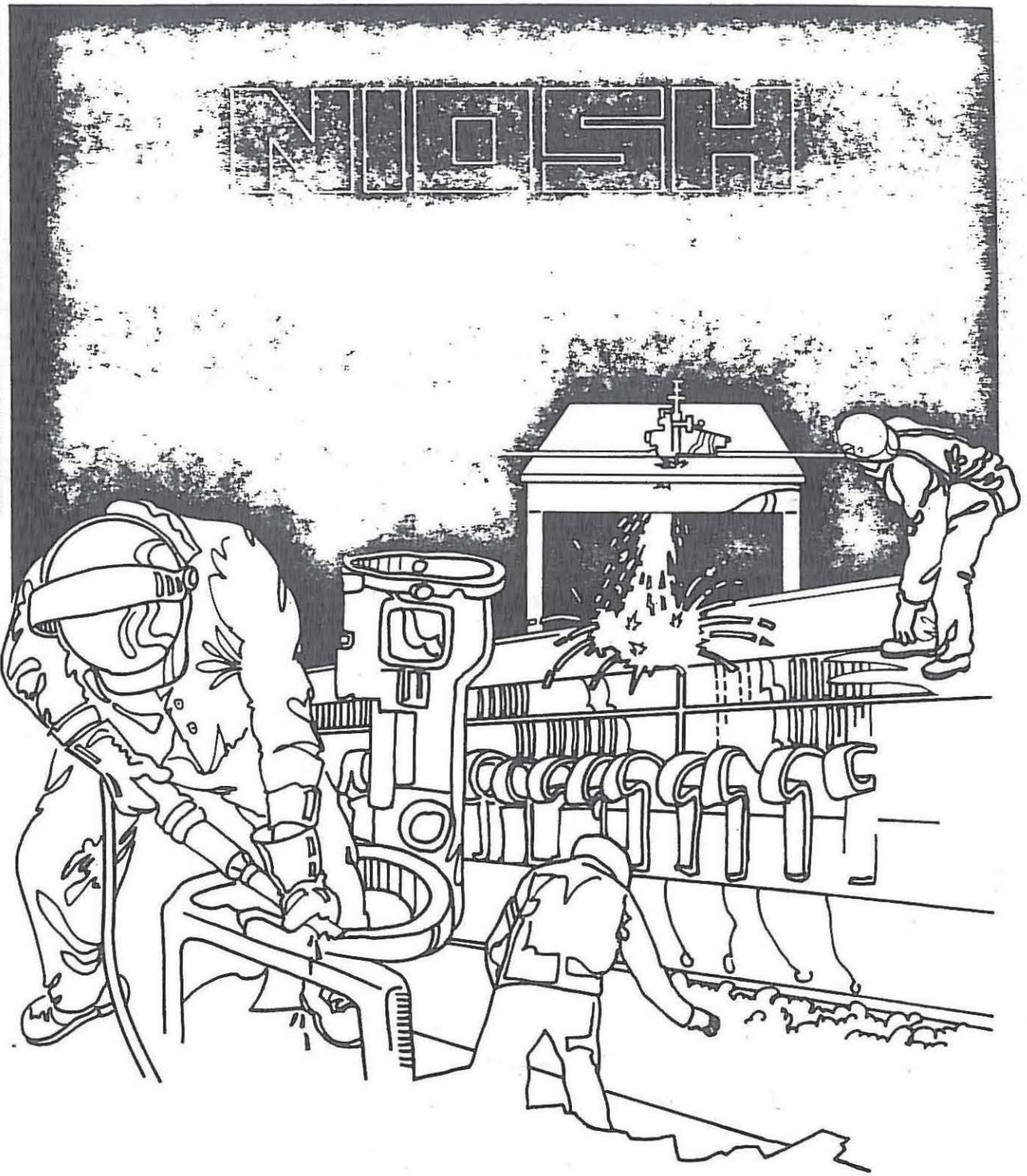
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

79-006-782

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 79-006-782
DECEMBER 1980
COASTAL INDUSTRIES, INC.
SELMA, ALABAMA

NIOSH INVESTIGATORS:
John R. Kominsky, I.H.
Edward A. Emmett, M.D.
Michael T. Donohue, P.A.

I. SUMMARY

A health hazard evaluation was conducted by the National Institute for Occupational Safety and Health (NIOSH) at Coastal Industries, Selma, Alabama on November 28-30, 1978, and July 24-25, 1979, to evaluate complaints of eye, respiratory and skin irritation in approximately 126 textile workers exposed to free formaldehyde. Exposures occurred during the sewing of fabric pre-treated with a post-cured resin, 1,3-dimethylol-4-5, dihydroxy-2-imidazolidinone.

Formaldehyde exposures were evaluated in forty-one 30-minute and sixteen 8-hour TWA personal breathing zone samples. Thirty-three (80%) of the 30-minute samples showed formaldehyde concentrations (mean 1.2 ppm, SD ±0.32, range 0.30 - 1.8) greater than the 1 ppm NIOSH recommended standard. None of the 8-hour TWA samples (mean 0.70 ppm, SD ±0.14, range 0.54 - 0.91) exceeded the 3 ppm 8-hour TWA OSHA standard. Measurements made 20-minutes prior to the beginning of the work shift showed that levels of formaldehyde increased substantially (mean 5 ppm, range 4-7) during periods (such as overnight) when the ventilation system was not operating. The average latent formaldehyde content of randomly selected cloth samples was 96.3 ug/gram of cloth.

Health questionnaires and limited physical examinations were completed on 88 workers. The questionnaire showed that 84 (95%) complained of eye irritation, 63 (72%) nasal irritation, 31 (35%) throat irritation, and 22 (25%) skin irritation. The abnormalities noted on physical examination included 9 (10%) eye irritation, 23 (26%) nasal irritation, 2 (2%) throat irritation, and 19 (22%) skin irritation.

The environmental-medical data collected at Coastal Industries, Selma, Alabama, show that workers are exposed to toxic concentrations of free formaldehyde. Exposure is associated with signs and symptoms of eye, respiratory and skin irritation. Recommendations to reduce employee exposures via fabric isolation and ventilation in storage areas, and improved local exhaust and dilution ventilation in the work areas are included in Section IX of this report.

KEYWORDS: SIC 2260 (Dyeing and Finishing Textiles), formaldehyde, glyoxal-formaldehyde resin, 1,3-dimethylol-4-5, dihydroxy-2-imidazolidinone (DMDHEU), post-cured resin.

II. INTRODUCTION

Under the Occupational Safety and Health Act, the National Institute for Occupational Safety and Health (NIOSH) investigates toxic effects of substances found in the workplace. On October 18, 1978, an authorized representative of Local 516C of the International Ladies' Garment Workers Union requested that NIOSH conduct a Health Hazard Evaluation in the sewing plant of Coastal Industries in Selma, Alabama. The requestor expressed concern that the machine operators are exposed to formaldehyde released from post-cured durable press fabrics with resultant eye, respiratory, and skin irritation. On November 28-30, 1978, NIOSH conducted a preliminary environmental-medical survey of the sewing plant. This survey showed that the workers were exposed to levels of formaldehyde vapor above the NIOSH recommended standard, and suggested that they were experiencing skin and mucous membrane irritation. To evaluate the apparent increased incidence of respiratory and skin related problems a follow-up medical survey was conducted by NIOSH on July 24-25, 1979.

The results of the November 28-30, 1978 survey were reported to the employee and employer representatives in Interim Reports I and II dated January and March 1979, respectively.

III. BACKGROUND

Coastal Industries is a manufacturer of military service apparel. The sewing plant employing approximately 126 persons is currently involved in manufacturing durable press trousers. The fabric is pre-cut; treated with a glyoxal-based resin system, 1,3-dimethylol-4,5, dihydroxy-2-imidazolidinone (DMDHEU); and dried, but not cured, prior to shipment to the sewing plant. The sewing plant personnel sew the fabric into trousers, which are then shipped back to the initial plant to be postcured. The postcuring procedure permits the trousers to retain their crease as well as their ability to recover from wrinkling due to washing.

IV. STUDY DESIGN AND METHODS

Environmental testing was conducted on November 28-30, 1978, to evaluate exposures of approximately 126 workers to free formaldehyde emitted from uncured fabrics. The sampling strategy was designed to address both short-term (30-minute) and long-term exposures (8-hours). Personal breathing zone samples for vaporous formaldehyde were collected on solid sorbent tubes containing 150 mg of impregnated charcoal. The samples were desorbed with hydrogen peroxide and analyzed using ion chromatography. Intermittent determinations of formaldehyde concentrations were made using direct reading colorimetric indicator tubes. Bulk cloth samples were analyzed for latent formaldehyde content determination using the aforementioned hydrogen peroxide desorption-ion chromatography method.

The July 24-25, 1979, medical survey involved administration of a health questionnaire and a physical examination of the employees. The questionnaire sought demographic information, occupational history, symptoms related to the skin, eye and respiratory system, and past history or family history of atopy (allergic sensitivity). The physical examination involved the eye, ears, nose, throat and the skin, and auscultation of the lungs.

V. EVALUATION CRITERIA

NIOSH recommends that no employee be exposed to airborne formaldehyde at a concentration greater than 1 part formaldehyde per one millon parts of air (ppm) for any 30-minute period.[1] The OSHA standard or Permissible Exposure Limit (PEL) is 3 ppm for an 8-hour Time-Weighted Average (TWA) exposure with an acceptable ceiling concentration of 5 ppm or an acceptable maximum peak above the acceptable ceiling concentration for an 8-hour work shift of 10 minutes.

The primary health effects of exposure to formaldehyde are irritation of the respiratory tract, eyes and skin.[1] Eye and respiratory tract irritation has been reported in workers exposed to concentrations of less than 1 ppm.[2-4] Recent studies have found that formaldehyde induced nasal cancer in rats exposed to high levels (15 ppm) of formaldehyde over a long period of time.[5] An excess cancer risk in humans has not been observed; epidemiologic studies to investigate this possibility are planned.

VI. RESULTS

A. Air Measurements

Exposures of approximately 126 workers to formaldehyde vapor were evaluated by obtaining forty-one 30-minute and sixteen 8-hour TWA personal breathing zone samples. Tables I-III present the results of these analyses. The average concentration for the forty-one 30-minute samples is 1.2 ppm (SD ±0.32, range 0.30 - 1.8). By comparison, 80% (33/41) of the 30-minute samples showed concentrations equal to or greater than the 1 ppm NIOSH recommended standard. The average concentration for the sixteen 8-hour TWA samples is 0.70 ppm (SD ±0.14, range 0.54 - 0.91). None of these samples exceeded the 3 ppm 8-hour TWA OSHA standard.

To determine whether the formaldehyde levels increased significantly during periods (such as overnight) when the ventilation system would be off, formaldehyde levels were measured approximately 20 minutes prior to shift start-up on November 29. Seven measurements made using direct-reading indicator tubes showed that the formaldehyde levels (average 5 ppm, SD ±1.5, range 4-7) increased substantially during periods when the ventilation was not operating. Bulk samples of cloth contained an average of 96.3 micrograms of latent formaldehyde per gram of cloth sample (SD ±14, range 86.5 - 106.1).

B. Medical Questionnaire and Examination

All of the 126 workers present were offered the opportunity to participate; 28 workers were absent from work and ten workers refused. The mean age of the 88 participants was 30.5 years and the average length of employment was 2.67 years; 86 were female.

The symptoms of the 88 workers, are listed in Table IV. Burning of the eyes (95%), tearing (50%), redness (48%) and itching (45%) were very common; 75% of affected workers indicated that these only occurred at work. Many workers indicated that these symptoms were most pronounced on entering the building at the beginning of the shift and at times when large amounts of fabrics were near to their worksite. Many individuals indicated that the burning lasted only 10 to 15 minutes at these times.

Symptoms of nasal irritation since commencing work at Coastal Industries were reported by 72% of the examined workers. Specific symptoms included running nose (35%), stuffiness (34%) and sneezing (28%). The workers indicated that these symptoms occurred only while they were at work. In contrast to eye symptoms, nasal symptoms, once they occurred, tended to last the entire day.

Scratchy sore throat was reported by 18% of workers, itching by 18% and burning by 20%. Thirty-five percent of all participants reported one or more throat symptoms; 20% of those affected reported that their throat symptoms occurred only at work.

Respiratory symptoms included phlegm production (14%), cough (13%), wheezing (8%) and episodic shortness of breath (11%); of the participants 12% of affected workers described their respiratory symptoms as occurring only at work. Twenty-five percent of the workforce reported a rash since commencing work at this facility.

The abnormalities observed on physical examination are shown on Table V. They included signs of ocular irritation in 10% of examined workers, nasal irritation in 26%, throat irritation in 2%, and various skin abnormalities in 22%.

Many of the symptomatic workers thought that increasing temperature and humidity increased the eye, respiratory and skin symptoms.

VII. DISCUSSION

Almost all workers reported eye irritation and almost half nasal irritation since beginning employment at Coastal Industries. In the majority of cases these symptoms were reported as occurring only on exposure to the work environment. In addition, lesser numbers of workers reported throat and chest irritation occurring only at work. As might be anticipated in the case of irritation of the nose and upper

airways the number of workers with physical signs of irritation on examination was less than the number reporting symptoms; nevertheless, 10% of examined workers had signs of eye irritation and 26% nasal irritation at the time of our visit. The NIOSH investigators experienced symptoms and signs of eye and nose irritation (which varied from mild to marked in individual cases) on visiting the plant. Although this study does not document formaldehyde as the cause of the symptoms, it would be expected from previous studies, as discussed in the evaluation criteria section of this report, that eye and respiratory tract irritation would occur from exposure to the formaldehyde levels occurring in this plant.

The fabrics used at this facility employ a glyoxal-formaldehyde based resin system, 1,3-dimethylol-4-5, dihydroxy-2-imidazolidinone (DMDHEU). Although irritant symptoms in persons exposed to these systems have generally been attributed to the effects of formaldehyde it may also be possible that other reactive resin components or products contribute to the effects. The reported relationship with temperature and humidity probably relates to the ability of water vapor to release free formaldehyde from the fabric.[3]

A number of individuals in this plant were observed to have dermatoses. Although in some previous studies we have found that it is not uncommon for about 25% of a working population to have non-occupational skin disease, two conditions were observed which may have environmental causes. Five persons were noted to have miliaria (prickly heat) a condition caused by hot environments and sweating which may be exacebated by high humidity such as found both inside and outside the plant at the time of our visit. Four individuals with urticarial reactions (hives) were noted; this condition could result from exposure to chemicals at the facility in individual cases, although a large number of other causes are known. Our results do not allow us to draw any more specific conclusions from this observation.

VIII. CONCLUSIONS

1. Irritation of the eyes and, to a lesser extent the upper respiratory tract was occurring among workers at this facility. The personal breathing zone levels of formaldehyde measured were sufficient to cause this irritation. Thirty-three of the 41 short term samples showed formaldehyde levels equal to or greater than the NIOSH recommended standard. The formaldehyde was released from the DMDHEU resin system used to impart the durable press characteristics to the finished fabric.

2. Five examined individuals at this facility had a skin condition, miliaria, attributable to heat.

IX. RECOMMENDATIONS

1. The airborne levels of formaldehyde measured are sufficient to cause discomfort in employees and engineering efforts should be implemented to reduce the levels. The most efficient manner to control formaldehyde exposure is to implement both local exhaust and dilution ventilation techniques. Since it is hard to predict a value for the concentration of formaldehyde (which is necessary to estimate the volume of air needed to dilute the irritant gases to a safe level), dilution ventilation should only be used to reduce the overall levels.

2. In a past study involving the same DMDHEU resin system, NIOSH has shown a definite correlation between the age of the resin treated fabric and latent formaldehyde content.[6] Storage of the fabric in a ventilated area away from workers for a determined time period, prior to the workers performing their sewing operations is recommended to substantially reduce the potential for worker exposure to formaldehyde vapor. Consideration also should be given to airing the fabric during storage.[3]

3. Our air sampling data show that there is a significant build-up of formaldehyde overnight when the ventilation system is not operating. Furthermore, the symptoms of eye and nose irritation are most pronounced on entering the building at the beginning of the shift. Therefore, it is recommended that the ventilation system be operated at least 30 to 60 minutes prior to the beginning of the shift, or for whatever period is required to reduce the formaldehyde concentrations to background levels.

X. REFERENCES

1. Criteria for a Recommended Standard...Occupational Exposure to Formaldehyde 1976, HEW (NIOSH) Publication No. 77-126.

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5. Chemical Industrial Institute of Toxicology, Progress Report on CIIT Formaldehyde Studies (January 16, 1980), Leon Goldberg, President, Research Triangle Park, N.C.

6. Fredericks, L. and Kominsky, J.R. Health Hazard Evaluation Determination Report HHE 77-74-720, National Institute for Occupational Safety and Health, Cincinnati, Ohio 45226.

XI. AUTHORSHIP AND ACKNOWLEDGEMENT

Report Prepared By:

John R. Kominsky
Project Officer
Hazard Evaluations and Technical Assistance Branch
NIOSH
Cincinnati, Ohio 45226

Edward A. Emmett, M.D.
School of Hygiene and Public Health
The John Hopkins University
Baltimore, Maryland 21205

Michael T. Donohue
NIOSH
Cincinnati, Ohio 45226

Study Conducted By:

John R. Kominsky
Michael T. Donohue
NIOSH
Cincinnati, Ohio 45226

Edward A. Emmett, M.D.
Joanne Ferrara, R.N.
Donald Molenaar, M.D.
The Johns Hopkins University
Baltimore, Maryland 21205

Originating Office

Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations, and Field Studies
Cincinnati, Ohio 45226

Report Typed By:

Leesa Berling
Clerk-Typist

XII. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this report will be available from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226 for 90 days. Thereafter, copies will be available from the National Technical Information Service (NTIS), Springfield, Virginia. Information concerning its availability through NTIS can be obtained from NIOSH at the above Cincinnati address.

Copies of this report have been sent to:

1. Plant Manager, Coastal Industries, Inc.
2. President, Local 516C, International Ladies' Garment Workers Union.
3. U.S. Department of Labor - OSHA, Region IV.
4. NIOSH, Region IV.

For the purpose of informing the "affected employees" the employer shall post this report for at least 30 days in a prominent place(s) near where employees work.

TABLE I

Formaldehyde - Personal Breathing Zone Exposures

Coastal Industries, Inc.
Selma, Alabama
November 29 and 30, 1978

Sample Description	Sample Period	Sample Volume Liters	Air Level ppm
Machine Operator 1: Stay Front Pockets	0725-0755	30	1.1
" " " " "	0900-0930	"	0.98
" " " " "	1104-1134	"	1.1
" " " " "	1315-1345	"	1.0
" " " " "	1440-1510	"	1.1
" " " " "	0718-1526	88	0.54 (0.51)[A]
Machine Operator 2: Hem Bottoms	0727-0757	30	0.87
" " " "	0857-0927	"	0.90
" " " "	1057-1127	"	0.76
" " " "	1310-1340	"	1.0
" " " "	1434-1504	"	0.84
" " " "	0701-1522	87	0.68 (0.64)
Machine Operator 3: Belt Loops	0729-0759	30	1.1
" " " "	0855-0925	"	0.95
" " " "	1058-1128	"	1.4
" " " "	1312-1342	"	1.6
" " " "	1438-1508	"	1.4
" " " "	0704-1523	89	0.62 (0.58)
Environmental Criteria			1.0[B] 3.0[C]

A The concentration in parenthesis is the 8-hr. time-weighted average exposure.
B NIOSH Criteria Document (1976), ceiling value.
C U.S. Department of Labor (OSHA), 29 CFR Section 1910.1000 (1978), 8-hr. time weighted average exposure.

TABLE II

Formaldehyde - Personal Breathing Zone Exposures

Coastal Industries, Inc.
Selma, Alabama
November 29 and 30, 1978

Sample Description	Sample Period	Sample Volume Liters	Air Level ppm
Machine Operator 12: Join Crotches	0710-0740	30	1.5
" " " "	1012-1042	"	1.4
" " " "	1258-1328	"	1.7
" " " "	1435-1505	"	1.4
" " " "	0711-1516	85	0.82 (0.75)[A]
Machine Operator 13: Front Pockets	0714-0744	30	1.1
" " " "	1017-1047	"	1.3
" " " "	1308-1378	"	1.1
" " " "	1437-1507	"	1.5
" " " "	0715-1515	89	0.51 (0.47)
Material Handler	0721-1512	83	0.67 (0.59)
Machine Operator 6: Left Fly	0747-1524	76	1.0 (0.86)
Machine Operator 7: Hem Bottoms	0733-1521	79	0.82 (0.72)
Machine Operator 8: Bands	0750-1520	64	1.1 (0.91)
Machine Operator 9: Set Front Pockets	0745-1525	92	0.56 (0.85)
Machine Operator 10: Hem Front Pockets	0742-1526	89	0.79 (0.70)
Machine Operator 11: Set Hip Pockets	0738-1525	81	0.64 (0.56)
Environmental Criteria			1.0[B] 3.0[C]

A The concentration in parenthesis is the 8-hr. Time-Weighted Average exposure.
B NIOSH Criteria Document (1976), ceiling value.
C U.S. Department of Labor (OSHA), 29 CFR Section 1910.1000 (1978), 8-hr. Time-Weighted Average exposure.

TABLE III

Formaldehyde - Personal Breathing Zone Exposures

Coastal Industries, Inc.
Selma, Alabama
November 29 and 30, 1978

Sample Description	Sample Period	Sample Volume Liters	Air Level ppm
Machine Operator 4: Slides and Stops	0726-0756	30	0.30
" " " " "	0854-0924	"	1.2
" " " " "	1102-1132	"	1.0
" " " " "	1314-1344	"	1.2
" " " " "	1441-1511	"	1.2
" " " " "	0708-1525	84	0.94 (0.88)
Machine Operator 5: Set Hip Pockets	0724-0754	30	1.1
" " " " "	0858-0928	"	1.0
" " " " "	1055-1125	"	1.2
" " " " "	1306-1336	"	1.6
" " " " "	1431-1501	"	1.5
" " " " "	0715-1520	80	0.68 (0.62)
Machine Operator 14: Side Seamer	0718-0748	30	1.8
" " " "	1010-1040	"	1.6
" " " "	1309-1339	"	1.5
" " " "	1433-1503	"	1.8
" " " "	0716-1511	88	0.90 (0.80)
Machine Operator 15: Bander	0725-0755	30	1.2
" " "	1011-1041	"	1.4
" " "	1310-1340	"	1.6
" " "	1440-1510	"	0.76
" " "	0725-1511	84	0.88 (0.78)
Environmental Criteria			1.0[B] 3.0[C]

A The concentration in parenthesis is the 8-hour Time-Weighted Average exposure.
B NIOSH Criteria Document (1976), ceiling value.
C U.S. Department of Labor (OSHA), 29 CFR Section 1910.1000 (1978), 8-hr. Time Weighted Average exposure.

TABLE IV

Symptoms in 88 Production Workers
Since Starting Work at Coastal Industries
Coastal Industries, Inc.
Selma, Alabama

July 24 and 25, 1979

	Number Affected	Percentage of 88 Participants Affected
Eyes:		
Specific Symptom		
Burning	84	95
Tearing	43	49
Redness	44	50
Itching	39	44
At Least One Eye Symptom	85	97
Eye Symptoms Only At Work	66	75
Nose:		
Specific Symptom		
Itching	36	41
Runny Nose	32	36
Stuffiness	31	35
Sneezing	25	28
At Least One Nasal Symptom	63	72
Nasal Symptoms Only At Work	39	44
Throat		
Specific Symptom		
Scratching/Soreness	16	18
Itching	16	18
Burning	18	20
At Least One Throat Symptom	31	35
Throat Symptoms Only At Work	18	20
Chest:		
Specific Symptom		
Phlegm Production	12	14
Cough	23	26
Wheezing	7	8
Episodic Shortness of Breath	10	11
At Least One Respiratory Symptom	30	34
Respiratory Symptoms Only At Work	11	12
Skin:		
Rash	22	25

TABLE V

Abnormalities Observed On Limited Physical Examination
of 88 Production Workers

Coastal Industries, Inc.
Selma, Alabama

July 24 and 25, 1979

	Number Affected	Percentage of 88 Participants Affected
Eye		
Conjunctival Irritation	9	10
Nose		
Edematous Mucous and/or Discharge	23	26
Throat		
Inflammation	2	2
Chest		
Rhonchi	2	2
Skin		
Miliaria	5	6
Urticaria	4	5
Intertrigo	3	3
Hypopigmentation	2	2
Hyperpigmentation	3	3
Acne Vulgaris	2	2
Eczema	1	1
Other Miscellaneous Conditions	2	2
Total Dermatoses	22	24