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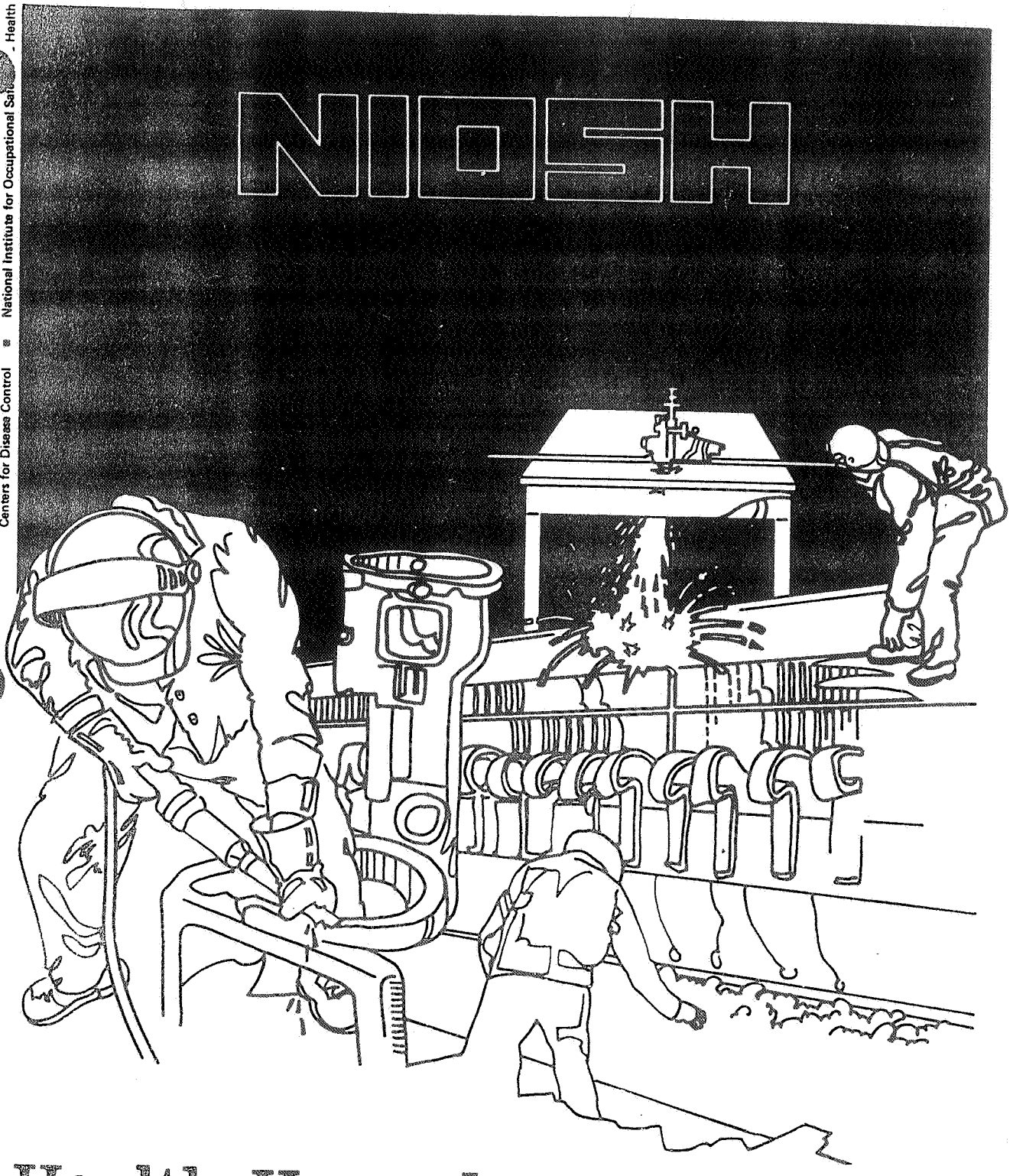
NIOSH



Health Hazard Evaluation Report

HETA 81-029-1088
INDUSTRIAL PLASTICS
VALLEY CITY, OHIO

PREFACE

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

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

HETA 81-029-1088
APRIL 1982
INDUSTRIAL PLASTICS
VALLEY CITY, OHIO

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I. SUMMARY

In October, 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from the Amalgamated Clothing and Textile Workers Union (ACTWU) to determine if the approximately one hundred employees at the Industrial Plastics Company's plant in Valley City, Ohio, were exposed to harmful concentrations of substances in their workplace. Workers are exposed to toluene diisocyanate (TDI), methylene bisphenyl isocyanate (MDI), styrene, fibrous glass, noise, trichloroethylene, 1,1,1-trichloroethane, methylene chloride, carbon monoxide, dust, methyl ethyl ketone (MEK), acetone, toluene, isopropyl alcohol, and benzoic acid in the production of molded and cast plastic and aluminum products. The request listed eye irritation, labored breathing and chest pains among employees' symptoms caused by these substances. A NIOSH industrial hygienist and medical officer conducted an evaluation on November 11, 1980, by visiting the plant for a walk-through survey, and subsequently conducted further testing in March and April, 1981. Personal and area environmental samples were collected for the substances listed above. Medical testing included questionnaires, pulmonary function tests, and carboxyhemoglobin determinations.

Carbon monoxide measurements ranged from 1 to 98 parts per million (ppm). Nine of twenty-five samples were above the recommended evaluation criteria of 35 ppm. Methylene chloride measurements ranged from 2 to 310 ppm, with 12 of 25 samples above the evaluation criteria of 75 ppm. Styrene concentrations ranged from 12 to 140 ppm, with 2 of 6 samples above the criteria of 100 ppm. Long-term (>1 hour) measurements of TDI indicated concentrations up to 1.7 parts per billion (ppb). While this is below the time-weighted average criteria of 5 ppb, findings on pulmonary function tests suggested TDI-related respiratory effects which may have been due to unmeasured higher peak concentrations. Noise measurements ranged from 82 to 93 dB(A), with 11 of 18 samples above the criteria of 85 dB(A). Airborne fibrous glass concentrations were all less than 0.05 fibers per cubic centimeter (the allowable limit is 3), although skin irritation as a result of non-airborne fibrous glass was noted. Measurements of other substances indicated them to be within recommended limits. Pulmonary function tests indicated a decline in forced expiratory volume at one second (FEV_1) over the work shift in workers exposed to TDI, although this decline was not statistically significant at the 0.05 level. The carboxyhemoglobin levels of non-smoking workers exposed to methylene chloride and carbon monoxide in the Foam Room increased significantly over the shift. Questionnaires administered to employees of all departments also elicited symptoms of respiratory irritation. Complaints of skin irritation were significantly higher in workers handling fibrous glass, and 60% of all workers reported at least one workplace episode of intoxicated or "high" feeling without alcohol or drugs. These responses are consistent with other environmental and medical findings.

Based on the results presented in this report, NIOSH concludes that employees at Industrial Plastics were over-exposed to carbon monoxide, methylene chloride, styrene, and noise. Some may have been overexposed to TDI. Recommendations are presented in Section VII for local exhaust ventilation, worker surveillence, additional testing, and altered work procedures to reduce employee exposure to these toxic materials.

KEYWORDS: SIC 3079, toluene diisocyanate (TDI), methylene bisphenyl isocyanate (MDI), styrene, fibrous glass, noise, trichloroethylene, 1,1,1-trichloroethane, methylene chloride, carbon monoxide, dust, methyl ethyl ketone (MEK), acetone, toluene, isopropyl alcohol, benzoic acid, plastic

II. INTRODUCTION

Under the Occupational Safety and Health Act of 1970, the National Institute for Occupational Safety and Health (NIOSH), investigates the toxic effects of substances found in the workplace. A request to conduct such an investigation was received in October 1980, from the president of Local 1820 of the Amalgamated Clothing and Textile Workers Union (ACTWU). The request expressed concern about exposure of employees at the Industrial Plastics plant in Valley City, Ohio, to Azdel® and its thermal decomposition products, and requested an evaluation of the various departments of the plant. Eye irritation, labored breathing, and chest pains were listed as employee's symptoms caused by these exposures.

A visit was made to the plant on November 7, 1980, to conduct a walk-through survey and to discuss the evaluation with representatives of union and management. A joint environmental/medical evaluation was made during the week of March 2, 1981, during which pulmonary function tests were conducted on employees and environmental measurements were made for a variety of potentially harmful substances in the workplace. The results of most environmental measurements made during this visit were reported to both labor and management on April 24, 1981. A follow-up was conducted on April 27, 1981, to further investigate the effects of carbon monoxide in the plant. During that visit, environmental measurements were made for carbon monoxide and methylene chloride, and employee's carboxyhemoglobin levels were measured. The unreported balance of environmental results for both sampling periods was reported on July 29, 1981. On June 1, 1981, NIOSH notified individuals of the results of the pulmonary function tests conducted on the March visit. On June 9, 1981, results of carboxyhemoglobin tests made during the April visit were reported.

III. BACKGROUND

The Industrial Plastics Company employs approximately one hundred people in its Valley City, Ohio, plant in the manufacture of molded and cast plastic and aluminum products. One building houses the three production departments, as well as necessary services such as shipping and receiving, maintenance, and office functions. The plastics department, primarily an injection molding operation, employs approximately twenty-five employees. The Die Cast department manufactures molded aluminum parts and is the smallest of the three departments with approximately a dozen employees. The Special Products department performs a variety of operations, and is the largest department with approximately fifty-five employees. The main operations of interest in this evaluation were in the Special Products Department and included the prodelin press (also called the antennae line), the foam room, and the guitar line. The prodelin press produces plastic "dish" antennaes for receiving signals from satellites; the

foam room produces foam cushion seats; and the guitar line produces molded plastic cases for guitars.

During the opening conference on November 7, 1980, union representatives identified a heterogeneous group of symptoms, processes, and exposures about which they were concerned, in addition to the particular problems identified in the written request. These included upper respiratory symptoms and rashes among workers exposed to fibrous glass in the compression molding process (Special Products); irritating smoke and vapors from compression molding and from Die Casting; and reports of intoxication from exposure to solvents--predominantly 1,1,1-trichloroethane and mixed aromatics--on the "guitar line" (Special Products). However, when the NIOSH investigators learned at the end of the visit that TDI and MDI (toluene diisocyanate and methylene bisphenyl isocyanate)--well known pulmonary sensitizers--were used without local ventilation in the Foam Room (Special Products), and that two employees had reportedly left their jobs at Industrial Plastics because of health problems that developed while they worked as Foam "gun" operators, it was decided to focus the follow-up investigation on respiratory symptoms and pulmonary function in employees of the Foam operation. During that first follow-up study in March 1981, NIOSH conducted a more extensive questionnaire survey to assess the prevalence of other reported problems as well.

Industrial hygiene data obtained during the March survey pointed to a second potentially serious problem in the Foam room: elevated levels of methylene chloride (used to flush the Foam gun after each use) and apparently elevated carbon monoxide levels of uncertain origin. Because methylene chloride is metabolized in the body to carbon monoxide, there was concern that the combined effects of methylene chloride and carbon monoxide might pose a health hazard for some individuals, especially those with compromised coronary artery circulation. Accordingly, NIOSH conducted a second survey in April 1981 to reevaluate exposures to carbon monoxide and methylene chloride and to assess carboxyhemoglobin levels in a presumably "exposed" and unexposed group.

The summary below lists the substances measured in the workplace, and gives the probable source and location where samples were obtained.

SUBSTANCES OF INTEREST

SUBSTANCE	SOURCE	OPERATION	DEPARTMENT
Noise	Machines	Prodelin Press	Special Products
		Foam room	Special Products
		Die cast	Die Cast
Fibrous glass	Prodelin plastic	Prodelin Press	Special Products

(continued)

SUBSTANCES OF INTEREST (continued)

SUBSTANCE	SOURCE	OPERATION
Airborne Particulate	Prodelin plastic Aluminum mold Various plastics	Prodelin Press Die cast Injection mold
Carbon monoxide	Various	All
Methylene chloride	Solvent	Foam Room
Trichloroethane	Glue	Guitar line
Trichloroethylene	Glue	Guitar line
Styrene	Prodelin plastic	Prodelin Press
Methyl Ethyl Ketone	Solvent	Paint Spray Foam room
Acetone	Solvent	Paint Spray Foam room
Toluene	Solvent	Paint Spray Foam room
Isopropanol	Solvent	Paint Spray Foam room
Benzoic Acid	Plastics	Injection Mold Prodelin Press
Isocyanate	Foam	Foam room

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Subsequent to the receipt of this request in October NIOSH project officer contacted the union and the co information regarding materials and processes of int November 7, 1980, a visit was made to the plant to o additional information on operational parameters and conduct of the evaluation with representatives of ma labor. This discussion and the ensuing observations plant resulted in the development of the list of mat (presented above) considered to be the probable sour exposures.

The environmental measurements made during the March and April, 1981, visits used a variety of sampling and analytical techniques. Most samples were taken for almost a full work shift (approximately seven hours). Observations indicate that the employee's duties during the unsampled period are not different from those performed during the collection of the samples, and, therefore, the results are compared with 8-hour time-weighted average criteria. In some cases, one sample could be analyzed for two or more compounds. Relevant sampling and analytical methods follow for the substances or groups of substances evaluated.

NOISE---Employee exposure to noise was measured using personal noise dosimeters with a dynamic range from 60 to 124 dB(A), slow response. These units were programmed to measure and record exposure, and to provide a print-out for each one minute sample interval up to an eight hour period.

ISOCYANATES---Methylene bisphenyl isocyanate (MDI) and toluene-2,2-diisocyanate (TDI) were sampled at 1.0 liters per minute (lpm) for a maximum of four hours in midget impingers containing approximately 15 ml of nitro reagent. Analysis was by high pressure liquid chromatography to quantitate the urea derivative formed by the reaction of the isocyanate with the impinger reagent. (P&CAM method 240 modified).[1]

METHYLENE CHLORIDE---Samples were collected on activated charcoal at 10 cubic centimeters per minute (cc/min) for a full shift. Samples were desorbed with carbon disulfide and analyzed by gas chromatography. (Method S329 modified).[12]

BENZOIC ACID---The sampling train contained silica gel sorbent in series with a glass fiber filter. Flow rate was 1.0 lpm. Analysis was by ion chromatography with a small ion surpressor column.

TRICHLOROETHANE and TRICHLOROETHYLENE---Samples were collected on activated charcoal at 100 cc/min. Desorption with carbon disulfide was followed by quantitation by gas chromatography. (P&CAM method 127 modified).[12]

STYRENE---Samples were collected on activated charcoal at flows of 50 and 100 cc/min. Desorption with carbon disulfide was followed by quantitation by gas chromatography. (P&CAM method 127 modified).[12]

METHYL ETHYL KETONE, ACETONE, TOLUENE and ISOPROPYL ALCOHOL---Samples were collected on activated charcoal at 100 cc/min. Desorption with carbon disulfide was followed by quantitation by gas chromatography. (P&CAM method 127 modified).[12]

FIBROUS GLASS---Samples were collected on mixed cellulose acetate filters in open-faced cassettes at 1.5 lpm for a maximum of approximately four hours. Analysis was by phase contrast microscopy, and included fibers greater than ten microns in length and less than 3.5 microns in width. (P&CAM method 239).[12]

AIRBORNE PARTICULATE---Samples were collected on preweighed polyvinyl chloride filters at 1.5 lpm for a maximum of four hours. The filters were subsequently reweighed to determine loading.

CARBON MONOXIDE---Long term, length-of-stain detector tubes were used at a flow rate of 10 cc/min for up to full shift personal samples. Short term measurements were made using length-of-stain detector tubes and electrochemical (Ecolyzer) analyzers.

AIR VELOCITY---Measurements of air velocity at various locations, especially at points of local exhaust ventilation, were made using smoke tubes and thermal anemometer.

B. Medical

1. Mail questionnaire survey of Foam room employees

Because the Foam process was seasonal and was not in operation during the initial visit in October, NIOSH asked the union to submit a list of recent Foam gun and Foam line employees. They provided the names of 9 present and 2 former workers. To assess the prevalence of respiratory symptoms which might represent TDI exposure or sensitivity, NIOSH sent questionnaires to all 11 workers in December, 1980, inquiring about the development of health problems which may have begun during work on the Foam line. They were questioned about a series of symptoms which are characteristic of TDI sensitization and symptoms unrelated to TDI exposure, and information was obtained about duration of employment.

2. Pulmonary function tests of Foam room workers and Questionnaire Survey of production workers in Special Products, Plastics, and Die Casting: March 1981

Because the information obtained in the mail survey increased concern about TDI effects in the Foam operation (see section VIB1."RESULTS AND DISCUSSION--Medical"), the NIOSH medical officer designed a follow-up medical survey consisting of pre- and post-shift pulmonary function tests and a questionnaire. In March 1981, NIOSH returned to do this follow-up study. Pre- and post-shift pulmonary function tests were administered to Foam room workers and controls, since TDI-exposed workers may experience a dramatic and asymptomatic drop in one second forced expiratory volume over the shift. The "exposed" group

consisted of the 14 workers in the Foam room (including 7 workers directly on the line, and 7 workers engaged in finishing work). Because the Injection Molding department employees had reported few problems during our initial visit, they were selected as a control group and 12 Injection Mold operators and floor persons were administered pre- and post-shift pulmonary function tests. NIOSH administered pulmonary function tests on Monday to reveal as clearly as possible the effect of what might be low levels of TDI.[4]

In the questionnaire survey, questions were asked about demographic data, smoking, current job description, and other jobs held at Industrial Plastics. Inquiries were made regarding the development of symptoms since coming to work at Industrial Plastics. The questionnaire focused on the development of symptoms and signs consistent with the syndromes of TDI exposure, including a night-time cough, symptoms consistent with chronic bronchitis, asthma (diagnosed by a doctor), wheezing, inappropriate breathlessness, chest tightness, and episodes of pneumonia. In addition to the questions directed at TDI sensitivity, questions were asked about allergies, visits to a physician within the past year, about dermatologic conditions, mucous membrane irritation, and episodes of intoxication at work without the use of drugs or alcohol.

NIOSH investigators administered questionnaires to all employees at work on the first and second shifts in Special Products, Plastics, and Die Casting. Of the 126 workers on the company's employment list for these departments, 88 were interviewed. Among the 38 not interviewed, 13 were on lay-off, 3 on official sick leave or pregnancy leave (none of the sick leave apparently work-related), 5 had officially quit, and the remainder were unaccounted for--a reflection of the casual attitude shared by both management and the union towards absenteeism.

3. Second Follow-up Survey: Carboxyhemoglobin Levels - April 1981

Because a number of the environmental samples taken during the first follow-up study in March, 1981, yielded evidence of apparent overexposures to both methylene chloride and carbon monoxide in the Foam room (Tables 5 & 6), and because methylene chloride is metabolized in the body to carbon monoxide,[9,10,11] the coexistence of apparently high levels of both carbon monoxide and methylene chloride in the Foam room were cause for additional investigation. NIOSH investigators returned to Industrial Plastics on April 27, 1981 to repeat the environmental sampling, and to perform a survey of carboxyhemoglobin levels in the Foam room workers and in a suitable control group.

At the time of the second return visit, there were 15 workers in the Foam room. Once again, NIOSH researchers asked the Injection Molding machine operators and floor persons to serve as our controls. There were 9 operators and floor persons at work in Plastics on that shift.

Two pre- and two post-shift breath samples, and one post-shift blood sample were collected from each individual. Breath samples were analyzed directly by the Carboxymeter and were collected for indirect analysis by the Ecolyzer method.

Although pre- and post-shift testing was done on 15 Foam workers and 9 Plastics workers, adequate expiration for the breath tests was provided by only 13 Foam workers and 9 Plastics workers. Blood was collected for carboxyhemoglobin on all 24 workers in these groups.

V. EVALUATION CRITERIA

Various criteria proposed by NIOSH, OSHA, and ACGIH for airborne concentrations of the chemicals measured in this evaluation are listed in Table 1 of this report. These criteria are the maximum concentrations of each substance to which most individuals can be exposed for eight hours per day, or forty hours per week, without adverse health effects. In most cases the occupational exposure limits are the same from each reference, but in those cases where there is a difference, the NIOSH recommended standard or the most stringent value is used. Table 1 also lists the major health effects or sites of action of those chemicals. A brief review of the toxicity of the chemicals of primary interest is given below.

A. Toluene

The primary acute exposure effect of toluene at high concentrations is narcosis. In concentrations of 300-600 ppm, fatigue, mental confusion, exhilaration (a "high" feeling), nausea, headache, and dizziness can result in as little as 2-3 hours. With chronic lower level exposure inconsistent changes in red and white blood cells have been reported with no definite consistent effects noted. Most industrial exposures result from breathing toluene vapor since it is absorbed slowly through the skin. Because of its irritant and defatting properties causing irritation, skin contact should be avoided.

B. Methyl Ethyl Ketone (MEK)

A highly volatile flammable liquid with an odor like acetone, this compound carries a much lower degree of toxicity than toluene or xylene. It can cause narcosis at high concentrations, but its

primary health effect is skin and mucous membrane (including eye) irritation.

C. Acetone

As with the above, narcosis is produced by exposure to high concentrations of acetone, along with symptoms of headache, nausea, vomiting, dizziness, and light-headedness. Defatting of the skin can lead to dryness and dermatitis. Eye and upper respiratory irritation is also produced by exposure to acetone.

D. Methylene Chloride

Narcosis is also the predominant effect of exposure to high concentrations of methylene chloride, along with dizziness, nausea, tingling or numbness of the extremities, a sense of heat, dullness and lethargy. Methylene chloride on absorbtion produces carboxyhemoglobin which decreases the oxygen carrying capacity of the blood, a potentially significant factor for workers with heart or lung impairment.

E. Isopropyl Alcohol

Local effects of isopropyl alcohol vapor are irritation of conjunctiva and upper respiratory tract. Inhalation of high concentrations of isopropyl alcohol produces narcosis but few other symptoms. Reports have not been found on intoxication resulting from inhalation of this compound. Ingestion of large amounts of isopropyl alcohol can result in central nervous system depression, respiratory failure and death.

F. Trichloroethylene

Trichloroethylene is absorbed rapidly by the lungs and affects the central nervous system, the cardiovascular system, the liver, and kidneys. It produces narcosis as well as eye and skin irritation. Trichloroethylene causes liver cancer in some rodents but is at most a weak human carcinogen. The NIOSH recommended maximum time weighted average environmental level is 25 ppm.

G. Airborne Particulate

The evaluation criteria for airborne particulate or "nuisance dust" is based on its ability to reduce workshop visibility, create unpleasant deposits in the ears, eyes, and nasal passages, or cause injury to the skin or mucous membranes by chemical or mechanical action per se or by rigorous cleansing procedures necessary for its removal.

H. Carbon Monoxide

Reaction of carbon monoxide with the hemoglobin in red blood cells to form carboxyhemoglobin decreases the ability of blood to circulate oxygen through the body. This can result in headaches, nausea, dizziness, and weakness, and in extreme cases can lead to unconsiousness and death. Long term effects include aggravation of heart and artery disease.

I. Isocyanates (TDI and MDI)

Exposure to isocyanates can cause sensitization of susceptible persons resulting in decrement of respiratory function similar to asthma. Acute effects include irritation of eyes and respiratory system.

J. Styrene

The primary acute effects of styrene are irritation of eyes, skin and respiratory tract. Chronic exposure can result in nausea, loss of appetite and general weakness. "Repeated or prolonged skin contact may lead to the development of dermatitis, marked by rough, dry and fissured skin,"[24] and styrene may be absorbed into the body through the skin.

K. Benzoic Acid

This dust is irritating to the nose and throat if inhaled,[29] but the toxicity is relatively low (it has been used as a food preservative). There is no established criteria for occupational exposure to benzoic acid. A maximum eight hour time weighted average exposure of 5 mg/cu meter would appear to be a reasonable criteria for the purposes of this evaluation.

L. Noise

Exposure to noise levels above the evaluation criteria can result in both temporary and permanent losses in hearing sensitivity. In addition, "noise may trigger changes in cardiovascular, endocrine, neurologic, and other physiologic functions."[26]

M. Fibrous Glass

Health effects resulting from exposure to fibrous glass are limited primarily to irritation of skin and respiratory tract, and are generally associated with larger diameter (greater than 3.5 micrometer diameter) particles.[27]

N. 1,1,1-Trichloroethane

Exposure to this compound can cause headache, dizziness, and drowsiness, and in severe cases irregular heart beat, unconsciousness, and death. Skin contact with the liquid may cause irritation or dermatitis.

Combined exposure

Toluene, MEK, acetone, methylene chloride, isopropyl alcohol, trichloroethane and trichloroethylene can act additively to produce irritation, headache, nausea, fatigue, narcosis, and other symptoms listed above. When an employee is exposed to 2 or more of these compounds, as is usually the case in this plant, their combined effect rather than that of one individual component should be considered. If the sum of the following fraction exceeds unity,

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \ldots + \frac{C_n}{T_n}$$

then the maximum allowable exposure should be considered as being exceeded. C_1 indicates the measured atmospheric concentration of compounds 1, C_2 the concentration of compounds 2, and so forth. T_1 indicates the maximum allowable exposure of compounds 1, T_2 the exposure of compounds 2, and so forth.

Carboxyhemoglobin

The absorption of carbon monoxide (CO) by the body is most conveniently measured by assessing the carboxyhemoglobin (COHb) level in the blood. Carboxyhemoglobin is formed when the blood's oxygen carrier--hemoglobin--is exposed to carbon monoxide in inspired air. Hemoglobin binds more avidly to carbon monoxide than to oxygen, forming a molecule which is about 200 times more stable than the oxyhemoglobin molecule. The commonest source of personal environmental carbon monoxide is cigarette smoke. Cigarette smokers may average as much as 10% COHb in the blood (i.e., one tenth of their hemoglobin is bound to CO instead of to oxygen). Non-smokers may have as much as 1-2% carboxyhemoglobin in the blood under "normal" circumstances.

Although COHb is an imperfect measure of CO effect--both because duration and intensity of CO exposure affect the COHb level, and because CO effects on oxidative enzyme systems are even more profound than the effects on hemoglobin--it is nonetheless the most useful and practical biological measurement available.

Over time, the COHb content of the blood will increase at a given level of CO in inspired air. For example, at a steady concentration of 50 ppm CO in air, COHb will gradually rise to about 7.5%. Because of this

change over time, symptoms of CO effect do not precisely correlate with COHb levels in the blood. Early symptoms of CO intoxication--headache and breathlessness with exertion--may occur in the range from as low as 5% up to greater than 20%. At levels between 20 and 40%, more severe symptoms, such as severe headache, emotional lability, unusual fatigue, and mental confusion may occur. Above 40%, disorientation, staggering, and unconsciousness may occur progressively, with death supervening in the range between 50 and 80% COHb. The NIOSH recommended TWA is 35 ppm, and the ceiling level of 200 ppm for not greater than 20 minutes is designed to ensure that the COHb remains below 5% in a non-smoking individual with a sedentary work habit.

VI. RESULTS AND DISCUSSION

A. Environmental

Measurement of personal exposures indicated that on the days during which the samples were taken, some employees were exposed to levels of substances greater than the recommended limits. NIOSH found overexposures to noise, carbon monoxide, methylene chloride, and styrene. These overexposures are in comparison to 8-hour time-weighted average criteria, since the portion of the work shift which was sampled (in most cases approximately seven hours) was observed to be similar to the unsampled portion. In most cases, the person showing overexposure would still be overexposed if removed completely from the plant environment to clean air and the 8-hour average time weighted in that manner. Results of all environmental samples collected during this evaluation are tabulated and attached as a part of this report. Data are grouped by substance in Tables 2 through 11 for measurements made in March, 1981. All data collected on April 27, 1981, are in Table 12. Exposures as a function of job classification are presented below.

DIE CAST DEPARTMENT---The die cast operator had the highest measured noise exposure of 93 dB(A). The recommended criteria is 85 dB(A). The only other measurements made in this department indicate dust concentrations within recommended limits.

INJECTION MOLDING DEPARTMENT---Personal and area samples were taken in this department for total particulate, carbon monoxide, methylene chloride and benzoic acid. Concentrations of all were determined to be within recommended limits.

GUITAR LINE---Two gluers were sampled for 1,1,1-trichloroethane and trichloroethylene, and both employees were determined to be safe from toxic exposures to these compounds. It is noted, however, that during the time these samples were taken, the guitar line was not in full production, and exposures could be significantly different during normal operation.

PRODELIN PRESS---Exposure to noise levels at or above the recommended criteria was measured on the press operator, a cutter, unloader/trimmers, and a grinder. Carbon monoxide was measured at the recommended limit of safety of 35 ppm on a driller. Styrene exposures of 140 ppm on a cutter and 120 ppm on an operator were measured. (The recommended maximum is 100 ppm.) Other measurements for these substances, plus measurements for benzoic acid and total particulate were determined to be within recommended limits. Airborne concentrations of fibrous glass were below recommended criteria. However, this criteria is designed to prevent effects due to inhalation of fibrous glass, and skin irritation reported by employees in this area could be the result of contact with non-airborne glass fibers.

FOAM LINE---Most measurements made on beaders were above the recommended levels for noise, although measurements taken on the crimper, trimmers, and carousel employees were within acceptable limits. All carbon monoxide mearurements made in the foam room on March 2, 3, and 4, were above the recommended concentration, in most cases more than double the 35 ppm criteria. Methylene chloride measurements made on these dates also exceeded recommended concentrations in all but one sample, and again in most cases were more than double the 75 ppm criteria. Measurements made on April 27, indicated one over-exposure to carbon monoxide and one to methylene chloride in a total of six measurements for each. Measurements in the foam room for isocyanates and toluene indicated these compounds were within recommended limits for eight hour average exposures, although short term peak values were not measured. Data from the medical portion of this evaluation would indicate that there were probably high peak exposures of isocyanates to some employees, including the foam gun operator.

PAINT SPRAY---The paint sprayer's exposure to carbon monoxide was measured at 50 ppm (recommended criteria is 35 ppm) on March 4. Other samples indicated exposures to MEK, acetone, toluene, and isopropyl alcohol to be within recommended limits.

Ventilation measurements made at the paint spray booth indicated an average face velocity of 125 to 150 feet per minute (fpm), and an average velocity at the workpiece of 90 to 120 fpm. A face velocity of 100 to 150 fpm is recommended for an operation of this nature.[13]

SHEARING MACHINE---The operator of this machine was sampled for carbon monoxide and methylene chloride, and was shown not to be over-exposed to either.

Effects of combined exposures indicated that no employee was exposed to unsafe levels of a combination of carbon monoxide and methylene chloride who was not over-exposed to one or both

separately. There was no combined exposure to solvents (1,1,1-trichloroethane, trichloroethylene, MEK, acetone, toluene, and isopropyl alcohol) exceeding the recommended criteria of unity.

Short term detector tube and electrochemical measurements of carbon monoxide concentrations are summarized below:

LOCATION	DATE	TIME	NUMBER	RANGE	MEAN
Foam room	March 2	5:20 - 5:45	10	25 - 36 ppm	29 ppm
Foam room	March 2	7:30 - 8:00	11	32 - 40	35
Prodelin press	March 3	9:55 - 10:40	3	55 - <60	<58
Die cast	March 3	9:55 - 10:40	3	32 - 47	39
General plant	March 3	9:55 - 10:40	6	25 - <60	<37
Foam room	March 3	4:25 - 4:35	5	17 - 18	18
Die cast	March 3	4:25 - 4:35	3	25 - <60	<40
Foam room	March 3	9:25 - 9:35	6	13 - 18	15
Die cast	March 3	9:30 - 9:35	2	22 - 27	25
Prodelin press	March 3	9:35 - 9:40	2	44 - <60	<52

Short term detector tube measurements were also made at various times for methylene chloride, hydrocarbons, styrene, and alcohol during the March evaluation. No alcohol or total hydrocarbons were detected. (The limits of detection were 100 and 1000 ppm respectively.) The results are summarized below for methylene chloride and styrene.

LOCATION	SUBSTANCE	NUMBER	RANGE	MEAN
Foam gun operator	Methylene chloride	3	200 - 460 ppm	290 ppm
Waxer	Methylene chloride	2	210 - 450	330
Prodelin press	Styrene	7	70 - 150	120

B. Medical

1. Results of mail questionnaire survey of Foam room employees: December 1980

Eight of 11 (72%) persons responded, including one of the 2 former workers, and 5 of 8 (62.5%) reported symptoms. Of the five symptomatic respondents, one had quit her job at Industrial Plastics because of bronchitis, wheezing, and a persistent cough which she related to her job as a Foam gunner. All four of the other symptomatic persons reported one or more symptoms consistent with TDI sensitivity: chest tightness, wheezing, breathlessness, and awakening from sleep unable to breathe. None of the 5 symptomatic respondents answered yes to a question unrelated to TDI exposure.

2. Results of Pulmonary Function Tests: March 1981

When the change over shift of the forced expiratory volume at one second (FEV_1) in exposed (Foam) is compared with that of control (Injection Mold) workers, the decline in FEV_1 was greater in the exposed group of Foam operation workers, although this did not quite reach significance (-5.05% in the Foam group compared with -1.67% in the Injection Mold group, $0.05<p<0.1$). Two of the 14 Foam operation workers were responsible for the larger drop in FEV_1 in Foam workers compared with Injection molders: the 2 workers experienced a greater than 20% drop in their FEV_1, a clear indication of an effect by an exposure occurring during the shift. Both of the affected individuals had worked in the Foam room for more than 6 months, and both of them had been Foam gun operators in the past. One of the 2 was a smoker. Despite the large decline in FEV_1, neither of them reported respiratory symptoms.

3. Results of Administered Questionnaire Survey: March 1981

By current job title, 57 persons worked in Special Products, 24 in Plastics, and 7 in Die Casting. However, workers rotated freely not only within departments but among departments. For the purposes of this study, workers were considered as working in a department if they appeared to have spent at least 90% of their work time there. On this basis, 48 persons were assigned to Special Products. Because Special Products contained the major exposures of concern, the characteristics of these employees were initially compared to those in the other work areas combined, for a total of 40 "Other" employees. The continual flux from one job to another made it very difficult to look at the relationship between individual jobs and the occurrence of symptoms in any meaningful way, except in the few instances that will be described in the remainder of this section.

a. Demographic and Job Characteristics

Special Products employees were similar to Other employees in age and racial distribution. There were significantly more women in Special Products than in Other ($p<0.001$), a fact probably explained by the predominance of males in Die Casting and by a preponderance of unskilled, lower paying jobs in Special Products. Special Products employees had been employed a mean of 2.5 years compared with a mean of 3.9 years for Others, again reflecting the preponderance of entry level jobs in Special Products.

b. Respiratory Symptoms

Special Products workers did not report a significant excess of chest tightness, wheezing, breathlessness, chronic bronchitis, night cough, or asthma. When the data was analyzed after reclassifying workers as those who reported having worked on the Foam operation (42) and those who did not report having worked on the Foam operation (46), there was similarly no excess reporting of respiratory symptoms in the Foam group. Variations in the thoroughness of reporting work histories made it impossible to determine the precise number of workers who had worked as Foam "gun" operators, and that question was not asked directly. Five of the 11 persons (45%) who had worked as gun operators reported at least one symptom characteristic of TDI sensitivity, and 3 specifically attributed their symptoms to their work as Foam gun operators. None of these 3 has continued to work as a gun operator or in the Foam room. In addition, at least one employee left work because of respiratory disease which developed during her work on the Foam line and was not included in this group. Fifty-two of 77 persons (67.5%) who had not worked as a Foam gun operator also reported at least one respiratory symptom with onset since coming to work at Industrial Plastics. On the basis of available information, there was no excess of respiratory symptom reporting among Foam gun operators.

From their own investigations and the work of others, Peters and Wegman have identified 5 "syndromes" of TDI-effect among exposed workers.[1] (A) In their series, approximately 2.5% of workers exposed to peak levels of less than 0.02 ppm TDI will become sensitized, developing an asthmatic or bronchitic picture. After sensitization, even very low levels of TDI produce intolerable wheezing and breathlessness. (B) In workers heavily overexposed to TDI, usually in an accident or other extreme situation, chemical bronchitis or pneumonitis can occur. This is a transient and self-limited illness which does not necessarily result in sensitization. (C) and (D) A large, asymptomatic drop in pulmonary function (FEV_1 or one-second forced expiratory volume) during a work shift may occur and may also result in an accelerated decline in pulmonary function over a period of years if the worker continues to be exposed. (E) TDI exposure may be associated with an increased incidence of adult-onset asthma.[1,2]

From the present study, at least one and probably two types of TDI effect are identified in some of the employees at

Industrial Plastics--(1) the asymptomatic drop in pulmonary function during the shift, and (2) TDI sensitivity. Although the measured TDI levels in the Foam room do not reach or exceed the recommended eight-hour average criteria, it is probable that the large drop in pulmonary function experienced by the workers over the shift occurred as a result of TDI exposure, since this effect can occur at peak levels below the eight-hour average criteria.[4] This profound drop of more than 20% in the absence of symptoms is strikingly characteristic of TDI effect,[1] and there is no other exposure in this workplace known to cause such an effect.

Although there is only historical evidence, the worker who left her job at the plant as a Foam gun operator because of bronchitis, wheezing, and persistent cough may have been a truly TDI-sensitized individual. The 3 of 11 (27%) former Foam gun operators still at the plant who reported at least one symptom compatible with TDI sensitization and which they attributed to work on the Foam gun may or may not be sensitive to TDI.

It is clear from the environmental data (Table 10) that the Foam gun operator is consistently the most highly exposed worker on the line. Although the time-weighted averages even for the Foam gun operator are below the NIOSH recommended standard, much of the data on TDI sensitization is based on "peak" concentrations.[1] Peak concentrations may be as much as 10 to 100 times greater than the time-weighted average. Based on the time-weighted averages measured in the Foam room, the Foam gun operators may be exposed to levels which have been shown to be "sensitizing".[1,3,4] However, it is not surprising that we did not see an increase in respiratory symptoms in the Foam room workers or in Foam gun operators. The rate of sensitization in TDI-exposed populations has been reported to range widely from approximately 0.5% to 66%.[1,5,6]

The frequency with which employees from other jobs and departments at Industrial Plastics reported respiratory symptoms and attributed these symptoms to workplace smoke, cigarette smoke, "fumes", and vapors outside the Foam room gives us two additional pieces of information: (A) employees perceive a variety of exposures as causing their respiratory symptoms, and (B) the presence of multiple respiratory irritants results in diffuse reporting of symptoms which in turn obscure the usual differences between "exposed" and "control" or comparison populations. A symptom survey alone cannot definitively establish TDI sensitization, and certainly cannot demonstrate

asymptomatic TDI effects. The pulmonary function tests provide the strongest evidence of a TDI effect in some exposed workers.

c. Dermatologic and Irritative Symptoms

Significantly more Special Products employees reported chronically itching skin or a rash compared with the Other group ($p<0.02$). Ninety-one percent of the 33 employees in Special Products who reported itching or a rash attributed it to fibrous glass. Irritative symptoms (sore throat, hoarseness, and burning or sore eyes) were not more prevalent among Special Products employees.

d. Reports of Feeling Intoxicated at Work

Fifty-three of 88 employees (60%) reported that they had been "high" at work at least once without the use of alcohol or drugs. Forty-seven percent associated their intoxication with methylene chloride exposure in the Foam operation or in flushing molds in Die Casting, 26% associated it with work on the guitar line, and 25% with various other exposures (working with SMC or Prodelin, molding Azdel, or spray painting). Although elevated levels of other solvents were not found, levels of both methylene chloride and styrene exceeded the NIOSH recommended standard. While it is acknowledged that the subjective impression of feeling "high" does not necessarily correspond to a clinical syndrome of true intoxication, these reports should be taken as an indication that employees may be exposed at levels potentially affecting both their perceptions and function, even if only transiently. In addition to the potential as a health hazard, this may pose a safety threat to employees working with or operating machinery.

e. Miscellaneous Health Complaints

Two Special Products employees reported that they had been treated for smoke inhalation as a result of an incident at work. While this may be an unusual event, it suggests that ventilation may be inadequate for the excessive quantities of smoke that may be liberated when plastic laminate overheats during the heating and molding processes. The initial union complaints about smoke from the presses and the Die Casting area suggest that the ventilation may be inadequate to handle even routinely produced emissions at levels which may be called irritating, if not always hazardous.

Two Special Products employees who worked on the satellite antenna line reported spontaneous nosebleeds after starting to work cutting the material. In view of the styrene overexposures documented among Prodelin cutters on the antenna line, it is possible that the styrene vapors caused or contributed to these nosebleeds. There are no reports of nosebleeds directly linked to styrene exposure, but the known drying and defatting properties of solvents (of which styrene is one) may contribute to this.

4. Results of Second Follow-up Survey in April 1981: Carboxyhemoglobin Levels

Table 13 shows the results of the breath tests and blood samples taken for carboxyhemoglobin on April 27. Inconsistencies in the results obtained on the two breath tests exist for various individuals. This is not entirely random, since the readings taken from the Carboxymeter tended as a group and in most individual cases to be higher than the other breath test values, although not significantly so. In addition, there were large inconsistencies between post-shift breath tests and blood carboxyhemoglobin levels for some individuals. Finally, none of the blood carboxyhemoglobin values was less than 2%, even in non-smokers.

None of the environmental samples for carbon monoxide or methylene chloride (with the exception of the methylene chloride level in the breathing zone of the Foam gun operator) were markedly elevated during this return visit in April (see Table 12 for environmental results), there are two possible explanations for the finding of relatively elevated COHb levels: (1) all participating workers, including non-smokers in both the Foam room and Plastics, may have chronic exposure to levels of carbon monoxide or methylene chloride sufficient to elevate their carboxyhemoglobins chronically, although a constant occupational source is not apparent for all workers. (2) A systematic laboratory error may have occurred which elevated all values. Without a second set of bloods drawn simultaneously and sent to another laboratory, this hypothesis cannot be tested.

Although the differences in carboxymeter, ecolyzer, and blood COHb test results for a given individual were sometimes great, we felt that it was legitimate to examine the group data on the assumption that individual differences would be diminished, especially when comparing only the pre- and post-shift values within one type of test.

The issue of greatest concern was whether or not changes in carboxyhemoglobin level occurred over the shift. Accordingly,

the means (averages) of the pre- and post-shift values in each of the breath test categories were compared (Table 13). Although the average values for carboxyhemoglobin (COHb) were higher post-shift than pre-shift in both Foam room workers and Plastics workers (injection molders) in all breath test categories and for both smokers and non-smokers, the increase in carboxyhemoglobin was statistically significant for only one group of workers: the non-smoking Foam room workers ($p<0.01$). This significance was true for both carboxymeter and ecolyzer breath tests. In addition, the mean carboxyhemoglobin measured in the blood of non-smoking Foam room workers was statistically significantly higher than the mean carboxyhemoglobin measured in the blood of non-smoking Plastics workers. By contrast, blood carboxyhemoglobin levels for smokers in both the Foam room and Plastics were very similar.

The significance of these findings is not entirely clear. Assuming that they have some relationship to environmental phenomena occurring during the shift, one possible explanation may be the jobs performed by smoking and non-smoking Foam room workers. In the group sampled on April 27, only 3 of 7 (43%) Foam room smokers work directly at or immediately adjacent to the Foam process where methylene chloride exposures are highest. By contrast, 4 of 6 (67%) Foam room non-smokers worked immediately adjacent to the methylene chloride flushing barrel. While this percentage difference does not reach statistical significance, it may be the reason for the increase in COHb levels among non-smokers compared with smokers. If this explanation is correct, even the moderate levels of methylene chloride present at that time apparently contributed to the rising carboxyhemoglobin levels of employees working nearer the methylene chloride barrel in the Foam room.

VII. RECOMMENDATIONS

1. Although NIOSH did not measure peak concentrations of TDI and the time-weighted averages did not exceed the NIOSH recommended level of 0.005 ppm, the medical evidence for a TDI effect in some workers is strong, i.e., two workers in the Foam room experienced a large drop in their FEV_1 during the shift. Since the loss of pulmonary function over a shift may also be related to an accelerated loss of lung function over a period of years, any worker who experiences such a drop should probably not continue to work in the Foam room until exposure levels can be decreased further. A local exhaust system should be attached to the foam gun which will scavenge TDI vapors before they escape into the breathing zone of the gun operator and into the open air. Adequate environmental sampling should be performed periodically to monitor levels of exposure.

Despite the company's efforts to reduce airborne contaminants, a fraction of employees may receive an exposure sufficient to "sensitize" them, a phenomenon different from the asymptomatic loss in pulmonary function. Employees and management alike should be alerted to this possibility so that any worker who develops asthmatic symptoms for the first time while working in the Foam room, or especially on the Foam gun, should be transferred out of the Foam room. Every effort should be made to keep exposures at a minimum.

2. Because of the elevated methylene chloride levels present during the first follow-up visit, and the elevated concentrations in the breathing zone of the gun operator and mold opener on the second follow-up visit, it is recommended that Industrial Plastics install local ventilation over the purging barrel so that methylene chloride vapors can be removed before they escape into the room. Decreasing the amount of methylene chloride used for each purge, as well as the total number of purges per day, would also have a beneficial effect. The resulting decrease in exposures should be of special importance during the cold weather months when area ventilation is less than in the warm months. Local exhaust ventilation will also protect employees from the increased load of carbon monoxide which accompanies methylene chloride exposure, which is of genuine concern in any person with compromised coronary circulation.

3. Additional winter sampling should be conducted for both carbon monoxide and methylene chloride when doors and windows are closed and heaters are in operation.

4. Reports of feeling "high" at work should be regarded as potential indicators of overexposure to a solvent. Appropriate and functioning local exhaust ventilation should be installed (or repaired), and respirators effective against organic vapors should be fitted for use until local ventilation is functioning effectively.

5. Unreacted styrene monomer is apparently released in the prodelin press area as the material is unrolled onto the cutting table. Allowing the material to off-gas prior to cutting, or obtaining it from the supplier with less unreacted styrene, are two possible alternatives to ventilating the entire area to reduce employee exposure to a safe level.

6. Over-exposure to noise was measured on several employees, and a more extensive evaluation of that noise is recommended in order to facilitate appropriate control measures. Such an evaluation might include audiometric testing to determine baseline levels. The use of ear plugs, ear muffs, or other personal protective devices is

acceptable only as an interim measure until noise levels can be reduced.

7. Irritation from fibrous glass is probably a result not of airborne exposure, but rather of exposure to this material picked up on the skin during the handling of work pieces or from other sources. This material may then be inadvertently transferred to the face and eyes. The use of gloves and long sleeves to cover hands and arms should reduce the exposure. Increased housekeeping to reduce the fibrous dust on plant surfaces is also recommended.

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1. Amalgamated Clothing and Textile Workers, Local 1820
2. Industrial Plastics Company
3. NIOSH, Region V
4. OSHA, Region V

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

Table 1

Summary of Exposure Limits and Health Effects
for Substances Measured at Industrial Plastics Company

HETA 81-029

Substance	Occupational Exposure Limit*			Health Effects	Reference
	OSHA Standard**	ACGIH TLV***	NIOSH Recommendation		
Methyl Ethyl Ketone	200 ppm	200 ppm; 300 ppm STEL	200 ppm	Eye, nose & throat irritation	14
Toluene	200 ppm; 300 ppm acceptable ceiling; 500 ppm max. ceiling (10 minutes)	100 ppm; 150 ppm STEL (10 minutes)	100 ppm; 200 ppm ceiling	CNS depressant	16
Acetone	1,000 ppm	1000 ppm; 1250 ppm STEL	250 ppm	Eye and nervous system	14
Methylene Chlorine	500 ppm; 1,000 ppm acceptable ceiling; 2,000 ppm peak above ceiling for 5 minutes in any 2 hours	200 ppm; 250 ppm; STEL	75 ppm; 500 ppm ceiling in presence of carbon monoxide	CNS; carbon monoxide toxicity; dermatitis	17
Isopropyl Alcohol	400 ppm;	400 ppm; 500 ppm STEL (15 minutes)	400 ppm; 800 ppm ceiling	Mucous membrane irritant	18

(continued)

Table 1 (continued)

Substance	Occupational Exposure Limit*			Health Effects	Reference
	OSHA Standard**	ACGIH TLV***	NIOSH Recommendation		
uisance Dust Total Particulate)	15 mg/m^3	10 mg/m^3	----------	Eye, skin & upper respiratory irritation	20
oise	90 dB(A) 115 dB(A) ceiling	85 dB(A) 115 dB(A) STEL	85 dB(A) 115 dB(A) ceiling	Hearing	26
lbrous glass	15 mg/cu meter****	10 mg/cu meter	3 fibers/cc (diameter <3.5 um, length >10 um)	Skin and respiratory irritation	27
rbon monoxide	50 ppm	50 ppm; 400 ppm STEL	35 ppm; 200 ppm ceiling	Headache, nausea, dizziness, heart and artery disease	22, 23
1,1-Trichloroethane	350 ppm	350 ppm; 450 ppm STEL	350 ppm ceiling	Headache, CNS depressant, eye irritation	23, 28
rene	100 ppm; 200 ppm acceptable ceiling; 600 ppm peak above ceiling for 5 minutes in any 3 hours	50 ppm 100 ppm STEL	----------	Eye, skin and respiratory irritation	23, 24

(continued)

Table 1 (continued)

Substance	Occupational Exposure Limit*			Health Effects	Reference
	OSHA Standard**	ACGIH TLV***	NIOSH Recommendation		
Trichloroethylene	100 ppm; 200 ppm acceptable ceiling; 300 ppm peak above ceiling for 5 minutes in any 2 hours	100 ppm 150 ppm STEL	25 ppm	Headache, nausea, eye irritation, cardiac arrhythmias, potential carcinogen	25
Toluene diisocyanate	0.02ppm	0.02 ppm	0.005 ppm 0.02 ppm ceiling (20 minutes)	eye and respiratory irritation, pulmonary effects	23, 27
Methylene bisphenyl isocyanate	0.02 ppm	0.02 ppm	----------	Eye and respiratory irritation, pulmonary effects	23, 27

* Limits are Time Weighted Average unless otherwise noted
** For OSHA Standards see Ref. 21
*** For ACGIH TLV's see Ref. 20
*** Classified as a nuisance dust

Table 2

Noise Levels

Industrial Plastics Company
Valley City, Ohio
HETA 81-029

March 2-4,1981

Area	Job	Date	Duration	Average Exposure	Maximum 1 Minute
Prodelin Press	Press Operator	3/3	12:36 - 15:20	87 dBA	92 dBA
Prodelin Press	Cutter	3/3	07:50 - 11:41	90	96
Die Cast	Die Cast Op.	3/3	09:05 - 11:45	93	100
Prodelin Press	Unload/Trim	3/3	12:45 - 15:20	90	96
Foam Line	Mold Opener	3/2	15:15 - 22:30	84	93
Foam Line	Beader	3/2	16:51 - 23:01	88	94
Foam Line	Beader	3/2	17:04 - 22:58	89	97
Foam Line	Beader	3/2	16:45 - 22:58	87	95
Foam Line	Inspect/Crimp	3/2	16:00 - 22:54	84	96
Foam Line	Beader	3/2	17:20 - 22:55	84	91
Foam Line	Trimmer	3/2	16:32 - 22:50	83	95
Foam Line	Trimmer	3/2	16:15 - 22:55	82	91
Prodelin Press	Grinder	3/4	07:47 - 14:36	92	104
Prodelin Press	Press Operator	3/4	07:58 - 14:35	89	99
Prodelin Press	Unload/Trim	3/4	08:05 - 09:55	91	98
Foam Line	Skin Machine Op.	3/3	15:50 - 23:30	83	91
Foam Line	Beader	3/3	16:03 - 23:12	90	98
Foam Line	Mold Opener	3/3	16:00 - 23:11	84	94
Permissible exposure level				85 (8-hour TWA)	115 (Ceiling)

Table 3

Fibrous Glass Concentrations

Industrial Plastics Co.
Valley City, Ohio
HETA 81-029

March 3-4, 1981

Area	Job	Date	Duration	Concentration
Prodelin Press	Cutter	3/4	07:55 - 14:30	0.01 Fibers/cc
Prodelin Press	Cutter	3/3	07:49 - 11:39	0.01
Prodelin Press	Driller	3/3	07:54 - 11:38	0.01
Prodelin Press	Grinder	3/3	12:35 - 15:10	0.02
Prodelin Press	Driller	3/3	12:35 - 15:20	0.04
Prodelin Press	Press Operator	3/3	07:47 - 11:52	0.01
Prodelin Press	Driller	3/3	07:32 - 11:43	0.01
Prodelin Press	Unload/Grind	3/3	07:38 - 11:40	0.01
Permissible exposure level (8 hour time weighted average)				3

Table 4

Total Particulate Concentrations

Industrial Plastics Co.
Valley City, Ohio
HETA 81-029

March 3-4, 1981

Area	Job	Date	Duration	Concentration
Prodelin Press	Cutter	3/3	12:40 - 15:18	0.4 mg/m^3
Prodelin Press	Inspect/Sand	3/3	07:35 - 11:38	0.8
Prodelin Press	Unload/Grind	3/3	07:40 - 11:40	1.5
Prodelin Press	Cutter	3/3	07:46 - 11:41	0.4
Prodelin Press	Trim & File	3/3	12:35 - 15:10	0.7
Injection Mold	Operators Area	3/4	08:56 - 14:29	0.2
Prodelin Press	Grinding	3/4	07:45 - 14:32	1.6
Die Cast	Machine Operator	3/4	08:36 - 14:35	0.7
Injection Mold	Operators Area	3/4	08:52 - 14:30	0.3
Permissible exposure level (8 hour time weighted average)				10.0

Table 5

Carbon Monoxide Concentrations

Industrial Plastics Co.
Valley City, Ohio
HETA 81-029

March 2-4, 1981

Area	Job	Date	Duration	Concentration
Prodelin Press	Press Operator	3/3	12:40 - 15:20	19 ppm
Foam Line	Seat Crusher	3/2	15:12 - 23:20	41
Foam Line	Skin Layer	3/2	15:35 - 23:20	81
Foam Line	Trimmer	3/2	16:17 - 22:50	75
Foam Line	Beader	3/2	17:20 - 22:50	76
Foam Line	Beader	3/2	16:45 - 22:50	77
Foam Line	Foam Gun Op.	3/3	15:55 - 18:45	98
Foam Line	Beader	3/3	16:12 - 23:14	73
Prodelin Press	Press Operator	3/4	07:50 - 14:34	31
Paint Spray	Sprayer	3/4	08:00 - 14:35	50
Prodelin Press	Driller	3/4	07:50 - 14:35	35
Lab (2nd floor)	Area	3/3	09:45 - 10:50	19
Permissible exposure level (8 hour time weighted average)				35

Table 6

Methylene Chloride Concentrations

Industrial Plastics Co.
Valley City, Ohio
HETA 81-029

March 2-3, 1981

Area	Job	Date	Duration	Concentration
Foam Line	Seat Crusher*	3/2	15:12 - 23:20	85 ppm
Foam Line	Skin Layer*	3/2	15:35 - 23:20	150
Foam Line	Beader*	3/2	17:20 - 22:50	310
Foam Line	Waxer	3/2	15:20 - 23:15	160
Foam Line	Beader	3/2	17:03 - 22:50	120
Foam Line	Foam Gun Op.	3/2	15:43 - 23:05	160
Foam Line	Foam Gun Op.*	3/3	15:55 - 18:45	270
Foam Line	Foam Gun Op.	3/3	18:45 - 23:05	220
Foam Line	Beader*	3/3	16:12 - 23:14	110
Foam Line	Crusher	3/3	15:58 - 23:10	5
Foam Line	Waxer	3/3	15:55 - 23:10	250
Foam Line	Skin Layer	3/3	15:57 - 23:08	78
Permissible exposure level(8 hour time weighted average)				75**

* Carbon monoxide sample also taken on this person. See table 5.
** Must be adjusted when carbon monoxide present in concentration greater than 9 ppm.

Table 7

1,1,1-Trichloroethane and Trichloroethylene Concentrations

Industrial Plastics Co.
Valley City, Ohio
HETA 81-029

March 3, 1981

Area	Job	Date	Duration	Trichloroethane	Trichloroethylene
Guitar Line	Gluer	3/3	08:05 - 11:48	88 ppm	0.5 ppm
Guitar Line	Gluer	3/3	08:05 - 11:48	47	1.3
Permissible exposure level (8 hour time weighted average)				350	25

Table 8

Styrene Concentrations

Industrial Plastics Co.
Valley City, Ohio
HETA 81-029

March 3-4, 1981

Area	Job	Date	Duration	Concentration
Prodelin Press	Press Operator	3/3	12:40 - 15:20	120 ppm
Prodelin Press	Cutter	3/3	12:45 - 15:20	140
Prodelin Press	Cutter	3/4	07:52 - 14:39	82
Prodelin Press	Cutter	3/4	07:54 - 14:31	42
Prodelin Press	Press Operator	3/4	07:50 - 14:34	77
Prodelin Press	Driller	3/4	07:50 - 14:35	12
Permissible exposure level (8 hour time weighted average)				100

Table 9

MEK, Acetone, Toluene and Isopropyl Alcohol Concentrations

Industrial Plastics Co.
Valley City, Ohio
HETA 81-029

March 2-4, 1981

Area	Job	Date	Duration	MEK	Acetone	Toluene	Alcohol
Paint Spray	Painter	3/4	09:19 - 10:14	1.3 ppm	0.8 ppm	6.8 ppm	0.8 ppm
Paint Spray	Painter	3/4	10:15 - 11:16	2.9	0.7	14.	1.4
Paint Spray	Painter	3/4	13:19 - 13:59	2.5	1.0	10.	1.0
Paint Spray	Packer	3/4	08:08 - 13:07	0.4	0.9	0.9	0.4
Paint Spray	Painter	3/4	08:00 - 14:35	3.1	1.3	12.	1.3
Paint Spray	Painter	3/4	08:00 - 14:35	2.0	1.7	13.	1.6
Foam Line	Trimmer	3/2	16:17 - 22:50	-----	-----	2.5	-----
Foam Line	Beader	3/2	16:45 - 22:50	-----	-----	2.2	-----
Paint Spray	Painter	3/3	08:08 - 11:49	-----	-----	0.6	-----
Permissible exposure levels (8 hour time weighted average)				200	250	100	400

Table 10

Isocyanate Concentrations

Industrial Plastics Co.
Valley City, Ohio
HETA 81-029

March 2-3, 1981

Area	Job	Date	Duration	Concentration, PPB* MDI	TDI
Foam Line	Skin Layer	3/2	15:35 - 19:13	N.D.**	N.D.
Foam Line	Skin Layer	3/2	19:13 - 22:30	N.D.	N.D.
Foam Line	Vacuum Former	3/2	15:30 - 19:10	N.D.	N.D.
Foam Line	Vacuum Former	3/2	19:10 - 22:30	N.D.	N.D.
Foam Line	Mold Opener	3/2	15:15 - 19:03	N.D.	0.1
Foam Line	Mold Opener	3/2	19:03 - 22:30	N.D.	0.3
Foam Line	Waxer	3/2	15:20 - 19:07	N.D.	N.D.
Foam Line	Waxer	3/2	19:07 - 22:30	N.D.	N.D.
Foam Line	Seat Crusher	3/2	15:12 - 19:05	N.D.	N.D.
Foam Line	Seat Crusher	3/2	19:05 - 22:30	N.D.	N.D.
Foam Line	Foam Gun Op	3/2	15:42 - 19:15	N.D.	1.4
Foam Line	Foam Gun Op	3/2	19:15 - 22:30	N.D.	1.7

(continued)

Table 10 (continued)

Area	Job	Date	Duration	Concentration, PPB*	
				MDI	TDI
Foam Line	Trimmer	3/2	16:27 - 19:30	N.D.	N.D.
Foam Line	Trimmer	3/2	19:30 - 20:36	N.D.	N.D.
Foam Line	Beader	3/2	16:50 - 19:20	N.D.	N.D.
Foam Line	Beader	3/2	19:20 - 22:30	N.D.	N.D.
Foam Line	Crimper	3/2	16:00 - 19:18	N.D.	0.3
Foam Line	Crimper	3/2	19:18 - 22:30	N.D.	N.D.
Foam Line	Foam Gun Op	3/3	16:31 - 17:31	N.D.	1.5
Foam Line	Foam Gun Op	3/3	21:17 - 21:59	N.D.	1.7
Foam Line	Mold Opener	3/3	18:18 - 18:48	N.D.	N.D.
Foam Line	Waxer	3/3	21:18 - 21:56	N.D.	N.D.
Foam Line	Waxer	3/3	22:30 - 22:47	N.D.	N.D.
Permissible exposure level (eight hour time weighted average):				5	5

* Parts of isocyanate per billion parts air.
** None detected. Limit of detection approximately 0.1 PPB.

Table 11

Benzoic Acid Concentrations

Industrial Plastics Co.
Valley City, Ohio
HETA 81-029

March 3-4, 1981

Area	Job	Date	Duration	Concentration, mg/m^3
Prodelin Press	Loader	3/3	07:43 - 11:37	Greater than 2.0
Prodelin Press	Cutter	3/3	07:45 - 11:42	Greater than 1.5
Prodelin Press	Cutter	3/3	12:37 - 15:15	Greater than 2.3
Injection Mold	Operator	3/4	08:45 - 14:30	0.1

TABLE 12

Carbon Monoxide and Methylene Chloride Concentrations

Industrial Plastics Company
Valley City, Ohio
HETA 81-029

April 27,1981

Area	Job	Duration	Carbon Monoxide	Methylene Chloride
Foam Line	Vacuum Former	17:42-23:57	2 ppm	62 ppm
Foam Line	Beader	17:47-23:44	1 ppm	28 ppm
Foam Line	Crimper	17:49-23:58	<1 ppm	2 ppm
Injection Mold	Operator	17:58-23:50	3 ppm	7 ppm
Spec. Products	Shearing Mach.	18:01-23:59	5 ppm	5 ppm
Injection Mold	Operator	17:55-23:51	13 ppm	10 ppm
Foam Line	Skin Layer	18:20-23:43	2 ppm	35 ppm
Foam Line	Mold Opener	22:28-23:46	<1 ppm	73 ppm
Foam Line	Gun Operator	17:37-23:45	1 ppm	200 ppm
Foam Line	Crusher	17:53-23:41	4 ppm	42 ppm
Loading Dock	Area Sample	18:07-00:01	5 ppm	4 ppm
Foam Line	Mold Opener	17:38-22:20	<1 ppm	48 ppm
Cutting Room	Area Sample	18:15-00:03	9 ppm	17 ppm
Recommended maximum eight hour time weighted average concentration:			35	75

TABLE 13

Carboxyhemoglobin Levels in Foam and Injection Molding Workers

Industrial Plastics Company
Valley City, Ohio
HETA 81-029

Area and Job (grouped by smoking status)	Pre-Shift Breath Tests A (% COHb)	Pre-Shift Breath Tests B (% COHb)	Post-Shift Breath Tests A (% COHb)	Post-Shift Breath Tests B (% COHb)	ΔA	ΔB	Blood COHb
Foam - smokers							
Skin layer	20.0	12.7	19.0	14.5			13.9
Carousel	2.0	3.7	7.4	5.7			4.5
Lead	21.0	9.7	15.5	12.9			11.1
Beader	7.4	4.3	7.4	4.3			5.1
Beader	7.7	9.3	11.5	8.5			8.8
Beader	2.5	3.1	7.4	5.7			5.3
Beader	4.2	4.5	7.4	5.7			4.5
(Average values)	9.3±8.0	6.8±3.7	10.9±4.7	7.9±4.8	NS	NS	8.8±4.6
Foam - nonsmokers							
Gun operator	2.0	2.2	8.0	5.3			4.3
Mold opener	4.8	2.2	6.8	6.9			6.5
Crusher	1.6	1.8	4.5	4.3			3.5
Vacuum former	0.9	2.5	7.2	5.3			5.4
Crimper	1.0	1.7	6.9	4.5			3.6
Trimmer	0.6	1.9	6.2	3.9			3.1
	1.5±1.7	1.7±0.6	6.6±1.2	5.0±1.1	p<0.01, df = 11	p<0.01, df = 11	4.4±1.3

(continued)

TABLE 13 (continued)

Area and Job (grouped by smoking status)	Pre-Shift Breath Tests A (% COHb)	Pre-Shift Breath Tests B (% COHb)	Post-Shift Breath Tests A (% COHb)	Post-Shift Breath Tests B (% COHb)	ΔA	ΔB	Blood COHb
Injection Mold - smokers							
Operator	5.8	7.1	7.2	6.9			6.4
Operator	7.2	8.7	13.5	13.9			12.2
Operator	7.7	7.9	8.1	9.3			8.2
Operator	5.9	4.7	7.4	6.9			8.7
Operator	7.2	7.1	6.7	5.7			5.4
Floor person	10.0	9.5	14.0	9.9			9.2
	7.3±1.5	7.5±1.7	9.5±3.4	8.8±3.0	NS	NS	8.4±2.9
Injection Mold - nonsmokers							
Operator	2.6	1.9	2.7	1.9			2.3
Floor person	1.5	2.5	3.3	3.1			2.3
Floor person	1.0	2.1	5.7	2.9			2.1
	1.7±0.8	2.2±0.3	3.9±1.6	2.6±0.6	NS	NS	2.2±0.1

A = Carboxymeter reading.
B = Ecolyzer (ppm carbon monoxide), COHb = $\frac{\text{CO breath}}{5}$ + 0.5.

COHb = Carboxyhemoglobin.
Only employees with valid breath tests of both types were included. Invalid tests were those wherein exhalation was inadequate for accurate reading.
ΔA, ΔB = The change in the average values for A & B.
NS = Not statistically significant as defined by $p<0.05$.
df = Degrees of freedom.