U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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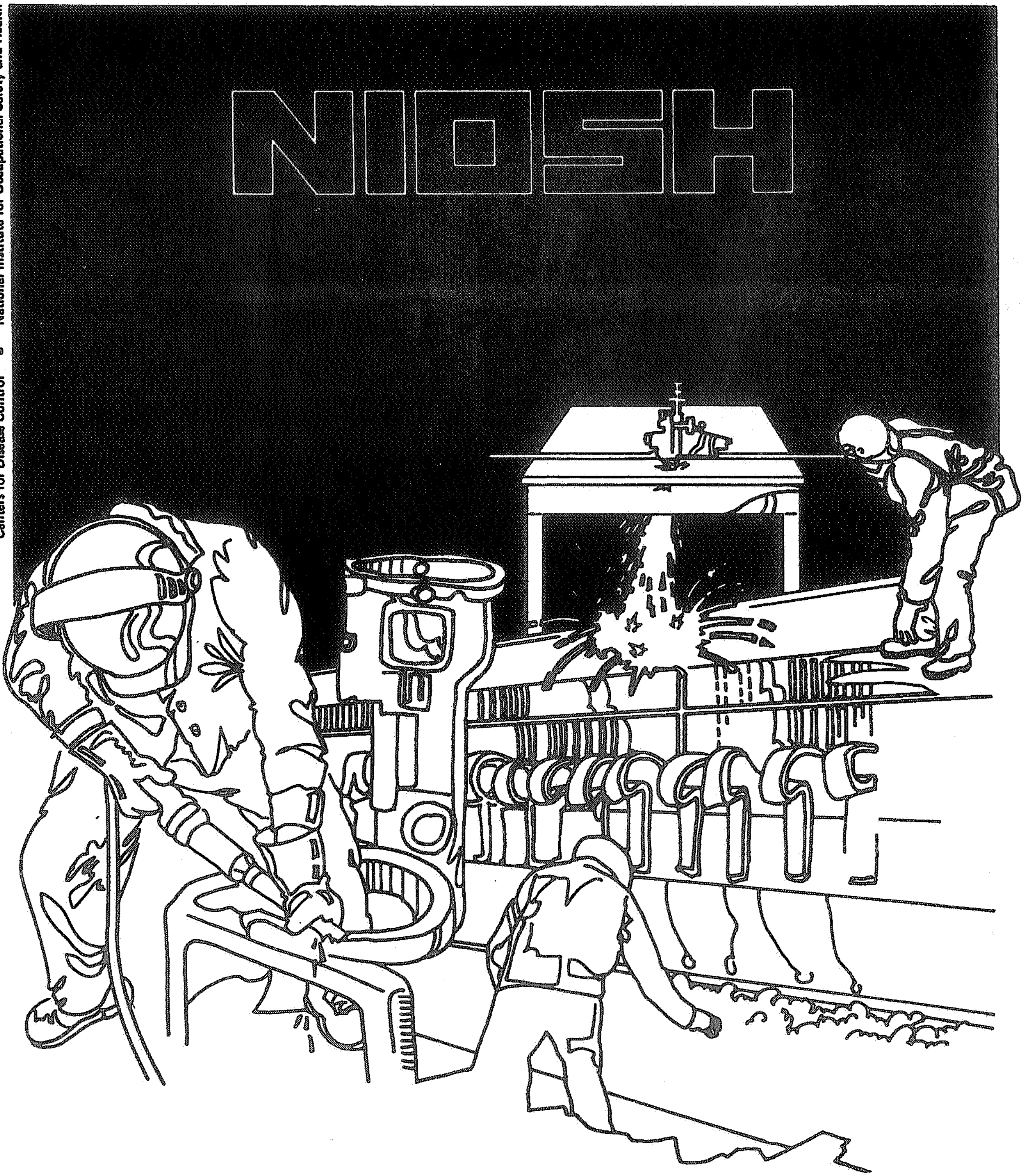


# Health Hazard Evaluation Report

HETA 81-128-1107
JANESVILLE PRODUCTS
BRODHEAD, WISCONSIN

# 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.

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## I. SUMMARY

In December 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Amalgamated Clothing and Textile Workers Union to conduct a health hazard evaluation at Janesville Products, Brodhead, Wisconsin. The request concerned potential employee exposure to toluene diisocyanate (TDI), methylene bisphenyl isocyanate (MDI), methylene chloride, and other chemicals. Workers have noted symptoms of eye irritation and respiratory problems.

In March 1981 NIOSH investigators conducted an initial survey. In a second survey in May 1981, environmental samples were collected to assess employee exposure to airborne contaminants; blood samples for carboxyhemoglobin were drawn; and confidential medical interviews and pulmonary function tests were administered to the employees. A follow-up environmental survey was conducted in September 1981 to evaluate the effectiveness of modifications to the local exhaust ventilation system in the repair area.

Personal breathing zone air samples showed TDI concentrations ranging from non-detectable to 0.001 parts per million (ppm) (NIOSH criteria - 0.005 ppm TWA, 0.02 ppm ceiling). Two area air samples collected in the repair area showed TDI levels of 0.004 ppm and 0.006 ppm. All samples collected for MDI were below the analytical limit of detection. Ceiling concentrations for methylene chloride ranged from 5.8 ppm to 399 ppm, (NIOSH criteria 500 ppm ceiling, 75 ppm TWA). Time weighted average (TWA) values for long term samples of methylene chloride ranged from 4.7 ppm to 39.5 ppm, with the highest exposures found in the repair area. Carbon monoxide levels in the repair area were approximately 25 ppm (NIOSH criteria 35 ppm TWA). During the follow-up environmental survey ceiling concentrations for methylene chloride ranged from 9.8 ppm to 14.2 ppm, with long term TWA concentrations of 8.1 ppm and 7.5 ppm, while the level of carbon monoxide was approximately 9 ppm. Because the toxicities of CO and methylene chloride are additive, the appropriate environmental limit of methylene chloride must be reduced in the presence of CO.

Thirty-four percent of employees interviewed noted shortness of breath. All individual pulmonary function results were within the predicted normal range. Three employees were found to have decreases in $FEV_1$ of more than 10% during the shift, yet for the group as a whole there were no significant decreases in mean $FEV_1$ or in the $FEV_1/FVC$. The mean blood carbon monoxide level was 2.53% prior to and 2.67% post shift. The three non-smoking repair workers showed an increase in their mean blood CO level from a normal value of 0.87% prior to the shift to a slightly elevated 3.93% after the shift.

NIOSH has determined that a potential toxic exposure to the combined effects of methylene chloride and carbon monoxide within the repair area of Janesville Products, was alleviated through engineering controls. Although a number of workers were reported as being sensitive to TDI, no definitive statements concerning chronic pulmonary effects from TDI exposure can be made. To reduce the possibility of future exposures, recommendations for continued environmental and medical surveillance are incorporated in Section VIII.

KeyWords: SIC 2531 (auto seats) Polyurethane Foams, Methylene Bisphenyl Isocyanate, Toluene Diisocyanate, Methylene Chloride, Carbon Monoxide,

## II. INTRODUCTION

On December 22, 1980 an authorized representative of employees submitted a health hazard evaluation request regarding possible respiratory hazards faced by employees of Janesville Products, Brodhead, Wisconsin. The request concerned potential employee exposure to various chemicals used in the plant, among these chemicals are toluene diisocyanate (TDI), methylene bisphenyl isocyanate (MDI), and methylene chloride. Workers reported being able to smell TDI on occasion, and were occasionally experiencing eye irritations and respiratory problems.

NIOSH investigators responded to the request by conducting an initial survey of the plant on March 17, 1981. An opening conference was held followed by a walk-through survey of the plant. On May 19, 1981 NIOSH investigators returned to the plant to conduct environmental sampling for TDI, MDI, methylene chloride and carbon monoxide. On May 26, 1981 a medical survey was conducted to perform Pulmonary Function Tests, draw blood samples to assess the amount of carbon monoxide absorbed, and administer confidential employee questionnaires. On September 18, 1981 a follow-up environmental survey was conducted to evaluate modifications in the local exhaust ventilation system at the MDI mixer head.

## III. BACKGROUND

### A. Plant Production and Workforce

Janesville Products has been involved in the production of polyurethane foams for the past nine years. The company's main product is polyurethane foam seats for the automobile industry. The production rate is approximately 50,000 pieces per week.

The plant operates two shifts per day and at the time of the initial survey provided employment for 135 hourly workers, 4 maintenance workers, and 20 administrative personnel. Employees work an 8-hour shift, 5 days per week.

### B. Process Description and Employee Duties

Polyurethanes are formed by the interaction of diisocyanates with polyhydroxy compounds (polyols). Depending on the finished product required, other products such as water, catalysts, foaming agents, stabilizers and fire retardants may be added.

The facility has two molding lines which are arranged in a race track type formation, with an inner and outer lane. The majority of the compounding is enclosed in tanks automatically controlled by metering pumps. Some chemicals (surfactants) are mixed in open metal containers. The chemical mixtures, both premixed and separate (TDI + polyols + catalysts, fire retardants, etc.), are pumped to a mixing head, where they are briefly foamed (mixed) and poured into open molds. The mixing head is then automatically flushed with methylene chloride to prevent plugging of the head by the TDI-polyol mix.

As the foam is poured into the molds it begins to react exothermically. A cover lid is closed and the entire mold then proceeds through an oven which ranges in temperature from approximately 300$^{o}$ F at the inlet to 225$^{o}$ F at the outlet. At the discharge end of the oven, the mold cover is opened and the cured foam pad removed from the mold by employees (demolders) who then place the foam pads onto a conveyor for transport to the trim and inspect area. The molds continue along the line, are sprayed with a water based mold release agent by a mechanical arm, and sent through a small oven for preheating. Wire inserts are then placed into the mold by employees (inserters) for structural support of the foam product and the process repeats.

The trim and inspect area involves sorting of foam pads which are acceptable and those which need repairing. Some pads require only a small amount of trimming of excess foam while others require additional foam in defective areas. The repair operation is performed by dispensing a small amount of MDI-polyol mix into a small hand held paper cone, and then poured into the area(s) needing repair. The mixing head is automatically flushed with methylene chloride to prevent plugging.

C. Engineering, Administrative, and Personal Protective Controls

The TDI-polyol reaction takes place rapidly so all mixing maneuvers have to take place at the point of application. The majority of compounding takes place in an enclosed system so there are no employee exposures. Local exhaust ventilation is provided at the mixing heads to prevent the spread of TDI and methylene chloride to other areas of the plant. Local exhaust ventilation is also provided at the mixing head in the repair area to prevent the spread of methylene chloride to adjacent areas, MDI does not present a problem in this area due to the fact that MDI has a much lower volatility than TDI and problems generally arise only in spray applications.

A mechanical arm is used to spray the foam molds with a water based mold release agent to avoid any employee exposures to this chemical and local exhaust ventilation is provided at the area of application.

Employees are required to wear safety glasses and are provided with clean gloves daily. Inserters and demolders rotate among themselves between the inner and outer molding lines to prevent any employee from having to spend an inordinate amount of time next to the ovens. Additionally, fans are provided to dissipate the heat from the ovens.

## IV. MATERIALS AND METHODS

A. Environmental:

During the opening conference detailed discussions focused on process description, engineering controls, health surveillance monitoring, personal protective equipment, work practices and environmental monitoring. Additionally, NIOSH investigators observed work practices and conditions and interviewed 36 employees.

During the environmental survey, personal breathing zone samples (at the workers lapel) and area samples for TDI and MDI were collected using battery powered pumps operating at 1.0 liters per minute (LPM) attached via tygon tubing to glass wool tubes and a glass-fiber filter housed in a 13 mm filter holder, respectively. Both TDI and MDI collecting media were impregnated with N-p-nitrobenzyl-N-propylamine. All TDI and MDI samples were analyzed according to modified NIOSH Method P&CAM 326 and NIOSH Method P&CAM 347, respectively.[1, 2]

Full shift and short term personal breathing zone samples for methylene chloride were collected using battery powered sampling pumps operating between 0.01 LPM and 0.1 LPM attached via tygon tubing to charcoal tubes. Samples were analyzed according to NIOSH Method P&CAM S329.[3]

Personal breathing zone samples for carbon monoxide were collected using direct reading long term detector tubes connected via tygon tubing to battery powered sampling pumps operating at 0.02 LPM.

B. Medical:

Standardized medical questionnaires were administered to the production workers in the car seat assembly and repair areas. This questionnaire solicited information with respect to job history, medical history, and current symptoms.

Pulmonary Function Testing (spirometry) was conducted by a Certified Pulmonary Function Technician using a Spirotech 200B. Employees were tested prior to and following the shift. Information was recorded concerning height, time since last cigarette, presence of an upper respiratory infection in the last 3 weeks, heavy meal in the last 2 hours, and use of bronchodialator medication.

Blood samples were drawn at the time of the Pulmonary Function tests from a venepuncture in the arm. The blood was analyzed by Metpath Laboratories for percent carbon monoxide utilizing whole blood. The analysis was performed by Instrument Laboratory's CO-Oximeter model 282.

## V. EVALUATION CRITERIA

### A. Methylene Chloride

Methylene chloride is a colorless liquid with an odor like chloroform. The current OSHA standard for methylene chloride is 500 parts of methlylene chloride per million parts of air (ppm) averaged over an eight-hour work shift, with an acceptable ceiling level of 1000 ppm and a maximum peak concentration of 2000 ppm for 5 minutes in any two hour period.[4] NIOSH has recommended that the permissible exposure limit (PEL) be reduced to 75 ppm averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling level of 500 ppm averaged over a 15-minute period. NIOSH further recommends that permissible levels of methylene chloride be reduced where carbon monoxide is present. Methylene chloride is metabolized by the liver to form carbon monoxide therefore, the toxicities of CO and methylene chloride are additive and the appropriate environmental limit and action level of methlyene chloride must be reduced in the presence of CO.[5]

Methylene chloride can be taken into the body through inhalation of vapors and percutaneous absorption of the liquid. In human experiments, inhalation of 500 ppm to 1000 ppm for 1 to 2 hours resulted in lightheadedness and sustained elevation of carboxyhemoglobin level. High exposures have resulted in deaths in industrial situations. Lower concentrations have caused symptoms of lightheadedness, weakness, nausea, and "drunken behavior" resulting in mistakes and accidental falls. In 1979 Putz, Johnson, and Setzer reported that methylene chloride or carbon monoxide exposure sufficient to produce a 5% level of carboxyhemoglobin in the blood had adverse effects on the human subjects ability to perform certain tasks.[6] Phosgene poisoning has been reported to occur in several cases where methylene chloride was used in the presence of an open fire. Liquid methylene chloride is irritating to the skin on repeated contact. Splashed in the eye it is painfully irritating but is not likely to cause serious injury.[7]

B. Carbon Monoxide

Carbon monoxide is a colorless, odorless, tasteless gas usually occurring as a by-product of incomplete combustion of carbonaceous materials, with the major source of atmospheric CO being gasoline powered internal combustion engines. Normal levels in the human blood stream of an urban dweller are 2% or below for non-smokers. Smokers may have up to a 9% level. Typical signs and symptoms of acute CO poisoning are headache, dizziness, drowsiness, nausea, vomiting, and at high levels collapse, coma, and death. In person's with preexisting cardiovascular disease low CO levels produce myocardial infarctions or decompensation.

The current OSHA standard for carbon monoxide is 50 ppm (55 mg/m$^3$).[4] The NIOSH recommended environmental limit is 35 ppm as a time weighted average basis (TWA) for a 10 hour workday, 40 hour work week, with ceiling concentrations not to exceed 200 ppm for a 15 minute period. These levels should limit carbon monoxide absorption to a blood level below 5% in a nonsmoker engaged in sedentary activity.[8]

C. Toluene Diisocyanate (TDI)

This substance is a light-yellow liquid which produces both acute and chronic effects on mucous membranes and the respiratory tract. The current OSHA standard for TDI is .02 ppm as a ceiling concentration for any 15 minute period.[4] NIOSH recommends an eight-hour TWA of 0.005 ppm and a ceiling level of 0.02 ppm for any 20-minute period.[9, 10]

1. Acute Effects

(a). Primary Irritation

At high concentrations of TDI, all exposed individuals are susceptible to effects on the respiratory tract, resulting in a burning sensation in the nose and throat, a choking sensation, dry or productive cough, and general chest pains. These effects are often mistaken for "colds" or upper respiratory tract infection. Exposure to higher concentrations can lead to severe bronchoconstriction, mimicking an asthmatic attack, and may produce a chemical pneumonitis as well.

At lower levels TDI may produce headaches, sleeplessness, ataxia, and euphoria. Nausea, vomiting and abdominal pain may also occur. If liquid TDI is allowed to remain in contact with the skin, it may produce redness, swelling, and blistering. Contact of liquid TDI with the eyes may cause severe irritation, which may result in permanent damage if untreated. Swallowing TDI may cause burns of the mouth and stomach.[8]

(b). Allergic Sensitization

TDI can produce an immunological sensitization and very low concentrations may elicit various symptoms. Shortness of breath and cough, as well as symptoms and signs of asthma, may appear in sensitized individuals. A stuffy-headed feeling, similar to hay fever, is often a sign of sensitization. Sensitization of individuals may occur at concentrations below 0.002 ppm but the frequency of sensitization increases following acute high level exposure such as after a spill. 4.3% of a population of 277 workers were found to be sensitized in a recent study.[11]

2. Chronic Effects

(a). Accelerated Loss of Lung Function

A third type of respiratory effect, from chronic low level exposure, is that of accelerated loss of lung function in the absence of sensitization. Weill et. al. reported in 1981 that 8 hour TWA levels of 0.002 ppm with excursions beyond 0.02 ppm occuring only 3% of the time produced a more rapid fall in $FEV_1$, $FEF_{25-75}$, and $FEF_{50}$ than would be expected from a cross-sectional study of normal populations.[11] These findings were more pronounced for non-smokers as the obstructive effects of smoking often masked this finding. Further, in the subgroup of workers who developed hypersensivity to TDI, some failed to attain pre-exposure values of $FEV_1$ or $FEF_{25-75}$ after removal from the area of exposure.[11]

D. Methylene Bisphenyl Isocyante (MDI)

Methylene bisphenyl isocyanate (MDI) vapor is a potent respiratory sensitizer. It is also a strong irritant of the eyes, mucous membranes and skin and can cause pulmonary edema. Exposure of humans to high concentrations causes cough, dyspnea, increased secretions, and chest pains. A recent case report in the American Review of Respiratory Diseases documents a case of hypersensitivity pnuemonitis in a worker exposed to MDI.[12]

The current OSHA standard for MDI is a ceiling level of 0.02 ppm. NIOSH recommends an eight-hour TWA of 0.005 ppm and a ceiling level of 0.02 ppm for any 20-minute period.[7, 8]

E. Pulmonary Function Tests

Normal values for Pulmonary Function Tests were developed by Ronald J. Knudson et. al. in 1976. They established predictive normal pulmonary function tables for the U.S. population, corrected for age and height. A value of 80% or greater for the subject's Forced Vital Capacity (FVC) and One Second Forced Expiratory Volume ($FEV_1$) when compared with the predicted is considered normal. A ratio of $FEV_1$/FVC of 75% or greater is considered normal as well.[13]

Confirming the 1977 work of Cochrane, Prieto and Clark, Hankinson and Boehlecke of NIOSH reported on intrasubject variation in PFT results in 1981. They found a coefficient of variation of 3.0% for both FVC and $FEV_1$ before and after a non-exposed shift, with a mean $FEV_1$ decreasing 10 ml during the repeat PFT's over a two year period.[14, 15].

VI. RESULTS

A. Environmental

Results of environmental samples collected for TDI showed only 10 of 32 (31%) samples above the analytical limit of detection. The limit of detection for this analysis was 0.3 ug (micrograms) of 2,4-TDI per sample. Of the 10 samples with detectable quantities of 2,4-TDI only one area sample (0.006 PPM) was above the NIOSH recommended limit of 0.005 PPM, and one area sample of 0.004 ppm approached this limit. Both samples were collected near the TDI mixer heads and these sites are not normal work stations for employees. All eight employee personal breathing zone samples with detectable quantities of 2,4-TDI were well below the NIOSH recommended limit and all other samples collected were below the analytical limit of detection. (See Table I)

Results of environmental samples collected for MDI were all below the analytical limit of detection. The limit of detection for this analysis of MDI was 0.3 ug per sample. (See Table II)

Short term environmental samples to assess ceiling concentrations for methylene chloride ranged from 5.8 ppm to 399 ppm. Cumulative Time Weighted Average (TWA) concentrations for methylene chloride ranged from 4.7 ppm to 39.5 ppm. The highest values were all consistently from the repair area, indicating a need for improved local exhaust ventilation at the MDI mixer head. At the time of the follow-up environmental survey a substantial decrease in ceiling concentrations for methylene chloride was noted in the repair area, levels ranged from 9.8 ppm to 14.2 ppm, with TWA concentrations of 8.1 ppm and 7.5 ppm. Carbon monoxide levels in the repair area were approximately 25 ppm during the first environmental survey. At the time of the follow-up environmental survey these levels had been reduced to approximately 9 ppm. Improvements in the local exhaust ventilation system at the MDI mixer head suggested by the NIOSH investigators, would account for the decreased levels of methylene chloride and carbon monoxide in the repair area.

B. Medical

1. Questionnaires

Standard medical questionnaires were administered to thirty-six employees, 11 males and 25 females. The questionnaire solicited information concerning employees past work history, medical history, smoking habits, etc. (See Appendix 1) The mean age of this group was 28.3 years with a standard deviation of 7.5 years. Job classifications and numbers of those interviewed were 12 demolders, 13 inserters, 2 line suppliers, 4 repair workers, 1 relief worker, 1 compounder and 1 trimmer.

Three employees indicated a history of allergies and 1 noted a history of asthma. Smoking habits and history of those interviewed were as follows: 44% (16) were current smokers, 8% (3) were past smokers, 42% (15) never smoked, and 6% (2) smoked cigars. Table V stratifies the smoking history of these employees by job category.

Table VI summarizes the symptomatologic data and stratifies for job category. Twenty-five percent of employees interviewed noted shortness of breath on walking up a slight hill, while 9% indicated more severe shortness of breath. Another 25% stated that they had shortness of breath on Mondays, and 36% noted shortness of breath at other times. Thirty-one percent stated that they suffered from wheezing at times other than when they had a cold. Over half of the employees indicated frequent nasal dripping, dry throat, headaches, and eye irritation. Slightly less than half stated that they suffered from frequent sinus irritation, 14% had episodic nose bleeds, and 25% indicated that they were frequently light-headed at work.

Inserters had substantially more symptoms than the other job categories. Fifty percent reported wheezing occurring without a upper respiratory infection, 71% noted sinus irritation, 86% stated eye irritation and dry throats, and 57% reported light-headedness.

2. Pulmonary Function Tests

Three female employees were found to be sensitive to TDI, with have decreases in $FEV_1$ of more than 10% during the shift the day of the medical evaluation. The results of the Pulmonary Function Tests (PFT's) on the entire group are summarized in Table VII. The job classifications of those participating in PFT's are as follows; 10 inserters, 9 demolders, 1 line supplier, 4 repair workers and 1 relief worker. Table VIII summarizes the PFT data according to shift.

Table IX compares the pulmonary functions of inserters and demolders. No differences could be found between the PFTs in these two groups, despite the increased frequency of symptoms amongst the inserters.

Table X details the carbon monoxide levels in blood taken before and after shift. The mean CO level was 2.53% prior to and 2.67% post shift. Increased environmental levels of methylene chloride and carbon monoxide were noted in the repair area at the time of the medical survey. To assess the human absorption of this increased environmental CO and to avoid the possible masking effect of cigarette smoking, non-smoking repair workers were compared with other non-smoking workers. The three non-smoking repair workers showed a statistically significant increase in their mean blood CO level from a normal value of 0.87% prior to the shift to a slightly elevated 3.93% after the shift.

## VII. DISCUSSION

Methylene chloride and carbon monoxide have an additive effect upon the body. Because the toxicities of CO and methylene chloride are additive, the appropriate environmental limit and action level of methylene chloride must be reduced in the presence of CO. At the time of the first environmental survey, one personal breathing zone sample collected to assess employee exposure to methylene chloride found a level of 399 ppm. Carbon monoxide detector tube samples collected indicated levels of approximately 25 ppm in the repair area. This indicates that the potential for exposure to a combination of CO and methylene chloride above the NIOSH recommended limits, at the time of the first environmental survey. When CO levels are more than 9 ppm, occupational exposure to methylene chloride shall be determined by a formula. Methylene chloride and carbon monoxide in the air are additive hazards, as the body handles them in similar fashion producing carboxyhemoglobin. Methylene chloride is metabolized by the human liver to form carbon monoxide. This internally produced carbon monoxide then binds with hemoglobin in the red blood cell in the same manner as inhaled carbon monoxide. The bound carbon monoxide prevents oxygen from being transported by the red blood cells to the tissues where it is needed. The NIOSH Criteria for a Recommended Standard for Occupational Exposure to Diisocyantes (publication number 76-138) should be consulted for more detailed information. The CO sample taken is not an eight-hour TWA and therefore it cannot be said with any certainty that overexposure did or did not occur at that time.

A follow-up environmental survey to evaluate modifications in the local exhaust ventilation system at the MDI mixer head in the repair area of the plant indicated that the methylene chloride levels had been reduce by a factor of twenty and CO levels had been reduced by almost two thirds.

During the initial environmental survey the local exhaust ventilation system at the MDI mixer head was such that it would draw methylene chloride vapors up and through the worker's breathing zone. This accounts for the high ceiling values observed on the two employees working in this area. Modifications in the local exhaust ventilation system suggested by the NIOSH investigators improved this situation by drawing the methylene chloride vapors away from the workers breathing zone. This is shown by the much lower environmental levels of methylene chloride and CO during the follow-up survey.

A. Potential Respiratory Hazard:

Three workers in this study appeared to be reacting to the low environmental levels of TDI. This is not unexpected in that 4.3% of the 277 TDI workers in a recent NIOSH study were reported to have become hypersensitive. The pulmonary functions of some of these hypersensitive individuals did not return to normal despite removal from exposure.[11] On this basis it has been determined that a potential pulmonary hazard exists for these three workers.

No acute or chronic pulmonary effects could be documented by spirometric testing for the group as a whole. There were no significant decreases in $FEV_1$ and $FEV_1/FVC$ during the shift. Further, despite the increased frequency of symptoms of mucous membrane irritation amongst the inserters, their pulmonary functions were not significantly different from those of the demolders.

All individual results fell within the normal limits of predicted functions corrected for age and height as well. This finding is not surprising as it is consistent with the environmental data. Only eight of twenty eight personal sampling tubes were found to have TDI. These eight tubes had a level of 0.001 ppm, the lowest detectable amount. In the recent prospective study by Weill et. al. long term decreases in $FEV_1$ were noted in workers with a mean exposure of 0.002 ppm on a time weighted average over 8 hours. When the subgroup of workers with a TWA exposure of 0.0011 ppm was looked at separately no significant deviation from the normal decline in $FEV_1$ expected with age could be detected.[11]

The present study does not permit definitive statements to be made concerning chronic pulmonary effects. Spirometric testing was done on a single day assessing the decrease across a shift, but not the chronic effects over time. The numbers of exposed workers was quite small and no control group was tested in this study. Environmental sampling was done on a single day thus not registering possible variations in environmental levels of TDI and MDI over weeks or months.

B. Potential Anoxic Hazard:

The levels of both carbon monoxide and methylene chloride detected in this plant and the corresponding blood levels of carbon monoxide are all well within the normal range. Further, the carbon monoxide levels detected in the blood are well within normal limits for both smokers and non-smokers with the exception of those workers in the repair area. This group of 4 workers were subjected to approximately 25 ppm carbon monoxide and additional methylene chloride. The 3 non-smokers' blood carbon monoxide levels increased above the normal range. This effect was masked for the smoker as the range of normal for smokers is higher than for non-smokers. Therefore, the combined levels of carbon monoxide and methylene chloride in the repair area did present a mild anoxic hazard to these employees.

C. Mucous Membrane Irritation:

The frequent mucous membrane irritation of the employees, with particular emphasis on the inserting area, indicate that methylene chloride and other airborne irritants below OSHA limits were producing discomfort. This study was unable to confirm any acute or chronic physical changes due to this irritation. Despite this, it would appear that in the inserting area, airborne irritants are affecting the employees.

## VIII. RECOMMENDATIONS

1. Good personal hygiene and work practices should be observed by all employees. Washing of hands before smoking, eating and drinking will help reduce possible contamination. Food, drinks, and cigarettes should not be kept at work locations or near the production area.

2. Management is encouraged to continue developing detailed written health and safety programs and instruct all employees of the hazards associated with the chemicals used in the facility and the proper usage of personal protective equipment.

3. Materials for neutralization and adsorption of chemical spills (i.e. TDI) and proper safety equipment should be located near the compound area and specific emergency/cleanup written procedures should be developed, taught to the employees and reviewed periodically. Emphasis should be placed on engineering controls, personal protection, limitation of the protection, proper use, maintenance, cleaning and storage of safety equipment used for spills and emergencies. All employees should be instructed in the hazards of the chemicals in use.

4. Recent changes in the local exhaust ventilation system at the MDI mixer head have substantially lowered employee exposures to methylene chloride and CO by drawing vapors away from the workers breathing zone, rather than up and through the breathing zone. These changes should be continued and the ventilation systems should be cleaned and maintained regularly.

5. Impervious plastic/rubber aprons should be provided to the compounder. Employees should wear chemical safety goggles and impervious gloves.

6. To prevent the development of serious pulmonary impairment from TDI or MDI, a medical surveillance program should be provided employees by management.

7. Employees with a history of respiratory illness, especially asthma, and those exposed to other respiratory irritants eg. tobacco smoke, should be counseled as to their increased risk of sensitization to the diisocyanates.

8. Each employee should receive a thorough preplacement medical examination, which includes a history of exposure to diisocyanates, a smoking history, and a history of respiratory illnesses. Each employee should receive a pulmonary function test, including $FEV_1$, FVC, and $FEV_1$/FVC, as well as a chest X-ray before beginning work.

9. Each employee who is exposed to TDI or MDI at the job should receive a physical examination and pulmonary function test yearly. Because of seasonal and diurnal variations in pulmonary function, the periodic examination of each employee should be performed at about the same time each year and at the same time of the day.

10. Any employee who begins to experience shortness of breath during a shift especially individuals who have been exposed to a spill or other accidental high level exposures, should have pulmonary function tests repeated after a shift and be offered the option of undergoing a methacholine or diisocyanate challenge testing under proper supervision. These tests will determine whether this individual has become sensitized to the Diisocyanate.

11. Individuals sensitive to TDI or MDI should be counseled as to the risks of continued exposure to these substances.

12. Records of pulmonary function and related medical tests should be maintained for thirty years.

13. Efforts should be made to reduce the workers exposure to airborne irritants in the inserting area.

14. The company's program of TDI and methylene chloride monitoring should be continued.

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## XI. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Services (NTIS), Springfield, Virginia. 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 the following:

A. Amalgamated Clothing and Textile Workers Union

B. Janesville Products, Inc.

C. U.S. Department of Labor, OSHA - Region V

D. NIOSH Regional Offices/Divisions

For the purposes of informing the affected employees, copies of the report should be posted in a prominent place accessible to the employees, for a period of 30 calendar days.

TABLE I

Results of Air Sampling for Toluene Diisocyanate
Janesville Products
Brodhead, Wisconsin
May 19, 1981

| Job Description/ Employee Number* | Exposure Time (Minutes) | TDI Concentration (ppm) |
|---|---|---|
| All 4 Blanks | -0- | N.D. |
| Inserter #1 | 27 | N.D. |
| " | 60 | N.D. |
| " | 69 | N.D. |
| " | 23 | N.D. |
| " | 15 | N.D. |
| " | 14 | N.D. |
| Inserter #2 | 64 | N.D. |
| " | 66 | 0.001 |
| " | 60 | N.D. |
| " | 65 | N.D. |
| Inserter #3 | 60 | 0.001 |
| " | 64 | 0.001 |
| " | 58 | 0.001 |
| " | 65 | N.D. |
| Inserter #4 | 62 | N.D. |
| " | 59 | 0.001 |
| " | 59 | 0.001 |
| " | 63 | N.D. |
| Demolder #1 | 65 | N.D. |
| " | 57 | N.D. |
| " | 62 | N.D. |
| " | 62 | N.D. |
| Demolder #2 | 59 | N.D. |
| " | 64 | N.D. |
| " | 58 | N.D. |
| " | 60 | 0.001 |
| Compounder | 54 | 0.001 |
| " | 61 | N.D. |
| Area Sample (TDI Mixer Head) | 67 | 0.001 |
| | 62 | 0.004 |
| Area Sample (Trim & Sort) | 58 | N.D. |
| | 61 | N.D. |

Abbreviations: $mg/M^3$ - milligrams of contaminant per cubic meter of air
PPM - parts of contaminant per million parts of air
N.D. - Not Detected - The limit of detection for these samples was 0.3 ug of 2,4-TDI per sample.

TABLE II

Results of Sampling for Methylene Bisphenyl Isocyanate
Janesville Products
Brodhead, Wisconsin
May 19, 1981

| Job Description/ Employee Number* | Exposure Time (Minutes) | MDI Concentration (ppm) |
|---|---|---|
| Blank | -0- | N.D. |
| Blank | -0- | N.D. |
| Blank | -0- | N.D. |
| Buffer | 369 | N.D. |
| " | 18 | N.D. |
| " | 13 | N.D. |
| " | 16 | N.D. |
| Repair | 77 | N.D. |
| " | 32 | N.D. |
| " | 21 | N.D. |
| " | 275 | N.D. |
| Area Sample (Repair) | 438 | N.D. |

Abbreviations: mg/M$^3$ - milligrams of contaminant per cubic meter of air
PPM - parts of contaminant per million parts of air
N.D. - Not Detected - The limit of detection for these samples was 0.3 ug of MDI per sample.

TABLE III

Results of Air Sampling for Methylene Chloride
Janesville Products
Brodhead, Wisconsin
May 19, 1981

| Employee Number * | Job Description | Exposure Time (minutes) | PPM | Cumulative TWA (PPM)** |
|---|---|---|---|---|
| 1 | Inserter | 340 | 6.3 | |
| | " | 20 | 5.8 | |
| | " | 15 | 5.8 | |
| | " | 15 | 5.8 | |
| | | 390 | | 5.1 |
| 2 | Demolder | 398 | 5.7 | |
| | | 398 | | 4.7 |
| 3 | Repair | 340 | 27.9 | |
| | " | 21 | 19.2 | |
| | " | 15 | 159.2 | |
| | " | 14 | 170.5 | |
| | | 390 | | 30.5 |
| 4 | Repair | 34 | 18.6 | |
| | " | 30 | 23.0 | |
| | " | 35 | 399.5 | |
| | | 99 | | *** |
| 5 | Area Sample (TDI Mixer Head) | 425 | 8.1 | |
| | | 425 | | 7.2 |
| 6 | Area Sample (MDI Mixer Head) | 365 | 51.9 | |
| | | 365 | | 39.5 |
| | Blank | | N.D. | |

Abbreviations: PPM = parts of contaminant per million parts of air
TWA = time weighted average
N.D.= Not Detected - the limit of detection for methylene chloride was 0.01 mg/sample.

* Employee numbers are randomly assigned
** Cumulative TWA values are calculated by combination of long term and short term sample values
*** Lack of exposure data does not permit estimation of cumulative TWA

TABLE IV

Results of Air Sampling for Methylene Chloride
Janesville, Products
Brodhead, Wisconsin
September 18, 1981

| Employee Number * | Job Description | Exposure Time (minutes) | PPM | Cumulative TWA (PPM)** |
|---|---|---|---|---|
| | Blank | | N.D. | |
| 1 | Repair | 187 | 9.4 | |
| | " | 10 | 13 | |
| | " | 11 | 9.9 | |
| | " | 180 | 10.6 | |
| | | 388 | | 8.1 |
| 2 | Repair | 182 | 8.9 | |
| | " | 10 | 14.2 | |
| | " | 10 | 10.4 | |
| | " | 175 | 9.8 | |
| | | 377 | | 7.5 |

Abbreviations: PPM = parts of contaminant per million parts of air
TWA = time weighted average
N.D.= Not Detected - the limit of detection for methylene chloride was 0.01 mg/sample.

* Employee numbers are randomly assigned
** Cumulative TWA values are calculated by combination of long term and short term sample values

TABLE V

SMOKING HABITS OF THE EMPLOYEES INTERVIEWED

| JOB CLASSIFICATION: | INSERTER N=14 | DEMOLDER N=12 | REPAIR N=4 | OTHER N=5 | ALL N=36 |
|---|---|---|---|---|---|
| SMOKERS: | | | | | |
| CIGARETTES | | | | | |
| Current | 50% | 50% | 25% | 40% | 44% |
| Past | | 8% | 25% | 20% | 8% |
| Never | 42% | 33% | 50% | 40% | 42% |
| Cigar | 8% | 8% | | | 6% |

TABLE VI

SYMPTOMS REPORTED BY THE EMPLOYEES INTERVIEWED

| JOB CLASSIFICATION: | INSERTER N=14 | DEMOLDER N=12 | REPAIR N=4 | OTHER N=5 | ALL N=36 |
|---|---|---|---|---|---|
| SHORTNESS OF BREATH: | | | | | |
| Walking up a slight hill | 29% | 17% | 50% | 20% | 25% |
| Walking on level ground | 14% | | | 20% | 9% |
| On Monday | 42% | | | 60% | 25% |
| Other times at work | 50% | 8% | 25% | 80% | 36% |
| WHEEZING (Without a cold) | 50% | 17% | | 40% | 31% |
| SINUS IRRITATION | 71% | 8% | 75% | 60% | 17% |
| EYE IRRITATION | 86% | 25% | 75% | 80% | 61% |
| RHINITIS | 71% | 33% | 75% | 60% | 56% |
| EPISTAXIS | 36% | | | | 14% |
| DRY THROAT | 86% | 25% | 50% | 60% | 56% |
| HEADACHES | 71% | 33% | 75% | 60% | 56% |
| LIGHT HEADEDNESS | 57% | | | 20% | 25% |

TABLE VII

PULMONARY FUNCTION TEST RESULTS
N=26

| TEST | Mean Value | Standard Deviation | P Value* | Mean % of Pred** | Standard Deviation | P |
|---|---|---|---|---|---|---|
| | | **BOTH SHIFTS** | | | | |
| $FEV_1$: | | | | | | |
| Pre-Shift | 3.38 L. | 0.80 | | 101.0 | 12.6 | |
| Post-Shift | 3.30 L. | 0.85 | 0.35 | 98.7 | 13.9 | 0.22 |
| FVC: | | | | | | |
| Pre-Shift | 4.09 L. | 0.95 | | 102.6 | 10.6 | |
| Post-Shift | 3.99 L. | 0.96 | 0.36 | 100.2 | 10.6 | 0.20 |
| $FEV_1$/FVC: | | | | | | |
| Pre-Shift | 0.83 | 0.06 | | | | |
| Post-Shift | 0.82 | 0.07 | 0.431 | | | |

* Utilizing a Student T Test for significance.

**Utilizing Knudsons tables for Predicted Normals.

TABLE VIII

PULMONARY FUNCTION TEST RESULTS
N=26

| TEST | Mean | Standard Deviation | P Value* | Mean % of Pred** | Standard Deviation | P Value |
|---|---|---|---|---|---|---|
| **1st SHIFT (N=16)** | | | | | | |
| $FEV_1$: | | | | | | |
| Pre-Shift | 3.20 L. | 0.78 | | 99.6 | 14.4 | |
| Post-Shift | 3.11 L. | 0.83 | 0.38 | 96.8 | 16.2 | 0.30 |
| FVC: | | | | | | |
| Pre-Shift | 3.91 L. | 0.91 | | 101.6 | 12.5 | |
| Post-Shift | 3.79 L. | 0.91 | 0.37 | 98.5 | 11.9 | 0.24 |
| $FEV_1$/FVC: | | | | | | |
| Pre-Shift | 0.82 | 0.06 | | | | |
| Post-Shift | 0.82 | 0.09 | 1.0 | | | |
| **2nd SHIFT (N=10)** | | | | | | |
| $FEV_1$: | | | | | | |
| Pre-Shift | 3.68 L. | 0.80 | | 104.4 | 8.9 | |
| Post-Shift | 3.60 L. | 0.83 | 0.23 | 101.7 | 9.0 | 0.25 |
| FVC: | | | | | | |
| Pre-Shift | 4.37 L. | 0.99 | | 104.2 | 7.0 | |
| Post-Shift | 4.31 L. | 1.01 | 0.13 | 102.8 | 7.9 | 0.34 |
| $FEV_1$/FVC: | | | | | | |
| Pre-Shift | 0.85 | 0.57 | | | | |
| Post-Shift | 0.84 | 0.07 | 0.38 | | | |

* Utilizing a Student T Test for significance.

**Utilizing Knudsons tables for Predicted Normals.

TABLE IX

DEMOLDERS (N=10) and INSERTERS (N=11)
PULMONARY FUNCTION TEST RESULTS
N=26

| TEST | Mean | Standard Deviation | P Value* | Mean % of Pred** | Standard Deviation | P Value |
|---|---|---|---|---|---|---|
| PRE-SHIFT $FEV_1$: | | | | | | |
| Demolders | 3.70 L. | 0.97 | | 100.9 | 9.4 | |
| Inserters | 3.30 L. | 0.66 | 0.29 | 104.5 | 15.0 | 0.53 |
| POST-SHIFT $FEV_1$: | | | | | | |
| Demolders | 3.70 L. | 1.00 | | 99.4 | 10.4 | |
| Inserters | 3.23 L. | 0.64 | 0.20 | 101.3 | 15.0 | 0.74 |
| PRE-SHIFT $FEV_1$/FVC: | | | | | | |
| Demolders | 0.80 | 0.03 | | | | |
| Inserters | 0.84 | 0.07 | 0.16 | | | |
| POST-SHIFT $FEV_1$/FVC: | | | | | | |
| Demolders | 0.81 | 0.05 | | | | |
| Inserters | 0.84 | 0.09 | 0.33 | | | |
| CHANGE IN $FEV_1$: | | | | | | |
| Demolders | -0.02 L. | 0.10 | | -0.7 | 3.0 | |
| Inserters | -0.11 L. | 0.19 | 0.19 | -3.0 | 5.3 | 0.24 |
| PRE-SHIFT FVC: | | | | | | |
| Demolders | 4.62 L. | 1.12 | | 105.0 | 8.6 | |
| Inserters | 3.96 L. | 0.70 | 0.11 | 103.5 | 12.9 | 0.75 |

* Utilizing a Student T Test for significance.

**Utilizing Knudsons tables for Predicted Normals.

TABLE X

CARBOXYHEMOGLOBIN LEVELS

| | PRE-SHIFT | | POST-SHIFT |
|---|---|---|---|
| SMOKERS AND NON SMOKERS | | | |
| ALL (N=26) | | | |
| Mean % COHB | 2.53 | | 2.67 |
| Standard Deviation | 2.70 | | 1.77 |
| P Value* | | 0.42 | |
| REPAIR (N=4) | | | |
| Mean % COHB | 2.88 | | 4.85 |
| Standard Deviation | 4.02 | | 2.17 |
| P Value | | 0.21 | |
| NON SMOKERS | | | |
| REPAIR (N=3) | | | |
| Mean % COHB | 0.87 | | 3.93 |
| Standard Deviation | 0.32 | | 1.42 |
| P Value | | 0.01 | |
| OTHERS (N=17) | | | |
| Mean % COHB | 1.58 | | 1.88 |
| Standard Deviation | 1.48 | | 1.17 |
| P Value | | 0.258 | |

*Student T Test

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