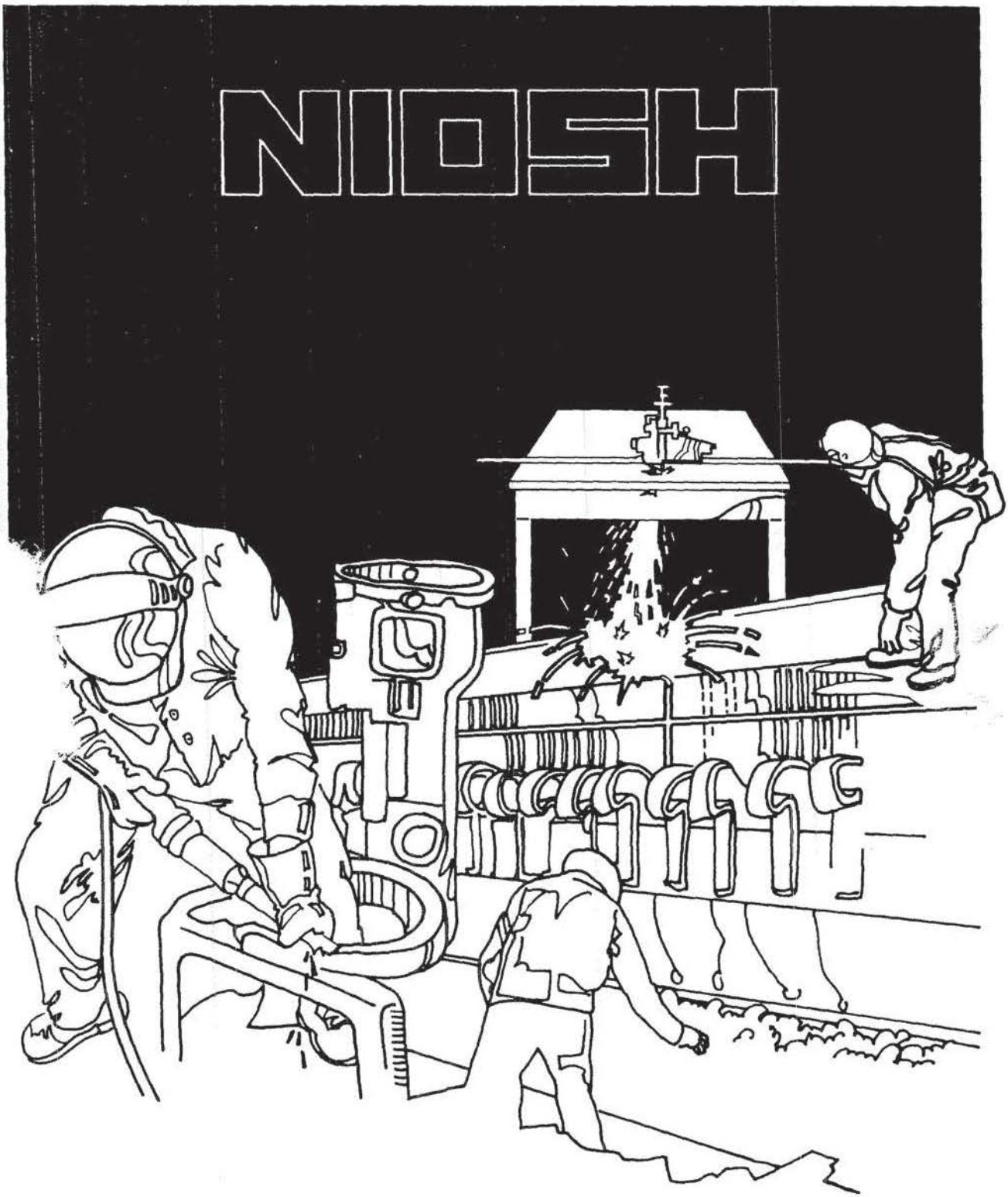
DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health

NIOSH



Health Hazard Evaluation Report

HETA 80-239-1170
BOEING ELECTRONICS
IRVING, TEXAS

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.

HHE 80-239-1170
August 1982
Boeing Electronics
Irving, Texas

NIOSH INVESTIGATORS:
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I. SUMMARY

In August 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request from an authorized representative of employees to evaluate approximately 6-10 encapsulating room employees' exposure to methyl ethyl ketone (MEK), xylene and toluene diisocyanate (TDI) at Boeing Electronics, Irving, Texas.

On September 17, 1980, an initial environmental walk-through survey was performed at the facility. Environmental monitoring was conducted on March 18, 1981. Results of 19 personal breathing-zone/general air samples were as follows: MEK [6 air samples ranging from 3-5 milligrams per cubic meter (mg/M^3)]; Xylene [6 air samples ranging from 1-3 mg/M^3]; and TDI [7 air samples, all of which were below the lower limit of detection for the analytical method]. Monitoring results were, therefore, well below "recommended exposure limits" for all three substances.

During the October 20, 1980, medical evaluation, the NIOSH medical officer interviewed nine employees including five workers involved in a July 18, 1980, solvent overexposure incident. Employees were asked about their involvement with the encapsulation room and about their health status. Those reporting symptoms which they associated with their workplace and/or with the July 1980, incident, were interviewed in detail. Copies of all pertinent medical records of affected employees were also obtained.

Workers, performing duties in the encapsulation room at the time of the incident, reported that they experienced severe headaches, feelings of being intoxicated and experienced weakness, nausea, a "raw, buring" chest pain and developed a cough productive of small amounts of green sputum which lasted for varying period of time. The two employees who did not return to work following the incident continued to experience cough, shortness of breath and fatigue. A review of their medical records, including follow-up pulmonary tests, did not reveal significant findings which appeared pertinent to the overexposure incident.

Interviews with the machine operator and assistant, who worked in the encapsulation room following the incident, did not reveal any medical symptoms.

Based on results of the environmental/medical evaluation, NIOSH found no evidence of a health hazard from employee exposure to MEK, xylene and TDI at the time of the evaluation. It appears that the five workers in the encapsulation room at the time of the July 1980 incident experienced acute solvent exposure to unknown, but intoxicating, levels of MEK/xylene/TDI and developed some form of acute bronchitis as a result of that exposure.

Recommendations, relating to this evaluation, are presented in Section VIII of this report.

KEYWORDS: SIC 3728 (Aircraft Parts and Auxiliary Equipment, Not elsewhere Classified); Methyl ethyl ketone; Xylene; Toluene diisocyanate

II. INTRODUCTION

Under the Occupational Safety and Health Act (OSHA) of 1970, the National Institute for Occupational Safety and Health (NIOSH) is authorized to investigate the toxic effects of substances found in the workplace. On August 20, 1980, NIOSH received a request from an authorized representative of employees to evaluate encapsulating room personnel exposures to methyl ethyl ketone (MEK), xylene and toluene diisocyanate (TDI) at Boeing Electronics, Irving, Texas.

III.. BACKGROUND

Boeing Electronics, a new subsidiary of the Boeing Corporation, commenced operating in January 1980 and manufactures electronic circuitry used in Boeing aircraft. Activities of the approximately 165 assembly production workers include silk-screening of patterns on electronic circuit boards, assembly of the boards, operation of a wave solder process, hand soldering, operation of the encapsulating machine, stripping or touching-up boards and quality control.

In the encapsulating room,circuit boards, which have been washed in a solution of de-ionized water and detergent, are loaded on a conveyer belt and transported into the machine, where a dispenser sprays the board with a coating mixture of 75 percent xylene, 3 percent MEK and 22 percent polyurethane resin, of which less than 0.5 percent is free TDI. The machine's ventilation system provides forced air, blowing down on the boards as they pass beneath the spray jets and an exhaust which pulls vapors out below. A "bag" filter protects the exhaust vent from the coating solution drippings. When the filter does become coated, the exhaust can no longer remove solvent vapors from the machine. Since the forced air input continues from above, air and solvent vapors may be forced out of the machine, if the "bag" filter pores are occluded.

After the circuit boards are sprayed with the above-described mixture, they continue on the conveyer belt, where they are briefly dried at 150 degrees Farenheit (°F), then removed by hand, turned and directed back through the machine to coat the remaining side and dried once again. Finally, the machine operator or an assistant removes the finished boards. Under normal conditions the encapsulating machine is run by one operator, with an assistant, on one shift only.

According to information provided by two former machine operators, only small batches of boards had been run until July 1980--usually no more than fifty (50) boards at any given time. A single run usually required less than one (1) hour and more than two (2) runs were rarely conducted on one (1) day. The job activities of the machine operator included: mixing the coating solution in a large glass beaker, filling the encapsulating machine, filling the tank used to clean the spray lines with MEK, operating the machine and changing the filter as required.

On July 18, 1980, an operator and an assistant ran the machine; two other assembly workers were touching-up and stripping boards in the same room. On that day a larger than usual number of boards (in excess of 150) were

apparently run and the machine operated continuously from 11:45 A.M. until approximately 1:45 P.M. There was no hood over the touch-up table and no other room exhaust in operation at that time.

During that two-hour period all four(4) employees working in the room reported smelling a strong, solvent odor, as well as noticing the gradual appearance of a mist in the room air. All four (4) employees became ill. A fifth "lead" worker, who entered the room at approximately 1:30 P.M., corroborated reports of a dense fog in the air, a strong, solvent odor and said that several employees in the room appeared pale and ill. All employees vacated the room at approximately 1:45 P.M. Three of the four (4) employees were then taken to the plant physician at a nearby clinic. The fourth employee became ill later in the day and visited the clinic the following day. The fifth "lead" employee also developed symptoms. Three of five (5) workers were placed on medical leave by the plant physician. At the time of NIOSH's visit in October 1980, two (2) employees still had not returned to work.

IV. EVALUATION DESIGN AND PROCEDURES

A. Environmental

An initial walk-through survey was performed at the facility on September 17, 1980. The purpose of that visit was to gather information on the characterization of substances used in the encapsulation area, as well as conditions of their use. Specific areas, where significant exposure to applicable chemicals might occur, were identified. Additional information was obtained on October 20, 1980, during a second visit to the plant, during which the NIOSH medical officer interviewed several employees.

To evaluate employee exposure to chemicals used in the encapsulating room, environmental monitoring was conducted on March 18, 1981. Personal breathing-zone and general area air samples were collected to evaluate employee exposures to MEK, xylene and TDI. Samples were collected by using standard charcoal tubes (MEK, xylene) and specially prepared, glass wool tubes (TDI). Analyses were performed by gas chromatography and high pressure, liquid chromatography, respectively.

B. Medical

During the October 20, 1980, evaluation, the NIOSH medical officer interviewed nine employees--including the five workers involved in the July 18, 1980, incident, one supply coordinator who issued solvents from June through October 1980, a maintenance engineer and two employees who had worked in the encapsulation room since the July 1980 incident. Three of the seven line workers have served as encapsulation machine operators, including one of the two employees who had not returned to work at the time of the NIOSH visit in October 1980. Employees were asked about their involvement with the encapsulation room and about their health status.

Those employees, reporting symptoms which they associated with their workplace and/or with the incident in July 1980, were interviewed in detail. The NIOSH medical officer also obtained copies of all pertinent medical records of affected employees.

V. EVALUATION CRITERIA

A. Environmental

Environmental standards and criteria, applicable to this evaluation, are shown below.

Substance	NIOSH, 8-10 hr. TWA Recommendation (mg/M^3)*	(a) ACGIH, TLV Committee 8-hr. TWA Recommendation (mg/M^3)*	(b) OSHA, 8-hr. TWA Standard (mg/M^3)*
Methyl ethyl ketone (MEK)	**	590	590
Xylene	434(c)	435	435
Toluene Diisocyanate (TDI)	0.036(d)	0.14***	0.14***

* Eight or ten-hour, time-weighted-average (TWA) concentrations in milligrams of substance per cubic meter of air sampled

** No recommendation available

*** Ceiling recommendation/standard

(a) ACGIH - American Conference of Governmental Industrial Hygienists, Threshold Limit Value Committee

(b) OSHA - Occupational Safety and Health Administration

(c) "Ceiling" recommendation, 868 mg/M^3

(d) "Twenty-minute" exposure recommendation, 0.14 mg/M^3

B. Toxic Effects

Methyl Ethyl Ketone [1,2]

Methyl ethyl ketone is an irritant of the eyes, mucous membranes and skin; at high concentrations it causes narcosis in animals and it is expected that severe exposure in humans will produce the same effect. In humans short-term exposure to 885 mg/M^3 was "objectionable," causing headache

and throat irritation; 590 mg/M^3 caused mild irritation of the eyes; 295 mg/M^3 caused slight nose and throat irritation. Repeated exposure to high concentrations may cause numbness of the fingers, arms and legs. Extremely high concentrations may cause symptoms of central nervous system depression, such as dizziness and drowsiness.

Xylene [3,4]

Xylene, a colorless, aromatic hydrocarbon, is predominantly absorbed through inhalation of vapors and, to a lesser extent, through skin absorption. Irritating to the eyes, nose and respiratory tract, xylene may, in high concentrations, cause dizziness, drowsiness and high, reversible damage to the liver and kidneys. It may also cause pulmonary edema, loss of appetite, nausea, vomiting and abdominal pain. Available literature does not indicate how long symptoms and signs of an acute exposure may be expected to last.

Toluene Diisocyanate (TDI) [5,6,7]

Toluene diisocyanate is a strong irritant of the eyes, mucous membranes and skin and is also a potent sensitizer of the respiratory tract. TDI inhalation exposure is associated with at least five different respiratory syndromes: (1) acute effects, after exposure to high concentrations, can lead to bronchitis or even pulmonary edema as well as to nausea, vomiting and abdominal pain; (2) allergic sensitization with wheezing, shortness of breath and a nocturnal cough may be induced by repeated exposures. After sensitization, exposure to minute quantities induces wheezing and breathlessness. Sensitivity may be confirmed by a controlled inhalation challenge and antibodies to TDI may be detected by the RAST test; (3) some TDI-exposed workers show an acute, asymptomatic drop in their pulmonary function over the workshift at concentrations below 0.02 mg/M^3; (4) this drop may be linked with a chronic, accelerated loss of lung function over years of exposure; (5)a 1978 study of polyurethane workers showed changes consistent with restrictive lung disease in workers exposed daily to concentrations of TDI less than the OSHA standard of 0.14 mg/M^3 for a period of 1-10 years.

VI. RESULTS

A. Environmental

Results appearing in Tables 1 and 2 show that airborne concentrations of six (6) methyl ethyl ketone, six (6) xylene and seven (7) toluene diisocyanate personal breathing-zone/general area air samples were either below: (a) applicable NIOSH, ACGIH or OSHA 8-10 hour TWA/"ceiling" recommended levels and/or standards or (b) the lower limit of detection for the analytical method.

B. Medical

At the time of the July 1980 incident, three of the four workers in the encapsulation room reported that they experienced severe headaches and all four reported feeling intoxicated. Similarly, all four experienced weakness, nausea and a "raw, burning" chest pain. The fifth "lead" worker, who intermittently entered the room, developed a headache and chest/epigastric pain. All five employees reported developing a cough productive of small amounts of tenacious, green sputum lasting for two days to several weeks following the incident.

The two employees, who did not return to work, continued to experience cough, shortness of breath and fatigue, although both reported a lessening of the symptoms over a period of time. A review of their medical records, including follow-up pulmonary tests, did not reveal significant findings which appeared pertinent to the exposure incident in July 1980.

Interviews with the machine operator and assistant, who worked in the encapsulation room following the incident, did not reveal any medical symptoms.

VII. DISCUSSION/CONCLUSION

It appears likely, and was also the concensus of treating physicians, that the five workers in the encapsulating room on July 18, 1980, experienced acute solvent exposure to unknown, but intoxicating, levels of MEK, xylene and probably TDI. It also appears that all five developed some form of acute bronchitis as a result of that exposure. The role of TDI is uncertain, but acute exposure may precipitate bronchitis. Based on employee reports and NIOSH environmental sampling results, it also appears that subsequent exposures in the encapsulating room were well within acceptable limits and TDI was not detected in the workplace.

There is a paucity of literature pertaining to persistent effects of acute overexposure to MEK, xylene and TDI, but anecdotal information suggests that most acute effects are reversible. Although a marked asthmatic syndrome can occur in TDI-sensitized individuals, this occurs in the presence of re-exposure. Thus, removal from the work environment, where TDI is present, should prevent the induction of the asthmatic reaction.

VIII. RECOMMENDATIONS

1. Proper operation of the encapsulating machine depends upon both a properly functioning machine and a properly instructed operator. The principles of how a machine functions should be clearly explained to all operators in order to avoid confusion and potential mishaps, as well as any tendency to exceed the performance limits of the system.

2. Although the effects of an acute solvent overexposure are usually reversible, every effort should be made to avoid the repetition of such events. Employees should be alert for symptoms of solvent overexposure and should exit any work area where overexposure is suspected of occurring.

3. Appropriate organic vapor respirators must be: (a) available; (b) well-fitted to the appropriate personnel; and (c) properly maintained in the event of an emergency spill or other overexposure to solvent vapors.

4. NIOSH is aware that Boeing Electronics has incorporated numerous engineering and ventilation system changes into its encapsulation room operation since July 1980. In the future, however, appropriate local and emergency exhaust systems should be in place prior to introducing new processes into production operations.

IX. REFERENCES

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XI. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information, Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After ninety (90) days, the report will be available through the National Technical Information Services (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. Boeing Electronics, Irving, Texas
2. Authorized Representative of Employees
3. U.S. Department of Labor, Region VI
4. NIOSH, Region VI
5. Texas State Department of Health

For the purpose of informing the approximately ten (10) affected employees, a copy of this report shall be posted in a prominent place, accessible to the employees for a period of thirty (30 calendar days.

Table 2

General Area Toluene Diisocyanate (TDI) Concentrations

Boeing Electronics, Inc.
Encapsulation Area
Irving, Texas

March 18, 1982

Sample Number	Location	Sampling Period	*Concentration (mg/M^3)
TDI-1	Entrance to Spray Assembly	1254-1400	(a)
TDI-2	#1 Work Bench	1254-1400	(a)
TDI-3	Oven #3, Top	1254-1400	(a)
TDI-4	Flammable Liquid Storage Cabinet, Top	1254-1400	(a)
TDI-5	Entrance to Spray Assembly	1445-1530	(a)
TDI-6	#1 Work Bench	1445-1530	(a)
TDI-7	Flammable Liquid Storage Cabinet, Top	1445-1530	(a)

OSHA, 8-hr TWA Standard..... 0.14
ACGIH, 8-hr. TWA Recommendation..... 0.14
ACGIH, 8-hr. TWA Proposed..... 0.04
NIOSH, 8/10-hr. Recommendation..... 0.036
NIOSH, Ceiling (20 min.) Recomendation..... 0.14

* - mg/M^3, Milligrams of substance per cubic meter of air sampled
(a) Less than lower limit of detection (0.03 microgram per sample) for the analytical method