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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION
REPORTS NOS. 75-25 and 75-163-305

STORAGE TECHNOLOGY CORPORATION, INC.
LOUISVILLE AND BROOMFIELD, COLORADO

JUNE 1976

TOXICITY DETERMINATION

It has been determined that employees are exposed to toxic concentrations of N-methyldicyclohexylamine (MCHA) during packaging operations involving the use of polyurethane foam. This determination is based on data collected during packaging operations at Broomfield on October 13-14, 1975. Included were (a) medical interviews and limited physical examinations; (b) environmental measurements for MCHA; (c) a review of available literature on MCHA and similar compounds. Five (5) breathing zone samples were obtained and varied from none detected to a maximum of 1.6 mg/M³ (average -0.6 mg/M³) of MCHA. There are no current American Conference of Governmental Industrial Hygienists (ACGIH) recommended Threshold Limit Values (TLVs), Federal Occupational Health Standards or other guides for MCHA. Medical results show that all employees developed symptoms which generally consisted of bad taste, nausea, dizziness and mucous membrane irritation. Such symptoms are consistent with exposure to amines of the MCHA type. It has been determined that employees are not exposed to toxic concentrations of methylene bisphenyl isocyanate (MDI) during packaging operations involving the use of polyurethane foam. Five (5) breathing zone samples were obtained and varied from none detected to a maximum of 0.03 mg/M³ for MDI. This represents approximately fifteen percent of the current ACGIH recommended TLV of 0.2 mg/M³ for MDI. Medical tests and results did not show any symptomatology which were considered as directly attributable to exposures of workers to MDI.

It has further been determined that employees are not exposed to toxic concentrations of lead, antimony, arsenic, nickel, chromium, pyrolysis products of rosin core solder (as formaldehyde), methyl methacrylate, and organic solvents (e.g., primarily Freon 113, toluene, naphtha, xylene and hexone) during metal electroplating, soldering and ancillary operations at the time of the final survey. All breathing zone sample results were well below the ACGIH recommended TLV for these substances, and no abnormal symptomatology was detected which could be attributed to any excessive exposure to these substances.

The above determinations are based on the environmental and medical data collected at the time of the surveys. Detailed information concerning the results of the initial survey and the final survey are contained in the body of this report. Recommendations are included in this determination report which are designed to reduce employee exposure to a minimum.

II. DISTRIBUTION AND AVAILABILITY OF THE DETERMINATION REPORT

Copies of this Determination Report are available upon request from NIOSH; Robert A. Taft Laboratories; 4676 Columbia Parkway; Cincinnati, Ohio 45226. Copies have been sent to:

- (a) Storage Technology Corporation; Louisville, Colorado 80027
- (b) Authorized Representative of Employees
- (c) U. S. Department of Labor - Region VIII
- (d) NIOSH - Regions VIII and VII

For the purpose of informing the approximately 280 exposed employees (including approximately 10 employees involved with the polyurethane foam operation), this report shall be posted in a prominent place readily accessible to workers for a period of at least 30 calendar days.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by an 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 National Institute for Occupational Safety and Health (NIOSH) received two requests from the management of Storage Technology Corporation, Louisville, Colorado, to evaluate the potential health hazards associated with employee exposures to organic solvents and other substances during packaging operations involving the use of polyurethane foam and also during metal electroplating, soldering and other ancillary operations. The requests were precipitated by the management's concern regarding possible exposures to emissions during these operations.

IV. HEALTH HAZARD EVALUATION

A. Description of Process - Conditions of Use

Storage Technology Corporation is engaged in the manufacture of computer data storage sub-systems at their main facilities at Broomfield and Louisville, Colorado. The main area of concern at both locations is after

the manufacture and assembly of the computer data sub-systems. This involves the use of polyurethane foam systems for packaging the computer sub-systems and electronic components prior to shipment. Exposures to organic compounds such as methylene bisphenyl isocyanate exists during polyurethane foaming operations. The process consists of a two-part liquid system dispersed through a single packaging console. Employees work with the packaging unit for periods varying from 6 to 12 hours a day to as little as 1 to 2 hours a week. Exposures were characteristically intermittent and, in general, much less than 40 hours per week. These operations were primarily confined to the Broomfield facility during the surveys.

There are several similar areas in both plants that have hand soldering stations involving printed circuit boards. Some soldering is performed by automatic wave soldering machines at the Broomfield facility. These operations also involve the use of various organic solvents for cleaning purposes, glues, spray paints, and other organic compounds as well as rosin core solder. In these areas, possible exposure to tin, lead, antimony, arsenic and several organic compounds exists. In addition, the Broomfield facility has an electroplating area where exposures to nickel, chromium, and methyl methacrylate can occur.

B. Study Progress and Design

The procedures used to evaluate the plant areas of concern included on-site interviews with employees and management, preliminary medical and environmental studies, contact with the manufacturers of products used in the process to identify toxic ingredients, the administration of medical questionnaires, a medical history from and examination of exposed workers, and extensive air sampling to evaluate potential exposure to airborne contaminants.

The initial and final environmental-medical evaluation visits or studies were conducted on April 22-24 and October 13-14, 1975, respectively. The final study included an evaluation of employee exposures involved with the following operations and chemicals:

1. Packaging operations utilizing polyurethane foam with primary exposures to methylene bisphenyl isocyanate (MDI) and N-methyldicyclohexylamine (MCHA) and secondary potential exposures to ethylene glycol monoethyl ether and fluorotrichloromethane. There was no evidence of even trace amounts of ethylene glycol monoethyl ether or fluorotrichloromethane during the initial survey, and therefore, these two compounds are not discussed further in this report. The operations evaluated were conducted in the warehouse facilities located at Broomfield, Colorado. Employee exposures varied from a few to several hours during a week.
2. Electroplating, soldering, and ancillary operations involve primary exposures to nickel, chromium, tin, lead, antimony, arsenic, rosin core solder pyrolysis products (measured as formaldehyde), methyl

methacrylate, and organic solvents which mainly included "freon-113", methyl isobutyl ketone (hexone), xylene, toluene, and naphtha, with secondary exposures to methylene chloride, t-butyl alcohol, n-propyl alcohol, 1,1,1-trichloroethane, isobutyl alcohol and n-butyl alcohol. There were only a few samples which gave positive trace indications (all less than ten percent of appropriate ACGIH recommended TLV's or Federal Occupational Health Standards) of any of the secondary exposures mentioned above. Therefore, these compounds are not discussed further in this report. The operations evaluated were conducted in the main facilities at Broomfield and Louisville, Colorado.

C. Evaluation Methods

1. Environmental Methods

Personal breathing zone air samples were used to evaluate employee exposures. The personal samplers were connected on or near the collar of the employees to collect a representative sample of air in the breathing zone of the workers. General area samples were collected in the vicinity of various operations.

N-methyldicyclohexylamine and organic vapor samples were collected on silica gel and charcoal tube media, respectively, and analyzed by gas chromatography. MDI and pyrolysis products (as formaldehyde) samples were taken with impingers containing appropriate collecting media and analyzed spectrophotometrically and colorimetrically, respectively. Tin, lead, antimony, arsenic, nickel, and chromium samples were obtained on AA filters and analyzed by atomic absorption spectroscopy methods. All samples were analyzed using standard analytical methods.¹

2. Medical Methods

The evaluation of the packaging area involving polyurethane foam operations included a walk-through examination of the production process. Each employee completed a directed medical questionnaire, furnished a medical history, and received a mucous membrane examination as well as certain respiratory function tests such as Forced Vital Capacities (FVC) and Forced Expiratory Volume at 1 second (FEV₁). Both pre- and post-shift examinations were performed on these employees on the day of the visit. In addition, a complete blood count and non-fasting Serum Multiphasic Analysis (SMA-6 and SMA-12) examinations were performed on each employee. These blood tests included but were not limited to red blood cell count, white blood cell count, hemoglobin, hematocrit, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), carbon dioxide (CO₂), lactic dehydrogenase (LDH), serum glutamic oxalacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), blood urea nitrogen (BUN) and albumin globulin ratio (A/G). These tests were performed to detect abnormalities in the blood which may be related to occupational or other diseases (e.g., abnormal liver function, anemia, etc.).

A walk-through evaluation of the Broomfield and Louisville electroplating, soldering, and ancillary areas was performed during the final survey. A directed medical history was taken from 31 employees identified from this group. If a positive response was received which was thought to be work-related, relevant physical examination was performed. The three groups of employees who were evaluated were those who had positive responses on a non-directed, randomly administered questionnaire given to employees in April 1975, those employees who were randomly selected for industrial hygiene monitoring during these surveys, and any other employees identified as symptomatic during the final survey.

D. Evaluation Criteria

1. Environmental Standards or Criteria

The evaluation criteria applicable to this evaluation are as follows: the Occupational Health Standards as promulgated by the U.S. Department of Labor, Federal Register, May 28, 1975, Title 29 Chapter XVII, Subpart G, Tables Z-1 and Z-2 (29 CFR Part 1910.1000); American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV) for Chemical Substances and Physical Agents in its Workroom Environment for 1975; and the NIOSH Criteria Documents recommending occupational standards.

For brevity, the recommended health guides of the ACGIH are used as reference points in the following presentation of evaluation criteria. Use of the two other sources of criteria would not change any conclusions contained in this report. The occupational health guide promulgated by the ACGIH (1975) applicable to the principal individual substances of this evaluation are as follows:

SUBSTANCE	TLV 8-HOUR TIME-WEIGHTED AVERAGE (TWA) EXPOSURE STANDARD OR GUIDE
"C" Methylene bisphenyl isocyanate (MDI)	0.2 mg/M ³
Nickel, metal and insoluble compounds (as Ni)	1.0 mg/M ³
Chromic acid and chromates (as CrO ₃)	0.1 mg/M ³
Lead, inorganic fumes & dusts (as Pb)	0.15 mg/M ³
Tin (inorganic compounds, except SnH ₄ and SnO ₂) (as Sn)	2.0 mg/M ³
Arsenic and compounds (as As)*	0.5 mg/M ³
Antimony and compounds (as Sb)*	0.5 mg/M ³

Methyl methacrylate	410.0 mg/M ³
Rosin core solder pyrolysis products (as formaldehyde)	0.1 mg/M ³
1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113)	7600.0 mg/M ³
Hexone (methyl isobutyl ketone)--skin	410.0 mg/M ³
Toluene (toluol)--skin	375.0 mg/M ³
Xylene (O-, M-, P- isomers)--skin	435.0 mg/M ³
Naphtha (petroleum)**	400.0 mg/M ³

mg/M³---Approximate milligrams of substance per cubic meter of air.

"C"-----Denotes a ceiling limit of concentration for the substance which should not be exceeded.

*-----Current evidence concerning antimony trioxide and arsenic trioxide indicates that these substances may have carcinogenic or cocarcinogenic potential. The suggested TLV for these compounds is 0.05 mg/M³ as As or Sb. It is further noted that NIOSH's Criteria Document, "Occupational Exposure to Inorganic Arsenic", recommends that no worker be exposed to a concentration of arsenic in excess of 0.002 mg/M³ in order to materially reduce the risk of arsenic-induced cancer.

**-----Assuming that nothing more toxic than toluene and xylene is present.

There are no ACGIH recommended TLV's, standards, or other health guides, and there is little other background information concerning the health effects of N-methyldicyclohexylamine.

Occupational health exposure limits for individual substances have been generally established at levels designed to protect workers occupationally exposed on an eight-hour per day, 40-hour per week basis over a normal working lifetime.

2. Medical Standards or Criteria

a. Methylene Bisphenyl Isocyanate (MDI) and N-Methyldicyclohexylamine (MCHA)

MDI in sufficient amounts is a primary irritant of the mucous membranes of the eyes, nose and throat and of the respiratory tract.² In addition,

it may cause allergic sensitization of the respiratory tract which may result in severe asthmatic attacks after exposure to even minute traces of MDI. Fully reacted MDI no longer elicits an allergic or irritant response.

N-methyldicyclohexylamine (MCHA) is a tertiary aliphatic amine. Although there is little background information concerning the possible health effects of N-methyldicyclohexylamine, some information is available concerning the toxicologic effects of other materials of this class and of certain closely related substances.³ Irritation of the mucous membranes of the eyes, nose and throat and in some cases respiratory distress and cough has been noted with one report of asthmatic symptoms.⁴ Amines of this type have a typical odor. Irritation of the skin may occur and may lead to dermatitis.⁵ Allergic skin sensitization has not been reported from methyldicyclohexylamine but does occur with some related materials. These effects appear to be due to local contact with the vapor. Headache, nausea, and anxiety occur after exposure to some materials of this class. Animal studies with certain aliphatic amines have reported changes in the lungs, liver, kidneys and heart. Certain other amines are potentially hepatotoxic to man.^{6,7}

b. Lead, Antimony, Tin, Arsenic, Nickel, and Chromium

Given sufficient exposure, these metals are all potentially toxic to humans. However, no detectable employee exposure or symptomatology was noted during this study.

c. Organic Solvents (Freon 113, hexone, toluene, xylene, and naphtha) and Methyl Methacrylate

The acute effects resulting from excessive exposure to these agents are generally similar although there are some minor differences. The effects are narcotic in appropriate exposures. Toluene has been most extensively studied, and concentrations slightly above the TLV of 375 mg/M³ give rise to mild fatigue, weakness and paresthesias of the skin. At higher concentrations nausea, headaches, dizziness and confusion appear which may progress (given sufficient exposure) to a loss of coordination and finally unconsciousness. Xylene is similar in its acute toxic effects, but it is noted to give rise to more pronounced gastrointestinal symptoms such as nausea, vomiting, and flatulence.

Chronic effects of exposure to such agents may include weakness, dizziness, headaches, fatigue, and in the case of skin contact, dermatitis. For the most part, the effects from each of the organic solvents are considered as additive and may contribute to an additive effect. Freon 113 is generally considered to be of low toxicity. The chief effects of exposure to Freon 113 at levels higher than the TLV are depression of the central nervous system and mild irritation of the respiratory tract. Very high concentrations may produce other systemic manifestations. Methyl methacrylate used in some areas of this plant is also potentially toxic, but detectable exposures were not found during these visits.

d. Rosin Core Solder Pyrolysis Products (as formaldehyde)

The fumes of pyrolysis products from soldering operations in relatively low concentrations irritate the mucous membranes of the eyes, respiratory tract and skin. Aliphatic aldehydes, as formaldehyde, were selected as the best indirect indicators for environmental analysis of rosin pyrolysis products.

E. Evaluation Results and Discussions

1. Environmental Results and Discussions

a. Polyurethane Packaging Operations

Ten (10) personal and general area impinger samples were obtained and analyzed for MDI during the initial study on April 22-24, 1975. MDI was not detected in these samples. Table I is a summary of the results from the six (6) samples obtained during the final study on October 13 & 14, 1975. The maximum concentration was 0.03 mg/M³ for MDI, which is less than twenty percent of the ACGIH recommended TLV of 0.2 mg/M³ for MDI.

Eleven (11) charcoal tube samples were obtained and analyzed for MCHA during the initial study. MCHA was not detected using a method with a sensitivity greater than 3.8 mg/M³. Further work on the sampling/analytical methodology showed that more sensitivity could be obtained by using silica gel tubes. Table II is a summary from the seven (7) silica gel samples obtained during the final evaluation. In three of the five personal samples, MCHA was detected with a maximum concentration of 1.6 mg/M³. Although there is no ACGIH recommended TLV or Federal Occupational Health Standards for MCHA, it is felt by the investigators that these levels may be indicative of significant exposure to the workers. In order to positively identify MCHA, samples were obtained directly in the visible vapor emanating from the foaming operation. Although these samples are not representative of employee exposures, the results (maximum of 640 mg/M³) do indicate that MCHA is present in significant quantities prior to significant dilution of the plume in the air. Table II presents additional data on sample results for MCHA.

b. Electroplating, Soldering and Ancillary Operations

Ten (10) personal and general area samples were obtained during this evaluation in the electroplating shop. These samples were analyzed for nickel and chromium. Nickel and chromium were not detected and were well below the ACGIH recommended TLV's for these substances. Three (3) personal and general area samples were obtained for methyl methacrylate during this evaluation. Methyl methacrylate was not detected in these samples, and all sample results were well below the ACGIH recommended TLV for methyl methacrylate.

Fifteen (15) personal and general area samples were obtained during the initial evaluation and analyzed for lead, antimony, tin and arsenic. None of these elements were detected with sensitivities much less than the ACGIH recommended TLV's for these substances. Fourteen (14) personal and general area impinger samples were obtained and analyzed for the pyrolysis products of rosin core solder (as formaldehyde) during the initial evaluation. Formaldehyde was detected in only two of these samples with a maximum result of 0.07 mg/M³ as formaldehyde. This is seventy percent of the ACGIH recommended TLV of 0.1 mg/M³ for rosin core solder as formaldehyde. As the sample results for these substances were well below their respective TLV's and there was no medical symptomatology associated with these exposures, additional samples were not considered necessary during the final evaluation.

A total of thirty-six (36) charcoal tube samples were obtained and analyzed for various organic solvents during the initial and final surveys. These sample results are presented in Table III-A and III-B. The main solvents of interest are toluene with an ACGIH recommended TLV of 375 mg/M³, xylene with a TLV of 435 mg/M³, naphtha with a TLV of 400 mg/M³, and hexone with a TLV of 410 mg/M³. One sample obtained during the initial survey exceeded the ACGIH recommended TLV with concentrations of 620 mg/M³ for toluene, 190 mg/M³ for xylene, 290 mg/M³ for naphtha and 280 mg/M³ for hexone. These concentrations are in excess of the TLV for toluene and approximately 3.5 times the appropriate TLV for the combined effect of the solvents which are considered as additive. All other results were significantly less than the ACGIH recommended TLV's for these solvents. It is noted that several of the samples were positive for Freon 113 (maximum concentration of 1200 mg/M³) although all were considerably less than the ACGIH recommended TLV of 7,600 mg/M³ for Freon 113. This is a common solvent used for cleaning purposes throughout the facility. Hexone, toluene and naphtha were not detected in samples obtained during the final survey. Samples were of sufficient duration to be considered as indicative of an estimated eight-hour time-weighted average. Although one sample at the time of the initial survey exceeded the TLV, exposures were much less at the time of the final study. It was felt that exposure of employees to organic solvents is well below suggested health standards on a daily basis, particularly when considering exposure over a weekly or 40-hour basis.

2. Medical Results and Discussions

a. Polyurethane Packaging Operations

A visible vapor was noted close to the polyurethane foam operation. An unpleasant effect of this vapor was noted by three members of the hazard evaluation team each of whom noted an unpleasant acrid (amine) odor. Two of the three members noticed an unpleasant taste which persisted for some hours but did not alter the taste of food subsequently eaten. This abnormal taste was resolved upon eating. All three observers noted throat irritation

and two noted irritation of the eyes. One noted nasal irritation, two noted chest tightness and one noted a dry cough. An odor could be detected by members of the evaluation team as far as 15 feet from the packing operation. The eye and chest irritation was relieved within less than 1/2 hour after moving away from the operation. None of the above investigators had a past history of asthma or sensitivity to these or other industrial materials.

All employees complained of past symptoms which included nausea, dizziness, cough and watering of the eyes. Some employees reported more severe symptoms in the past when the operation was performed in a smaller, less open area. One employee had suffered from shortness of breath in the past. This had been suspected as possibly due to MDI sensitization, but the employee had been able to return to work without redeveloping the symptoms which was not consistent with this diagnosis. From exposures on the day of examination, four of the five employees complained of a bad taste, three of nausea, one of dry mouth and lips, one of headache and one of dizziness. All of these symptoms developed during the shift. There was no change observed from examination of the conjunctiva, nose or pharynx over pre- and post-shift time. Exposures to the operation of the five employees varied from one to four hours during the day of the evaluation.

The average pre-shift FEV₁ for the five employees was 109% of the predicted value and the average post-shift FEV₁ was 108% of the predicted value. The average pre-shift FVC was 110% of the predicted value and the average post-shift FVC was 108% of that predicted. The average ratio of pre-shift FEV₁/FVC was 83.7 and the average post-shift ratio of FEV₁/FVC was 84.5. No significant change was found in the FEV₁ or in the pre- and post-shift FEV₁/FVC ratio for any individual employee or for any average value of the five employees. In particular, none of the tested employees showed a drop greater than 5% in the ratio of FEV₁/FVC during the course of the shift. Therefore, on the basis of these results, there was no evidence of occupational asthma such as seen in respiratory sensitization to MDI or obstructive lung diseases in these employees.

Investigations performed were red blood cell count, white blood cell count, hemoglobin, hematocrit, MCV, MCH and MCHC. No abnormalities were noted in any of the five employees. In particular, there was a lack of absolute eosinophilia (greater than 350/cmm) in all employees after exposure to the operation. The results for the analyses for glucose, sodium chloride, CO₂ and LDH were uninterpretable. Results of serum BUN, Creatinine, uric acid, total protein, albumin, globulin, A/G ratio, calcium, phosphate, cholesterol, alkaline phosphatase, SGOT, and total bilirubin were normal for all five employees. One employee had an increased SGPT concentration and another employee had an increased SGPT and slightly elevated serum triglyceride concentration.

No evidence of respiratory sensitization or asthma such as had been previously reported from exposure to MDI was noted in these subjects. These results are in accord with previous studies using the same foaming equipment and

compounds. Although one employee in our study complained of symptoms which would have been compatible with respiratory sensitization to MDI, physical examination, pulmonary function testing and eosinophil counts failed to show any evidence of respiratory sensitization in him or any of the other four employees.

Virtually all employees exposed to the polyurethane foam system, however, did develop symptoms which generally consisted of a bad taste, nausea, dizziness and mucous membrane irritation. Chest tightness, cough and vomiting apparently have occurred with more intense exposures. These symptoms appear related to exposure to the tertiary amine as similar symptoms have been described from other compounds of this type; for example, cyclohexylamine and dicyclohexylamine. Available data suggest that these materials are irritants and may also result in central nervous system symptoms. Two of the subjects had an abnormal SGPT liver function test. Although such abnormalities can result for other reasons, this observation suggests that careful observations of employees exposed to this agent must be continued in order to confirm whether or not liver abnormalities may be specifically associated with exposure to N-methyldicyclohexylamine or other materials used in the foam process.

A review of OSHA and other medical records concerning employees at the polyurethane foam operation revealed that in 1975 four cases of illness were reported. All complained of anorexia, fatigue and dizziness. Chest x-rays and liver profiles were performed on each of these employees. Chest x-rays were normal in all cases, and one man was noted to have abnormal liver function tests and was withheld from working in the area until the liver function tests had been repeated.

b. Electroplating, Soldering, and Ancillary Operations

Twelve of the 24 employees who gave positive responses to a non-directed questionnaire given in April 1975 were evaluated on this occasion. Two employees had previously suffered from dermatitis which had now been resolved. One employee had suffered from eye irritation and two had difficulty with the use of safety glasses, but these problems had been resolved. One had previously suffered itch on exposure to fiberglass but this was no longer a problem. Five employees had complained of headaches secondary to various exposures especially to freon. All had a pre-employment history of headaches, but none of these employees currently had a serious headache problem. No abnormalities were documented on physical examination which appeared relevant to the workplace findings.

Seventeen interviews were conducted with the randomly selected group of employees who underwent industrial hygiene sampling or who were identified as symptomatic by informal contact. Seven of these employees had been symptomatic. Three employees complained of some previous headaches and

dizziness associated with overexposure to solvent vapors. These symptoms had only occurred if a solvent leak developed or if too much time was spent degreasing in open unventilated spaces. One employee complained of eye irritation and two of nose bleeds under similar exposure circumstances. No employees complained of being symptomatic at the time of the final survey. Three employees gave a history of dermatitis which had been attributed to exposure to epoxy or solder fumes or contact with metals. No dermatitis was seen at the time of our evaluation and these complaints could not be further investigated.

Based on the history, physical examination and industrial hygiene data there did not appear to be any routine overexposure to freons or other solvents within the plant at the time of our evaluation. Although several allergenic metals and other materials from soldering operations such as formaldehyde are used in various operations which are capable of producing allergic contact dermatitis, no current evidence of dermatitis was noted. Some higher exposures had apparently occurred in the past, particularly from degreasing operations and from the unventilated open pan degreasing of nonimmersible parts. At the time of our final survey the majority of these complaints appeared to have been resolved by alterations in operating procedures. No evidence of permanent or serious complications from exposures to these agents was detected in this examined population.

F. Conclusions

The following conclusions are based upon the above environmental and medical findings:

1. Employees are exposed to toxic concentrations of MCHA and are not exposed to toxic concentrations of MDI. The data from this evaluation did not show any symptomatology which was considered as directly attributable to exposure of MDI. Previous similar studies performed by the manufacturer of the polyurethane foaming equipment have also shown that workers at other plants are not exposed to toxic concentrations of MDI during similar operations. Although this study does establish MCHA as the contaminant of primary concern, further studies would be necessary to fully determine whether the symptomatology was specifically associated with exposure to only MCHA or to a combined effect of MCHA plus other contaminants such as MDI.
2. Employees are not exposed to toxic concentrations of lead, antimony, arsenic, nickel, chromium, pyrolysis products of rosin core solder (as formaldehyde), methyl methacrylate, and organic solvents (primarily freon 113, toluene, naphtha, xylene and hexone) during electroplating, soldering and ancillary operations.

G. Recommendations

In view of the above conclusions and findings, the following recommendations are made to reduce or ameliorate the existing hazards and to provide a better working environment:

1. Immediate action should be taken to lower the potential exposure of employees to fumes or vapors of MCHA emanating from the polyurethane operations. This could be accomplished by providing a local exhaust system at the point of operation for exhausting vapors or fumes of MCHA away from the operation and employees. Appropriate respirators approved by NIOSH may be used until adequate engineering controls are provided. The medical department should determine if the employees are having any adverse symptomatology as noted during the initial and final evaluation to assure that engineering controls are adequate. In addition, the following medical monitoring is recommended for those employees involved with polyurethane operations:
 - a. Employees should be medically examined at least every six months until it is clear that no further problem exists from these exposures. Such examinations should, as a minimum, consist of a medical history, physical examination, complete blood count, liver function studies, BUN, urinalysis and other such indices as may be indicated at that time.
 - b. The extent to which symptoms as described above have been reduced by the engineering controls should be ascertained.
 - c. Subjects with any abnormality in liver function tests should be investigated to determine whether the cause is non-occupational or likely to be occupational.
 - d. Liver function tests at least including SGOT, SGPT, alkaline phosphatase and LDH should be performed every six months on exposed employees unless it is clear that no further alterations in liver function are occurring.
 - e. Employees with persisting abnormal liver function tests should not continue to work exposed to the polyurethane operations.
2. The following recommendations are made concerning the soldering and ancillary operations:
 - a. The use of open buckets or containers (e.g., cake pans of organic solvents) without adequate ventilation should be discontinued.
 - b. Employees should be informed of the hazards of working with organic solvents and should limit the extensive use of such materials without adequate ventilation. They should be

instructed that such exposures can give rise to undue symptoms such as headaches or dizziness. If such symptoms are noted, the casual exposure should be promptly terminated and measures taken to ensure that the condition does not recur.

V. REFERENCES

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TABLE I

RESULTS OF BREATHING ZONE AND GENERAL AREA SAMPLES FOR METHYLENE BISPHENYL ISOCYANATE (MDI) AT STORAGE TECHNOLOGY'S WAREHOUSE PACKAGING FACILITY IN BROOMFIELD ON OCTOBER 13, 1975. (ALL SAMPLE RESULTS EXPRESSED AS MILLIGRAMS OF COMPOUND PER CUBIC METER OF AIR SAMPLED - mg/M^3).

<u>JOB DESCRIPTION OR LOCATION</u>	<u>SAMPLE NUMBER</u>	<u>TIME</u>	<u>SAMPLE VOLUME (LITERS)</u>	<u>MDI* mg/M^3</u>
Packer Specialist	1-A	9:02-11:42 AM	160	.02
Packer Specialist	2-A	9:06-10:10 AM	64	ND
Packer Specialist	4-A	10:55-11:55 AM	60	.03
Packer Specialist	5-A	1:45--3:32 PM	107	.03
Packer Specialist	6-A	2:03--3:40 PM	97	ND
General Area	3-A	9:15--3:40 PM	275	.01

NOTE: Sample 3-A was off between 12:00-1:50 p.m. as no operations during this period.

ND - None Detected.

*ACGIH Standards for eight-hour time-weighted average--Threshold Limit Value for MDI is $0.2 \text{ mg}/\text{M}^3$. The limit of $0.2 \text{ mg}/\text{M}^3$ is also considered as a ceiling limit which should not be exceeded, even for short periods of time.

TABLE II

RESULTS OF BREATHING ZONE AND GENERAL AREA SAMPLES FOR N-METHYLDICYCLOHEXYLAMINE (MCHA) AT STORAGE TECHNOLOGY'S WAREHOUSE PACKAGING FACILITY IN BROOMFIELD ON OCTOBER 13, 1975. (ALL SAMPLE RESULTS EXPRESSED AS MILLIGRAMS OF COMPOUND PER CUBIC METER OF AIR - mg/M^3).

<u>JOB DESCRIPTION OR LOCATION</u>	<u>SAMPLE NUMBER</u>	<u>TIME</u>	<u>SAMPLE VOLUME (LITERS)</u>	<u>MCHA* mg/M^3</u>
Packer Specialist	SG-1A	9:02-11:42 AM	15.3	0.6
Packer Specialist	SG-2A	9:07-10:10 AM	3.4	ND
Packer Specialist	SG-4A	10:55-11:55 AM	20.4	ND
Packer Specialist	SG-6A2	2:03--3:40 PM	6.3	1.6
Packer Specialist	SG-4AA	1:45--3:32 PM	36.4	0.8
General Area	SG-3A	9:15-12:00 PM & 1:50--3:40 PM	103.0	0.2
General Area	SG-2B	10:50-12:00 PM & 1:50--3:40 PM	15.1	ND

*NOTE: There are no ACGIH guides for eight-hour time-weighted average--Threshold Limit Value or other Federal Occupational Health Standards for MCHA. In order to more fully identify MCHA as the primary compound, two samples of 15 liters each were obtained directly in the plume of vapor at two inches from point of origin during breaking of foam and do not represent exposure of employees. These sample results were $530 \text{ mg}/\text{M}^3$ and $640 \text{ mg}/\text{M}^3$ for MCHA. Another 15 liter sample was obtained directly in the plume about one to two feet away from the origin and resulted in a concentration of $14 \text{ mg}/\text{M}^3$ which does not represent exposure of employees although it is felt that employees could be exposed to the level of $14 \text{ mg}/\text{M}^3$ for very short periods of time. All samples were obtained for a period of fifteen minutes.

ND - None Detected.

TABLE III-A

RESULTS OF BREATHING ZONE AND GENERAL AREA SAMPLES FOR ORGANIC SOLVENTS AT THE BROOMFIELD (B) AND LOUISVILLE FACILITIES OF STORAGE TECHNOLOGY ON APRIL 22-23, 1975. (ALL SAMPLE RESULTS EXPRESSED AS MILLIGRAMS OF COMPOUND PER CUBIC METER OF AIR SAMPLES - mg/M³).

JOB DESCRIPTION OR LOCATION	SAMPLE NUMBER	TIME	SAMPLE VOLUME (LITERS)	"FREON-113"* mg/M ³	HEXONE* mg/M ³	TOLUENE* mg/M ³	XYLENE* mg/M ³	NAPHTHA* mg/M ³
Assembler	1	7:40--1:00 PM	13.8	ND	10	10	ND	ND
Assembler	2	7:47--12:58 PM	12.6	20	ND	ND	ND	ND
Assembler	3	7:45--1:23 PM	19.8	30	ND	ND	ND	ND
Assembler	4	7:39--1:02 PM	12.8	ND	280	620	190	290
Machine Assembler	5	7:35--1:01 PM	13.6	ND	ND	10	ND	20
Assembler	6	7:50--1:00 PM	16.3	ND	ND	ND	ND	40
Assembler	7	8:25--1:06 PM	9.0	50	ND	ND	ND	ND
Assembler	8	9:43--12:58 PM	78.0	340	ND	ND	ND	ND
Assembler-10 min. wash tank operation	9	9:43--12:58 PM	10.0	1200	ND	ND	10	ND
Assembler	B-1	4:45--7:59 PM	6.1	60	ND	ND	ND	ND
Wave Solder	B-2	4:08--8:06 PM	7.3	130	ND	ND	ND	ND
Loader Assembler	B-3	4:40--8:09 PM	5.4	ND	ND	ND	ND	300
Solder Assembler	B-4	4:23--7:59 PM	12.7	ND	ND	ND	ND	ND
Assembler	B-5	4:25--8:05 PM	9.6	10	ND	ND	ND	ND
Assembly	B-6	4:21--7:57 PM	6.6	60	ND	ND	ND	ND
Rework Assembly	B-7	4:00--8:10 PM	6.6	ND	ND	ND	ND	40
3600 Assembly	B-8	4:39--8:01 PM	8.3	ND	ND	ND	ND	40
Wave Solder	B-9	4:13--6:46 PM	53.5	50	ND	ND	ND	ND
Assembler-10 min. wash tank operation	B-10	6:50--7:00 PM	10.0	480	ND	ND	40	ND
General Area-Recon Room	B	11:02--2:00 PM	10.2	ND	ND	ND	ND	30
General Area-Recon Room	A	11:00--2:00 PM	45.0	20	ND	ND	ND	ND

*ACGIH Standards for eight-hour time-weighted average--Threshold Limit Value for the above compounds are as follows:

1,1,2-trichloro-1,2,2-trifluoroethane ("Freon")--7,600 mg/M³
 Hexone (Methyl isobutyl ketone)--410 mg/M³
 Toluene--375 mg/M³
 Xylene--435 mg/M³
 Naphtha--400 mg/M³

ND - None Detected.

TABLE III-B

RESULTS OF BREATHING ZONE SAMPLES FOR ORGANIC SOLVENTS AT THE BROOMFIELD FACILITY OF STORAGE TECHNOLOGY ON OCTOBER 13-14, 1975. (HEXONE, TOLUENE, XYLENE AND NAPHTHA NOT DETECTED).

<u>JOB DESCRIPTION OR LOCATION</u>	<u>SAMPLE NUMBER</u>	<u>TIME</u>	<u>SAMPLE VOLUME (LITERS)</u>	<u>"FREON 113"* mg/M³</u>
Wave Solder	B-1	5:20--7:51 PM	8.8	40
Wave Cleaner	B-2	5:25--7:50 PM	16.5	80
Assembler	B-3	5:26--7:45 PM	17.0	10
Assembler	B-4	5:36--7:59 PM	16.5	20
Assembler	B-5	5:40--7:29 PM	9.5	20
Assembler	B-6	5:56--7:56 PM	14.1	40
Wave Solder	B-10	8:40--1:48 PM	15.5	60
Wave Cleaner	B-11	8:42--1:47 PM	29.3	680
Assembler	B-12	9:55--1:48 PM	15.6	50
Assembler	B-13	8:47--1:05 PM	16.9	310
Assembler	B-14	8:57--1:40 PM	25.0	20
Sub-Assembler	B-15	8:55--1:42 PM	26.6	60
Power Boards Assembler	B-16	9:00--1:43 PM	25.2	30
Assembler	B-17	8:51--1:46 PM	24.4	30
Super Disc Assembly	B-18	8:50--1:45 PM	36.8	30

*ACGIH Standards for eight-hour time-weighted average--Threshold Limit Value for the above compounds are as follows:

1,1,2-trichloro-1,2,2-trifluoroethane ("Freon")--7,600 mg/M³
 Hexone (Methyl isobutyl ketone)--410 mg/M³
 Toluene--375 mg/M³ Xylene--435 mg/M³
 Naphtha--400 mg/M³

All sample results expressed as milligrams of compound per cubic meter of air sampled - mg/M³.

TABLE IV

SUBJECT NO.	LEVEL OF MCHA EXPOSURE	SYMPTOMS
1	1.6 mg/M ^{3*}	Unpleasant taste, nausea, cough dry mouth and lips
2	0.8 mg/M ^{3*}	Unpleasant taste, nausea, headache
3	0.6 mg/M ^{3*}	Unpleasant taste, nausea, headache
4	0.2 mg/M ³⁺	Unpleasant taste and odor, eye irritation, throat irritation
5	0.2 mg/M ³⁺	Unpleasant odor, eye irritation, throat irritation
6	0.2 mg/M ³⁺	Unpleasant taste, cough, transient involuntary airway constriction
7	ND *	Unpleasant taste, dizziness

* Personal sampler data

+ Area sampler data

Correlation between symptomatology of NIOSH site visit team and exposed employees with MCHA exposure levels during polyurethane packaging operations at the Broomfield facility on October 13, 1975.