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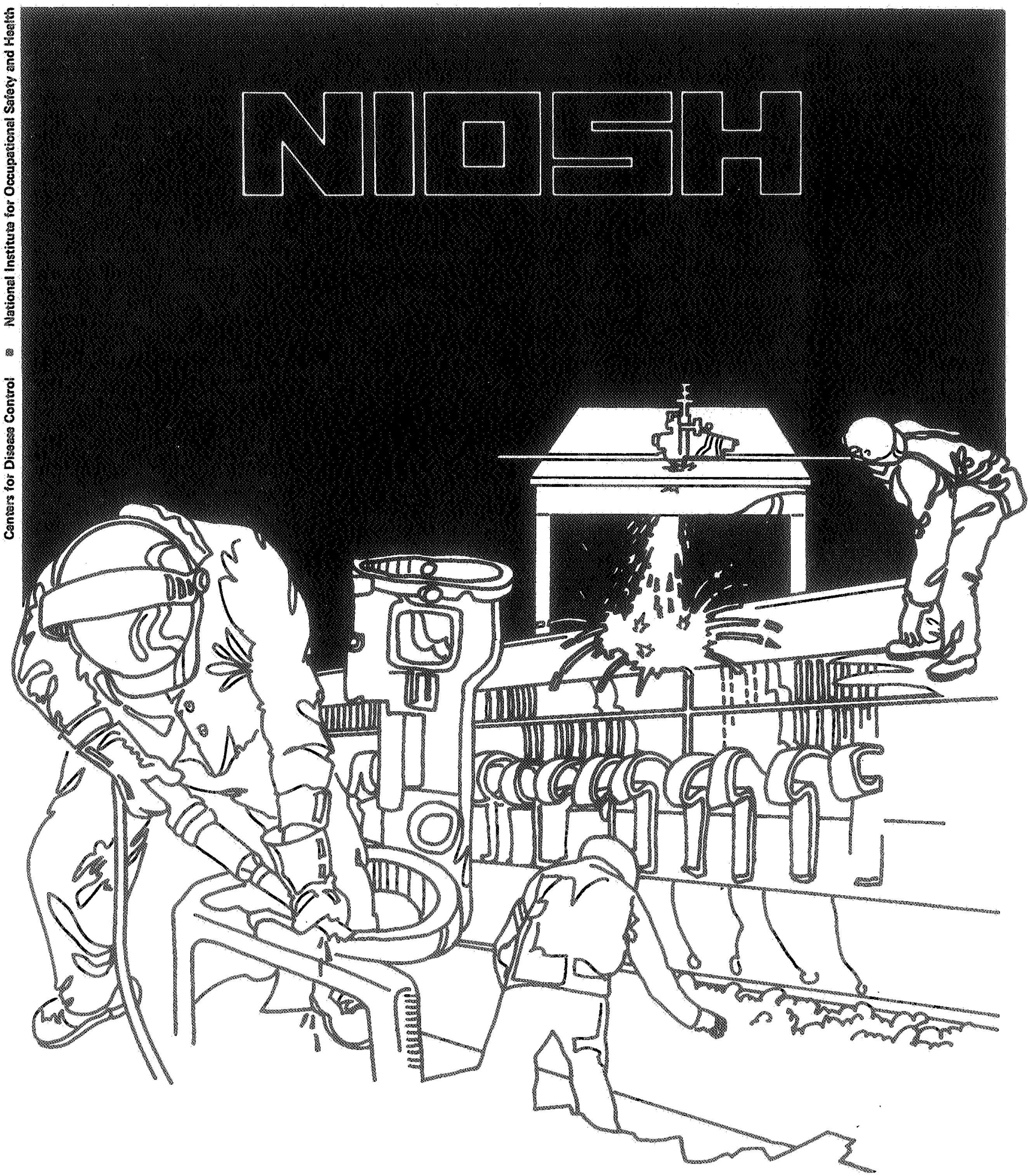

Health Hazard Evaluation Report

HETA 80-209-1396
CRAIN WESTERN
COMPTON, CALIFORNIA

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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CRAIN WESTERN
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I. SUMMARY

In July 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate the potential health effects to approximately 100 workers from exposure to toluene diisocyanate (TDI), methylene bisphenyl isocyanate (MDI), methylene chloride, methyl chloroform, and fluorotrichloromethane (Freon) at Crain Western, Comptom, California. Workers reported symptoms which included eye, nose, skin, throat, and respiratory irritation.

During September 1980, March 1981, and May 1982, NIOSH investigators conducted an industrial hygiene and medical evaluation at the plant. Personal and area air samples were obtained, the company's personal protection program was reviewed, and exhaust and make-up ventilation systems were evaluated. The medical evaluation consisted of medical questionnaires and pulmonary function tests.

Data from the environmental evaluation showed that concentrations of TDI in both the personal and area samples ranged up to 4.4 mg/m^3, which exceeds the NIOSH criteria for both time-weighted average (TWA) and short-term ceiling (C) exposure levels of 0.035 and 0.14 mg/m^3, respectively. Methylene bisphenyl isocyanate levels were all non-detectable and below the NIOSH criterion of 0.05 mg/m^3. The methylene chloride results ranged from 0.27 to 3.6 mg/m^3, which is less than the NIOSH criterion of 270 mg/m^3. The methyl chloroform results ranged up to 7.4 mg/m^3, which is less than the Occupational Safety and Health Administration (OSHA) standard of 1900 mg/m^3, and the Freon results ranged from 0.28 to 8.46 mg/m^3, which is also less than the current OSHA standard of 5600 mg/m^3.

The medical evaluation showed both acute and chronic symptoms of TDI exposure in a portion of the 14 workers evaluated. This included eye irritation, decreases in lung function, respiratory obstruction over the workday, and one case of reduced pulmonary function, which is compatible with chronic effects of TDI exposure.

Based on the data obtained in this investigation, NIOSH investigators determined that a health hazard existed from occupational exposure to toluene diisocyanate at Crain Western, Compton, California. The personal protection program and the existing exhaust ventilation systems were considered marginal in their ability to protect and/or reduce the exposure to the workers. Recommendations are included in Section VIII of this report to assist in resolving the concerns addressed in this report.

KEYWORDS: SIC 3069 (Fabricated Rubber Products, Not Elsewhere Classified), urethane foam, toluene diisocyanate, methylene bisphenyl diisocyanate, methylene chloride, methyl chloroform, fluorotrichloromethane, foam manufacturing.

II. INTRODUCTION

On July 15, 1980, an authorized representative of employees at Crain Western, Compton, California, submitted a Health Hazard Evaluation request stating that a number of potential health hazards existed to approximately 100 employees working in or around a urethane foam production process. Medical concerns included eye, nose, skin, throat, and respiratory irritation. An environmental and medical survey was conducted during September 1980 and March 1981. After each evaluation, recommendations were made during the closing conference, and these are included in this report. Individuals were contacted by mail regarding their medical results, and an interim medical report was sent to management on May 18, 1981. This medical information is also included in this report.

Because of questions which arose from the environmental data collected during the first two evaluations, NIOSH investigators reevaluated their sampling and analytical methods and performed a third evaluation in May 1982. The intent of this third investigation was to determine if either of the NIOSH methods used during the first two survey periods adequately addressed the true exposure conditions at Crain Western. Basically, it was felt by the NIOSH investigators and laboratory personnel that the environmental sampling technique used during the 1980 survey may have overestimated the TDI exposures at the plant. These concerns, as well as further discussions on the proper sampling and analytical techniques for evaluating foam operations, are discussed in this report.

III. BACKGROUND

Crain Western, Compton, California, is a producer of urethane foam materials; specifically, large polyurethane foam blocks (referred to as buns) which are sold to other wholesale manufacturers who use the foam material in a variety of different products. Crain Western also cuts these blocks, approximately 3 x 7 feet, into various lengths and into seat cushions, which are then sold primarily to furniture manufacturing companies.

A. Process Description

Crain Western's polyurethane foam production machine is located in the southwest area of the building and normally operates for approximately 3 hours per day, 5 days per week. This operation usually takes place between 12 noon and 3:00 p.m., and approximately 10-15 employees are engaged in the foam production process. It is Crain Western's intent to increase its production rate sometime during 1982 or 1983.

In order to produce the foam blocks, one fully automated machine integrates a variety of raw materials and, through an exothermic reaction, forms the final foam product. The raw materials used to form the urethane block are made of approximately 95 percent polyol and toluene diisocyanate (TDI) and 5 percent additional ingredients. These ingredients are amine catalyst, silicone surfactants, Freon (blowing agent), methylene chloride (fire retardant), and a pigment, if required.
The operation begins in the morning when one employee fills various small chemical tanks used as reservoirs to feed into the polyurethane foam process. The larger quantity of materials (TDI and polyol) is fed directly into the machine from larger tanks and tank cars located outside the building. All ingredients are fed automatically into a mixing valve by way of a computerized control panel. There are several types of foam produced, and the control panel accurately varies the ingredients as desired (e.g., color of foam, fire retardant material, length of run for that desired foam, etc.).

The individual chemicals are fed into the mixing valve and then into a trough where the actual flow of the urethane foam down the foam line begins. The foam line is a long, enclosed tunnel (approximately 80 x 8 x 5-1/2 feet) which receives the liquid chemical mix at one end from the trough and produces a continuous foam block out the other end. As the trough is filled, it eventually overflows onto a conveyor which moves the overflow foam down the enclosed tunnel. As the liquid foam moves through the tunnel, it begins its thermo reaction (temperature equals 200-250 degrees Fahrenheit) and rises like a cake. Within minutes the foam has risen to approximately 90 percent of its height.

In the beginning phase of running the liquid foam out of the trough and into the conveyor tunnel, three to four employees are required to assist in making sure the foam runs properly through the tunnel. Here the employees use long poles and a bun retainer block which is used as a barrier between the initial foam material coming out of the trough and the open tunnel. After the flow begins and the conveyor starts moving, the employees, with the aid of long poles positioned against the block, move through the tunnel holding the poles against the block until the foam is completely outside the end of the tunnel. As the flow continues, the foam block then travels approximately 40-50 feet to a cutting station where it is automatically cut into blocks by a band saw. The band saw operator stands approximately 10 feet away from the saw. The blocks are cut into various lengths, depending on the customer's order. As the blocks are cut, one employee codes/marks the side of the block and four to eight workers transfer the block from the conveyor belt onto dollies. They then move the block by way of dollies into the main warehouse floor, which is adjacent to the foam tunnel. While the blocks are on the floor, the thermo reaction will increase the initial temperature of 200-250^{o}F to about 300-325^{o}F.

The blocks stay on the warehouse floor until the next day, when they are transferred to another area for further cutting and shipping. After this portion of the process is complete, the initial foam preparation process starts once again.

B. Employees at Risk

The employees with the highest potential exposure (at highest risk) to the chemicals evaluated in this survey are those who work directly with the production of the urethane foam blocks (e.g., technical director, pour control operators, foam handlers, band saw operator, marker, lineman, and foam stackers). These jobs/exposures are located at the control panel, trough area, outside and inside the entire length of the tunnel and/or catwalk, band saw control panel area, bun marker area, or any employee who is in the immediate area where the foam buns are positioned on the warehouse floor.

Another group of employees with potential exposure are those responsible for cleaning the conveyor rollers with methylene chloride. This task is performed about every third day and takes between 3-4 hours to perform.

C. Engineering Controls

At present, the automated foam line and the area where the foam buns are placed in the warehouse takes up approximately 24,000 square feet of space. During the survey period, there were various types of both local and general exhaust ventilation systems in use.

The local exhaust systems were located in the foam tunnel and over the band saw cutting area. There were two exhaust hoods in the tunnel and each was approximately 3 feet in diameter. The other local exhaust system was directly over the band saw.

D. Personal Protective Equipment

During the survey, Norton 7500-30 half mask-type respirators with TC-23C-49 organic vapor-type cartridges were available to the foam line employees. At the time of the NIOSH survey, the respiratory program had only been implemented for a short period. Respirators were the only personal protective equipment used by the foam line workers.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

A variety of sampling techniques were used to evaluate the suspected contaminants. Personal samples were taken on selected employees from each area of concern. Area air samples were also taken during the survey periods. The following is a description of the sampling techniques used:

1. Toluene Diisocyanate and Methylene Bisphenyl Isocyanate

   Personal and area samples for the isocyanates were taken using NIOSH Method Nos. P&CAM 141 and 142, and an impregnated glass fiber filter (P&CAM No. 347 - Proposed). The air was pulled through the media with high- and low-flow sampling pumps. The flow rates were set at 1 liter per minute (lpm), 50 cubic centimeters per minute (cc/m), and 200 cc/m.

2. TDI-Field Comparsion Methods

   As described in the introduction section of this report, the NIOSH investigators and laboratory personnel thought that the results found when using the 1980 sampling technique (Marcali Method) differed sufficiently enough from the 1981 technique (Proposed NIOSH Nitro Reagent Method) to question the validity of the results. After comparing the two sets of data, it was apparant that either the process at the plant had changed significantly or the evaluation methods were erroneous (suspect), which might account for the major differences in the results found during the two survey periods.

   In regards to the former concern, the company stated that the production process and/or rate of production during the 1980 versus the 1981 survey did not change. Therefore, it was the opinion of the NIOSH investigators that this should not have significantly altered the results. From this information, it was assumed that one of the analytical methods may be in question as a viable technique to measure the true chemical exposures that existed at Crain Western.

   Because of these considerations, NIOSH investigators decided to attempt to reevaluate both methods, as well as a new method, and sample all three of these side by side in an attempt to resolve the discrepancy. The third method used during the reevaluation survey was the MOPIP method, which is a new NIOSH research and development method. This method uses a derivative forming reagent 1-(2-methoxyphenyl), piperizine, which samples monomeric aromatic and aliphatic isocyanates. Each of the three methods used an impinger technique, and air was pulled through the sampling pumps at a flow rate of 1 to 1.5 lpm.

   Each of the three sampling systems were positioned in seven locations in the production area. Further information is described on these sampling systems later in this report.

3. Methylene Chloride, Methyl Chloroform, and Fluorotrichloromethane

Personal and area samples for these chemicals were taken using charcoal tubes and low-flow pumps. The pumps drew the air through the tubes at a flow rate of 50 cubic centimeters per minute. The samples were analyzed by gas chromatography following a modification of NIOSH Method No. P&CAM 127.

B. Medical

The NIOSH medical evaluation included:

1. General discussions with company and employee representatives,

2. Review of previous evaluations (insurance carrier and private consultants),

3. Observation of work processes and work practices,

4. Review of employee medical records, e.g., pulmonary function tests and X-rays.

Medical interviews and pulmonary function tests were performed on workers on the foam production line, including workers who pulled the foam at the end of the line. The tests on 13 workers were performed before and after the shift on March 17, 1981. One worker went home with the flu on March 16, 1981, and only participated in the first and third tests. Workers were interviewed to elicit the following information: length of employment; previous exposures to TDI; smoking history; history of pulmonary disease or allergy; and presence of symptoms--skin, eye, and respiratory irritation, chest tightness, and shortness of breath.

Pulmonary function tests were performed on a Spirotech 200B recording spirometer and included determination of forced vital capacity (FVC), 1-second forced expiratory volume (FEV_1), and calculation of the ratio of FEV_1/FVC in volumes and percent normals. FVC measures the total amount of air one can force out of his lungs after breathing in as deeply as possible. FEV_1 measures the amount of air one can breathe out in the first second. The FVC can be impaired by restrictive lung disease, such as pulmonary fibrosis. FEV_1 can be impaired by cigarette-related lung damage or some other conditions causing obstruction to air flow. Any condition that impairs FVC usually impairs FEV_1, but the reverse is not true. Conditions that impair FEV_1 do not necessarily impair FVC. The FEV_1/FVC ratio is also used to help evaluate obstructive lung disease.

In interpreting the results, the best test ~~results~~ are used. They are compared to "predicted values," which take into account age, height, sex, and race. Pulmonary function is considered "normal" if the best FEV_1 and the best FVC are each 80 percent or more of their respective predicted values, and the FEV_1/FVC ratio using the best values is 70 percent or more.

Each worker's height was measured and, if a worker complained of chest symptoms, a brief examination was performed with a stethoscope.

V. EVALUATION CRITERIA AND TOXICOLOGY

A. Environmental

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 (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, 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 only 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.

The environmental and medical (toxicological) evaluation criteria used for this investigation are presented below:

	Permissible Exposure Limits 8-Hour Time-Weighted Exposure Basis (mg/m^3)		
	NIOSH	OSHA	TLV
Toluene diisocyanate (TDI)*...........	0.035 0.14(C)[1]	0.14	0.04
Methylene bisphenyl isocyanate (MDI)..	0.05	0.2(C)[2]	0.2(C)[2]
Methylene chloride....................	270 1800(C)	1800	360
Methyl chloroform.....................	1900(C)	1900	1900
Fluorotrichloromethane................	----	5600	5600(C)

mg/m^3 = milligrams of substance per cubic meter of air.
(C)[1] = ceiling level which cannot be exceeded beyond a 20-minute period.
(C)[2] = ceiling level which cannot be exceeded beyond a 15-minute period.
Note: The TDI standard is based on the monomeric effects and do not consider the potential polymeric effects. Also, NIOSH states that their recommended standard is expanded to include all diisocyanates, but not their polymerized forms.

B. Medical/Toxicology

1. Toluene Diisocyanate (TDI)

TDI is used in a variety of manufacturing products. The polymer-forming abilities of these compounds constitute the bulk of their use in products such as polyurethane foams (soft and rigid), coatings (paints, varnishes, finishes), elastomers, adhesives, castings resins, thermoset engineering plastics, and synthetic fibers. It is a volatile liquid, vaporizing easily in normal room conditions. Its liquid and vapor are both highly reactive and irritating. In low concentrations, it can irritate eyes or respiratory passages[2], and can cause narrowing of the small airways in the lungs. In high concentrations, it can affect the nervous system, causing such symptoms as loss of balance and memory loss.

Nearly all of the toxicology data available on isocyanates address the monomeric forms of diisocyanates. Many of these investigations have been directed towards determining the extent, nature, and mechanism of the "sensitization" phenomenon associated with these compounds, and only a few have addressed the toxicology associated with the polymeric form.

The result of this sensitization is an adverse respiratory response in individuals when they are exposed at concentrations much lower than those that irritate the respiratory tract in most people. The reaction may be gradual and require more than one exposure, or it may be sudden. In either case, the usual response is an asthma-like reaction. A classic immunotoxic response, or sensitization, implies an altered degree of susceptibility caused by a primary exposure and manifested in a reaction due to a subsequent exposure to the same material or one closely related to it. This prior sensitization needs to be by the same material. The close relationship in the case of isocyanates could well be merely the presence of the isocyanate functionality. In a classic immune response, antibodies would be produced and subsequent exposures would result in typical antigen/antibody interactions which provoke the physical manifestations, in this case, the asthma response.

Evidence of true immunologic interactions to date has been scant. A small number of people, however, do develop sensitivity to TDI, which then causes reactions as described above. This can also manifest itself as a skin rash. TDI-induced asthma can become incompacitating or even cause death. It has been suggested that people with a history of asthma or allergy should not work with isocyanates, but it has not been shown that these people are any more liable than anyone else to become sensitized to TDI. Attempts to predict who would become sensitized to TDI by measuring their reaction to methacholine challenges have not been successful[4].

Long-term exposure to low levels of isocyanates has been associated with an increased number of acute chest infections, and with a chronic decrease in pulmonary function[5]. The decrease does not affect all workers, but has been detected in groups of workers by showing an average decrease of FEV_1 over a 2-year period[6]. An average decrease of FEV has been shown also over the course of a single day. Workers were tested before and after work on Monday, and showed decreases which returned to normal while they were off work[7].

TDI is mutagenic when assayed using the Ames test[8]. This effect may be due to the amine analogues formed during the hydrolysis of isocyanates, which may occur when isocyanate vapors are caught on moist surfaces, skin, or respiratory mucosa. The TDI analogue 2,4 toluene diamine has been shown to produce cancer in rats.

Two animal carcinogenicity studies of TDI have been conducted. Both are limited in study design and show conflicting results[9,10]. A gavage study found TDI to be carcinogenic in rats causing subcutaneous fibromas or fibrosarcomas in males and females, pancreatic acinar-cell adenomas in males and pancreatic islet-cell adenomas, neoplastic nodules of the liver, and mammary gland fibroadenomas in females[9]. TDI was also carcinogenic in female mice causing hemangiomas or hemangiosarcomas and hepatocellular adenomas. It was not carcinogenic for the male mice.

An inhalation study of male and female mice found no statistically significant increase in tumor incidence[10]. However, exposure levels were quite low. The low exposure group (0.05ppm) received a dose equivalent to human occupational exposures in the 1950's and 1960's (0.02 - 0.06 ppm)[14]. While mice were exposed for 2 years, humans are exposed for periods up to 25 years. Thus, the low exposure group was exposed to a dose approximately 10 times lower than lifetime human occupational exposure. Major pathological dose-related changes in the nasal cavity were reported. The specific incidence of squamous metaplasia, a potential precursor of malignant disease, was omitted from the report.

No epidemiologic studies of TDI workers have been published that look at the question of cancer risk in exposed worker groups.

The recent concern for the potential toxicity of polyisocyanates in TDI production stems from the fact that these polyisocyanates are very reactive and may have much the same reactivity with biosystems as the monomeric material. Inhalation of an aerosol that contains active isocyanate groups could well lead to respiratory irritation. This possibility is currently driving a number of research studies which are investigating the toxicology of polyisocyanates.

These investigations can best be summarized with a recent study by Weyel, et al., (1982), at the University of Pittsburgh were they investigated the inhalation toxicology of polyisocyanate exposures. They found, in mice, that certain polyisocyanates acted primarily as a pulmonary irritant which induced a decrease in respiration rate. The sensory irritation they observed was not characteristic of upper respiratory irritants as in monomeric isocyanate exposures, but was shown to be an irritation of the lower airways. Further exposures of mice to 2,4 TDI failed to induce a decrease in the respiratory rate due to pulmonary irritation. Weyel stated that the polyisocyanate (DES-N) studied had a pulmonary irritation potency approximately six times that of NO_2, and proposed that since the TLV-TWA for NO_2 to prevent pulmonary irritation is 6 mg/m^3, a good TLV-TWA for DES-N might be 1 mg/m^3. In order to prevent exposures above 1 mg/m^3, a TWA value of 0.5 might be appropriate.

2. <u>Methylene Bisphenyl Isocyanate (MDI)</u>

MDI is less volatile than TDI. For this reason, it is less likely to be found in toxic amounts in the workplace, and is less reactive. Its effects are otherwise similar to those of TDI[1].

3. <u>Methylene Chloride</u>

Methylene chloride is a colorless liquid solvent used in paint removers, fire extinquishers, and plastics. It can irritate the eyes, skin, and respiratory tract, and in high concentrations it can depress the nervous system or cause liver and kidney damage[1].

4. <u>Methyl Chloroform (Trichloroethane)</u>

Methyl chloroform is a colorless liquid used as a solvent and cleaning agent. In high concentrations, it can cause depression of the nervous system, and in low concentrations is a mild eye irritant[1].

4. <u>Fluorotrichloromethane (Freon 11)</u>

Freon is a trade name for certain halogenated hydrocarbons. Freon 11 is fluorotrichloromethane, and is used as a solvent, as a propellant for aerosols, and in fire extinguishers[1]. It can cause skin irritation, sensitize the skin, and cause allergic dermatitis[11]. When inhaled at elevated concentrations, it is a central nervous system depressant causing sleepiness, loss of concentration and manual dexterity, and "heaviness" in the head. These symptoms usually disappear rapidly when the exposure is ended. It may cause cardiac arrhythmias when inhaled, probably by sensitizing the heart to the effects of epinephrine[12]. Cases of sudden death have been reported following heavy exposures; and these may have been due to heart arrhythmias[13].

VI. RESULTS AND DISCUSSION

Employee exposure to suspected airborne concentrations of toluene diisocyanate, methylene bisphenyl isocyanate, methylene chloride, methyl chloroform, and fluorotrichloromethane (Freon) were elevated. An evaluation of the general and local exhaust ventilation systems, as well as the company's personal protection program, was also assessed during the survey periods. The following are the results and conclusions of NIOSH's evaluation.

A. Environmental

1. Toluene Diisocyanate-September 1980 and March 1981 Results

A total of 36 personal air samples and 57 area air samples (42 for the comparative sampling study which is discussed in the next subsection) were taken during the survey periods for TDI (refer to Tables 1-4).

The results for the personal samples ranged from 0.22 - 0.33 mg/m^3 for the September 1980 evaluation (MARCALI METHOD), and non-detected (ND) to 0.08 mg/m^3 for the March 1981 survey (NITRO METHOD). The ceiling level samples for the September 1980 study ranged from ND to 1.05 mg/m^3, and ND to 0.17 mg/m^3 for the March 1981 evaluation. These results did indicate a significant exposure to those individuals evaluated during the September survey for both sampling periods when compared to NIOSH's 20-minute ceiling level of 0.14 mg/m^3.

The area sampling results for TDI (Table 3) ranged from ND to 1.94 mg/m^3 and were taken during the March 1981 survey. Again, this sampling was with the new NIOSH sampling method and does indicate levels which exceed the criteria established for this study.

The results for the March evaluation also suggest exposures exceeding the criteria, although there was a significant difference between the percent of excursion above the criteria for the September 1980 study versus the March 1981 survey (75%

versus 7%). Because of this major difference in results, the NIOSH Project Officer and laboratory personnel thought that this was not due to a change in the work process, chemical process, or production rate, since these variables remained relatively constant for both surveys. NIOSH investigators thought that the major difference in results from the September 1980 versus March 1981 study may have been due to the different sampling techniques used during these surveys.

2. Toluene Diisocyanate (TDI)-May 1981 Comparison Study

Before describing the results from the May 1981 comparison study, it is important to discuss a few of the recent concerns regarding the need for choosing to do the comparative study at Crain Western. In the past few years, NIOSH and others have been involved in field investigations where there have been complaints from workers of respiratory problems while working with various isocyanate systems. The majority of these complaints came from workers using polyisocyanate-based urethane coatings and paints, especially during spray applications. In nearly all of these instances, environmental sampling showed exposures to monomeric diisocyanate to be well below current PEL's or TLV's. This was true even for systems which used monomeric diisocyanates as one of the reactive components. Given the reactivity of the polyisocyanate systems and the potential for biologic interaction, it seemed logical to consider a monitoring approach that would provide information on the presence of the reactive functionality of the system, whether it be monomer or polymer.

The most current sampling methods used for determining TDI exposures in an environment are the Marcali and the Nitro Methods, and each of these have their inherent errors when sampling TDI exposures.

The Marcali method is not specific for individual isocyanates and suffers from positive interferences, including polymeric isocyanate.

The Nitro Method is specific, but not very clean and will often be influenced by a large number of interfernces indicative of reactive polymer, which could bias the results.

A third technique, the MOPIP Method, was selected to attempt to resolve these biases. The MOPIP Method uses a urea-forming reagent (1-(2-methoxyphenyl) piperizine which is used for specific sampling of monomeric and aliphatic isocyanates. An added feature of this method is that it easily allows quantitation of both monomer in addition total isocyanate present in the sample. Therefore, an attempt was made on the May 1981 comparison survey to answer the following questions:

1. Was there a significant contribution from polymeric material or an aromatic amine to sufficently bias the September 1981 results?

2. What was the nature of the material being monitored by sampling systems susposedly designed to detect the monomer only. If the Nitro data are less than the Marcali, the difference could possibly be due to polymer in the Marcali sample and, therefore, result in biasing the data.

When reviewing the comparison data (refer to Table 4), the Nitro and MOPIP concentrations are consistently lower than the Marcali data, indicating the presence of aromatic amine or polymer. Therefore, the comparison sampling methods indicate that, for the TDI-based urethane foam fabrication process evaluated at Crain Western, the predominant airborne exposure was to polymeric rather than monomeric isocyanate.

3. Methylene Bisphenyl Isocyanate (MDI)

A total of 36 personal air samples and 15 area air samples were taken during the survey periods for MDI (refer to Tables 1-3). The levels for both the surveys ranged from ND to 0.007 mg/m^3, which does not indicate that a health hazard from MDI existed for the employees during any of the survey periods.

4. Methylene Chloride, Methyl Chloroform, and Freon

A total of 18 personal samples were taken and analyzed for methylene chloride, methyl chloroform, and fluorotrichloromethane (Freon) (refer to Table 4). Each of the results for these chemicals was below the criteria established for the survey. It should be noted, however, that the results for methylene chloride (those with the asterisk) were reported by the laboratory to have a significantly large portion of the material on the reference section (B-portion) of the sampling tube. This sampling tube has an A and B portion, and if any material is present on the B-portion, this is an indication that a significantly larger quantity of the material is present in the environment and, therefore, large enough to saturate the A-section and a portion of the backup B-section, which should not have any material on it. Since these samples were drawn at only 50 cubic centimeters per minute, this is suggestive that these results are substantially lower than they should have been, and that a much larger concentration of methylene chloride was present. It was also noted by the Project Officer that some of those individuals did show skin irritation on their hands and face, and all of these employees did complain of eye irritation. Both of these symptoms are common with exposures to methylene chloride.

5. Engineering Controls

During the NIOSH investigation, three local and two general exhaust ventilation systems were evaluated. The two exhaust systems located in the foam tunnel were approximately 3 feet in diameter. While foam was being produced through the tunnel, the exhaust rates ranged from 100-150 feet per minute (fpm) at the entrance/trough area, 1000-1500 fpm at the windows along the sides of the tunnel, and 1000-1500 fpm where the foam exits the tunnel.

The exhaust hood located over the band saw where the foam is cut was 10 x 12 feet and was suspended approximately 5-1/2 feet off the ground. During the foam production, the distance from the top of the foam bun to the face of the hood is about 2 feet. The exhaust rates received while the foam was passing under the hood ranged from 150-250 fpm.

There are two general area exhaust fans which are located in the roof of the curing area where the foam blocks are placed. One is a 5-horsepower, 21,000 cubic feet per minute (cfm) exhaust fan, and the other 10-horsepower, 45,000 cfm. It was difficult to determine how effective these systems were, but during a smoke tube and volumetric test, investigators determined that very little (5-15 fpm) air was moving in the curing area while the foam buns were in this area.

6. Personal Protection Program

Investigators found the only personal protection offered to the foam operators was respirators (half-mask/organic vapor types), which were worn only occasionally by the workers. The overall respiratory program was marginal, at best, and does not address education concerning respiratory use, respirator fit testing, determination of the health of the employee to wear a respirator, or respirator recordkeeping. Finally, there was no eye protection or special protective clothing worn by any of these employees during the foam operation.

B. Medical

Two workers gave a history of allergy at some time in the past. Eight had symptoms of an upper respiratory infection at the time of the study. These symptoms included a stuffy or running nose, sore throat, or cough. Seven workers (including two with a respiratory infection) developed symptoms during the shift suggesting irritation from TDI. These were eye burning, itching, or tearing in all seven, and chest tightness or soreness, a wheeze, or shortness of breath in two. All seven of the workers stated that these symptoms either developed or became worse during the working day; all but one reported disappearance of symptoms overnight. Four workers showed a change in pulmonary function, consisting of a decrease of FEV_1, during the working day. Two of these individuals may not have made a maximum effort during spirometry and, for this reason, are not felt to have had a clearly defined obstructive defect. Of the remaining two, one had a concurrent respiratory infection. The fourth worker was one of those who reported irritative symptoms that became worse during the day. He demonstrated a moderate decrease during the day on his pulmonary function test. (See Table 5.)

One other worker had a moderately reduced FEV_1 which did not change during the day. He is a non-smoker with a history of allergies who has worked with TDI for many years; his decreased function is compatible with a chronic effect of TDI exposure.

The average FEV_1 for the entire group dropped 0.116 liters at the end of the working day. The following morning (Tuesday), it was still 0.078 liters below the average value on Monday morning. This decrease is compatible with that reported by others[5,6].

VII. CONCLUSIONS

1. Environmental

NIOSH investigators concluded that a portion of the employees at Crain Western were being overexposed to TDI, and this adversely affected their health. These conclusions are based on both the environmental and medical data collected, as well as the lack of adequate exhaust ventilation and personal protection available to the employees involved in the foam operation.

The data collected for the comparison evaluation indicate that the TDI-based urethane foam fabrication process at Crain Western produces primarily a polymeric rather than monomeric isocyanate. Therefore, the greatest exposure to the majority of workers on the foam line is to the airborne isocyanate polymer rather than the monomer present in the operation. Specifically, the monomer contaminate in this type of operation would normally be found in and around the pouring area, while the polymer contaminate would be found in areas outside this location.

Based on these considerations, the following are the major conclusions which can be made about the comparison study:

1. The NITRO and MOPIP methods agreed well for TDI, which is good since both are specific for TDI.

2. Both NITRO and MOPIP were lower than Marcali and, thus, there was a positive bias in Marcali.

3. The MOPIP determination of polytypic isocyanate were the most significant data in regards to the true exposure in this environment.

2. Medical

Medically, the concentrations of TDI on the foam line have also been sufficient to cause symptoms of irritation in half of the work force. One worker showed a moderate effect on his lungs during the working day, and one worker showed chronically decreased pulmonary function. These lung effects are also compatible with exposure to TDI. We did not find conclusive evidence that any workers have yet become sensitized to TDI.

It should be noted that it was told to the NIOSH investigators that the production rate and/or time of production was going to be increased due to greater demand for the foam products at Crain Western. With this information, and that described above, it can only be assumed that the exposure to the workers NIOSH evaluated would be greater with this proposed increase in production.

VIII. RECOMMENDATIONS

In view of the NIOSH environmental and medical study, the following recommendations are made to ameliorate potential health hazards and to provide a better work environment for the employees covered by this determination. These recommendations are especially necessary because of the increase in production anticipated and information presented in previous evaluations (Olin, 1976, and Firemen's Fund, 1978), each of which also showed excursions.

A. Environmental

Whenever possible, engineering controls are the preferred method for decreasing potential exposures to toxic substances. Therefore, based on the evaluation of the present data and the environmental problems discussed in Section VI, the following recommendations should be implemented as soon as possible, if they have not been already.

1. Ventilation

a. Local Exhaust Ventilation

The local exhaust systems used in the foam tunnel are providing sufficient exhaust to remove the contaminants at both the windows and the pouring area. However, in order to reduce the offgasing which is occurring outside the tunnel, an additional exhaust system between the tunnel exit point and the band saw cutting area should be added. An additional exhaust system should be one hood which extends from the tunnel exit point to beyond the cutting area. This would then have two exhaust ducts with one canopy hood feeding both.

Another recommendation which would increase the capture velocity of the existing system, as well as the proposed exhaust system, would be side shields or drapes on both sides of the line which would extend from the exit point to the cutting area. This proposed addition would be similar to the present foam tunnel, with either portable sides (drapes) from the floor to the exhaust hood, or curtains which could open and close as necessary during production. In order to increase the overall exhaust of the contaminant, it is also essential that the existing hood or the proposed hoods extend as far down to the product as possible. By instituting this type of exhaust system, the sides of the blocks (buns), which are also offgasing, would be exhausted as well.

b. General Exhaust Ventilation

The proposed system described above would reduce the exposure to those individuals who work in and around the exit point of the tunnel and band saw cutting areas. It is also necessary to reduce the exposure in the curing area where the buns are placed. At present, there are two overhead roof exhaust fans which did not appear to effectively remove the contaminated air. Thus, it is recommended that additional roof exhaust fans be installed. An additional means of effectively removing the contaminants would be to totally partition off this curing area from the foam tunnel, band saw cutting area, and other areas where employees are potentially exposed. These additions would confine/enclose this area and provide the most efficient exhausting system and, therefore, reduce the exposure to those employees working on the foam production line. This could be attained by permanent walls or partitions (drapes or curtains), which could be opened and closed as necessary.

2. Personal Protective Procedures

a. Respiratory Protection

When the limits of exposure cannot be immediately met by limiting the concentrations in the work environment by engineering and administrative controls, the company should utilize a program of respiratory protection. The following is a brief description of some of the primary concerns which should be addressed in such a program. (Further information on this topic is available in the NIOSH Publication No. 76-180, "A Guide to Industrial Respiratory Protection.")

(1) Each of the employees who work inside the tunnel when the foam operation first begins should wear a respirator during this phase of the process. The respirator should be a NIOSH/MSHA-approved combination vapor and particulate type. Those employees who are responsible for moving the foam buns from the line to the curing area should use respirators throughout this operation. Also, those employees responsible for cleaning the rollers with methylene chloride should be required to wear a respirator throughout the process.

(2) Respirators should be issued with caution. There might be individuals in the group for whom wearing a respirator carries certain specific dangers, i.e., highly increased resistance to airflow in a person with compromised pulmonary function may be associated with acute respiratory insufficiency. Employees experiencing frequent and continuous breathing difficulty while using respirators should be evaluated by a physician to determine the ability of the worker to wear a respirator.

(3) Each employee should be fit tested to assure his respirator is providing maximum protection.

(4) Employees should be given instructions on the proper use of respirators.

(5) There should be an established in-plant procedure and means and facilities provided to issue respiratory protective equipment, to decontaminate and disinfect the equipment, and to repair or exchange damaged equipment. Complete records of these activities should be maintained.

The respiratory program should be designed to the OSHA requirements outlined in 29 CFR part 1910.134. Finally, for those individuals who are not getting a proper respirator face mask fit, alternative respirators should be made available.

b. Other Personal Protective Needs

(1) Personal protective clothing including shoes should be provided to those employees in the foam production operation. This clothing should be disposable clothing or clothes to be worn only at work and should be washed or disposed of according to need. This would include shoes, pants or coveralls, and shirt.

(2) Eye protection (protective goggles) should be provided and worn by every employee who must be in immediate contact with the raw or final product, e.g., preparations man, employees inside the tunnel, bun movers, as well as those employees who clean the rollers.

(3) Protective gloves that are impervious to methylene chloride should be used by the bun movers and the employees who clean the rollers.

c. Other Recommendations

The following health concerns were noted during the survey period.

(1) The practice of cleaning one's hands with methylene chloride should be eliminated. This increases not only inhalation of this substance by the worker, but also exposure by cutaneous absorption.

(2) The use of a high-pressure nozzle for cleaning one's shoes, clothes, and equipment should be eliminated. This will also increase the exposure to the worker.

(3) Smoking should not be permitted anywhere around the foam production area.

(4) It should be noted that many of the above recommendations were mentioned in previous reports and that many of these have been only partially implemented. With the advent of the increase in production, it is imperative for the workers' health that these concerns be resolved. Finally, once the company increases its production and improves its exhaust ventilation systems, it is imperative that another environmental survey be performed in order to effectively characterize the new exposures. NIOSH can provide this service at that time.

3. Environmental Monitoring

Based on the comparative study that was performed in this investigation, NIOSH investigators recommend that when the company performs environmental monitoring of the workplace, special emphasis be placed on the need to properly characterize the specific type of exposure. That is, based of the results of the May 1981 study, it would appear that the proper technique would be either the NITRO or MOPIP methods. This should then address more adequately the true TDI exposures that exist in the foam production operation at Crain Western.

B. Medical

1. All workers on the foam line should be followed with annual spirometry examinations. If these are abnormal or show a progressive decrement, full pulmonary function tests should be done.

2. The worker with pulmonary function tests compatible with chronic effects of TDI exposure should have a complete examination and his health status followed by a physician.

3. The worker with a clearcut reduction of FEV_1 following exposure to TDI should have further examinations including pulmonary function tests following a challenge with TDI. If he has become sensitized to TDI, he will need to be protected against further TDI exposure.

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Union and Management:

NIOSH is thankful to the management and the employees for their cooperation and assistance with this Health Hazard Evaluation. The information gathered from this study will not only assist in maintaining the health and safety of those persons working at this company, but also other companies who perform similar operations.

XI. DISTRIBUTION AND AVAILABILITY

Copies of this 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 Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies of this report have been sent to:

1. Crain Western.
2. U.S. Department of Labor/OSHA - Region IX.
3. NIOSH - Region IX.
4. California State Department of Health.
5. State Designated Agency.

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

TABLE 1

SUMMARY OF PERSONAL AIR SAMPLES FOR
TOLUENE DIISOCYANATE-BY MARCALI METHOD

Crain Western
Compton, California

September 1980

Sample Date	Job/Area Description	Sample Time (minutes)	Toluene Diisocyanate (mg/m^3)
9/9/80	Assistant Superintendent	90	0.33*
9/9/80	Foam Cutter	90	0.22*
9/9/80	Foam Handler	90	0.22*
9/9/80	Foam Handler	90	0.33*
9/11/80	Assistant Superintendent	20	ND
9/11/80	Foam Cutter	20	1.05*
9/11/80	Foam Cutter	20	0.20*
9/11/80	Foam Cutter	20	ND
ENVIRONMENTAL CRITERIA		NIOSH	0.035 mg/m^3
			0.14 mg/m^3 (C)[1]
		OSHA	0.14 mg/m^3
LIMIT OF DETECTION			4 ug

* = Sample exceeded ceiling criteria
ND = Non-detectable (below level of analytical detection)
mg/m^3 = Milligrams of substance per cubic meter of air
ug = Micrograms per sample
(C)[1] = Ceiling level not to be exceeded for a 20-minute period

TABLE 2

SUMMARY OF PERSONAL AIR SAMPLES FOR
TOLUENE DIISOCYANATE-BY NITRO METHOD

Crain Western
Compton, California

March 1981

Sample Date	Job/Area Description	Sample Time (minutes)	Toluene Diisocyanate (mg/m^3)
3/17/81	Supervisor	180	ND
3/17/81	Assistant Superintendent	180	ND
3/17/81	Pouring Operator	180	ND
3/17/81	Production Helper	180	ND
3/17/81	Marker	180	0.01
3/17/81	Cutter	180	0.01
3/17/81	Foam Handler	180	0.01
3/17/81	Supervisor	20	ND
3/17/81	Assistant Supervisor	20	ND
3/17/81	Pouring Operator	20	ND
3/17/81	Production Helper	20	ND
3/17/81	Marker	20	0.06
3/17/81	Cutter	20	0.07
3/17/81	Foam Handler	20	0.07
3/19/81	Foam Handler	180	0.003
3/19/81	Foam Stacker	180	ND
3/19/81	Lineman	180	0.02
3/19/81	Marker	180	0.03
3/19/81	Cutter	180	0.08*
3/19/81	Foam Stacker	180	0.02
3/19/81	Foam Handler	180	0.02
3/19/81	Foam Handler	20	0.02
3/19/81	Foam Stacker	20	0.05
3/19/81	Lineman	20	0.07
3/19/81	Marker	20	0.07
3/19/81	Cutter	20	0.08
3/19/81	Marker	20	0.17*
3/19/81	Foam Handler	20	0.06

ENVIRONMENTAL CRITERIA	NIOSH	0.035 mg/m^3 0.14 mg/m^3 (C)[1]
	OSHA	0.14 mg/m^3
LIMIT OF DETECTION		3 ug

* = Sample exceeded criteria
ND = Non detectable (below level of analytical detection)
mg/m^3 = Milligrams of substance per cubic meter of air
ug = Micrograms per sample
(C)[1] = Ceiling level not to be exceeded for a 20-minute period.

TABLE 3

SUMMARY OF AREA AIR SAMPLES FOR
TOLUENE DIISOCYANATE-BY NITRO METHOD

Crain Western
Compton, California

March 1981

Sample Date	Job/Area Description	Sample Time (minutes)	Toluene Diisocyanate (mg/m^3)
3/17/81	Pouring Area	180	0.07*
3/17/81	Booth Window	180	1.94*
3/17/81	Tunnel Exit	180	0.07*
3/17/81	Flow Control Stand	180	0.02
3/18/81	Booth Railing	180	0.01
3/18/81	Stacking Area	180	0.01
3/18/81	Stacking Area	180	0.003
3/18/81	Stacking Area	180	ND
3/18/81	Foam Cutting	180	0.01
3/18/81	Pouring Area	180	1.67*
3/18/81	Booth Window	180	0.94*
3/19/81	Pouring Area	20	0.01
3/19/81	Pouring Area	20	0.02
3/19/81	Pouring Area	20	0.03
3/19/81	Pouring Area	20	0.02
ENVIRONMENTAL CRITERIA		NIOSH	0.035 mg/m^3 0.14 mg/m^3 (C)[1]
		OSHA	0.14 mg/m^3
LIMIT OF DETECTION			3 ug

* = Sample exceeded criteria
ND = Non detectable (below level of analytical detection)
mg/m^3 = Milligrams of substance per cubic meter of air
ug = Micrograms per sample
(C)[1] = Ceiling level not to be exceeded for a 20-minute period.

TABLE 4

FIELD COMPARISON OF 2,4-TOLUENE DIISOCYANATE
SAMPLING AND ANALYTICAL METHODS

May 1982

Sample Date	Job/Area Description	Sample Time (minutes)	NITRO	mg/m^3 MOPIP	MARCALI
5/3/82	Pouring Area	180	0.009	0.009	0.03
5/3/82	Booth Window	180	0.22*	0.15*	4.4*
5/3/82	Booth Exit	180	0.01	0.09*	0.09*
5/3/82	Marker Area	180	0.02	0.01	0.10*
5/3/82	Cutter	180	0.007	0.005	0.06*
5/3/82	South Wall	180	0.003	0.003	0.05*
5/3/82	North Wall	180	0.004	0.003	0.04*
5/4/82	Pouring Area	180	0.03	0.013	0.10*
5/4/82	Booth Window	180	0.10*	0.10*	2.7*
5/4/82	Exit Booth	180	0.007	0.007	0.04*
5/4/82	Marker Area	180	0.008	0.008	0.16*
5/4/82	Cutter	180	0.006	0.007	0.04*
5/4/82	South Wall	180	0.002	0.003	0.02
5/4/82	North Wall	180	0.001	0.001	0.007

ENVIRONMENTAL CRITERIA	NIOSH-TDI	0.035 mg/m^3
	OSHA-TDI	0.14 mg/m^3
LIMIT OF DETECTION		3 ug

* = Sample exceeded criteria
ND = Non detectable (below level of analytical detection)
mg/m^3 = Milligrams of substance per cubic meter of air
ug = Micrograms per sample

TABLE 5

SUMMARY OF SAMPLES FOR
METHYLENE CHLORIDE, METHYL CHLOROFORM, AND FLUOROTRICHLOROMETHANE (mg/m^3)

Crain Western
Compton, California

September 1980

Sample Date	Job/Area Description	Sample Time (minutes)	Methylene Chloride	Methyl Chloroform	Freon 11
9/9/80	Roller Cleaning	270	3.6*	NA	0.28
9/9/80	Roller Cleaning	270	1.31*	NA	4.50
9/9/80	Preparation (Foam Line)	270	1.21*	NA	0.38
9/9/80	Spray Adhesive	270	2.54*	0.1	7.69
9/9/80	Foam Cutting	270	0.81	7.4	0.64
9/9/80	Supervisor	90	1.35	0.12	6.97
9/9/80	Assistant Supervisor	90	1.45*	0.15	8.46
9/9/80	Foam Marker	90	0.61	NA	0.85
9/10/80	Foam Handler	90	1.09	NA	0.91
9/10/80	Foam Handler	90	2.50	NA	2.08
9/10/80	Foam Cutter	90	2.11	NA	0.79
9/10/80	Foam Handler	90	1.33	NA	0.42
9/10/80	Lineman	90	0.81	NA	0.44
9/11/80	Foam Handler	30	2.08	NA	0.62
9/11/80	Foam Stacker	30	1.05	NA	0.42
9/11/80	Foam Cutter	30	0.27	NA	0.47
9/11/80	Pouring Assistant	30	2.80*	NA	0.50
9/11/80	Pouring Operator	30	0.69	NA	0.69
ENVIRONMENTAL CRITERIA (mg/m^3)			270	1900	5600
LIMIT OF DETECTION (mg)			0.01	0.01	0.01

NA = Non-applicable (not analyzed on this sample)
mg/m^3 = Milligrams of substance per cubic meter of air

*NOTE: Laboratory results stated that these samples had greater than one-third of methylene chloride on the reference portion (B-portion) of the charcoal tubes.

TABLE 6

PULMONARY FUNCTION TESTING

Crain Western
Compton, California

March 1981

Case No.	FEV$_1$% TRIAL 1	2	3	FEV$_1$/FVC TRIAL 1	2	3
1	87	88	84	78	78	76
2	95	94	93	84	84	84
3	98	91	93	79	75	77
4	117	105	111	77	72	75
5	95	93	94	76	79	80
6	91	91	91	86	86	86
7	96	99	95	84	85	84
8	83	-	85	67	-	69
9	98	102	97	83	87	83
10	89	78	86	83	72	83
11	119	118	120	86	84	85
12	88	76	82	78	68	75
13	75	75	71	57	59	59
14	111	108	109	82	81	82

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