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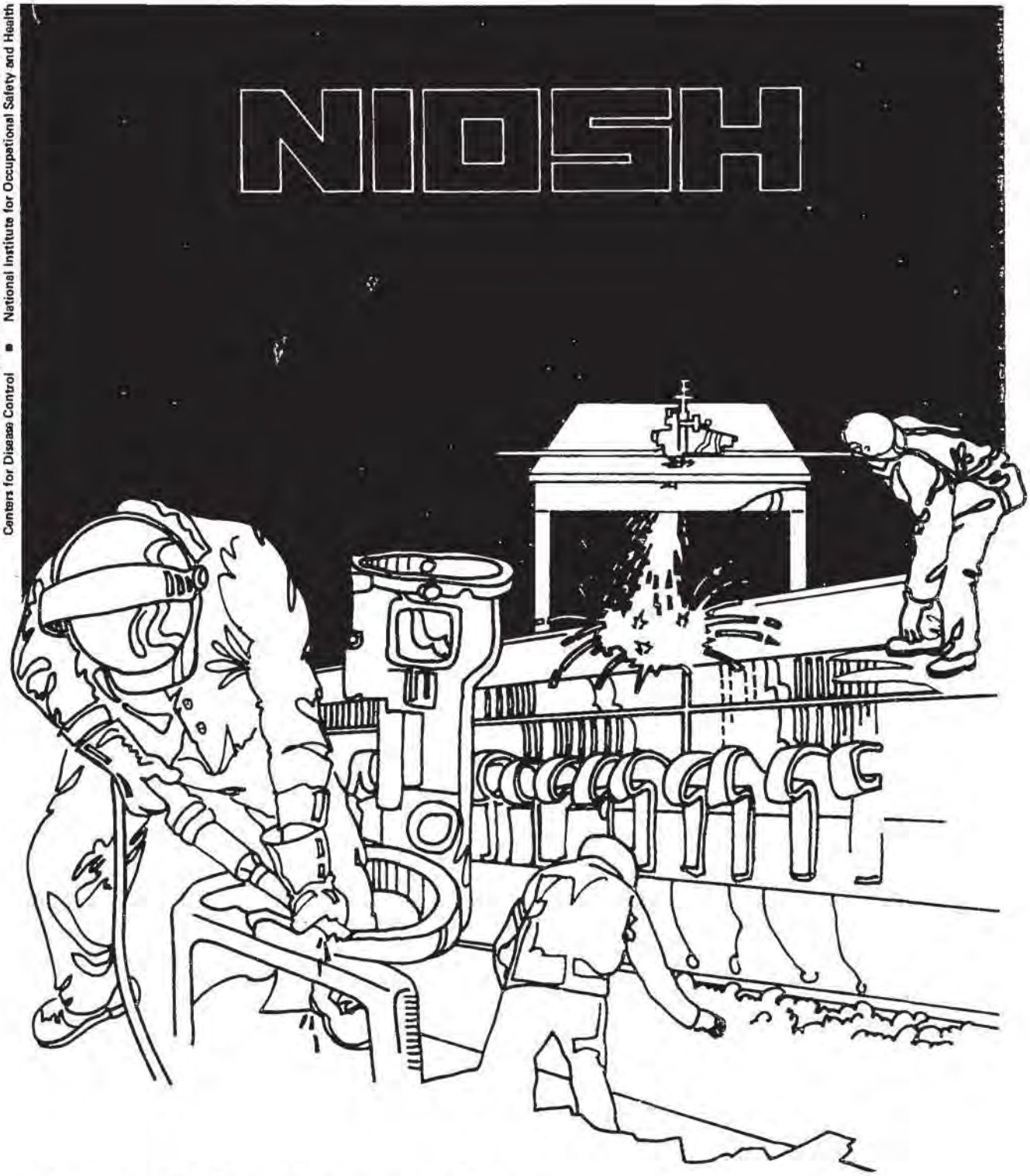

Health Hazard Evaluation Report

HETA 84-289-1798
KIRBY MANUFACTURING COMPANY, INC.
McCLURE, PENNSYLVANIA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HETA 84-289-1798
May 1987
KIRBY MANUFACTURING COMPANY, INC.
McCLURE, PENNSYLVANIA

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I. SUMMARY

On April 16, 1984, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from an employer representative at the Kirby Manufacturing Company, McClure, Pennsylvania. Workers there reported respiratory symptoms. The fabrics being used were treated with a formaldehyde-containing resin which imparts wrinkle-resistant properties to the material.

On August 15, 1984, NIOSH investigators conducted environmental and medical evaluations. Full-shift breathing-zone and general area air monitoring for formaldehyde exposure was conducted at the Kirby facility utilizing solid sorbent air sampling techniques. Personal exposure formaldehyde concentrations for 14 samples ranged from 0.5 to 1.5 ppm and averaged 1.0 ppm. The OSHA standard for an 8-hour exposure is 3 ppm. NIOSH considers formaldehyde a potential occupational carcinogen, and recommends that exposures be maintained at the lowest feasible level.

A self-administered symptom questionnaire was completed by 100 workers. Sneezing was significantly more prevalent during the 3-month period preceding the survey than during January - March 1984 (76% vs. 49%, $X^2 = 12.2$, $p < 0.001$). The other most frequently reported symptoms during both the recent and earlier time periods were nasal irritation (64% and 57%, respectively), headache (57% and 43%), eye irritation (55% and 51%), throat irritation (54% and 44%), and coughing (53% and 42%). Considering only the 65 workers who had the same job during both time periods, sneezing was again significantly more prevalent during the recent period (75% vs 49%, $X^2 = 8.27$, $p < 0.01$). The other most frequently reported symptoms among this group were again nasal irritation (68% and 54% for the recent and earlier time periods, respectively), eye irritation (61% and 52%), headache (60% and 41%, $X^2 = 3.94$ $p = 0.05$), cough (54% and 40%), and throat irritation (53% and 39%). The prevalence of all 13 symptoms was greater during the recent time period; the probability of this occurring by chance is 0.0001.

It was concluded that exposures to formaldehyde at the concentrations measured constituted a health hazard. The frequently reported symptoms are consistent with exposure to formaldehyde. Exposure to formaldehyde-containing lint may explain why sneezing and nasal irritation were more prevalent than eye symptoms. The greater prevalence of symptoms during the three-month period immediately preceding the NIOSH investigation suggests that exposures were greater at this time than during January - March 1984. Ventilation is recommended to lower exposure.

KEYWORDS: SIC 2260 (Dyeing and Finishing Textiles), formaldehyde.

II. INTRODUCTION

In April 1984 an employer representative of the Kirby Manufacturing Company, Incorporated, McClure, Pennsylvania requested that NIOSH investigate the possibility that formaldehyde exposure was the cause of respiratory symptoms among their workforce. The symptoms reported included coughing, sneezing, wheezing, and difficulty in breathing.

Environmental and medical evaluations were conducted on August 15, 1984. The results of the environmental evaluation and recommendations for lowering exposures to formaldehyde were reported to the company in a letter in February 1985. This final report combines the medical evaluation results with those of the environmental evaluation.

III. BACKGROUND

Kirby Manufacturing makes daywear, nightwear, loungewear, sportswear, and robes on contract with various clients. The company employed approximately 100 hourly workers at the time of the NIOSH survey. They were manufacturing robes. A majority of the workers were sewing machine operators (80 workers). Other jobs were fabric cutting, folding, pressing, and inspection.

From January to March 1984 Kirby was making a garment using Seatex, a water-repellent, wrinkle-resistant fabric. Irritation symptoms experienced while using this fabric prompted the hazard evaluation request. At the time of the evaluation three other fabrics were being used, and all had been treated with a similar glyoxal-based, formaldehyde-containing resin (dimethylol dihydroxyethylene urea, DMDHEU) which gave them wrinkle-resistant properties.

The main production building (N25000 sq. ft.) was heated with hot water in the winter and air-conditioned in the summer. There was no provision for ventilation other than by opening windows and doors.

IV. EVALUATION DESIGN AND METHODS

A. Environmental Evaluation

The environmental evaluation included personal breathing-zone, and general area air monitoring. Thirteen personal samples were collected. Eleven long-term (4- to 15-hour duration) general area air samples were collected. Five of these were collected in a fashion to determine an increase or decline in formaldehyde concentration overnight.

The breathing-zone and long-term area air samples were collected using NIOSH Method 2502.[1] This is a solid sorbent sampling method. The sorbent is Chromosorb 102 (180 mg) coated with 2-(benzylamino)ethanol. Air was drawn through the sorbent tube, using a battery-powered sampling pump, at a nominal flow rate of 0.02 liters per minute (lpm). The formaldehyde reacts with the 2-(benzylamino)ethanol, at a known rate, to produce 3-benzyloxolidine. This is then desorbed from the sorbent tube with isooctane, and measured using a gas chromatograph equipped with a flame ionization detector. The analytical limit of detection for this method is 2.0 micrograms per sample (ug/sample).

B. Medical Evaluation

All available employees were invited to participate in the medical survey, which consisted of a symptom questionnaire self-administered in small groups. The questionnaire asked about (a) symptoms during the preceding three months while working on the current job, and (b) the same symptoms during January - March 1984 while working with Seatex.

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLVs usually are based on more recent information than are the OSHA standards. The OSHA permissible exposure limits (PELs) also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH Recommended Exposure Limits (RELs), by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

A. Formaldehyde - Toxicological Effects

Formaldehyde is a severe irritant to the eyes and upper respiratory tract. The threshold for mild eye irritation may be as low as 0.01 parts per million (ppm) in some individuals; 4 ppm and above usually produces lacrimation, although continued exposure may result in some acclimatization to the irritant effect on the eyes. Mild effects on the throat have been noted at 0.5 ppm, and marked irritant effects on the nose and throat at 10 ppm. Formaldehyde vapor and dilute aqueous solutions can irritate the skin. Formaldehyde can produce skin sensitization, and cases of allergic contact dermatitis have been reported both in persons occupationally and non-occupationally exposed to formaldehyde. In addition, there are reports of asthma-like symptoms occurring in persons occupationally exposed to formaldehyde.[2]

Formaldehyde vapor was found to cause a rare form of nasal cancer in Fischer 344 rats exposed to a 15 ppm concentration for 6 hours per day, 5 days per week, for 24 months. Whether these results can be extrapolated to human exposure is the subject of considerable speculation in the scientific literature. Conclusions cannot be drawn with sufficient confidence from published mortality studies of occupationally exposed adults as to whether or not formaldehyde is a carcinogen. Studies of long term human occupational exposure to formaldehyde have not detected an increase in nasal cancer.[3]

The findings from recent epidemiologic investigations in the garment industry, conducted by NIOSH researchers, provide limited evidence of a relationship between formaldehyde exposure and the development of upper respiratory cancers and lymphopoietic neoplasms in man.[4,5] Mean formaldehyde exposures from the three manufacturing facilities included in these studies ranged from 0.09 to 0.22 ppm. Personal exposures ranged as high as 0.51 ppm.[6]

In four health hazard evaluations in the garment industry, conducted by NIOSH investigators, personal exposure averages ranged from 0.25 to 0.70 ppm. One other evaluation conducted at a bed-sheet making facility measured formaldehyde exposures averaging 1.1 ppm.[7,8,9,10,11]

Formaldehyde in wrinkle- and shrinkage-resistant fabrics was first reported to cause health problems in 1959. Bourne reported symptoms of burning, stinging eye, headaches, and nose and throat irritation in dress shop employees in Ohio.[12] Air sampling measured 0.13-0.45 ppm formaldehyde in the air. Samples of fabric contained 500-800 ppm formaldehyde in rayon and 340 ppm formaldehyde in cotton. In a 1966 study of a clothing store in California, complaints of eye irritation were reported. Air formaldehyde concentrations ranged from 0.9-3.3 ppm.[13]

Studies of textile factories have reported similar findings. In 1966 a study was conducted at a textile factory in California where "perma-press" clothing was manufactured.[14] Workers complained of irritation to the eyes, nose and throat. Air formaldehyde concentrations ranged from 0.9-2.7 ppm. In a 1968 study of eight textile plants where fabric was treated with formaldehyde-containing resins, from 5-15% of the employees at each plant reported symptoms of mucous membrane and respiratory irritation. Air formaldehyde concentrations ranged from 0-2.7 ppm with a mean of 0.68 ppm.[15]

C. Formaldehyde Exposure Criteria

The OSHA formaldehyde standard is based on a threshold for irritant and upper respiratory complaints. The current OSHA standard requires that formaldehyde exposures be limited to an 8-hour time-weighted average (TWA) of 3 ppm, a ceiling level of 5 ppm, and an acceptable maximum peak above the ceiling level of 10 ppm for no more than a total of 30 minutes during an 8-hour work shift.[16] NIOSH recommends that formaldehyde be handled in the workplace as a potential occupational carcinogen. Safe levels of exposure to carcinogens have not been demonstrated, but the probability of developing cancer should be reduced by decreasing exposure. An estimate of the extent of the cancer risk to workers exposed to

various levels of formaldehyde, at or below the current 3 ppm standard, has not yet been determined. In the interim NIOSH recommends that occupational exposure to formaldehyde be reduced to the lowest feasible level.[3]

VI. RESULTS AND DISCUSSION

A. Environmental

General area sampling results are presented in Table 1. Overnight sampling in the assembly and pattern shops indicates that formaldehyde concentrations decrease from the end of one shift to the beginning of the next shift. The full-shift area samples from throughout the plant showed formaldehyde concentrations ranging from 0.8 ppm in the assembly and pressing areas to 1.4 ppm in the automatics area.

The personal exposure results are presented in Table 2. Personal formaldehyde exposure concentrations ranged from 0.5 to 1.5 ppm, and averaged 1.0 ppm for 14 samples. By job category, exposure concentrations averaged 1.1 ppm for the small parts area sewing machine operators, and 1.2 ppm for the fabric spreaders in the pattern shop. One sewing machine operator in the automatics a5ea was exposed to 0.9 ppm of formaldehyde.

When compared to formaldehyde exposures measured by NIOSH investigators at other garment manufacturing plants, those at the Kirby plant are higher. In seven other studies the typical full-shift personal exposures averaged below 0.7 ppm. One plant manufacturing bed sheets had measured exposures averaging 1.1 ppm for 25 samples.

The exposure to formaldehyde at the Kirby plant results from using fabrics treated with the DMDHEU resins. In general, the levels of exposure to formaldehyde are related to the freshness of the fabric and the surface area of the fabric exposed to the air during the manufacturing process. At Kirby, the workers exposed to the freshest fabric were those in the pattern shop. This group of workers had the highest average formaldehyde exposures (1.2 ppm).

Another factor which will have a significant effect upon the exposure concentration is the effectiveness of plant ventilation systems. The Kirby plant had heating and cooling, but no designed ventilation. That is, no provisions were made for exhausting contaminated air and providing fresh replacement air.

Elimination of fabrics treated with formaldehyde-containing resins is the obvious remedy for this occupational exposure. Fabric specifications are generally determined by clients and are not controllable at the finishing-plant level. However, until such time as textile manufacturers find a replacement for these types of treatments, the burden of controlling exposure to formaldehyde to prevent worker ill-health will be born by the companies who use these fabrics.

B. Medical

One hundred employees participated in the questionnaire survey. Ninety-four were women; six were men. All 94 participants who specified their race were white. The participants ranged in age from 18 to 61 years, with a median of 38. Their time employed at Kirby ranged from 1 month to 30 years, with a median of 2-3/4 years. Sixty-six participants were sewing machine operators; none of 21 other jobs was reported by more than 6 participants. Thirty-one (31%) of the 99 participants who answered the question currently smoked cigarettes. Nineteen (22%) of 88 participants who answered the question reported "hayfever, grass allergies, or any other seasonal allergy".

Sneezing, nasal irritation, headache, eye irritation, throat irritation, and coughing were the most frequently reported symptoms for both the three-month period immediately preceeding the survey and January - March 1984 (Table 1). Sneezing was significantly more prevalent in the recent period than during the earlier period (76% vs. 49%, $X^2 = 12.2$, $p < 0.001$). Nine other symptoms were also more prevalent in the recent period, but the differences were not statistically significant ($p > 0.05$, X^2 or Fisher's exact test, two-tailed). Only one symptom, skin problems, appeared more prevalent in the earlier period, but the difference was minimal (23% vs. 21%) and not statistically significant. Assuming that all symptoms were independent and equally likely to be present during either time period, the probability of at least 10 of the 13 symptoms being more prevalent during the recent period by chance alone is 0.046.

Sixty-five participants, 61 women and 4 men, worked at the plant during the January - March period and had the same job during both time periods. They ranged in age from 20 to 61 years, with a median of 41. Their time employed at Kirby ranged from 6 months to 30 years, with a median of 4 years. Forty-seven (72%) were sewing machine operators. Twenty (31%) currently smoked cigarettes.

Twelve (21%) of the 57 who answered the question reported "hayfever, grass allergies, or any other seasonal allergy." Thus, except for their expected slightly greater median age and duration of employment at Kirby, the 65 workers did not differ substantially from the entire survey group with respect to smoking, allergies, or proportion of sewing machine operators.

Sneezing, nasal irritation, eye irritation, headache, coughing, and throat irritation remained the most frequently reported symptoms for both time periods (Table 4). All 13 symptoms were more prevalent during the recent time period; the probability of this occurring by chance, assuming that all symptoms are independent and equally likely to be present during either time period, is 0.0001. The differences in prevalence for sneezing and headache were statistically significant at the 0.01 and 0.05 levels, respectively.

Since there were relatively few workers in any job category other than the sewing machine operator, and since the environmental data did not suggest substantial differences in airborne formaldehyde exposure among the various jobs or locations in the plant, we did not attempt to analyze symptoms according to job category.

VII. CONCLUSIONS

The formaldehyde exposures measured and the symptoms reported led the investigators to conclude that a health hazard existed at this plant.

The frequently reported symptoms, especially eye and nasal irritation, are consistent with exposure to formaldehyde. Exposure at this plant included formaldehyde vapor and formaldehyde-containing particulates (lint). The presence of the latter may explain why sneezing and nasal irritation were more prevalent than eye symptoms.

The greater prevalence of symptoms during the period immediately preceeding the NIOSH investigation suggests that exposures were greater at that time than during January - March 1984. This is not certain, however, since there may be a tendency for people to better remember more recent symptoms than those further in the past. Also, the prevalences calculated in this study are three-month cumulative prevalences and, unless all symptoms occur on a daily basis, are greater than the prevalences on any given day.

Personal exposures to formaldehyde are some of the higher exposures measured by NIOSH in the textile/garment industry. These formaldehyde concentrations can feasibly be better controlled through the use of ventilation. The workers in this industry would benefit from the replacement of the DMDHEU resin with one not containing formaldehyde.

VIII. RECOMMENDATIONS

1. A contractor specializing in industrial ventilation systems should be consulted to provide specifications for a dilution ventilation system optimized for the Kirby facility. The specifications should clearly state that indoor air containing formaldehyde vapor should not be recirculated.

2. Airing of fabrics treated with formaldehyde-containing resins prior to use is recommended. A method which may be tried involves aerating the fabric in a ventilated chamber, while at the same time adding heat to drive the formaldehyde out of the cloth. This would mean unrolling the bolt of cloth at one end of the process, and rolling it back at the other end in order to use your current pattern cutting technology. Proper temperature, humidity, and airing time would need to be determined empirically.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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1. Kirby Manufacturing Company, Inc.
2. NIOSH, Cincinnati Region
3. OSHA, Region V

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE 1

Overnight and Full-Shift Area Formaldehyde Results

Kirby Manufacturing Company
McClure, Pennsylvania
HETA 84-289

August 14-15, 1984

Location	Sample Information Field No.	Volume (l)	Duration	Formaldehyde Concentration (ppm)
Assembly, Center Rows - overnight	K-1	4.8	1500-1900	1.7
	K-2	4.8	1500-2223	1.4
	K-3	5.8	1500-2300	1.3
Pattern Shop, Table 3 - overnight	K-5	10.3	1454-2254	1.2
	K-4	6.7	1454-0632	0.7
Assembly, Row 8	K-11	7.0	0713-1536	0.8
Pressing	K-16	8.5	0738-1531	0.8
Trim and Inspection	K-17	6.2	0740-1537	1.0
Automatics	K-19	5.2	0753-1542	1.4
Packaging	K-20	6.9	0733-1543	0.9
Reception/Office	K-25	6.2	0735-1536	1.2

TABLE 2

Full-Shift Personal Formaldehyde Results

Kirby Manufacturing Company
McClure, Pennsylvania
HETA 84-289

August 15, 1984

Job	Sample Information				Formaldehyde Concentration (ppm)	
	Location	Field No.	Volume (l)	Duration		
Sewing machine operator	Assembly, Row 2	K-6	6.7	0703-1538	1.2	
	Assembly, Row 3	K-7	6.6	0706-1533	0.9	Average=1.1,
	Assembly, Row 4	K-8	5.6	0705-1533	1.2	SD+0.2
	Assembly, Row 6	K-9	5.8	0710-1534	1.3	n=5
	Assembly, Row 7	K-10	10.6	0710-1535	0.7	
	Small parts, Row 3	K-12	5.0	0716-1537	1.5	
	Small parts, Row 6	K-13	6.5	0717-1537	0.9	Average=1.0,
	Small parts, Row 9	K-14	7.5	0719-1538	0.5	SD+0.4
	Small parts, Row 12	K-15	7.0	0720-1539	0.9	n=4
	Automatics, Row 1	K-18	6.2	0746-1541	0.9	
Fabric Spreader	Pattern shop	K-21	4.9	0801-1525	1.2	
	Pattern Shop	K-22	7.8	0806-1525	1.0	Average=1.2,
	Pattern shop	K-23	6.2	0807-1527	1.2	SD+0.1
	Pattern shop	K-24	5.6	0813-1526	1.2	n=4
				(n=14) Average	1.0	
				SD	+0.3	
—				Criteria: NIOSH	LFL*	
				OSHA	3	

*LFL - lowest feasible limit

TABLE 3

Number and (%) of questionnaire survey participants reporting symptoms

Kirby Manufacturing Co.
McClure, Pennsylvania
HETA 84-289

August 15, 1984

Symptom	Time Period: Three Months Preceding Survey[A]		Time Period: January-March 1984[B]	
Sneezing	76	(76)[C]	37	(49)[C]
Nose irritation	64	(64)	43	(57)
Headaches	55	(57)	32	(43)
Eye irritation	54	(55)	39	(51)
Throat irritation	53	(54)	32	(44)
Coughing	52	(53)	30	(42)
Runny nose	34	(34)	22	(30)
Sore throat	32	(33)	24	(33)
Tearing	31	(31)	17	(23)
Dermatitis or [other] skin problems	20	(21)	16	(23)
Difficulty breathing	12	(13)	8	(11)
Wheezing	10	(10)	5	(7)
Nose bleeds	4	(4)	3	(4)

A - Denominators vary from 95 to 100 because not all participants answered all questions.
B - Denominators vary from 70 to 76 because (a) not all participants answered all questions, and (b) several did not work at the plant during January - March 1984.
C - $X^2 = 12.2$, $p < 0.001$

TABLE 4

Questionnaire survey participants who had the same job during both time periods, number and (%) reporting symptoms

Kirby Manufacturing Co.
McClure, Pennsylvania
HETA 84-289

August 15, 1984

Symptom	Time Period: Three Months Preceding Survey[A]		Time Period: January-March 1984[B]	
Sneezing	49	(75)[C]	31	(49)[C]
Nose irritation	44	(68)	34	(54)
Eye irritation	39	(61)	33	(52)
Headaches	38	(60)[D]	26	(41)[D]
Coughing	34	(54)	24	(40)
Throat irritation	34	(53)	24	(39)
Runny nose	24	(38)	17	(28)
Tearing	23	(35)	14	(23)
Sore throat	21	(33)	19	(31)
Dermatitis or [other] skin problems	16	(26)	15	(25)
Difficulty breathing	9	(15)	7	(11)
Wheezing	9	(14)	4	(7)
Nose bleeds	4	(6)	3	(5)

A - Denominators vary from 61 to 65 because not all participants answered all questions.
B - Denominators vary from 60 to 65 because not all participants answered all questions.
C - $X^2 = 8.27$, $p < 0.01$
D - $X^2 = 3.84$, $p = 0.05$