U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION REPORT
HE 80-29-741

STORAGE TECHNOLOGY CORPORATION
LOUISVILLE, COLORADO

SEPTEMBER 1980

I. SUMMARY

In November 1979 the National Institute for Occupational Safety and Health (NIOSH) received a request from Storage Technology Corporation, Louisville, Colorado, to evaluate occupational exposures to methylene bisphenyl isocyanate (MDI), N-methyldicyclohexylamine (MCHA), and diethylene glycol monoethyl ether at their facilities at Boulder and Broomfield, Colorado. These facilities are engaged in the manufacture of computer data storage sub-systems (SIC 3670). Workers in these areas used polyurethane foam systems for packaging the computer sub-systems and electronic components prior to shipment. Each worker was monitored for breathing zone air concentrations of MDI, MCHA, and diethylene glycol monoethyl ether. General room air samples were also obtained for these chemicals. Since MDI and MCHA are respiratory irritants, pre- and post-shift pulmonary function testing was performed. Workers were also administered a brief medical questionnaire. Environmental evaluation illustrated that workers were not overexposed to air contaminants. Ventilation was adequate and proper work techniques were used. Medical data did not show any abnormal changes in pre- and post-shift pulmonary function testing.

On the basis of the environmental and medical data, NIOSH concluded that a health hazard did not exist at Storage Technology Corporation at the time of this survey from exposure to methylene bisphenyl isocyanate, methyldicyclohexylamine, or diethylene glycol monoethyl ether. Recommendations on work practices necessary to control any future hazard are included on page 6 of this report.

II. INTRODUCTION

NIOSH received a request in November 1979 from management of Storage Technology Corporation to evaluate "recent employee complaints and concern with symptoms of exposure to both isocyanates and N-Methyl dichclohexylamine" at their facilities at Boulder and Broomfield, Colorado.[1] Expressed concern of warehouse workers was a spray foam containing methylene bisphenyl isocyanate (MDI) in packaging parts of shipment in the Broomfield and Boulder, Colorado, plants. An environmental and medical survey was conducted on February 4, 1980, to evaluate potential exposures to MDI, MCHA, and diethylene glycol monoethyl ether. The requester was notified in April of environmental and medical results.

III. BACKGROUND

Storage Technology Corporation is engaged in the manufacture of computer data storage sub-systems at their facilities at Boulder and Broomfield, 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 component 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. About 12 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.

IV. METHODS AND MATERIALS

A. Environmental

Breathing zone and general room air samples for MDI were collected in impingers and analyzed according to NIOSH Method P&CAM No. 142. MCHA breathing zone and general room air samples were collected on silica gel tubes and analyzed by gas chromatography. Diethylene glycol monoethyl ether breathing zone and general room air samples were collected on filters and analyzed according to NIOSH Method S-361.

B. Medical

Eighteen warehouse workers (15 men and 3 women) were chosen for participation in this study because of their direct involvement in packaging parts using Instapak. Instapak is a spray foam packing containing methylene bisphenyl isocyanate. The group comprised all the employees who were available in and around the area at the time

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[1]Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 19 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by any employer or authorized representative to 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 investigation took place. The age range of the 15 men was 20 to 42 years with a median age of 27 years. The age range of the three women was 23 to 32 years with a median age of 24 years. The median length of employment for the 15 men was 1-1/2 years with a range of one month to eight years and a median of one year for the three women interviewed with a range of 1/2 to 1 year.

Classification of employees was done by exposure, job title, sex, reported health problems on questionnaire, and pre- and post-shift pulmonary function testing. The ten day shift employees (4 Broomfield Plant and 6 Boulder Plant) were the identified exposed group. The eight Boulder Plant evening shift employees were used as a control group for acute pulmonary function abnormalities, as the spray foam packaging process was not run on the evening shift due to a warehouse clean-up conducted the evening of the study. All day and evening shift employees were age and sex matched for comparison purposes.

Each worker was administered a respiratory, eye, and dermatological (skin) symptom questionnaire, which also included an occupational and smoking history and specific symptoms known to be associated with MDI toxicity.

In addition to the questionnaire, pre- and post-shift pulmonary function testing was performed following the employees weekend off. Two Cybermedic Medistor II Spirometers were used. Pulmonary function parameters measured were FVC, FEV_1, FEV_1/FVC, and FEF_{25-75}. (Appendix A)

Pulmonary function testing (spirometry) results were analyzed using standard comparative norms. These norms were developed by the American Thoracic Society. (Appendix A)

V. EVALUATION CRITERIA

A. Environmental

Two sources of criteria used to assess the workroom concentrations were the Occupational Safety and Health Administration (OSHA) standards (29 CFR 1910.1025), January 1978, and the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs), 1979.

	Permissible Exposures 8-Hour Time-Weighted Exposure Basis (mg/M^3)	
MDI.....	0.2 (TLV)	0.2 (OSHA)
MCHA.....	*	* (OSHA)
Diethylene Glycol Monoethyl Ether..	120 (TLV)**	--- (OSHA)

mg/M^3 = milligrams of substance per cubic meter of air

* No criteria available.
** This is the TLV for methyl cellosolve acetate which is closely related to diethylene glycol monoethyl ether. There is no TLV for this chemical.

Occupational health standards are established at levels designed to protect individuals occupationally exposed to toxic substances on an 8-hour per day, 40-hour per week basis over a normal working lifetime.

B. Toxicological

Methylene Bisphenyl Isocyanate (MDI) -- MDI in sufficient amounts is a primary irritant of the mucous membranes of the eyes, nose, and throat and of the respiratory tract. (Reference 1) 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) -- N-methyldicylclohexylamine (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. (Reference 2) 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. (Reference 3) Amines of this type have a typical odor. Irritation of the skin may occur and may lead to dermatitis. (Reference 4) Allergic skin sensitization has not been reported for 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. (Reference 5, 6).

Diethylene Glycol Monoethyl Ether -- Ethyl glycol ethers are only mildly irritating to the skin. High exposures may cause conjunctivitis and upper respiratory tract irritation. Eye irritation is the most dominant characteristic of high exposures. The butyl and methyl ethers penetrate the skin easily. (Reference 7)

VI. RESULTS

A. Environmental

All breathing zone and general room air samples taken for MDI, MCHA, and diethylene glycol monoethyl ether were below the laboratory detection limits. This is due to good local ventilation and proper work techniques such as good housekeeping and proper storage and use of the packaging chemicals. Results may be reviewed in Tables 1, 2, and 3.

B. Medical

The results of questionnaire and pulmonary function testing of the eighteen employees working in the warehouse on the day and evening shift of the investigation were as follows:

REPORTED HEALTH PROBLEMS AND PULMONARY FUNCTION RESULTS

Chronically Exposed Group	No. in Group	Sex	Reported Health Problems	Pulmonary Function Testing	
				Pre-Shift	Post-Shift
Group #1	15	M	4	1	1
Group #2	3	F	1	0	0
Totals	18		5	1	1

PULMONARY FUNCTION ABNORMALITIES

Group	Number	Job Title	Sex	Pre-Shift	Post-Shift
Acutely Exposed	6	Material Specialists	M	0	0
	2	Material Specialists	F	0	0
	2	Other	M	1	1
Totals	10			1	1
Non-Exposed	3	Material Specialists	M	0	0
	1	Material Specialists	F	0	0
	4	Other	M	0	0
Totals	8			0	0

A total of five workers (28 percent) reported the following health problems possibly related to work.

Number	Symptoms
4	Eye Irritation
2	Respiratory Irritation
1	Throat Irritation

Two day shift Boulder Plant employees reported work-related eye irritation of tearing and burning, while three afternoon shift Boulder employees reported both respiratory and eye symptoms. The two workers reporting respiratory symptoms were both smokers. One afternoon shift Boulder employee also reported throat irritation.

Seventeen of the eighteen chronically exposed employees had pre- and post-shift pulmonary function tests within normal limits. One employee, however, had both an abnormal pre- and post-shift pulmonary function test.

Comparison of pulmonary function testing results of the ten potentially exposed employees during the shift with the eight employees who did not (control group), identified no abnormal changes in either group from pre- and post-shift. One employee in the exposed group had both an abnormal pre- and post-shift pulmonary function test.

No correlation was evidenced between questionnaire responses and pulmonary function test data. The one person with a positive pulmonary function test had both abnormal pre- and post-shift tests and reported no respiratory symptoms (only eye irritation) on the questionnaire.

VII. DISCUSSION AND CONCLUSIONS

Based on the results of the environmental data, pre- and post-shift pulmonary function testing, and questionnaire responses, no current health problems could be related to exposure to methylene bisphenyl isocyanate, methyldicyclohexylamine, and diethylene glycol monoethyl ethers at the time of this investigation. The process eliminating use of the Instapak due to be instituted in February 1980 will eliminate any potential exposure risk.

VIII. RECOMMENDATIONS

1. Respiratory effects and sensitization from past exposure to MDI should continue to be monitored through periodic examinations which should include:

   a. Comprehensive and interim medical, work, and smoking histories.

   b. Physical examination giving particular attention to the respiratory tract.

   c. Pulmonary function testing including measurements of FVC and FEV_1.

   d. Maintenance of pertinent medical records. Records of environmental exposures to an employee should be included in the employee's medical records. Such records should be kept for at least 30 years after the last occupational exposure to MDI.

2. Periodic (every six months) air monitoring should be done to ensure workers are not being exposed to hazardous chemicals.

3. Smoking, eating, and drinking must be prohibited in the work area.

IX. REFERENCES

1. Documentation of the Threshold Limit Values, ACGIH, Third Edition, 170-171, 1971.

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5. McGill, D.G., and Mottor, J.D.: An indusytrial outbreak of toxic hepatitis due to methylenedianiline. New Eng. J. Med. 291: 278-282, 1974.

6. Kopelman, H., Schever, P.J., and Williams, R.: The liver lesion of the Epping Jaundice. Quart. J. Med. 35: 553-564, 1966.

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XI. DISTRIBUTION AND AVAILABILITY

Copies of this determination report are currently available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies of this report have been sent to:

1. Storage Technology Corporation.
2. U.S. Department of Labor/OSHA - Region VIII.
3. NIOSH - Region VIII.
4. Colorado Department of Health
5. State Designated Agency

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

TABLE 1

Breathing Zone and General Room Air Concentrations of
Methylene Bisphenyl Isocyanate (MDI)

Storage Technology Corporation

February 4, 1980

Sample Number	Job Classification	Sampling Time	mg/M^3 MDI
I-21	Materials Specialist	10:40 AM - 2:15 PM	*
I-3	Foamer Packager	10:15 AM - 12:00 N	*
I-30	Foamer Packager	12:00 N - 2:10 PM	*
I-2	Foamer Packager	7:45 AM - 11:51 AM	*
I-20	Materials Specialist	10:40 AM - 12:00 N	*
I-1	Foamer Packager	7:40 AM - 11:51 AM	*
	EVALUATION CRITERIA		0.2
	LABORATORY LIMIT OF DETECTION mg/sample		0.002

* = below laboratory limit of detection

TABLE 2

Breathing Zone and General Room Air Concentrations of
Methyldicyclohexylamine (MCHA)
in the Packaging Department

Storage Technology Corporation

February 4, 1980

Sample Number	Job Classification	Sampling Time	mg/M^3 MCHA
01	Packager	10:40 AM - 1:50 PM	0.015
03	Packager	12:20 PM - 2:12 PM	*
11	Packager	7:35 AM - 11:50 AM	*
22	Supervisor	7:50 AM - 12:00 N	*
02	Packager	12:20 AM - 2:12 PM	*
	EVALUATION CRITERIA		**
	LABORATORY LIMIT OF DETECTION mg/sample		0.015

* = below laboratory limit of detection
** = no TLV or OSHA standard

TABLE 3

Breathing Zone and General Room Air Concentrations of
Diethylene Glycol Monoethyl Ether
in the InstaPak Department

Storage Technology Corporation

February 4, 1980

Sample Number	Job Classification	Sampling Time	mg/M^3 Diethylene Gylcol Monoethyl Ether
52	Packager	12:20 PM - 2:00 PM	*
56	Packager	12:20 PM - 2:12 PM	*
1	Packager	10:40 AM - 2:05 PM	*
69	Foamer	7:35 AM - 11:50 AM	*
72	Supervisor	7:50 AM - 11:55 AM	*
	EVALUATION CRITERIA		120**
	LABORATORY LIMIT OF DETECTION mg/sample		0.01

* = below laboratory limit of detection
** = This is the TLV for methyl cellosolve acetate which is closely related to diethylene glycol monoethyl ether. There is no TLV for the latter.

APPENDIX A

Screening Pulmonary Function Examinations
Interpretation and Abnormalities

NORMAL VALUES

FVC at least 80 percent of predicted
FEV_1 at least 80 percent of predicted
FEV_1/FVC at least 70-75 percent

Sources of Variability in the Same Person

2-6 percent -- biological and instrument

Daily and Seasonal: highest in afternoon and slight drop in evening
highest in summer

Normal aging:	Males:	annual decline FVC	30 ml	FEV_1	25 ml
	Females:	annual decline FVC	25 ml	FEV_1	25 ml

MOST ABNORMALITIES DETECTED BY SCREENING SPIROMETRY IN WORKING POPULATIONS ARE DUE TO CIGARETTE SMOKING.

Abnormal Declines: Compare the current test to the previous highest. If not attributable to non-disease related variables, retest. If it persists, refer to a physician.

FEV_1 or FVC	decline greater than 8 percent
FEV_1/FVC	decline greater than 6 percent
FEV_1/FVC	less than 70 percent at any time

Obstructive Lung Disease (pure)

FEV_1 is below 80 percent of predicted and
**
FEV_1/FVC is below 70 percent.
FVC is normal or just slightly less than normal

Restrictive Lung Disease (pure)

** FVC is below 80 percent of predicted
FEV_1/FVC is 70 percent or greater

Cotton Dust Standard: Refer to Cotton Dust Standard. Federal Register, Vol. 43, No. 122 -- Friday, June 23, 1978, especially pages 27397-8 and 27418