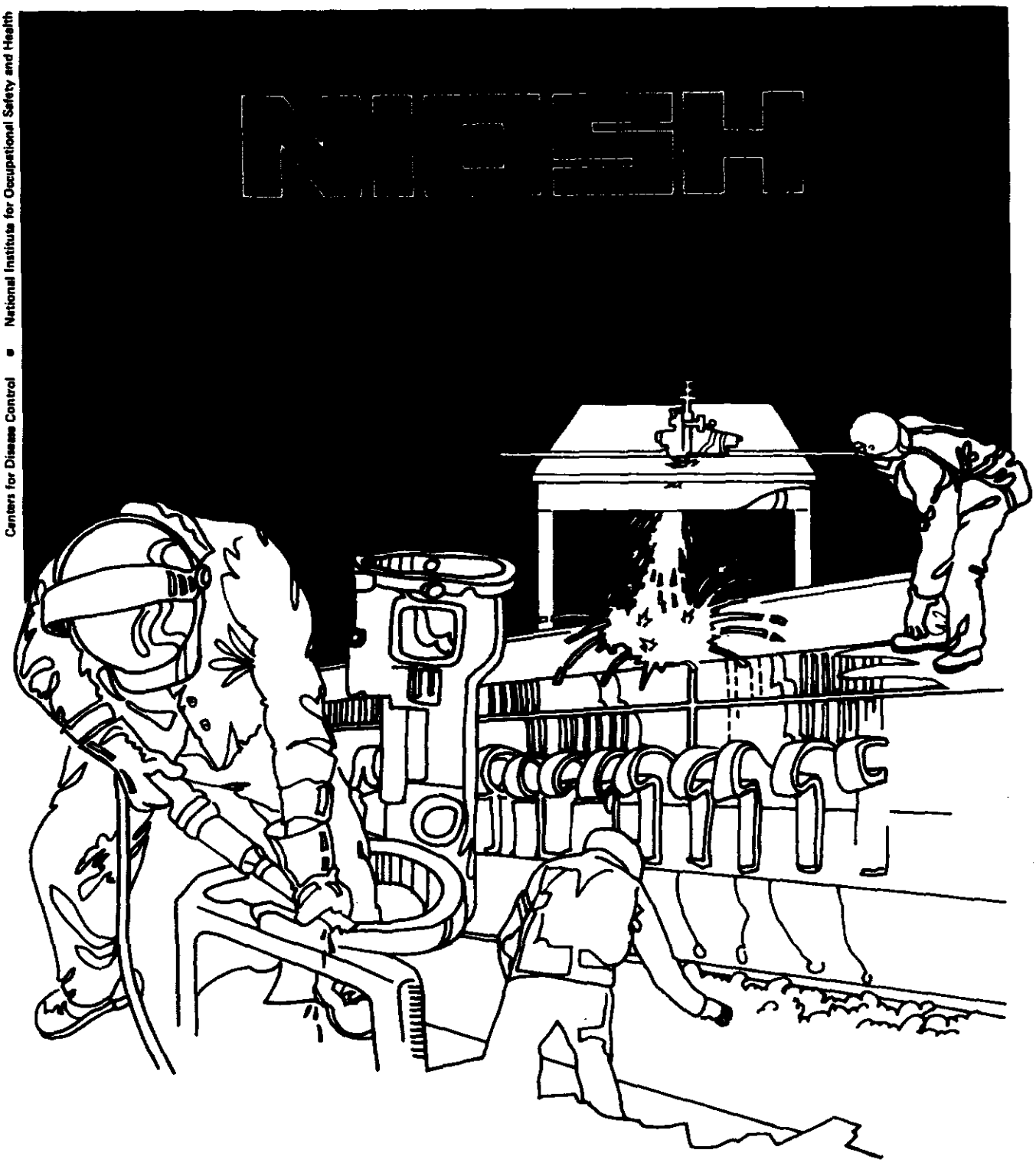
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 89-212-2020
SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

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.

HETA 89-212-2020
MARCH 1990
SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

NIOSH INVESTIGATORS
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I. SUMMARY

On April 17, 1989, Schlegel Tennessee, Inc., a producer of rubber weather stripping for automobiles, requested that the National Institute for Occupational Safety and Health (NIOSH) conduct a health hazard evaluation (HHE) at its facility in Maryville, Tennessee. The request dealt with management concerns about (1) medical problems (dizziness, nausea, tingling lips, headaches, and depression) experienced by packers, and (2) an employee's positive urine iodine-azide test (indicating possible over-exposure to carbon disulfide [CS_2]). Union representatives also expressed concern about a possible high incidence of cancer among current and former employees and asked NIOSH to sample for nitrosamines (potential occupational carcinogens). Site visits were conducted on June 5, 1989 and July 16-17, 1989.

A review of medical records and discussions with employees revealed that between March 15, 1989 and May 23, 1989 workers experienced health problems, including irritation of the eyes and respiratory tract, dizziness, nausea, nervousness, and unusual mood swings. These problems were attributed to odors in the workplace. Three employees had abnormal neurologic examinations and two others had abnormal urine iodine-azide tests.

Our testing of employees did not detect 2-thiothiazolidine-4-carboxylic acid (TTCA) in any pre-shift or post-shift urine specimens, indicating that workers were not exposed to more than 0.5 parts per million (ppm) airborne CS_2 at the time of the survey. Similarly, environmental monitoring for airborne CS_2 did not find personal breathing zone or area air samples to have concentrations of CS_2 above the NIOSH recommended exposure limit at the time of the survey.

A standardized morbidity ratio (SMR) analysis of reported cancers among employees did not show an overall excess of disease, compared to the general population of the United States. (SMR = 0.8) Monitoring for nitrosamines did not reveal detectable levels.

Based on biological and environmental monitoring data, NIOSH investigators could not definitively determine the etiology of medical problems experienced by employees. Recommendations for reducing potential hazardous exposures are presented in Section VIII.

KEYWORDS: SIC 2822 (Synthetic Rubber), carbon disulfide, nitrosamine, volatile organic compounds, biological monitoring, 2-thiothiazolidine-4-carboxylic acid, TTCA

II. INTRODUCTION

On April 17, 1989, Schlegel Tennessee, Inc. requested that the National Institute for Occupational Safety and Health (NIOSH) conduct a health hazard evaluation (HHE) at its facility in Maryville, Tennessee. The request dealt with management concerns about (1) medical problems (dizziness, nausea, tingling lips, headaches, and depression) experienced by packers, and (2) an employee's positive urine iodine-azide test (indicating possible over-exposure to carbon disulfide [CS_2]). Union representatives also expressed concern about a possible high incidence of cancer among current and former employees and asked NIOSH to sample for airborne nitrosamines (potential occupational carcinogens). In response to these requests, NIOSH conducted site visits on June 5, 1989 and July 16-17, 1989. An interim report was issued on June 26, 1989.

III. BACKGROUND

At the Schlegel Tennessee, Inc. facility in Maryville, workers produce rubber weather stripping for automobiles. Approximately 70 salaried and 200 production employees work in a 115,000 square-foot, one-story building that was built in 1974. The facility operates 24 hours/day, 5 days/week.

The main areas of the plant are the Mill Area, where components of the rubber are mixed, and the Extrusion Department, where weather stripping is made. Approximately 40-45 employees work in the Mill Area, 107 in the Extrusion Department, and 26 in the Maintenance Department. The Finishing Department, where weather stripping is modified to specification, was moved in the Fall of 1988 from the Maryville facility to three satellite plants.

The process begins in the Mill Area, where raw chemicals are fed into a Banbury mixer by a Banbury operator. The resultant rubber batches are then discharged to a large rolling mill, where a mill operator rolls them to a desired thickness. After rolling, the product is coated with clay, cut, air cooled, placed on pallets, and stored for 24 hours in the "chill room."

In the Extrusion Department, four automated extrusion lines fabricate weather stripping. (The operation of these lines is controlled by line operators and assistant line operators.) At the ends of the lines, finished weather stripping is placed in "buggies" (storage bins) by finishers. Finished weather stripping consists of rubber strips with hollow cores called "bubbles." Located near the buggies are waste receptacles, where weather stripping scrap is placed. Most scrap is generated at the beginning of shifts during the "stringing" operation, when the line operator "strings" or threads rubber through the working parts of the extrusion line. Quality assurance personnel and inspectors monitor the operations of the Extrusion Department. Local exhaust ventilation systems, including a bubble evacuator which removes air from within bubbles, are located along the extrusion lines and in the buggies.

Most production uses sponge and dense rubbers, which are ethylene propylenediene monomer-based. For sponge rubber, about 90% of the composition is ethylene propylenediene tetrapolymer, carbon black, hydrated magnesium silicate, paraffinic oil, and hydrated aluminum silicate. For dense rubber, about 90% of the composition is ethylene propylenediene tetrapolymer, carbon black, calcium carbonate, and paraffinic oil. A small percentage of production uses neoprene rubber, which consists of polychloroprene rubber, carbon black, calcium carbonate, and aromatic oil. (Because they are proprietary, the minor ingredients for sponge, dense, and neoprene rubber are not cited.)

In 1979-1981, NIOSH investigators conducted a health hazard evaluation (HHE) at Schlegel Tennessee, Inc. to investigate eye irritation among employees and found that certain employees were over-exposed to carbon disulfide (CS_2), a byproduct of the production process. The mean air concentration of CS_2 was 1.8 milligrams per cubic meter (mg/m^3), with a range of 0.2-3.8 mg/m^3.

The NIOSH recommended exposure limit (REL) for CS_2 is 3 mg/m^3 (1 part per million [ppm]) as a 10-hour, time-weighted average (TWA), and 30 mg/m^3 (10 ppm) as a 15-minute ceiling limit.[1] Results of 522 air sample analyses for 38 additional compounds (including nitrosamines) did not detect any other airborne concentrations above evaluation criteria. After the HHE, engineering changes were made to reduce exposure to CS_2.

In April 1989, environmental sampling was done at the request of Schlegel Tennessee, Inc. by an environmental consultant. This sampling indicated that full-shift, personal breathing zone CS_2 exposures for employees working at the ends of extrusion lines 2, 8, 9, and 10 were less than 1 ppm. CS_2 levels of up to 9.5 ppm inside finished weather stripping bubbles were also detected. (These levels dissipated to less than 3 ppm after 24 hours.)

The consultant repeated environmental sampling in May 1989. These results indicated that CS_2 concentrations inside weather stripping bubbles were as high as 2500 ppm, and in the air around filled scrap receptacles as high as 28 ppm. On the basis of these findings, the consultant recommended (1) extending and modifying the bubble evacuator, (2) installing a local exhaust ventilation system for the scrap receptacles, and (3) educating employees about work practices that could decrease their exposure to CS_2.

IV. METHODS AND MATERIALS

A. Medical

On April 17, 1989, the medical records of 13 employees were reviewed. These employees had experienced medical problems while working and were referred by Schlegel Tennessee, Inc. to medical

consultants. In addition, confidential medical interviews were conducted with 22 employees identified by company and union representatives as having experienced possible work-related medical problems.

On July 16-17, 1989, biological monitoring for exposure to carbon disulfide (CS_2) was conducted. Pre-shift and post-shift urine specimens were obtained from 22 employees and analyzed for 2-thiothiazolidine-4-carboxylic acid (TTCA). (Appendix A) TTCA is a metabolite of CS_2. It can be detected in the urine of workers exposed to as little as 0.5 ppm CS_2 (on a time-weighted basis), compared to the 17 ppm required for a positive iodine-azide test.[2]

B. Epidemiologic

To assist in the evaluation of the incidence of cancer, a union representative provided NIOSH with a list of cases of cancer that occurred among current and former employees since the plant opened in 1974. The list was compiled by the representative (who had worked at Schlegel Tennessee, Inc. since 1974) from memory. To determine if these cases represented an excess cancer mortality, an overall standardized morbidity ratio (SMR) and site-specific SMR's (for breast, bladder, colon, lung, stomach, and throat cancers) were calculated. The SMR's were based on person-years-at-risk (PYAR) for developing cancer, applied to age-specific and race-specific cancer rates for 1978-1981 (published by the National Cancer Institute's Surveillance, Epidemiology, and End Results [SEER] Program).[3] For purposes of determining PYAR, it was assumed that an average of 300 employees had worked at Schlegel Tennessee, Inc. each year since 1974, and that the annual employee turnover rate was approximately 10%. SMR's could not be calculated for cancers of the "female organs," liver, "male organs," or skin, as these cancers were not listed as such by the SEER Program. No attempt was made to verify the cases of cancer or to find additional cases among employees.

C. Environmental

On July 16, 1989, personal breathing zone (PBZ) and area air samples were collected to assess employee exposure to CS_2, nitrosamines, and various volatile organic compounds.

1. Carbon Disulfide

Twenty-one 8-hour PBZ air samples were collected, as detailed in Table 1. One short-term PBZ air sample was also collected on a line operator who was stringing a line. Ten area air samples were collected at the following locations: inside

weather stripping bubbles, inside and near the buggies, three feet above a waste receptacle, between finishing lines, and in the chill room. The air samples were collected using battery-powered sampling pumps operating at a flow rate of 0.2 liters per minute. The pumps were attached via Tygon^R tubing to charcoal tube collection media and drying tubes. The drying tubes contained a dessicant, granular anhydrous sodium sulfate, with a color indicator. The drying tubes were changed when the color indicator noted that the capacity of the desiccant had been reached. The charcoal tubes were kept refrigerated during shipping, and were analyzed for CS_2 by gas chromatography using NIOSH Method 1600.[4] The limits of detection and quantitation were 2 micrograms/sample and 6 micrograms/sample, respectively.

2. Nitrosamines

Four 8-hour PBZ air samples were collected on three finishers and one line operator. One area air sample was collected in the lunch room, which served as a control area (as no source of nitrosamines would be expected in this area). The air samples were collected using battery-powered sampling pumps operating at a flow rate of 2 liters per minute.

The pumps were attached via Tygon^R tubing to a solid sorbent tube (Thermosorb/N^R). The tubes were analyzed for nitrosamines by gas chromatography using NIOSH Method 2522.[5] The seven nitrosamines analyzed for and their respective limits of detection and quantitation (in micrograms per sample) were as follows: N-nitrosodimethylamine (1.0 and 3.0), N-nitrosodiethylamine (1.0 and 3.5), N-nitrosodipropylamine (2.2 and 7.0), N-nitrosodibutylamine (2.6 and 8.5), N-nitrosopyrrolidine (1.8 and 5.9), N-nitrosopiperidine (0.5 and 1.6), and N-nitrosomorpholine (5.7 and 20.0).

3. Volatile Organic Compounds

Four short-term (5-10 minute) area air samples were collected from inside weather stripping bubbles. The air samples were collected using battery-powered sampling pumps operating at a flow rate of 0.1 liters per minute. The pumps were attached via Tygon^R tubing to a thermal desorption tube (Supeloco Carbotrap 300^R). The tubes were analyzed for volatile organic compounds by gas chromatography.

In addition, smoke tubes were used to qualitatively evaluate the capture efficiency of the local exhaust ventilation systems and to assess air movement between work areas.

V. EVALUATION CRITERIA

A. General

To evaluate the hazards posed by chemicals in the workplace, NIOSH investigators use evaluation criteria. These criteria are intended to suggest levels of airborne exposure to which most employees can be exposed for up to 10 hours per day, 40 hours per week (over a working lifetime), without experiencing adverse health effects. It is important to note, however, that not all employees will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience problems because of individual susceptibility or pre-existing medical conditions. In addition, (1) some hazardous chemicals may act in combination with other workplace exposures to produce adverse health effects (even at levels below those set by the criteria), and (2) exposure to some chemicals can be increased via dermal and mucous membrane absorption. Finally, environmental criteria may change over the years as new toxicologic information becomes available.

The primary sources of environmental criteria for the workplace are: (1) NIOSH's recommended exposure limits (REL's), (2) the American Conference of Governmental Industrial Hygienists' (ACGIH) threshhold limit values (TLV's), and (3) the Occupational Safety and Health Administration's (OSHA) permissible exposure limits (PEL's).

Environmental criteria are usually based on time-weighted averages (TWA's), which refer to average airborne concentrations of chemicals during normal 8-10 hour workdays. Sometimes, there are additional short-term exposure limits (STEL's) or ceiling limits which are intended to supplement TWA's when there are recognized toxic effects from high short-term exposures.

B. Carbon Disulfide

CS_2 has been associated with a variety of medical problems in the occupational setting, including ocular and auditory disorders, coronary heart disease, peripheral neuropathy, encephalopathy, neurobehavioral abnormalities, and adverse reproductive outcomes.[6]

NIOSH's 10-hour TWA REL is 3 mg/m^3 (1 ppm), with a 15-minute ceiling limit of 30 mg/m^3 (10 ppm).[1] OSHA's 8-hour TWA PEL is 12 mg/m^3 (4 ppm), with a 15-minute short term exposure limit of 36 mg/m^3 (12 ppm).[7] The ACGIH 8-hour TWA TLV is 30 mg/m^3 (10 ppm), with a skin notation indicating the possibility of absorbing CS_2 through the skin and mucous membranes, either via airborne exposure or direct contact.[8]

C. Nitrosamines

N-nitrosodimethylamine (NDMA), one of the nitrosamines, has produced tumors of the liver, kidney, lung, and nasal cavity in animals.[9] NIOSH, the ACGIH, and OSHA recommend that NDMA be regarded as a potential occupational carcinogen and that exposure to it be controlled to the lowest feasible level.[7-9]

VI. RESULTS

A. Medical

The review of 13 employees' medical records revealed the following information:

The employees were seen by company physicians between 3/15/89 and 5/23/89. Ten employees experienced irritation of the eyes and/or respiratory tract, 8 experienced headaches, 7 experienced dizziness, 6 experienced nausea, 5 experienced nervousness, and 5 experienced unusual mood swings. Two people (who had not been drinking alcoholic beverages) experienced intoxication-like episodes while working. A variety of other medical problems were mentioned, but none were experienced by more than 1 or 2 employees.

Three employees had abnormal neurologic examinations. Five had normal examinations, and for 5 others, exam results were not noted.

With the exception of "polypoid laryngitis" in 1 employee, no other abnormalities were found on physical examination. For 5 employees, exam results were not noted.

Two employees had abnormal urine iodine-azide tests. The tests were conducted on 3/16/89, 3/29/89 and 4/5/89. (One employee had two positive tests.) These employees were not the ones with abnormal neurologic examinations. An abnormal urine iodine-azide test means that a worker may have been exposed to at least 17 ppm carbon disulfide (CS_2) on a time-weighted basis.

The medical interviews confirmed the information cited above and revealed that:

The medical problems occurred intermittently and without warning. They were frequently attributed to odors in the workplace.

The problems began a few months before the interviews, but no employee had any theory as to why they started at that time.

Most employees felt better on weekends, though some stated that they did not feel better until they had been away from work for 1-2 weeks.

Employees who worked on the extrusion lines experienced the variety of problems discussed above. The 4 Mill Area employees interviewed complained primarily of eye and/or respiratory tract irritation.

None of the pre-shift or post-shift urine specimens had detectable levels of TTCA, indicating that employees who participated in the investigation were not exposed to more than 0.5 ppm CS_2 during the day that they were monitored. (This conclusion, based on biological monitoring, is in agreement with environmental sampling results.)

B. Epidemiologic

The SMR analyses produced the following results:

Cancer	# Expected	# Observed	SMR
Breast	4.5	2	0.4
Bladder	1.0	1	1.0
Colon	1.9	3	1.6
Lung	4.0	4	0.9
Stomach	0.5	1	2.0
Throat	1.5	2	1.3
Overall*	25.7	20	0.8

*Includes "Female Organs," Liver, "Male Organs," and Skin, in addition to Breast, Bladder, Colon, Lung, Stomach, and Throat.

A SMR less than 1 indicates a lower incidence of cancer among employees than in the general population of the United States. A SMR of greater than 1 indicates a higher incidence of cancer.

C. Environmental

1. Carbon Disulfide

The results of the PBZ air samples for CS_2 are presented in Table 1. All are below the NIOSH REL of 1 ppm. For the 8 "finishers" sampled, the concentrations of CS_2 ranged from

0.05 ppm to 0.42 ppm, with a mean concentration of 0.25 ppm. For the three line operators and one assistant line operator sampled, the concentrations of CS_2 ranged from 0.09 ppm to 0.39 ppm, with a mean concentration of 0.19 ppm. During the 20-minute period in which one line operator was performing the stringing operation, the CS_2 concentration was 0.29 ppm. All other production workers tested (hot melt applicator, quality assurance technician, inspector, mill operator, and Banbury operator) had airborne CS_2 exposures of less than or equal to 0.18 ppm. The three office workers sampled had airborne CS_2 exposures of 0.06, 0.03, and 0.03 ppm. All area air samples collected in locations that might be occupied by workers for a full shift also had concentrations less than the NIOSH REL of 1 ppm.

The concentration of CS_2 inside fresh weatherstripping bubbles ranged from 117 ppm to 288 ppm. Inside the buggies, the concentrations of CS_2 were 1.06, 0.40, and 0.34 ppm. For the two area air samples collected (at a height of 3 feet) above a relatively full and a partially full waste receptacle, the concentrations of CS_2 were 1.43 and 0.05 ppm, respectively. For the one area air sample collected in the chill room, the concentration of CS_2 was 0.51 ppm.

It should be noted that some measurements may represent an underestimation of CS_2 exposure due to the "breakthrough" of collected air samples through the charcoal tube collection media (as determined by analysis of the "back-up" section).

2. Nitrosamines

None of the PBZ or area air samples collected revealed concentrations above the limit of detection for any of the seven nitrosamine compounds tested for.

3. Volatile Organic Compounds

The analysis of air from inside weather stripping bubbles revealed the presence of CS_2 and numerous nitrogen-containing compounds (including amines, morpholines, and substituted formamides). CS_2 was the substance present in highest concentration.

4. Ventilation System Evaluation

Visualization with smoke tubes indicated that the local exhaust ventilation systems were only effective within a limited distance from the face of their hoods. (During the stringing

operation, the operator frequently moved rubber tubing out of the range of these systems.) In addition, the local exhaust ventilation systems in the buggies did not draw sufficient volumes of air from inside weather stripping bubbles to significantly reduce the concentration of contaminants within the bubbles. Finally, the air flow pattern in the plant is such that air flows from waste receptacles (where the levels of CS_2 are highest) to finishers' work stations.

VII. DISCUSSION AND CONCLUSIONS

Many of the chemicals used in the production of weather stripping and their decomposition or reaction products can produce some of the medical problems that have been experienced by employees, especially irritation of the eyes and/or respiratory tract and headaches. However, it is not possible to attribute the reported medical problems which prompted this investigation to specific substances because of (1) the large number of chemicals and degradation products, (2) the interactions between these chemicals and products, and (3) variable individual sensitivity.

It is clear that large amounts of carbon disulfide (CS_2) are generated within weather stripping bubbles, and that - as sampling by the environmental consultant indicated - significant concentrations can be intermittently found in the air above the waste receptacles. It is possible that, while the average exposure of employees to airborne CS_2 is within the NIOSH REL, employees who work near the scrap receptacles (carrying scrap weather stripping, pushing the receptacles, etc.) may on occasion be exposed to concentrations that can adversely affect their health.

The SMR analysis of cancers among employees did not reveal an overall excess of cancer. The SMR's for cancers of the colon, stomach, and throat were slightly elevated, but the small sample size makes it difficult to comment on the significance of these ratios. It is important to realize the limitations of the SMR analysis: the reported cases were not verified by reviewing medical records and death certificates; the specific types of cancer were not noted in all reported cases; no attempt was made to find other cases; and the precise number of employees at risk for developing cancer was not determined. Based on this analysis, however, along with a review of the chemicals used at Schlegel Tennessee, Inc. and environmental monitoring data showing non-detectable levels of nitrosamines in personal breathing zone air samples, it can be said that employees are probably not at increased risk for developing work-related cancers.

VIII. RECOMMENDATIONS

A. Employees should not smoke in the production area. Smoking (1) causes irritation of the eyes and respiratory tract, headaches, and nausea (among smokers and nearby non-smokers), and (2) may increase inhalation and ingestion of airborne chemicals.

B. Modifications to local exhaust ventilation systems proposed by the environmental consultant should be made, including extending and modifying the bubble evacuator and installing local exhaust ventilation systems for the scrap receptacles.

C. Scrap receptacles should be emptied more frequently and should be placed further away from work stations.

D. Scrap weather stripping that is carried to waste receptacles should be kept as far away from the workers' breathing zones as possible.

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X. AUTHORSHIP AND ACKNOWLEDGEMENTS

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XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are temporarily available upon request from NIOSH, Hazard Evaluations and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Schlegel Tennessee, Inc.
2. Amalgamated Clothing and Textile Workers' Union (ACTWU) Local #1933.
3. ACTWU national headquarters.
4. Occupational Safety and Health Administration.

For the purpose of informing affected employees, copies of this report should be posted by Schlegel Tennessee, Inc. in a prominent place that is accessible to employees, for a period of 30 calendar days.

TABLE 1

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE
HETA 89-212

Personal Breathing Zone Air Concentrations of Carbon Disulfide

Job Description	Sampling Period	Sampling Volume (L)	Concentration (PPM)
Finisher (line 2)	06:38-15:01	94.2	0.42
Finisher (line 2)	06:27-14:53	94.3	0.40
Finisher (line 10)	06:33-15:45	93.4	0.31
Finisher (line 10)	06:22-15:04	100	0.31
Finisher (line 10)	22:20-07:04	101	0.21*
Finisher (line 10)	22:18-06:59	100	0.27*
Finisher (line 2)	22:14-07:01	101	0.07*
Finisher (line 2)	22:42-07:03	101	0.05*
Line operator (line 2)	06:42-15:13	93.5	0.39
Line operator (line 10)	06:39-15:10	97.3	0.18*
Line operator (line 8)	22:09-07:05	99.9	0.09*
Line operator (while stringing line 8)	11:09-11:38	5.58	0.29
Assistant line operator (line 2)	06:33-15:45	98.0	0.10
Hot melt applicator (lines 9&10)	07:16-15:07	86.5	0.18
Hot melt applicator (line 9)	22:12-07:04	101	0.09
QA technician	07:12-14:53	91.7	0.16
Inspector (lines 8,9,10,&11)	22:10-07:03	106	0.08*
Mill operator	22:08-06:34	97.0	(0.02)
Banbury operator	22:07-06:33	101	(0.01)
Office worker	08:04-15:25	86.7	0.06
Office worker	07:29-15:18	88.2	0.03
Office worker	07:19-15:18	94.0	0.03

Evaluation Criteria:

National Institute for Occupational Safety and Health (NIOSH)	
10-hour time-weighted average (TWA)	1.0
Ceiling limit (15-minute)	10.0
Occupational Safety and Health Administration (OSHA)	
8-hour TWA	4.0
Short-term exposure limit	12.0
American Conference of Governmental Industrial Hygienists (ACGIH)	
8-hour TWA	10.0

L liters
PPM parts of contaminant per million parts of air sampled
() approximate value; between limit of detection (2.0 micrograms/sample) and limit of quantification (6.0 micrograms/sample)
* may represent an underestimation due to breakthrough

APPENDIX A

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE
HETA 89-212

Pre-shift and post-shift urine specimens were collected from workers, immediately frozen, and stored in a freezer (at -18° C). Urinary creatinine determinations, which were used to correct for urine dilution, were performed by the Jaffe reaction using a Baker Encore Centrifugal Analyzerox^{R}.[10] Urinary TTCA concentrations were determined using a high performance liquid chromatographic (HPLC) method developed by a NIOSH investigator. The method is based on modifications of methods published by van Doorn[11], Rosier[12], Campbell[13], and Ogata[14]. Briefly, 4 ml of urine were treated with 300 mcL of 5N HCl and NaCl flakes to saturation. The TTCA was extracted 4 times from the urine with peroxide-free ethyl ether (5 mL each time). The organic extract was evaporated to dryness in a water bath at 40°C. The residue was reconstituted with 100 mcL of water. A 15 mcL aliquot of the reconstituted residual was injected into the HPLC system. The HPLC system consisted of 2 reversed-phase columns in series: E.M. Hiber^{R} LiChrospher^{R} 100 CH-8, 10 mcm packing (250mm L x 4.6mm ID) followed by a Whatman Partisil^{R} 5 ODS-3 C-18 (250mm L x 4.6mm ID). The following chromatographic parameters at ambient temperature were used: wavelength of 272 nm (Kratos Spectroflow^{R} model 783, UV detector), flow rate of 1.0 mL/min, and 2 mobile solvent phases. Solvent A, consisting of 98% distilled water, 1% acetonitrile, and 1% acetic acid, was used from 0-7 minutes and 14-39 minutes. Solvent B, consisting of 95% methanol, 4% distilled water, and 1% acetic acid, was used from 7-14 minutes. The retention time for TTCA was approximately 11.5 minutes. The modified chromatographic method was verified in studies that included recovery and stability. Recoveries were greater than 98%; storage stability at -18°C was greater than 1 year. The limit of detection for urinary TTCA was 0.03 mg/L. The correlation coefficient for the standard curve was r = 0.995 (range = 0.045-1.35 mg/L). The method can measure urinary TTCA concentrations equivalent to CS_2 air concentrations of less than 0.5 PPM.[15]