

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE  
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH  
CINCINNATI, OHIO 45202

HEALTH HAZARD ~~EVALUATION~~ DETERMINATION  
REPORT NO. 74-42-168

TRIONIC INDUSTRIES, INCORPORATED  
HARRISBURG, PENNSYLVANIA

JANUARY 1975

I. TOXICITY DETERMINATION

It has been determined that employee exposure to toluene 2,4-diisocyanate (TDI) vapor is potentially toxic to employees at the mold clamping station. This determination is made because high concentrations of TDI vapor were measured during an evaluation of the work place conducted on May 30 and 31, 1974. These levels exceeded both the recent NIOSH recommended standard as well as the existing OSHA, Department of Labor standard for TDI vapor.

The Company previously performed a deflashing operation on the polyurethane foam which has been discontinued. This consisted of deflashing by means of belt sander which caused pulmonary problems to some apparently sensitized employees and could not be evaluated.

The highest exposures found at the time of the evaluation were at the clamping station which is adjacent to the curing tunnel entrance. No adverse health effects were elicited from the present employees during medical interviews. However, five former employees were noted who had experienced respiratory difficulties. This occurred during the period when deflashing was performed by belt sanding and their disability may have been due to the release of unreacted TDI into the atmosphere.

Detailed information concerning the medical and environmental results of this determination are contained in the body of the report. Recommendations are included in this determination which are designed to keep employee exposure to this agent to a minimum.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are available upon request from the Hazard Evaluation Services Branch, NIOSH, U. S. Post Office Building, Room 508, 5th and Walnut Streets, Cincinnati, Ohio 45202. Copies have been sent to:

- a) Trionic Industries Incorporated
- b) U. S. Department of Labor - Region III
- c) NIOSH - Region III

For the purpose of informing the approximately 9 "affected employees" the employer will promptly "post" the Determination Report in a prominent place(s) near where effected employees work for a period of 30 calendar days.

### III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S. Code 669(a)(6) authorizes the Secretary of Health, Education, and Welfare, following a written request by 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.

A health hazard evaluation request was submitted by the employer at Trionic Industries, Inc. The request was initiated because of worker illness which the employer felt was due to exposure to airborne contaminants.

### IV. HEALTH HAZARD EVALUATION

#### A. Description of Process - Conditions of Use

The Trionic Industries Plant is composed of three departments, (1) polyurethane foam molding, (2) metal stamping, (3) electrical cable. The department evaluated was the polyurethane molding department. This department is engaged in producing plugs for artillery shells. Steel molds are cleaned with a commercial solvent containing mineral spirits. These molds are put on a conveyor, preheated, the polyurethane resin is injected into the mold, the clamps are tightened and the molds are passed into a foaming-curing tunnel followed by a cooling tunnel. After cooling the clamps are opened, the plug is removed, flashing is removed and the plugs are packaged. The polyurethane resin is composed of components A & B with the agent of interest being TDI. The duration of the complete cycle is about 45 minutes. Employees are then rotated to perform other work.

Approximately 9 employees are exposed to airborne TDI vapor which is generated by the foaming process. The purpose of this health hazard evaluation was to determine whether potentially toxic concentrations of TDI vapor existed in this plant during near normal operating conditions.

#### B. Study Progress and Design

On May 6, 1974, an initial environmental-medical survey of the Trionic Industries Plant was conducted by Dr. John Cromer, NIOSH Medical Officer, and Walter J. Chrostek, NIOSH Industrial Hygienist. A walk-through survey and medical interviews (with employees on the molding lines) were conducted. Subsequently, the NIOSH industrial hygienist returned to the plant on May 30-31, 1974, to determine air concentrations of TDI.

## C. Evaluation Methods

### 1. Toluene Diisocyanate Air Sampling

Employee exposure samples and general air samples were collected using midge impingers. Reagents and analytical procedures followed the modified "Marcali method" as reported by Grim and Linch<sup>1</sup>. Samples were analyzed by NIOSH, Cincinnati laboratory.

Ventilation determinations and air flow pattern were determined utilizing Anor Jr. velometer and Kitagawa air flow indicator tubes.

## D. Evaluation Criteria

### 1. Environmental Standards

Occupational health standards for individual substances are established at levels designed to protect workers occupationally exposed on an 8-hour per day, 40-hour per week basis over a working lifetime. However, with respect to TDI the standard may not be protective to workers already sensitive to it.

Recently the National Institute for Occupational Safety and Health (NIOSH) has gathered criteria for the recommendation of a new standard for TDI to the Department of Labor (OSHA). This recommendation calls for an eight-hour, time-weighted average (TWA) exposure level of 0.005 p.p.m. (0.036 mg/M<sup>3</sup>) or 0.02 p.p.m. (0.14 mg/M<sup>3</sup>) for any 20-minute period. NIOSH believes that from all information currently available these criteria are the most acceptable.

### 2. Medical Standards

The medical criteria used to determine a toxic response to TDI consist of symptoms and signs associated with it when toxic exposure occurs.

TDI is a strong irritant, especially to the eyes and upper and lower respiratory tract.

If TDI liquid comes into contact with the eyes, severe conjunctival irritation occurs. With exposure to low concentrations of the vapor burning or smarting in the eyes is noted. Gastrointestinal complaints of nausea, vomiting, and abdominal pain have been reported following inhalation of the vapor or aerosol. Of all the adverse effects, the most notable are those involving the respiratory tract. Two specific effects have been noted:

(1) Primary irritancy- at sufficient concentrations of TDI, all exposed individuals are susceptible to effects on the respiratory tract resulting in burning of the nose and throat, a choking sensation, dry or productive cough and general chest pain. These effects have sometimes been

mistaken for a "cold" or upper respiratory tract infection. Exposure to higher concentrations of TDI can lead to severe irritation of the respiratory tract mimicing an asthmatic attack.. Additional symptoms include headache, sleeplessness, ataxia and euphoria.

(2) Allergic sensitization -- when one has become "sensitized" to TDI, very small concentrations of TDI may elicit various symptoms. Nocturnal shortness of breath and cough as well as symptoms and signs of asthma may appear in sensitized individuals (such asthmatic reactions in a few instances have been fatal).

A third type of effect of TDI on the respiratory tract is under further evaluation i.e. the relationship of long term exposure to TDI and cumulative impairment of lung function. Although some studies suggest that long term exposure to non-irritating and non-sensitizing concentrations of TDI may impair lung function, further investigation is needed.

## E. Evaluation Results

### 1. Environmental Results

#### a. TDI Air Sampling

Table I contains the results of air sampling for TDI vapor which was conducted on May 30-31, 1974. A total of 9 samples were collected and analyzed. Employee exposures at the clamping station, for an 8-hour time weighted average (TWA), ranged from 0.016 p.p.m. for a single cycle (45 minutes) to 0.033 p.p.m. should two cycles (90 minutes) be spent per 8-hour day. These concentrations exceed the TWA of 0.005 p.p.m. for an 8-hour workday or for any 20-minute period of 0.02 p.p.m. as recommended by NIOSH.<sup>2</sup>

During my discussion at the plant, I was informed that at times, when absences occur it may be necessary for an employee to spend two or more cycles at any one station. This was the reason for estimating the TWA for a 90 minute period at the clamping station.

#### b. Ventilation Measurements and Air Flow Observations

Ventilation measurements were adequate at the mold cleaning station (300-500 feet per minute). At the pouring station air velocity exhaust was 150 feet per minute, however at the clamping station the velocity of the air exhausted was 75 feet per minute. In addition a thermal draft is created by the heated air escaping from the tunnel. Air flow indicator tubes showed this contaminated air to flow toward the breathing zone of the operator and into the work atmosphere. The rate of air flow from the tunnel was approximately 75 feet per minute, equal to the exhaust rate and negating vapor capture. This source can be considered as the cause for exposures to TDI vapor as the tunnel is electrically heated with no exhaust ventilation.

## 2. Medical Results

The plant's medical facilities include a first aid station with an employee trained in first aid who attends ill or injured workers. There is also a local doctor who has an agreement with the plant to care for minor medical problems. Patients with problems of a more severe nature are seen at a nearby hospital emergency room. There is no pre-employment medical history other than asking the employee if he/she has an allergic condition; physical examinations are not done.

Historically, problems of coughing and other respiratory complaints from employees began in the fall of 1973. These problems continued until January-February, 1974, when the belt sanding of flash from the plug was discontinued and the present removal by a sheering knife was instituted.

All nine (9) employees currently employed in the polyurethane molding area were interviewed. Four of the five (4/5) individuals on the mold line had worked for the company for two months or less. None of the five (0/5) had medical complaints which were felt to be related to the work environment. Only one of the five (1/5) had been present when the previous problems were noted, although she had experienced no problems herself. The four other individuals in the area of concern all denied any symptomatology; however, it was pointed out that five previously adversely affected individuals have quit employment with the company in recent months.

Conversation with the physician who evaluated the five symptomatic individuals revealed that four of the five (4/5) had abnormal pulmonary function tests. However, all affected individuals were smokers and the test abnormalities seen in three of the four individuals were restrictive changes rather than the obstructive changes usually associated with TDI sensitization.

## F. Discussion and Conclusions

Several observations are apparent from the history given by the employer, employees, and the physician consultant. First of all, individuals presently employed in the polyurethane molding area show no symptoms of TDI sensitivity. However, as shown by the results of air sampling, ventilation measurements, and air flow indicator observations, the operator at the clamping station is exposed to potentially toxic concentrations of TDI emanating from the unvented curing tunnel. Although asymptomatic at present, the clamping station operator is at risk to TDI sensitization because of his degree of exposure.

There appears to have been excessive exposure to TDI in the past which was associated with the sanding off of flash from the plugs after their removal from the molds. Presumably this was due to the release of unreacted TDI in the foam by the sanding process. The specific type of toxic exposure and response (i.e. primary irritancy vs. allergic sensitization) which the

affected workers may have experienced is unclear. However, the histories related to the medical officer by other plant personnel and by the consulting physician were very suggestive of TDI sensitivity. Unfortunately, because the affected employees were no longer employed at the plant, medical histories, physical examination, and appropriate laboratory examination could not be obtained from them personally.

As was pointed out in the evaluation results the concentrations of TDI found during the evaluation would exceed the levels proposed by NIOSH. These levels also would approach, for one cycle (45 minutes), and exceed, for two cycles (90 minutes) the permissible ceiling value for TDI as defined in OSHA standards,<sup>3</sup> (.02 p.p.m.).

Particular environmental and medical recommendations should be followed to remedy the present deficiencies. The following recommendations are made in the interest of controlling employee exposures to TDI to a minimum and preventing adverse health effects.

(1) Install local exhaust ventilation on both ends of the curing tunnels. Modification of the tunnels may be necessary to avoid exhausting the vapors through the employee's breathing zone.

(2) Modify the drum under the isocyanate pouring station so that it is closed and exhaust ventilation applied.

(3) Modify the local exhaust ventilation at the clamping station to more effectively capture the isocyanate vapor.

(4) In the event of a spill of foam material, all employees should be evacuated from the area and workmen equipped with approved respirators and protective clothing as specified in the NIOSH criteria document "Occupational Exposure to Toluene Diisocyanate" should then clean up the spill.

(5) Foam technicians should wear approved respirators during maintenance and servicing of foam equipment when exposure to the isocyanate containing component is possible.

(6) Until such a time as adequate engineering controls are installed, supply and require exposed employees to wear approved respiratory protective equipment. This equipment shall be maintained in a sanitary manner.

Institution of a preplacement and periodic medical evaluation program is also recommended. The NIOSH publication, Occupational Exposure to Toluene Diisocyanate, recommends a medical surveillance program which should be used for employees exposed to TDI. Of particular importance are the following:

(1) Preplacement medical examination:

- (a) Medical history - paying particular attention to any respiratory symptoms.
- (b) 14" x 17" chest roentgenogram.
- (c) White blood cell count with differential.
- (d) Pulmonary function testing which includes forced vital capacity (FVC) and forced expiratory volume at one second (FEV<sub>1</sub>).
- (e) Absolute eosinophil count - recommended as an additional useful measurement.

(2) Periodic medical examination:

This should include the above examinations (with the exception of the chest roentgenogram) and should be provided annually or as otherwise indicated by professional medical judgment so long as occupational exposure to TDI continues.

V. REFERENCES

1. Grim, E.K. and A.L. Linch, Recent Isocyanate in Air Analysis Studies. Am. Ind. Hyg. Assoc. J., Vol. 25, May-June, 1965.
2. Criteria for a Recommended Standard...Occupational Exposure to Toluene Diisocyanate. U. S. Dept. of Health, Education, & Welfare, PHS, NIOSH, 1973.
3. Federal Register, Vol. 39, No. 125 Part II, Subpart G, June 27, 1974.

VI. AUTHORSHIP AND ACKNOWLEDGMENT

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TABLE I

Toluene -2,4-Diisocyanate Air Concentration Data  
May 30-31, 1974

Sample Number	Job Description	Air Volume Meter <sup>3</sup>	Concentrations		Time Duration (Minutes)	Calculated 8-Hr. T.W.A. ***	
			mg/M <sup>3</sup> *	p.p.m. **		mg/M <sup>3</sup>	p.p.m.
16273	Operator's exposure pouring	.06	0.018	.0026	45	.0017	.0002
16274	Operator's exposure mold opening	.06	0.004	.0005	45	.0004	.0002
16280		.07	0.006	.0009	45	.0006	.0001
16275	General air, end of oven	.06	0.013	.0019	45	.0012	.0002
16278		.07	0.028	.0040	45	.0026	.0004
16276	Operator's exposure clamping	.06	0.056	.0080	45	.0053	.0008
16279		.06	1.220	.174	45 90	.1144 .2288	.0163 .0326 ****
16277	Operator's exposure deflashing	.06 .10	0.004 0.002	.0005 .0003	45 45	.0004 .0002	.0001 .0001

\* mg/M<sup>3</sup> denotes - milligram of substance per cubic meter of air sampled

\*\* p.p.m. denotes - parts of substance per million parts of air sampled

\*\*\* T.W.A. denotes Time Weighted Average

\*\*\*\* 8 - hour - denotes calculated 8-hour T.W.A. should employee spend 2 cycles (90 minutes) which is necessary at times.