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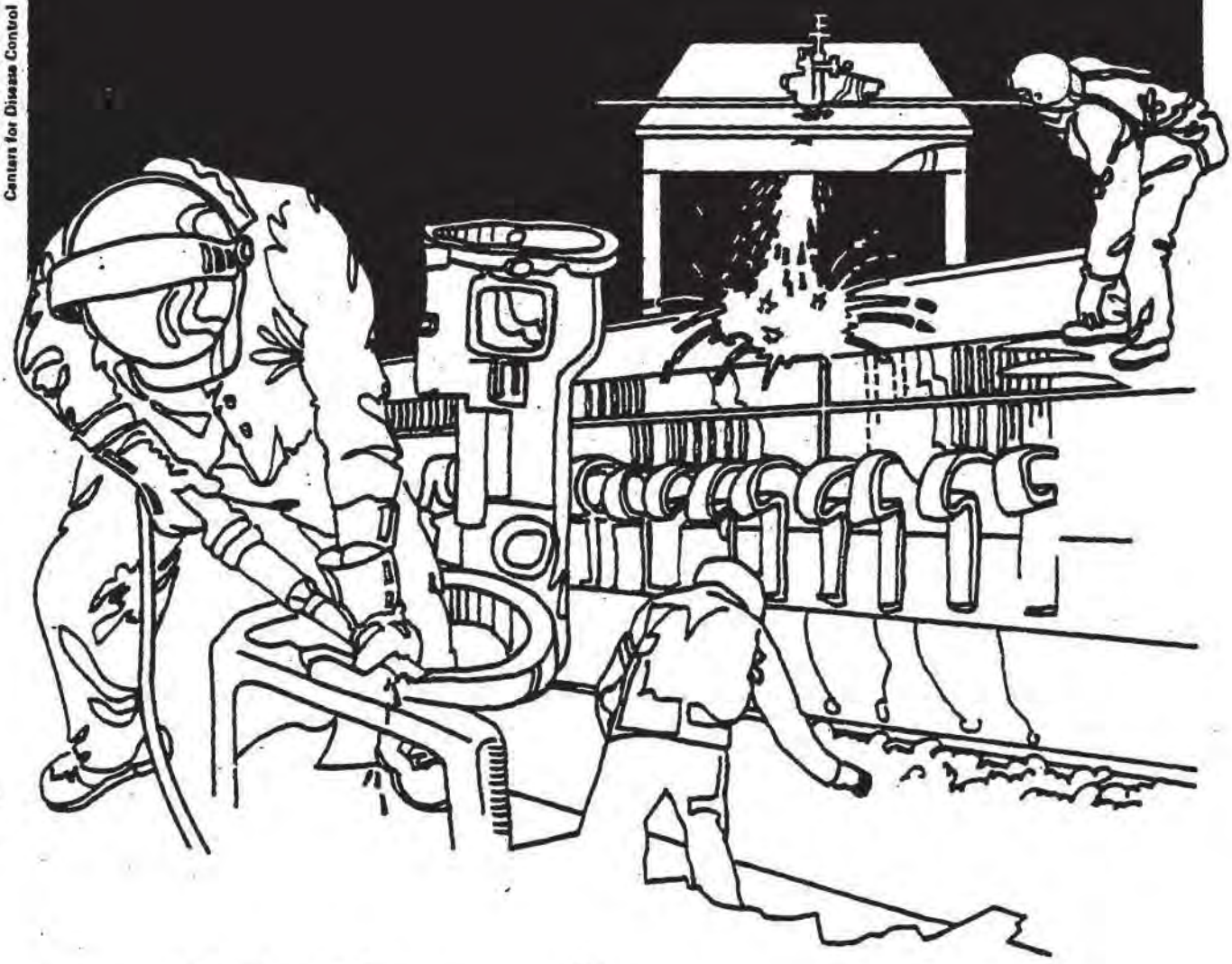

Health Hazard Evaluation Report

HETA 84-117-1696
MARTIN MARIETTA MICHOUD OPERATIONS
NEW ORLEANS, LOUISIANA

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 84-117-1696
May 1986
MARTIN MARIETTA MICHOUD OPERATIONS
NEW ORLEANS, LOUISIANA

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I. SUMMARY

On January 5, 1984, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate cases of asthma and liver test abnormalities among workers in the Thermal Protection System (TPS) insulation areas at the Martin Marietta Michoud Operations plant in New Orleans, Louisiana. In these areas there is potential exposure to diphenylmethane diisocyanate (methylene bisphenyl isocyanate, MDI) and to various solvents.

On March 26-28, 1984, NIOSH investigators conducted an environmental/medical survey. Plant employees were interviewed and industrial hygiene records were reviewed. Medical records of selected workers with a history of asthma or abnormal liver function tests were reviewed. A cohort of employees with potential exposure to isocyanates in 1981 was defined from company records. This cohort was followed for two years through company medical records to see if there was any group decline in one-second forced expiratory volume (FEV_1).

On the basis of interviews and review of medical records, three cases of probable MDI-induced asthma which had begun within the previous five years were identified among workers. There was no detectable group decline in FEV_1 associated with exposure to MDI. However, company spirometric procedures did not meet American Thoracic Society criteria for epidemiologic studies. Therefore, a small group decline in lung function related to exposure could have existed but would not have been detected by this study.

Environmental levels of MDI as reported in company records were generally below 25 ppb. Operators and sprayers in locations where MDI was present were required to wear respiratory protection. Concentrations of cellosolve acetate, heptane, methyl ethyl ketone, chlorofluorocarbons, styrene, and trichloroethylene were reported to be below their action levels in areas not restricted to personnel wearing proper personal protective equipment.

In the final assembly area, 9 of 103 workers tested in 1983 had "abnormal" serum liver enzyme concentrations. Although a number of potential liver toxins are used in the final assembly area, the company's reference ranges for "normal" enzyme levels were probably unnecessarily stringent, making it difficult to evaluate the significance of these results.

Based on the findings of this investigation it is probable that some employees at the Martin Marietta Michoud Operations plant developed asthma as a result of exposure to MDI. Recommendations for reducing worker exposures to MDI and for evaluation of abnormalities detected by medical monitoring are contained in Section VII of this report.

KEYWORDS: SIC 3769 (Guided missile and space vehicle parts and auxiliary equipment, not elsewhere classified), diphenylmethane diisocyanate (CAS 101-68-8), isocyanates, asthma, hepatotoxcity

II. INTRODUCTION

On January 5, 1984, a confidential request was received from workers at the Martin Marietta Michoud Operations plant in New Orleans, Louisiana to evaluate cases of asthma and liver function test abnormalities among workers in the Thermal Protection System (TPS) insulation areas. In these areas there is potential exposure to diphenylmethane diisocyanate (methylene bisphenyl isocyanate, MDI) and to various solvents.

On March 26-28, 1984 NIOSH investigators visited the plant to discuss the request with company and union (United Auto Workers, Local 1921) representatives and to conduct a walk-through survey. The NIOSH investigators observed the various manufacturing processes, interviewed workers in the various TPS areas, reviewed a sample of medical records, and identified the various chemicals used in the TPS area. Copies of company data on abnormal liver function tests and MDI air monitoring results were obtained. On May 7, 1984 a letter was sent to company and union representatives (and to the requesters) summarizing the work done March 26-28 and making interim recommendations.

III. BACKGROUND

In the Thermal Protection System areas, the external fuel tank for the National Aeronautics and Space Administration (NASA) space shuttle is covered with one or more MDI insulating foams or super-light ablator (SLA), a non-isocyanate carbon/cork insulator. The insulating processes include both mold forming and spray application. Pouring of isocyanate (or other insulation) into small molds occurs in all TPS areas, which include the small components and final assembly areas of Building 103, the vertical assembly building (VAB), and the final close-out area of Building 420. Workers pouring isocyanates are supplied with personal protective equipment, and unprotected worker bystanders are advised to maintain a 10-foot distance for 30 minutes after the mixing of the reactive isocyanate components.

In the VAB, final assembly area, small components spray-on foam insulation (SOFI) area, and Building 420 (final close-out area), the workers are potentially exposed to gun-sprayed isocyanate foam insulation as well. Hand spraying is said not to exceed 2 to 3 hours cumulatively in a given shift. Workers who are spraying are protected with air-line supplied-air respirators, and others in the area are advised to maintain a 25-foot distance for 30 minutes after the operation is completed. Large-volume spraying of isocyanate foam occurs in the VAB in enclosed production cells which are closed to workers during spraying operations.

Various other organic chemicals are also used in the areas described above. DeSoto Primer, which contains methylene chloride, cyclohexanone, methyl isobutyl ketone, and xylene, is applied to metal

substrates to protect them before applying foam insulation. One person is often responsible for mixing primer daily for several weeks at a time. Methylene chloride is also present in Dupont Freon TMCT, which is used widely in the final assembly area as well as in other TPS areas. It is used to clean the metal tank and workers' tools. Workers report that they may be exposed for 5- to 30-minute periods as many as three to four times daily in an open room.

Styrene monomer is present in Isochem PE bond MM/IP Unsaturated Polyester Resin T, an adhesive used to repair cured isocyanate in the final assembly area. Exposure may occur for 10 to 15 minutes, up to three times daily, according to interviews with workers. Respiratory protection is required, and compliance is reportedly good because of the strong solvent smell of the product.

Toluene is present in modified polyamide 910-787 primer curing solution. Varnish makers and painters (VM & P) naphtha is present in Dow Corning 1200 RTV Primer T, which is used as a base coat to prepare metals for SLA application. VM & P naphtha may contain toluene, xylene, benzene, and other aromatic hydrocarbons. Dimethyl phthalate is present in Isochem Super MEK Peroxide. Cellosolve acetate is used to clean the spray guns in the small components SOFI area.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Environmental monitoring records and procedures for several years were reviewed. Because there are multiple exposures in the various TPS areas, the NIOSH investigators limited their exposure assessment primarily to areas where workers are potentially exposed to isocyanates and to chemicals present in the final assembly area of Building 103, where the apparent excess of abnormal liver function tests occurred.

B. Medical

Asthma Case Finding

Current and former workers with a history of possible work-related asthma, brought to our attention through interviews with workers and company officials, were interviewed, and medical records were obtained in an attempt to identify cases of work-related (isocyanate-induced) asthma.

Epidemiologic Evaluation of Lung Function

All male TPS workers with potential exposure to isocyanates in January 1981 were identified from a January 1981 job title roster

provided by the personnel department. They all had yearly spirometric tests, since this is required of all workers in the areas where there is exposure to isocyanates. Serial spirometric results from September 1981 (when a new spirometer was purchased) through March 1984 were abstracted from available Martin Marietta medical records for this cohort. The "TPS workers" classification constituted the "low exposure" category. "TPS mechanics" were considered potentially moderately exposed, and "sprayers" were potentially more highly exposed. Sprayers actually spray the isocyanate foam onto the fuel tank, mechanics do jobs which are likely to bring them into the general area of the spray operation, and the "TPS worker" is most likely to be working at a distance from the spray operation. In order to include more sprayers in the study, medical records for all additional sprayers ("high-exposure") who started in that job between January 1981 and April 1982 were also reviewed. A total of sixty-three male workers' charts were available for review.

Prevalence of Liver Function Abnormalities

Results of routine annual blood tests for serum liver enzyme concentrations from workers in various parts of the plant were reviewed, and selected workers from the final assembly area with a history of abnormal liver enzymes were interviewed.

V. EVALUATION CRITERIA

A. Environmental Criteria

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

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

Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (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.

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.

B. Specific substances

1. Diphenylmethane diisocyanate (MDI)[1,2]

MDI belongs to a group of compounds called diisocyanates, or simply isocyanates. Occupational exposure to isocyanates has well-recognized adverse health effects. Isocyanates are irritants of the skin, eyes, and respiratory tract. Repeated exposure can lead to the development of allergic sensitization in some persons, resulting in asthma-like reactions (immediate, delayed, or both) at concentrations much lower than those producing irritation. Other chronic effects that have been reported include impairment of pulmonary function [one-second forced expiratory volume (FEV_1) and forced vital capacity (FVC)], shortness of breath, bronchitis, and hypersensitivity pneumonitis (another type of allergic lung disorder).[3,4]

The OSHA standard for MDI is a ceiling concentration of 20 ppb. Because this criterion is not adequate to prevent either cases of isocyanate-induced asthma or excess group declines in lung function, NIOSH recommends that exposure to MDI not exceed a 10-hour time-weighted average concentration of 5 ppb nor a 10 minute ceiling concentration of 20 ppb.

MDI and toluene diisocyanate (TDI) have been reported to be mutagenic,[5] and TDI has been found to cause cancer in rats and mice.[6] Based on these studies, NIOSH has initiated a mortality study of workers exposed to TDI.

2. Other substances [benzene, cellosolve acetate (2-ethonyethyl

acetate), cyclohexanone, dimethyl phthalate, methyl isobutyl ketone (hexone), methylene chloride, styrene, toluene, xylene]

In general, these organic compounds, in sufficiently high concentrations, are irritating to the eyes, nose, and throat, and can cause central nervous system effects such as drowsiness, dizziness, giddiness, and incoordination. Other effects produced by some of them include headache, nausea, numbness of the hands or feet, and dermatitis (from contact with the compounds in liquid form). Methylene chloride causes cancer in experimental animals,[8] and dimethyl phthalate and cellosolve acetate[9] cause birth defects or other adverse reproductive outcomes.

Some of these compounds have effects on the liver in experimental animals (methylene chloride, cyclohexanone, methyl isobutyl ketone[10]) or in humans following very high exposures (toluene, xylene). There is some evidence of liver toxicity from occupational exposure to styrene.[11]

VI. RESULTS AND DISCUSSION

A. Environmental

Results from the Martin Marietta Company's MDI environmental monitoring program were obtained and reviewed. The program has used the MDA Scientific, Inc., MDI Continuous Monitor Model 7000 for area sampling. Environmental data were available for various locations in the TPS mixing and application areas for the period March 1981 through January 1984. Sampling has been periodically conducted outside of the spray booths to measure for MDI leakage into the surrounding work areas. No leakage was reported as having been detected from the booths. Measurements made within the spray booths indicated the highest concentration in an occupied booth was 25 ppb. A peak value of 28 ppb and an 8-hour TWA of 10 ppb were reported for the final assembly area. All other concentrations reported, with the exception of a robot operation in a spray booth, were equal to or less than 25 ppb. Reported values, however, were area concentrations rather than personal exposures. Operators and sprayers are required to wear supplied-air respirators (full-face, positive-pressure demand types).

Environmental air samples have also been collected for cellosove acetate, heptane, methyl ethyl ketone, chlorofluorocarbons, styrene and trichloroethylene. A variety of sampling methods has been employed, including Miran 101 and 1-A Infrared spectrometers and Draeger tubes for screening specific operations and area monitoring, and 3M organic vapor monitors and charcoal tubes for personal samples. All sample results were reported as either being

below the action level for the particular chemical involved or in areas restricted to personnel wearing proper protective equipment.

General safety precautions for spraying operations require the wearing of a chemical vapor respirator with a dust filter or an air-line respirator, rubber gloves, safety goggles or full-face mask supplied with the respirator, and coveralls with long sleeves.

Although the air concentrations of substances to which employees were potentially exposed were within acceptable levels, or in areas where respirators were required, there appears to be no consistent sampling strategy involved in the company's monitoring program. As a result, changes in exposure patterns are difficult to identify.

B. Medical

Asthma Case Finding

Reports from workers or management personnel of individuals who might have work related asthma were investigated. Individual interviews and review of Martin Marietta and private medical records identified three workers with histories and supporting medical records suggestive of isocyanate-related asthma. For purposes of this investigation, a worker was not considered to have isocyanate asthma unless the disease met certain epidemiologic criteria:

1. Asthmatic symptoms first began after starting work in one of the TPS areas where isocyanates are used.

2. Symptoms became worse on the day of, or night following, exposure and improved when exposure ended (for example, over vacation).

3. The diagnosis of asthma was made by a physician and was supported by objective physical or laboratory findings (wheezing or improvement of FEV_1 with bronchodilators).

4. The worker noted the asthmatic symptoms to be associated with exposure to isocyanates.

5. The worker's physician considered the asthma to be caused by work.

Three cases of isocyanate asthma were identified. It was not possible to determine whether sensitization to isocyanates in the asthma cases resulted primarily from continued low-dose exposure or from a single high-dose exposure, such as a spill or accident. Each of the affected individuals described an insidious onset of wheezing and shortness of

breath within 8 months of beginning work in an area where isocyanates were sprayed. One worker was employed as a "TPS worker" at the time symtoms developed; two were employed as sprayers. In one case, symptoms compatible with work-related asthma were noted in the company medical chart more than 1 1/2 years before the worker was removed from exposure by the plant physician.

Although the diagnosis of isocyanate-induced asthma could be more definitely made on the basis of pre- and post-shift spirometry during the time of exposure (or perhaps with bronchial challenge testing even now), the individuals affected did not have pre- and post-shift testing done during the time of exposure and are no longer exposed.

It is the opinion of the NIOSH medical investigator that the three probable cases encountered are likely to underestimate the true number of such illnesses. The criteria for isocyanate-induced asthma excluded workers with late asthmatic reactions (typically four or more hours after exposure starts). Such workers may not recognize the work-relatedness of their disease, and identifying the specific agent is difficult. Other possible cases were excluded because asthma was not objectively documented in a medical record, because the patient's physician equivocated as to whether it was work-related, or because the patient had left the plant and could not be contacted for interview by the NIOSH investigators.

The presence of probable cases of isocyanate-induced asthma strongly suggests that workers in the TPS area have, at least intermittently, been exposed to levels of isocyanates exceeding the NIOSH recommended standard. That less-exposed workers became ill suggests that all workers in the area are at risk, not just sprayers.

Epidemiologic Evaluation of Lung Function

The Martin Marietta Michoud Operation currently uses an Ohio Medical spirometer with display of expiratory curve and automated printout of three expiratory trials. It is calibrated weekly. Based on a review of the two most recent spirometry printouts in six randomly selected charts, the quality of lung function data collected by the company was evaluated according to American Thoracic Society (ATS) criteria for epidemiologic studies.[12] Four out of six charts had one or more spirometric tests which did not meet the ATS criteria. Nevertheless, data were tabulated, and changes in pulmonary function were compared between exposure groups.

The mean yearly decline in FEV_1 was calculated for the three exposure groups. There seemed to be a greater decline with higher exposure (Table 2), but this was not statistically significant, either when the high- or medium-exposure group was compared to the low-exposure group or when the high-exposure group was compared to an expected population

decline of 0.028 l/year [13] ($p > 0.05$ by t-test). Although these data do not appear to document an isocyanate-related deterioration in lung function, such an effect may have been missed because of the short time span (2 years), the relatively small number workers (especially in the high-exposure group), the sub-optimal quality of the pulmonary function data, and misclassifications of exposure because of job changes during the 2-year period.

There was a significantly accelerated decline (-0.192 1, s. d. = 0.167) among the 17 smokers with two years of FEV measurements than among the 14 non-smokers (-0.06, s. d. = 0.177) ($p = 0.4$ by t-test). In order to control for the possible confounding effect of smoking, a linear regression of first and second and 2-year change in FEV_1 on exposure and smoking status was performed. It did not reveal a statistically significant decline accounted for by MDI exposure ($F = 0.32$, $p = 0.77$).

Other possible biases or confounders in this study were evaluated. Workers who had three separate lung function tests over at least a two-year period had no more rapid decline in FEV_1 than workers who had only two tests (at least a one year apart), the latter group conceivably including workers who left because of heazlth problems. There was no statistically significant difference between the mean changes in the first- or second-year FEV_1 among the 24 workers less than 25 years old and those among workers older than 25.

Although these data do not appear to document an isocyanate-related deterioration in lung function, such an effect may have been missed because of the short time span (2 years), the relatively small number of workers (especially in the high-exposure group), the sub-optimal quality of the pulmonary function data, and misclassifications of exposure because of job changes during the 2-year period.

Prevalence of Liver Function Abnormalities

As part of a screening physical examination of workers employed in the TPS (and other) areas, the Martin Marietta medical department measures serum glutamic pyruvic transaminase (SGPT) as an indication of liver damage. (This is an appropriate and sensitive initial screen for evidence of liver disease.[14]) Until recently, employees with a repeated concentration above 33 units/l were removed from areas where there is chemical exposure. When no positions are available in other areas of the plant, these workers are sent home on temporary disability until the SGPT returns to normal.

The number of abnormal SGPT measurements by department in the plant has been compiled by the company safety department. Assuming the expected population abnormal rate is 3.5% (based on the plant-wide rate), the only area where there appears to be, based on a sufficient number of

workers, a substantial increase in prevalence of abnormal SGPT concentrations is the final assembly area (Table 3). However, a review of the statistical distribution of SGPT measurements conducted by a company consultant, and reviewed by the NIOSH investigators, suggests that a "normal" range would be 7-43 units/l (the middle 95% of the population) rather than the 33 units/l ceiling used until shortly before the NIOSH visit by the company medical department to define an "abnormal" result. Therefore, some workers who actually had a "normal" SGPT may have been removed from work in the TPS area.

Although there are chemicals in the final assembly area which are potentially hepatotoxic, exposure to most of them is sporadic and for short periods, according to interviews with employees. In addition, many of these chemicals are present in other parts of the plant, where there is not an increased prevalence of abnormal SGPT.

Further medical evaluations by the affected workers' private doctors have not been available to anyone for overall evaluation of all the cases, an activity that could help determine whether liver damage resulted from chemical exposure. For example, knowing that a worker has a case of hepatitis B (an infectious disease unrelated to chemical exposure) rather than an unexplained liver disease with a biopsy suggestive of a toxic hepatitis (which could be explained by chemical exposure) would be helpful in deciding whether an occupational exposure problem exists.

Without careful delineation of the precise prevalence of abnormal SGPT, using criteria appropriate for the population in the Marin Marietta plant (as described above), and without adequate followup of individual cases, it is difficult to say whether liver disease has resulted from chemical exposure in the final assembly area.

Other Worker Concerns

In each area visited, workers expressed concern over the absence of information on potential adverse health effects of the materials used, especially of information on the possible long term effects of chemicals with which they work. Labels on chemical containers on the shop floor do not mention symptoms of either immediate or possible long-term effects, nor do they provide advice for dealing with spills or other accidents. Of seven workers who were shown a sheet with health information which reportedly arrives at the plant with each drum of BX-250™ isocyanate foam reactants, only one worker reported having previously seen the information sheet.

VII. RECOMMENDATIONS

1. If health effects information is not contained in the appropriate process instruction (PI) sheets, it should be made available to

employees at the applicable production areas on the shop floor. The Martin Marietta Safety Standard Manual contains much of this information for immediate effects. Long-term effects would be unusual for many chemicals used in these areas, but these effects should be emphasized where appropriate. Examples include asthma resulting from isocyanate exposure in humans and birth defects in animals resulting from cellosolve acetate exposure. This latter effect was not noted in the manual. Such information will address workers' concern as to exactly what chemical hazards they face, and it may also help workers understand the importance of their personal protective equipment.

2. The 25-foot hazard radius (or 10-foot radius in the case of pouring operations) should be marked, where possible, to warn workers of the areas they should avoid during processes using MDI.

3. The 25-foot radius for isocyanate spraying operations (or 10-foot radius in the case of pouring operations) should be investigated by means of personal air sampling for both time-weighted average and ceiling (10-minute) exposures to workers at the edge of the radius. This would help insure that this is a safe distance for workers with bystander exposure and perhaps shed some light on the origin of the cases of isocyanate-induced asthma which have occurred at the plant.

4. The 20 ppb permissible exposure limit ceiling for MDI used by Martin Marietta is not adequate, by itself, to prevent either work-related asthma or a group decline in respiratory function. The NIOSH recommended standard for isocyanates is a 10-hour time-weighted average exposure limit of 5 ppb in addition to a short-term ceiling exposure limit of 20 ppb.

5. Some workers with isocyanate-provoked asthma will react to air concentrations of 1 ppb or less.[1] Therefore, essentially any exposure can provoke asthmatic attacks in these individuals. Once the diagnosis is suspected, an immediate attempt should be made to confirm the diagnosis (for example, with pulmonary function tests at the beginning and end of the work day and work week, or with serial peak-flow measurements), and these workers should be given the immediate option of transferring to another part of the plant. It is not advisable to reassign these workers to a job in any area where isocyanates are used (as has been done in the past at Martin Marietta), even if exposure is less than that in the job where asthmatic complaints were first noted.

6. Disease which is recognized as possibly work-related should be carefully investigated. For example, a case of probable isocyanate-induced asthma should serve as a warning that other workers are at risk. The circumstances surrounding the exposure which provoked the illness should be investigated, and steps should be taken to warn and protect similarly exposed workers.

7. Where they will not violate the confidentiality of an individual worker, the results of monitoring and work-related investigations should be posted (with interpretation) in the workplace or otherwise be made available to workers and their representatives.

8. Bringing the sprirometric testing into conformance with ATS criteria for epidemiologic studies would make it possible to give more definitive answers to questions about group effects of MDI exposure or alleged exposure to other pulmonary toxins.

9. Although most processes we viewed in TPS seem not to be amenable to engineering controls (which would eliminate the need for personal protective equipment), the possibility of doing mixing and pouring of SLA™ and PDL™ under a hood should be investigated.

10. The prevalence of abnormally high serum liver enzyme concentrations in the final assembly area, using the new criteria for abnormal SGPT, should be compared to other parts of the plant. One approach to addressing this issue is to encourage all workers with abnormal SGPT to go to the same consulting physician for further evaluation or to provide this physician with the results of evaluations done elsewhere. If work in the final assembly area is causing liver damage, a suggestive pattern is much more likely to be recognized by one doctor evaluating or reviewing all cases of abnormal test results. Conversely, liver disease not related to work can be recognized as such, and employees can be reassured. Worker compliance with appropriate medical referral would be more likely if management involves the workers' elected representatives in selecting a mutually acceptable consulting physician.

11. Evaluation of jobs with exposure to potential hepatotoxins and air sampling of worst case exposures would be helpful in identifying possible hazards to employees. Such results would also be helpful in guiding the plant medical department and workers' personal physicians in determining whether the work environment is safe for workers with pre-existing liver disease.

12. A monitoring strategy that will reflect the temporal and spatial variations in potential exposure conditions should be developed and implemented.

VIII. REFERENCES

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through te National Technical Information Service (NTIS, 5285 Port Royal, Springfield, Virginia 22161). 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. Confidential requester
2. United Auto Workers, Local 1921
3. Martin Marietta, Michoud Division, New Orleans, Louisiana
4. United Auto Workers, International Health and Safety Office
5. NIOSH, Region VI
6. OSHA, Region VI

TABLE 1

Summary of Exposure Limits[1] for
Substances Used in Final Assembly Area

Martin Marietta Michoud Operations
New Orleans, Louisiana
HETA 84-117

Substance	OSHA[2]	ACGIH[3]	NIOSH[4]
Diphenylmethane diisocyanate	0.02 ppm	.02 ppm	0.005 ppm
Styrene	100 ppm	50ppm	50 ppm
Methylene chloride	500 ppm	100 ppm	LFL[5]
Cyclohexanone	50 ppm	25 ppm	25 ppm
Methyl isobutyl ketone	100 ppm	50 ppm	50 ppm
Xylene	100 ppm	100 ppm	100 ppm
Toluene	200 ppm	100 ppm	100 ppm
Dimethyl phthalate	5 mg/m^3	5 mg/m^3	-----
Cellosolve acetate	100 ppm	5 ppm	-----
Benzene	10 ppm	10 ppm	1 ppm[6]

1. OSHA and ACGIH limits are 8-hour time-weighted averages; NIOSH limits are 10-hour TWA's.
2. 29 CFR 1910.1000.
3. Threshold Limit Values and Biological Exposure Indices for 1985-86.
4. NIOSH Pocket Guide to Chemical Hazards (DHHS (NIOSH) publication no. 85-114).
5. Lowest feasible limit. Reference: NIOSH Current Intelligence Bulletin 46 -- Methylene chloride (DHHS (NIOSH) publication no. 86-114).
6. 60-minute ceiling.

TABLE 2

First-year, Second-year, and Two-year Cumulative Change in FEV_1 by MDI Exposure Level

Martin Marietta Michoud Operations
New Orleans, Louisiana
HETA 84-117

	MDI Exposure		
	LOW	MODERATE	HIGH
First-year change	-0.368 (13, 0.190)*	0.006 (41, 0.201)	0.154 (9, 0.306)
Second-year change	-0.036 (9, 0.157)	-0.083 (16, 0.207)	.098 (6, 0.453)
Two-year change	-0.082 (9, 0.129)	-0.130 (16, 0.180)	-.150 (6, 0.266)

*Change in FEV_1, expressed as liters, and (number of workers, standard deviation)

TABLE 3

Employees with Elevated SGPT, January 1, 1983 - November 30, 1983

Martin Marietta Michoud Operartions
New Orleans, Louisiana
HETA 84-117

DEPARTMENT	NUMBER WITH ELEVATED	NUMBER TESTED	% ELEVATED
3611 Tool Design	3	139	2
3614 Mfg. Eng.	1	94	1
3616 Tool Fab.	10	191	5
3621 Weld Assembly	4	134	3
3622 Mech. Assembly	5	100	5
3625 Mach. Shop	1	76	1
3631 Proof Test	1	23	4
3632 Final Assembly	9	103	9
3633 S/S Test C/O	1	52	2
3634 Elect. Harness	1	13	8
3636 TPS Closeout	1	58	2
3641 Shop Control	2	321	0.6
3642 Shop Control	3	39	8
3643 Tool Control	3	76	4
3644 Reqmt. Control	1	36	3
3654 Cost Mgt.	1	19	5
3670 TPS Comps.	0	3	0
3671 TPS SLA	0	57	0
3672 TPS Mix Ops.	0	38	0
3673 TPS SOFI	0	027	0
3674 TPS Mach. Shop	0	28	0
3681 TPS VAB Ops.	0	84	0
3682 Bldg. 114/131	4	103	4
3691 Process Develop	1	22	5
3080 Personnel	1	90	1
3100 Facilities	8	175	5
3500 Engineering	3	146	2
3700 Quality Assurance	13	370	4
3800 Material	1	95	1
3922 NSTL	1	35	3
TOTAL	79	2478	4