U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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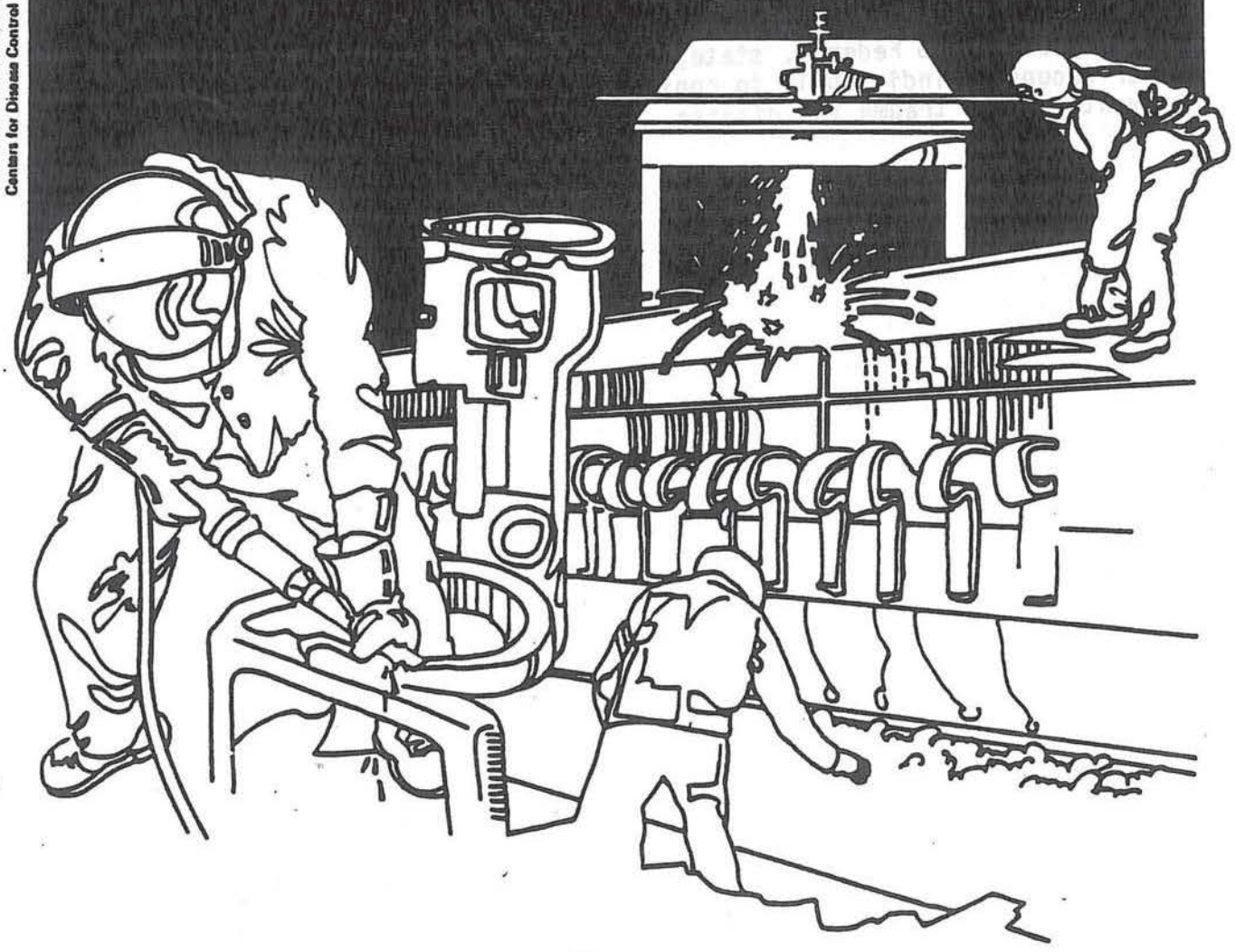

Health Hazard Evaluation Report

HETA 85-251-1620
TRW ELECTRONICS, INC.
COLORADO SPRINGS, COLORADO

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 85-251-1620
JULY 1985
TRW ELECTRONICS, INC.
COLORADO SPRINGS, COLORADO

NIOSH INVESTIGATOR
Bobby J. Gunter, Ph.D.

I. SUMMARY

In March 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request from plant management at TRW Electronics, Inc., Colorado Springs, Colorado to evaluate a potential health hazard from exposures to organic solvents, lead, zinc and toluene 2, 4, diisocyanate used in the manufacturing of electronic circuits.

On April 22 and 23, 1985, NIOSH investigators conducted an environmental evaluation in all production areas of TRW Electronics. Thirty-five breathing zone and two general area air samples were collected for trichlorotrifluoroethane (Freon 113) and methyl ethyl ketone (MEK). Levels of Freon 113 ranged from 5 mg/M^3 to 1294 mg/M^3, with an average concentration of 123 mg/M^3. The two general area samples were 8 and 52 mg/M^3. MEK was found in 3 breathing zone air samples concentrations were 0.3, 2.8, and 0.4 mg/M^3. All other MEK samples were below the laboratory limit of detection of 0.01 mg/sample. Six breathing zone air samples were taken for 2-ethoxyethanol. The average concentration was 6.2 mg/M^3. NIOSH recommends worker exposures be reduced to the lowest feasible limit. Thirty-five breathing zone and two general area samples were collected for toluene. All concentrations were below the evaluation criteria. The average concentration was 3.1 mg/M^3 with a high concentration of 60 mg/M^3 and a low of less than 0.01 mg/ sample. Toluene 2, 4, diisocyanate was collected on eight breathing zone air samples--all were below the evaluation criteria of 0.04 mg/sample. Thirty-three breathing zone and two general area breathing zone air samples were collected for xylene. All concentrations were below the evaluation criteria, with an averge concentration of 0.6 mg/M^3 and a high concentration of 13 mg/M^3 and a low of less than 0.01 mg/sample. Thirteen breathing zone and two general room air samples were collected for petroleum distillates. The highest concentration was 35 mg/M^3 and the lowest was less than 0.1 mg/sample. Average concentration was 6.0 mg/M^3. Fourteen breathing zone air samples were analyzed for cellosolve acetate. All were below the evaluation criteria. The average concentration was 0.8 mg/M^3. The highest level was 6.7 mg/M^3 and 9 of the 14 were below the laboratory limit of detection of 0.01 mg/sample. Twenty breathing zone air samples collected for MIBK were all below the evaluation criteria. The average concentration was 3.0 mg/M^3 with a high of 24 mg/M^3, and a low less than 0.01 mg/sample. Twenty-one breathing zone air samples were collected for methyl chloroform. All were below the evaluation criteria. The highest concentration was 21 mg/M^3, and 14 of the 21 were below the laboratory limit of detection of 0.01 mg/M^3. The average was 1.3 mg/M^3. Seven breathing zone and three general area samples were collected for lead and zinc. All lead concentrations were below the laboratory limit of detection of 0.005 mg/sample. Zinc was present in four of the ten, with a high of 0.04 and a low of less than 0.002 mg/sample.

Numerous employees were informally interviewed. The only consistent complaints were narcosis, burning eyes and defattying dermatitis, which are typical complaints when working with organic solvents.

Solvents and paints were stored in unacceptable places and posed both a fire and health hazard.

On the basis of environmental data, NIOSH concluded that a health hazard existed from over exposure to 2-ethoxyethanol at TRW, Electronics Inc. Recommendations on correcting these exposures are included in this report.

Keywords: SIC: 3674 (semiconductors and related devices) organic solvents, electronic industry.

II. INTRODUCTION

In March 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request from management of TRW Electronics Inc., Colorado Springs, Colorado to evaluate their facilities to see if there were health hazards that had been overlooked by the company's medical and industrial hygiene staff.

On April 22, 23, 1985, NIOSH conducted an environmental evaluation. Environmental sampling results were discussed with the requestor as soon as they were received from the laboratory in June 1985.

III. BACKGROUND

This facility produces solid state electronic circuits for military and spare contractors. Many of the work areas were operating under a high level of security. Major processes monitored during this survey included areas where hand soldering, vapor degreasing, circuit board coating, and wave soldering were occurring.

IV. ENVIRONMENTAL DESIGN AND METHODS

Sixty breathing zone and two general area air samples were collected on charcoal tubes using vacuum pumps operated at 50-200 cc/minute for measurement of 2-ethoxyethanol, freon 113, toluene, MEK, xylene, petroleum distillates, cellosolve acetate, methyl isobutyl ketone (MIBK), and methyl chloroform. These samples were analyzed according to NIOSH methods 1403, 1300, 1003, 1500, and 1501. Ten lead and zinc samples were collected on AA filters using vacuum pumps operated at 1.5 - 2.0 liters/minute. These samples were analyzed according to NIOSH method 173. Eight TDI samples were collected with impingers using vacuum pumps operated at 0.5 - 1.0 liters/minute, and analyzed according to NIOSH method 5505.

V. EVALUATION CRITERIA AND TOXICOLOGY

A. Environmental

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

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

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based solely on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

	Environmental Exposure Limits 8-Hour Time-Weighted Average (TWA) mg/M^3		
NAME	NIOSH	ACGIH	OSHA
2-Ethoxyethanol	LFL	185	740
Trichlorotrifluoroethane	*	5000	7600
Toluene	375	375	750
Methyl Ethyl Ketone	590	590	590
Xylenes	435	435	435
Petroleum Distillates	*	525	2900
Cellosolve Acetate	*	24	540
Methyl Isobutyl Ketone	200	205	410
Lead	0.05	0.05	0.05
Zinc Oxide	5	5	5
Toluene 2, 4, Diisocyanate	0.14(1)	0.04	0.14
Methyl Chloroform	1900	1900	1900

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(1) - 20 Minute Ceiling
* - No NIOSH Criteria
mg/M^3 - Milligrams per cubic meter
LFL - lowest feasible level

B. Toxicology

2-Ethoxyethanol - is also called ethylene glycol monoethyl ether and cellosolve. 2-Ethoxyethanol is mildly irritating to the skin. It may cause conjestion and upper respiratory tract irritation. Temporary corneal clouding may occur and last several hours. Acute exposure to high concentration will result in narcosis, pulmonary edema, and severe kidney and liver damage. Symptoms of over-exposure include: fatigue, lethargy, headache, nausea, anorexia, and tremor. Acute poisoning by ingestion resembles ethylene glycol toxicity, with death from renal failure. The National Institute for Occupational Safety and Health (NIOSH) recommends that 2-methoxyethanol (2ME) and 2-ethoxyethanol (2EE) be regarded in the workplace as having the potential to cause adverse reproductive effects in male and female workers. These recommendations are based on the results of several recent studies that have demonstrated dose-related embryotoxicity and other reproductive effects in several species of animals exposed by different routes of administration. Of particular concern are those studies in which exposure of pregnant animals to concentrations of 2ME or 2EE at or below their respective Occupational Safety and

Health Administration (OSHA) Permissible Exposure Limits (PEL's) led to increased incidences of embryonic death, teratogenesis, or growth retardation. Exposure of male animals resulted in testicular atrophy and sterility. In each case the animals had been exposed to 2ME or 2EE at concentrations at or below their respective Occupational Safety and Health Administration (OSHA) PEL's.

Therefore, appropriate controls should be instituted to minimize worker exposure to both compounds. NIOSH suggests that producers, distributors, and users of 2ME and 2EE, and of substances and materials containing 2ME and 2EE, give this information to their workers and customers, and that professional and trade associations and unions inform their members.[1]

Cellosolve Acetate is mildly irritating to the skin. Eye and respiratory irritation are common. Acute exposure may result in pulmonary edema and severe kidney and liver damage. Anemia and encephalopathy have been reported. Preplacement exams should include blood, CNS, renal and liver function. The skin and respiratory tract should also be evaluated.[2]

Lead - Inhalation (breathing) of lead dust and fume is the major route of lead exposure in industry. A secondary source of exposure may be from ingestion (swallowing) of lead dust deposited on food, cigarettes, or other objects. Once absorbed, lead is excreted from the body very slowly. Absorbed lead can damage the kidneys, peripheral and cental nervous systems, and the blood forming organs. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women.

Blood lead levels below 40 ug/deciliter whole blood are considered to be normal levels which may result from daily environmental exposure. The new Occupational Safety and Health Administration (OSHA) standard for lead in air is 50 ug/M^3, calculated as an 8-hour time-weighted average for daily exposure.[3] The standard also dictated that workers with blood lead levels greater than 60 ug/deciliter must be immediately removed from further lead exposure and, in some circimstances, workers with lead levels of less than 50 ug/deciliter must also be removed. Removed workers have protection for wage, benefits, and seniority for up to 18 months until their blood levels decline to below 40 ug/deciliter and they can return to lead exposure areas.

Methyl Chloroform (1-1-1-trichloroethane) can effect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if ingested. Acute exposure affects include: headache, dizziness, drowsiness, unconsciousness, irregular heart beat, and death. Eye contact usually causes irritation. Chronic exposures may cause skin irritation. Reproductive abnormalities have been noted in animals chronically exposed to high concentration.[4]

Methyl Ethyl Ketone (MEK) 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 300 ppm was "objectionable," causing headache and throat irritation; 200 ppm caused mild irritation of the eyes; 100 ppm caused slight nose and throat irritation. MEK can be recognized at 25 ppm by its odor, which is similar to acetone but more irritating. The TLV recommended by the ACGIH (200 ppm) was established at a level to prevent injurious effects and minimize complaints about odor and irritation.[5]

Methyl Isobutyl Ketone (MIBK) has a camphor-like odor detectable at 100 ppm. In humans, at levels of 400 ppm, it is quite objectionable causing eye and nasal irritation. Eye irritation is noted at a level of 200 ppm. Workers exposed to about 100 ppm complained of nausea and headache, but developed a tolerance after several days of repeated exposure. The OSHA standard of 100 ppm was set at a level believed to prevent eye irritation. NIOSH believes the current standard is not adequate and has recommended the level be lowered to 50 ppm.[6]

Petroleum Distillate - The petroleum distillates used in the printing industry and the one in use at this facility include the distillate that distills between 95 degrees and 175 degrees Centigrade. These are chiefly aliphatic hydrocarbons chiefly of C_7 - C_{10} series. The composition may vary widely since anyone of several fractions within this boiling range may be used.

Depression of the central nervouse system is one of the symptoms of exposure. Prolonged exposure causes irritation to mucous membranes, skin irritation, and defatting dermatitis. Liver and kidney damage can occur if excessive exposure is long term.

This product should be used under well ventilated conditions. If airborne concentrations are high (excess of 1000 mg/M^3, the action level or one-half the TLV or OSHA standard), local exhaust ventilation should be used; for short exposure a respirator may be used.[7]

Toluene can affect the body by all three routes of entry. Acute exposures may cause irritation to eyes, respiratory tract and skin. It may cause fatigue, weakness, confusion, headache, dizziness, and drowsiness.

Chronic exposure may cause difattying dermatitis. Reversible liver and kidney damage can occur in over-exposed workers. Hippuric Acid in urine is an index of worker exposure to toluene.

Toluene-2, 4-Diisocyanate (TDI) is a strong irritant of the eyes, musous membranes and skin, and is also a potent sensitizer of the respiratory tract. In sufficient concentrations, TDI causes irritation of the eyes, nose, and throat, a choking sensation, and a productive cough. Depending on the length of exposure and level of concentration above 0.5 ppm (3.6 mg/M^3), respiratory symptoms will develop with a latent period of four to eight hours. Although the acute effects may be severe, a more important consideration is that respiratory sensitization can occur in susceptible individuals after repeated exposure to levels of TDI as low as 0.02 ppm (0.14 mg/M^3). Initial symptoms are often night time shortness of breath or cough with progression to asthmatic bronchitis. After symptoms subside, a return to work can cause an acute and severe asthmatic attack almost immediately or within a few hours.[8] A person who has become sensitized to TDI must avoid future exposure completely. Some decrease in lung function in the absence of symptoms has been observed in some workers exposed to TDI for long periods of time, even at concentrations as low as 0.002 ppm (0.014 mg/M^3)[9]. The ACGIH TLV (0.02 ppm) was set at a level which was believed to be low enough to prevent respiratory sensitization. After a thorough review of the literature available at the time, NIOSH recommended a workplace environmental standard of 0.005 ppm (0.035 mg/M^3).[10] More recent findings by Wegman et al. indicates that even this low value may not protect sensitized workers.[11]

Trichlorotrifluoroethane (Fluorocarbon 113) - Local effects include mild irritation to the respiratory system; dermatitis may occur but is very rare. Central nervous system (CNS) depression may occur from very high exposures. Tremors and incoordination may result from high exposures. Cardiac arrhythmias may also occur. Once removed from exposure, the worker usually recovers immediately.[12]

Xylene vapor may cause irritation of the eyes, nose, and throat. Repeated or prolonged skin contact with xylene may cause drying and defatting of the skin which may lead to dermatitis. Liquid xylene is irritating to the eyes and mucous membranes, and aspiration of few milliliters may cause chemical pneumonitis, pulmonary edema, and hemorrhage. Repeated exposure to the eyes to high concentrations of xylene vapor may cause reversible eye damage. Acute exposure to xylene vapor may cause central nervous system depression and minor reversible effects upon liver and kidneys. At high concentrations, xylene vapor may cause dizziness, staggering, drowsiness, and unconsciousness.[13] Workers exposed to concentrations above 200 ppm complain of loss of appetite, nausea, vomiting, and abdominal pain. Brief exposure of humans to 200 ppm has caused irritation of the eyes, nose, and throat.[14]

The current OSHA standard for xylene is 100 ppm averaged over an 8-hour work shift. NIOSH has recommended that the permissible exposure limit be changed to 100 ppm, averaged over a work shift of up to 10 hours per day, 40 hours per week, with an acceptable ceiling level of 200 ppm averaged over a 10-minute exposure. The ACGIH TLV first adopted in 1967, is retained with a short term exposure limit (STEL) of 150 ppm for a 15-minute exposure.[15]

Zinc Oxide - The syndroms of metal fume fever is most important. This is charaterized by fever and chills with accompanying joint pain and soreness. Cough and shortness of breath may occur along with weakness and fatigue. Zinc excretion in the urine can be used as an index of exposure.[16]

VI. ENVIRONMENTAL RESULTS AND DISCUSSION

On April 22 and 23, 1985, NIOSH investigators conducted an environmental evaluation in all production areas of TRW Electronics. Thirty-five breathing zone and two general area air samples were collected for trichlorotrifluoroethane (Freon 113) and MEK. Levels of Freon 113 ranged from 5 mg/M^3 to 1294 mg/M^3, with an average concentration of 123 mg/M^3. The two general area samples were 8 and 52 mg/M^3. MEK found in three breathing zone air sample concentrations was 0.3, 2.8, and 0.4 mg/M^3. All other MEK samples were below the laboratory limit of detection of 0.01 mg/sample. Six breathing zone air samples were taken for 2-ethoxyethanol. The average concentration was 6.2 mg/M^3. NIOSH recommends exposures should be reduced to the lowest feasible limit. Thirty-five breathing zone and two general area samples were collected for toluene. All concentrations were below the evaluation criteria. The average concentration was 3.1 mg/M^3, with a high concentration of 60 mg/M^3 and a low of less than 0.01 mg/ sample. Toluene 2, 4, diisocyanate was collected on eight breathing zone air samples; all were below the evaluation criteria of 0.04 mg/sample. Thirty-three breathing zone and two general area breathing zone air samples were collected for xylene. All concentrations were below the evaluation criteria, with an averge concentration of 0.6 mg/M^3 and a high concentration of 13 mg/M^3 and a low of less than 0.01 mg/sample. Thirteen breathing zone and two general room air samples were collected for petroleum distillates. The highest concentration was 35 mg/M^3 and the lowest was less than 0.1 mg/sample. Average concentration was 6.0 mg/M^3. Fourteen breathing zone air samples were analyzed for cellosolve acetate. All were below the evaluation criteria. The average concentration was 0.8 mg/M^3. The highest level was 6.7 mg/M^3 and 9 of the 14 were below the laboratory limit of detection of 0.01 mg/sample. Twenty breathing zone air samples collected for MIBK were all below the evaluation criteria. The average concentration was 3.0 mg/M^3, with a high of 24 mg/M^3 and a low less than 0.01 mg/sample. Twenty-one breathing zone air samples were collected for methyl chloroform; all were below the evaluation criteria. The highest concentration was 21 mg/M^3, and 14 of the 21 were below the laboratory limit of detection of 0.01 mg/M^3. The

average was 1.3 mg/M^3. Seven breathing zone and three general area samples were collected for lead and zinc. All lead concentraions were below the labortory limit of detection of 0.005 mg/sample. Zinc was present in four of the ten, with a high of 0.04 and a low of less than 0.002 mg/sample.

Numerous employees were informally interviewed. The only consistent complaints were narcosis, burning eyes, and defattying dermatitis, which are typical complaints when working with solvents.

Solvents and paints were stored in unacceptable places and posed both a fire and health hazard. Explosion proof cabinets should be provided for the storage of solvents and paint. Local exhaust ventillation existed at most work stations which eliminates workers receiving excessive exposures.

VII. CONCLUSION

Based on environmental sampling and employee interviews, health and safety hazards did exist during this evaluation from over-exposure to 2-ethoxyethanol. Also, solvents and paints were found to be improperly stored. A complete environmental and safety survey should be performed at this facility each six months. This needs to be done in order to characterize each department and know where and when chemicals are used and if workers are exposed. A large number of exposures did not occur. A facility making these types of high technology products must maintain a clean atmosphere or they will have a poor product.

VIII. RECOMMENDATIONS

1. Industrial hygiene survey each six months until baseline information is accumulated.

2. Proper storage cabinets should be installed for the storage of flammable solvents and paints.

3. All workers should be educated on chemicals they are using and the precautions to take in order to prevent over-exposures.

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X. AUTHORSHIP AND ACKNOWLEDGMENTS

Report Prepared by: Bobby J. Gunter, Ph.D.
Regional Industrial Hygienist
NIOSH, Region VIII
Denver, Colorado

Evaluation Assistance: Paul Pryor, NIOSH, Denver
Pierre Belanger, NIOSH,
San Francisco, California

Originating Office: Hazard Evaluation & Technical Assistance Branch (HETAB)
Division of Surveillance, Hazard Evaluations, & Field Studies (DSHEFS) NIOSH
Cincinnati, Ohio

Report Typed By: Marile Brewer, Secretary
NIOSH, Region VIII
Denver, Colorado

XI. DISTRIBUTION AND AVAILABILITY

Copies of this 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 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. TRW Electronics, Inc.
2. U.S. Dept. of Labor/OSHA/Region 8
3. NIOSH/Region 8
4. Colorado Department of Health

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

Table 1

Breathing Zone and General Room Air Concentrations of
Trichlorotrifluoroethane, Toluene, Methyl Ethyl Ketone,
Xylenes and Petroleum Distillates
at TRW Electronic Products, Inc.,
Colorado Springs, Colorado
April 22, 23, 1985

Sample #	Job	Location	Tri-CFE, mg/M^3	TLE, mg/M^3	MEK, mg/M^3	XYL, mg/M^3	PTD mg/M^3
100	assembler	CS-1	70	*	*	*	5
101	Process Engr.	Engr. Lab	77	*	*	*	0.2
102	Assembler	Engr. Lab	10	*	*	*	*
103	Mech. Insp.	El Paso	115	*	*	*	*
104	Assembler	CS-1	131	*	*	*	22
105	Controller	Chem. Wrh.	1294	*	*	*	*
106	Area Sample	Engr. Lab	8	*	*	*	*
107	Assembler	Engr. Lab	16	*	2.8	*	*
200	Assembler	CS-1	98	*	*	*	35
201	Assembler	CS-1	92	*	*	*	8
202	Inspector	El Paso	37	*	*	*	*
203	Area Sample	Engr. Lab	52	*	*	0.6	6
204	Process Engr.	Engr. Lab	148	.5	*	0.6	6
205	Assembler	Engr. Lab	33	*	0.4	*	4
206	Assembler	Engr. Lab	32	*	*	*	5
Evlaution Criteria			5000	375	590	435	*525
Laboratory limit of detection mg/sample			0.01	.01	0.01	0.02	0.1

*This is 1984-85 TLV for Stoddard solvent which is closely related to this aliphatic petroleumm distillate.

TLE = Toluene
MEK = Methyl Ethyl Ketone
XYL = Xylene
PTD = Petroleum Distillates

Table 2

Breathing Zone and General Room Air Concentrations of
Cellosolve (2-ethyoxyethanol) at
TRW Electronic Products, Inc.,
Colorado Springs, Colorado
April 22, 23, 1985

Sample #	Job	Location	mg/M^3 2-Ethoxyethanol
11	Supervisor	Bond and Coat	*
12	Marking	CS-3-closed	9.4
13	Marking	CS-3-closed	3.8
14	Marking	CS-3-closed	353
13A	Marking	CS-3-closed	2.5
13B	Marking	CS-3-closed	1.7

Evaluation Criteria — LFL
Laboratory limit of detection mg/sample — 0.01
LFL - lowest feasible level

Table 3

Breathing Zone and General Room Air Concentrations of Xylene, Toluene, Cellosolve Acetate, Methyl Isobutyl Ketone and Methyl Ethyl Ketone at TRW Electronic Products, Inc., Colorado Springs, Colorado April 22, 23, 1985

Sample #	Job	Location	XYL	TLE	CEA	MIBK	MEK
					mg/M3		
51	Operator	Conform coat	*	8	1.4	*	0.9
52	Operator	Conform coat	*	3.2	0.8	*	0.3
53	Operator	Conform coat	*	13	*	*	*
110	Conform Coat	Assistant	*	5.6	*	*	*
111	Area Sample	C.A. Dumping	*	10.4	*	*	*
112	Area Sample	C.A. Dumping	*	6.3	0.5	*	*
113	Specialist II	Conform coat	*	1.8	1.2	*	*
114	Operator	Conform coat	0.8	*	*	1.2	*
115	Operator	Conform coat	11	*	*	18	*
116	Operator	Conform coat	4	*	*	6	0.3
117	Operator	Conform coat	1.7	0.3	*	4	0.5
118	Operator	Conform coat	0.8	0.3	*	1.6	*
119	Operator	Confrom coat	2.9	0.4	*	4	*
120	Conform Coat	Assistant	*	60	6.7	*	*
Evaluation Criteria			435	375	24*	205	590
Laboratory limit of detection			0.01	0.01	0.01	0.01	0.01

XYL = Xylene
TLE = Toluene
CEA = Cellosolve Acetate
MIBK = Methyl Isobutyl Ketone
MEK = Methyl Ethyl Ketone

Table 4

Breathing Zone and General Room Air Concentrations of Lead and Zinc at TRW Electronic Products, Inc., Colorado Springs, Colorado
April 22, 23, 1985

Sample #	Job	Location	Sampling Time	mg/M^3 Lead	Zinc
100	Solderer	TTC	7:10 - 4:10	*	*
101	Solderer	TTC	7:10 - 4:15	*	*
102	Solder Pats	BATSON	7:22 - 4:20	*	*
103	Solder Pats	BATSON	7:25 - 4:20	*	0.002
104	Tinning	CS-3-open	7:32 - 4:20	*	*
105	Tinning	CS-3-open	7:30 - 4:25	*	0.007
106	Flow Solderer	CS-3-closed	7:45 - 2:07	*	0.04
107	General Area	Flow Solderer	7:50 - 4:25	*	0.003
108	General Area	CS-1-open	7:19 - 3:43	*	*
109	General Area	El Paso	7:45 - 4:02	*	*
Evaluation Criteria				0.05	5
Laboratory limit of detection ug/sample				5	2

Table 5

Breathing Zone and General Room Air Concentrations of Toluene 2, 4, Diisocyanate at TRW Electronic Products, Inc., Colorado Springs, Colorado April 22, 23, 1985

Sample #	Job	Location	Sampling Time	mg/M^3 TLE, 2, 4, DCY
I-1	Formal Coat	TDI	1:30 - 2:30	*
I-2	Formal Coat	TDI	1:30 - 2:30	*
I-3	Formal Coat	TDI	1:15 - 2:30	*
I-4	Formal Coat	TDI	1:30 - 2:30	*
I-21	Formal Coat	TDI	10:20 - 12:40	*
I-22	Formal Coat	TDI	10:20 - 12:40	*
I-23	Formal Coat	TDI	10:20 - 12:40	*
I-24	Formal Coat	TDI	10:20 - 12:40	*
Evaluation Criteria				0.04
Laboratory limit of detection ug/sample				0.3

TLE, 2, 4, DCY = Toluene 2, 4, Diisocyanate

Table 6

Breathing Zone and General Room Air Concentrations of
Methyl Ethyl Ketone, Trichlorotrifluoroethane,
and Methyl Chloroform at
TRW Electronic Products, Inc.,
Colorado Springs, Colorado
April 22, 23, 1985

Sample #	Job	Location	Sampling Time	MEK	TCFE	MCF
1	Soldering	BATSON	7:22 - 10:35	*	53	*
2	Bonder Solder	TTC	7:06 - 10:24	*	46	*
3	Boards	BATSON	7:20 - 10:30	0.3	263	*
4	Solderer	TTC	7:08 - 10:24	*	76	*
5	Supervisor	TTC	7:11 - 10:20	*	13	*
6	Assembly	CS-3-open	7:35 - 10:40	*	118	*
7	Solderer	CS-3-open	7:35 - 10:42	*	240	*
8	Lead Line	CS-3-closed	7:43 - 11:10	*	240	2
9	Chemical man	CS-3-open	7:35 - 11:15	*	157	*
10	Micro Clean	CS-3-closed	7:45 - 11:15	*	155	21
1-A	Solderer	BATSON	10:30 - 1:40	*	18	*
1-B	Solderer	BATSON	1:40 - 4:20	*	17	*
2-A	Solderer	TTC	10:26 - 4:10	*	33	*
3-A	Boards	BATSON	10:30 - 4:20	*	179	0.1
4-A	Solderer	TTC	10:24 - 4:20	*	43	*
5-A	Supervisor	TTC	10:20 - 4:20	*	5	*
7-A	Solderer	CS-3-open	10:42 - 4:50	*	99	*
8-A	Lead line	CS-3-closed	11:12 - 2:07	*	106	3
8-B	Lead line	CS-3-closed	2:07 - 4:25	*	115	3
9-A	Chemical man	CS-3-open	11:15 - 4:50	*	129	0.5
10-A	Micro-clean	CS-3-closed	11:15 - 4:25	*	16	0.3
Evaluation Criteria				590	5000	1900
Laboratory limit of detection mg/sample				0.01	0.01	0.01

MEK = Methyl Ethyl Ketone
TCFE = Trichlorotrifluoroethane
MCF = Methyl Chloroform

Table 7

Breathing Zone and General Room Air Concentrations of Xylene, Toluene, Methyl Isobutyl Ketone and Methyl Ethyl Ketone at TRW Electronic Products, Inc., Colorado Springs, Colorado April 22, 23, 1985

Sample #	Job	Location	Sampling Time	mg/M^3 XYL	TLE	MIBK	MEK
11A	Supervisor	Bonded coat	10:50 - 1:50	*	*	*	*
11B	Supervisor	Bonded coat	1:50 - 4:50	*	0.6	*	*
12A	Marking	Bonded coat	10:58 - 1:50	13	*	24	*
14A	Marking	CS-3-closed	11:05 - 2:00	3	*	*	*
14B	Marking	CS-3-closed	2:00 - 4:40	0.6	*	3	*
21	Conform coat	CS-1-closed	1:45 - 3:45	*	*	*	1.3
Evaluation Criteria				435	375	205	590
Laboratory limit of detection				0.01	0.01	0.01	0.01

XYL = Xylene
TLE = Toluene
MIBK = Methyl Isobutyl Ketone
MEK = Methyl Ethyl Ketone

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