

Industrial Hygiene Survey Report
of
TRW ELECTRONIC PRODUCTS INC.
3650 North Nevada Avenue
Colorado Springs, Colorado 80907

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DISCLAIMER

Mention of company or product name in this report does not constitute endorsement by the National Institute for Occupational Safety and Health (NIOSH).

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PURPOSE OF SURVEY: To evaluate worker exposures, personal protection equipment and engineering controls in work areas using any of four ethylene glycol ethers (2-ME, 2-MEA, 2-EE, 2-EEA) proposed for revised regulation by OSHA. This information will be used to assess the feasibility of any additional health studies of glycol ether-exposed workers.

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ABSTRACT

The National Institute for Occupational Safety and Health (NIOSH) is conducting a study entitled "An Exposure Assessment of Industries Using Ethylene Glycol Ethers" in collaboration with PEI Associates, Inc. (PEI), Cincinnati, Ohio. This work is being conducted to determine the extent of occupational exposure to these compounds to assess the feasibility of any additional health studies of glycol ether-exposed workers. In addition, the Occupational Safety and Health Administration (OSHA) is interested in this information because they are proposing to revise their current regulations for 2-methoxyethanol, 2-ethoxyethanol, and their respective acetates.

The NIOSH study involves surveying several workplaces where these glycol ethers are manufactured or used as ingredients in process materials. Each survey involves collecting industrial hygiene samples and obtaining information concerning glycol ether usage, process operations, and engineering controls, past exposure levels, the size of the potentially exposed workforce, and the corporate industrial hygiene and safety programs. This information is being compiled by PEI and reported to OSHA's Office of Regulatory Analysis for its assessment of the technical feasibility and economic impact of revising the exposure standards for the glycol ethers.

The specific results from a survey conducted at the TRW Electronic Products, Inc. plant in Colorado Springs, CO are presented in this report. At this facility, a liquid mixture used for marking parts for printed circuit boards contains an ethylene glycol ether, 2-ethoxyethyl acetate (2-EEA). During the survey, the potential for inhalation and dermal exposure to 2-EEA existed

only during the following periodic activities: (1) blending the multiple components of a coating mixture, and (2) applying the coating to printed circuit board parts. The monitoring results from the survey indicate nondetectable concentrations for all samples, obviously below the 100 ppm OSHA PEL, the 5 ppm ACGIH TLV, and the "lowest feasible level" NIOSH REL. These results were probably due to the very limited use of the glycol ether-containing materials, the effective work practices, and the presence of adequate engineering controls.

A previous study [NIOSH 1985] at this same plant had indicated measurable concentrations of 2-EE and 2-EEA, however, much of the earlier usage of glycol ether-containing materials has since been discontinued or greatly decreased.

Due to the undetectable exposures to 2-EEA during our recent survey and the small number of potentially exposed workers at this facility, this work group would not appear to be suitable for future occupational health studies of glycol ether-exposed workers.

INTRODUCTION

Adverse central nervous system (encephalopathy) and hematotoxic (anemia, leukopenia) effects in workers exposed to 2-methoxyethanol (2-ME) were first noted in the late 1930s [Donley 1936; Parsons and Parsons 1938]. The hematotoxic effects of exposure to 2-ME and other ethylene glycol ethers were later confirmed in animal studies [Miller et al. 1983; Werner et al. 1943ab]. In the late 1970s, studies reported adverse reproductive effects, including testicular atrophy, infertility, fetotoxicity, and fetal malformations in laboratory animals exposed to different ethylene glycol ethers [Doe et al. 1983; Miller et al. 1982, 1984, Brown et al. 1984].

Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs) were established for eight glycol ethers (including 2-ME (25 parts per million or ppm), 2-methoxyethyl acetate or 2-MEA (25 ppm), 2-ethoxyethanol or 2-EE (200 ppm) and 2-ethoxyethyl acetate or 2-EEA (100 ppm)) in 1981 based upon the 1968 American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs[®]). The TLVs[®] were based on the hematotoxic and neurotoxic effects and on exposure concentrations reported in the early case reports of human health effects. However, more recent information from experimental animal studies indicates that adverse reproductive effects may occur at exposure concentrations below the current OSHA PELs. Therefore, because of the increased concern about their potential to cause reproductive and embryotoxic effects, OSHA is currently developing a proposal to revise its regulation of these four glycol ethers.

Under contract to OSHA's Office of Regulatory Analysis (ORA), PEI Associates, Inc. (PEI) is assessing the technical feasibility and economic impact of revising the exposure standard for ethylene glycol ethers. This work involves compiling information concerning: glycol ether usage patterns, workplace exposures, control technology, and compliance costs. Data are being collected through both mail questionnaires and site visits.

The National Institute for Occupational Safety and Health (NIOSH) is evaluating workplace exposures by cooperatively conducting industrial hygiene surveys with PEI at approximately 11 different plants representing the major usage groups (e.g., industrial coatings, jet fuel additives, commercial printing, aircraft painting, automobile refinishing, maintenance painting, and electronics manufacture) of the four regulated glycol ethers. Each survey involves industrial hygiene sampling and collecting information concerning process operations and engineering controls, glycol ether usage patterns, the size of the potentially exposed workforce, and exposure control methods. NIOSH intends to use this information to determine the feasibility of conducting any additional health studies of glycol ether-exposed workers.

This report presents the results of a site visit conducted at the TRW Electronic Products, Inc. plant in Colorado Springs, CO during September 13-14, 1988.

BACKGROUND

Physical and Chemical Properties. The glycol ethers 2-methoxyethanol and 2-ethoxyethanol, and their respective acetates, are part of the family of ethylene glycol ethers; their chemical and physical properties are summarized in Table 1. The ethylene glycol ethers are manufactured by the reaction of ethylene oxide with the appropriate alcohol (e.g., ethanol, methanol); the glycol ethers are used to form acetates by their reaction with acetic acid. In general, glycol ethers and their acetates are colorless liquids with versatile solvent properties (e.g., miscible in water and most hydrocarbon solvents, low vapor pressure, slow evaporation rate) which make them useful in a wide variety of industrial applications.

Production, Use, and Exposure. The total U.S. production of the regulated ethylene glycol ethers and acetates in 1983 is listed in Table 2.

Ethylene glycol ethers and acetates have been used commercially for over 50 years, primarily as solvents in the manufacture of protective coatings such as paints, lacquers, metal coatings, baking enamels, phenolic varnishes, epoxy resin coatings, and stains [NIOSH 1983]. Ethylene glycol ethers and acetates are also used as solvents for printing inks, textile dyes and pigments, and leather finishes; as anti-icing additives in military jet fuels; and in the manufacture of printed circuit boards. Many of these uses require direct handling of the glycol ethers by workers during the formulation and/or evaporation stages, thus leading to the potential for occupational exposure via inhalation and/or skin absorption [Dugard et al. 1984]. Based on data obtained during the National Occupational Hazard Survey (NOHS) conducted by NIOSH during 1972-1974, an estimated 2.5 million men and women may be occupationally exposed to glycol ethers (NIOSH 1977). The numbers of workers potentially exposed to the regulated glycol ethers are presented in Table 3.

Toxicology. The effects of the short-chain ethylene glycol ethers (2-ME, 2-MEA, 2-EE, and 2-EEA) on reproduction and fetal development have been studied extensively in rats, rabbits, and mice. The results uniformly show developmental toxicity, including increased incidences of fetal malformations and resorptions. In general, the evidence suggests that the glycol ether acetates have the same toxicologic activity as their parent glycol ethers. Some studies have indicated that behavioral teratogenic effects may occur in the offspring of rats treated with 2-ME and 2-EE [Nelson and Brightwell 1984]. Testicular damage has also been caused in rats after acute exposures to 2-ME [Doe et al. 1983].

Changes in the blood and adverse effects on the bone marrow and thymus have been observed in rats, mice, and rabbits exposed to 2-ME. The effects of lowered red and white blood cell counts appear to be the result of bone marrow suppression. Recent studies [Miller et al. 1983a] have confirmed histologically the reported depressant effect of 2-ME on the bone marrow and thymus of rats and rabbits. Grant et al. [1985] have reported at least partial reversal of these effects in rats following short-term exposure to 2-ME. Limited information suggests that 2-EE, 2-EEA, and 2-MEA also produce

TABLE 1

PHYSICAL AND CHEMICAL PROPERTIES OF FOUR ETHYLENE GLYCOL ETHERS

Property	2-ME	2-MEA	2-EE	2-EEA
IUPAC Chemical Name	2-methoxyethanol	2-methoxyethyl acetate	2-ethoxyethanol	2-ethoxyethyl acetate
CAS No.	109-86-4	110-49-6	110-80-5	111-15-9
RTECS No.	KL5775000	KL5950000	KK8050000	KK8225000
Empirical formula	C ₃ H ₈ O ₂	C ₅ H ₁₀ O ₃	C ₄ H ₁₀ O ₂	C ₆ H ₁₂ O ₃
Molecular weight	76.1	118.1	90.1	132.1
Specific gravity	0.97	1.01	0.93	0.97
Density (lbs/gal)	8.04	8.37	7.75	8.10
Vapor pressure (mmHg) 25°C	9.7	2.0-3.7	5.7	2.8
20°C	6.0	2.0	4.0	2.0
Boiling point (°C)	124.5	145.0	135.0	156.0
Flash point (°F) open cup	115	140	120	138
1 ppm=mg/m ³ (25°C, 760mmHg)	3.11	4.83	3.69	5.41
1 mg/m ³ =ppm (25°C, 760mmHg)	0.32	0.21	0.27	0.19
Other identifiers:	methyl cellosolve ethylene glycol monomethyl ether Dowanol EM	methyl cellosolve acetate ethylene glycol monomethyl ether acetate	cellosolve ethylene glycol monoethyl ether Dowanol EE	cellosolve acetate ethylene glycol monoethyl ether acetate

Clayton and Clayton, 1982

TABLE 2

U.S. PRODUCTION OF FOUR ETHYLENE GLYCOL ETHERS

Compound	1983 Production (pounds)
2-ME	83,000,000
2-MEA	1,000,000
2-EE	187,000,000
2-EEA	153,000,000

SRI 1984

adverse effects in the peripheral blood of rats [Werner et al. 1943b], mice [Nagano et al. 1979], and dogs [Werner et al. 1943a].

TABLE 3

ESTIMATE OF U.S. WORKERS POTENTIALLY EXPOSED TO ETHYLENE
GLYCOL ETHERS AND ACETATES

Compound	Number of Workers
2-ME	100,000
2-MEA	20,500
2-EE	407,000
2-EEA	321,000

NIOSH 1977

Methoxyacetic acid (MAA) has been isolated and identified in urine as the major metabolite of 2-ME in rats [Miller et al. 1983]. Although all of the glycol ethers are not metabolized via a single pathway, it has been suggested that the major metabolites of 2-ME and 2-EE, MAA and ethoxyacetic acid (EAA), respectively, act to cause the testicular [Miller, et al., 1982, 1984], developmental [Brown et al. 1984], and hematotoxic [Miller et al. 1982] effects observed in rats treated with 2-ME or 2-EE.

Neurologic and hematologic effects were observed in workers following inhalation and dermal exposure to 2-ME [Donley 1936; Greenburg et al. 1937; Zavon 1963; Ohi and Wegman 1978]. A cross-sectional study assessing fertility among men engaged in the production of 2-ME reported decreases in testicular size; no quantitative estimates of exposure concentrations were provided [Cook et al. 1982]. A cross-sectional evaluation of semen quality among men exposed to 2-EE (concentrations ranged from zero to 23.8 ppm 2-EE) found significantly lower sperm count per ejaculate [NIOSH 1986]. Painters exposed to both 2-EE and 2-ME (full-shift exposure concentrations of 2-EE averaged 15 ppm; the concentration of 2-ME was not mentioned) had sperm abnormalities including reduced sperm counts, and abnormalities of both red and white blood cells [Welch and Schrader 1986].

APPLICABLE STANDARDS AND RECOMMENDED LIMITS

Based on toxicological data, NIOSH recommended in Current Intelligence Bulletin (CIB) No. 39 The Glycol Ethers, with Particular Reference to 2-Methoxyethanol and 2-Ethoxyethanol: Evidence of Adverse Reproductive Effects that 2-ME, 2-EE, and structurally related glycol ethers be regarded in the workplace as having the potential to cause adverse reproductive effects in male and female workers. Also noted were and embryotoxic effects, including

teratogenesis, in the offspring of the exposed pregnant females [NIOSH 1983]. The NIOSH current recommended exposure limit (REL) is therefore "reduction of workplace levels to the lowest extent possible." Since publication of CIB No. 39, additional data on the glycol ether compounds have been published (as summarized in ECETOC 1985). These data are currently being evaluated during the development of a criteria document for the ethylene glycol ethers.

The current NIOSH RELs, OSHA PELs and ACGIH TLVs[®] established for the targeted glycol ethers are summarized in Table 4.

TABLE 4

APPLICABLE STANDARDS AND RECOMMENDED LIMITS

Compound	Exposure Limit ^a (ppm)		
	NIOSH REL	OSHA PEL	ACGIH TLV [®]
2-ME	*	25 ^S	5 ^S
2-MEA	*	25 ^S	5 ^S
2-EE	*	200 ^S	5 ^S
2-EEA	*	100 ^S	5 ^S

CFR 1984; ACGIH 1987

^a 8-hour time-weighted-average (TWA₈)

^S Skin notation

* Reduce exposure to lowest feasible level

HISTORY AND DESCRIPTION OF THE FACILITY

TRW Electronic Products Inc. (TRW/EPI) is a wholly-owned subsidiary of TRW Inc. whose headquarters are in Cleveland, Ohio. TRW Inc.'s 90,000 employees work in over 300 locations in more than 25 countries.

The TRW Electronic Products facility in Colorado Springs, CO, was established in 1970 to produce electronic hardware under government contract. The facility occupies three primary buildings referred to as CS-I, CS-II, and CS-III, (197,000 total square feet). Many of the work areas at the Colorado Springs facility operate under a high level of security. Several work areas were being consolidated and redesigned at the time of the survey.

PROCESS DESCRIPTION

The manufacturing of electronic hardware at this facility involves the coating/marking, bonding, soldering, degreasing and surface mount assembly of printed circuit boards. The only process operation which currently involves any potential exposure to ethylene glycol ethers is the touch-up marking of circuit boards in CS-3 area.

The specific ethylene glycol ether-containing formulation used for marking is produced by blending the coating (Part A) and catalyst (Part B) components of a product designated as CONAP CE-1155; Part A contains 25.0 weight percent of 2-EEA, whereas Part B contains 17.6 weight percent 2-EEA. The blend consists of approximately 60 weight percent of Part A and 40 weight percent of Part B. Approximately 5 to 55 gallons of this mixture is used per year.

Weighing and blending of the bonding mixture components presently occur for approximately 15 minutes per day, three to five times a week. A wooden tongue depressor is used for stirring the mixture. The blended product is applied to the boards or parts by means of Q-tips or paint brushes. There is a potential for accidental spills when handling the stock containers of liquid solutions (one-pint to one-gallon capacities), pouring and weighing the liquids in plastic cups, mixing together the catalyst and coating components, and applying the bonding mixture to the parts.

Other formulations are also used in the marking area. These include inks containing up to 35 weight percent of diethylene glycol monoethyl ether acetate (DEGMEA) or butyl cellosolve (2-BE).

A coating containing less than five weight percent 2-EEA was used by TRW in the past for spraying of printed circuit boards in conformal coat equipment (which includes a conveyor, an enclosed and locally exhausted automatic spray chamber, and a thermal oven). This equipment, which had a capacity to process more than 500 boards per month, was in the process of being dismantled and sold to another TRW division at the time of the survey because of the low volume of work at the Colorado Springs plant.

TRW is planning on conducting any future printed circuit board coating operations manually in a paint spray booth (38" x 42" x 73") because of the anticipated lower volume throughout. TRW expected future spraying operations to occur for less than one hour per week corresponding to a processing rate of less than a dozen boards per year. There were no ongoing printed circuit board coating operations at the TRW plant during the time of the survey.

DESCRIPTION OF THE WORKFORCE

The TRW plant presently operates on shift per day, five days per week, 250 days per year. There are presently 450 employees at the Colorado Springs facility; the total employment peaked in 1986 at approximately 1,500. There are a total of 15 workers at the plant who may be exposed to 2-EEA. These employees can be grouped into the following job classifications:

Manufacturing Specialists: These operators are responsible for marking and bonding of circuit boards. Duties include weighing and mixing of catalyst and coating components and subsequent application of this marking mixture onto electronic parts. There are currently eight female and two male workers in this job category.

Inspectors: Inspectors perform quality control testing on incoming raw materials and chemicals. This usually involves only expiration date checks for the glycol ether-containing products. There are four female workers and one male worker in this job category.

Other job classifications at the TRW facility potentially exposed to concentrations of glycol ethers include solderers and tinning operators; these workers do not directly handle any glycol ether-containing products but work in the same area where marking occurs. The number of these workers typically varies with the number of on-going contracts at any given time.

CONTROL DESCRIPTION

The plant has a heating, ventilation, and air conditioning (HVAC) system; 10 percent make-up air is used in winter. High efficiency particulate (HEPA) filters are used to maintain a particle count of <200,000 at 0.5 microns in the work areas. There are lip suction side-draft hoods in the marking area with design face velocities of 100 linear feet per minute (lfpm); weighing and blending operations are conducted alongside these hoods. These hoods were operational during the survey.

PERSONAL PROTECTIVE EQUIPMENT

Safety glasses and surgical gloves are worn by the operators when blending catalyst and coating components. Inspectors who perform limited quality control testing on incoming chemicals reportedly wear butyl gloves over surgical gloves during their tasks. It was reported that half-mask respirators with organic vapor cartridges would be worn during any future coating operations in the paint spray booth.

MEDICAL AND INDUSTRIAL HYGIENE PROGRAMS

Physicals are scheduled annually for employees who have been identified as having potential for exposure to hazardous chemicals. Medical services are contracted to a clinic which provides an on-site nurse part-time for 10 hours per week.

The TRW plant has a safety program that is coordinated with the corporate office in Cleveland, OH. Safety meetings on hazard communications and occupational exposures are held regularly by the senior facilities engineer. Material safety data sheets (MSDSs) are located in each work area for the specific chemicals and products handled in the area; a master copy of the MSDSs are located in the main office.

Industrial hygiene concerns are referred through the senior facilities engineer. TRW has never sampled for ethylene glycol ethers at the Colorado Springs plant.

However, the monitoring results from a NIOSH Health Hazard Evaluation (HHE) Survey conducted in April 1985 [NIOSH 1985] are available and presented in Table 5. The HHE was conducted in response to a request from plant management for an evaluation of workplace exposures to organic solvents and metals. The average full-shift concentration for six personal samples collected in the CS-3 area (marking) was 1.7 ppm 2-EE. (Note: A marking product containing 2-EE, different from the current 2-EEA-containing mixture, was used in 1985). A total of 14 personal and area samples were collected for 2-EEA in the conformal coating area. Nine of the fourteen sample results were below the limit of detection of the analytical method; the highest concentration detected was 1.24 ppm 2-EEA, and the average concentration was 0.15 ppm. Based on the environmental sampling results, the HHE investigators concluded that health hazards did exist from over-exposure to 2-ethoxyethanol.

TABLE 5
MONITORING RESULTS FOR ETHYLENE GLYCOL ETHERS
DURING NIOSH HEALTH HAZARD EVALUATION (April 22-23, 1985)
TRW ELECTRONIC PRODUCTS, INC.
Colorado Springs, CO

GLYCOL ETHER	LOCATION	JOB CATEGORY	CONCENTRATION (ppm)
2-EE	Bond and Coat	Supervisor	ND ^a
2-EE	CS-3 (Marking)	Manufacturing Specialist	2.54
2-EE	CS-3 (Marking)	Manufacturing Specialist	1.03
2-EE	CS-3 (Marking)	Manufacturing Specialist	5.35
2-EE	CS-3 (Marking)	Manufacturing Specialist	0.68
2-EE	CS-3 (Marking)	Manufacturing Specialist	0.46
2-EEA	Conformal Coat	Operator	0.26
2-EEA	Conformal Coat	Operator	0.15
2-EEA	Conformal Coat	Operator	ND ^a
2-EEA	Conformal Coat	Assistant	ND ^a
2-EEA	C.A. Dumping	Area sample	ND ^a
2-EEA	C.A. Dumping	Area sample	0.09
2-EEA	Conformal Coat	Specialist II	0.22
2-EEA	Conformal Coat	Operator	ND ^a
2-EEA	Conformal Coat	Operator	ND ^a
2-EEA	Conformal Coat	Operator	ND ^a
2-EEA	Conformal Coat	Operator	ND ^a
2-EEA	Conformal Coat	Operator	ND ^a
2-EEA	Conformal Coat	Operator	ND ^a
2-EEA	Conformal Coat	Assistant	1.24

^a Non-detectable (analytical limit of detection = 0.01 mg/m³).

SAMPLING STRATEGY AND METHODS

A one-shift sampling survey was conducted on September 14, 1988 at the TRW Electronic Products Inc. plant in Colorado Springs, CO to measure the extent of exposures associated with the typical usage of formulations containing 2-ME. Personal and area long-term (6- to 7-hour) and short-term (6- to 15-minute) samples were collected. Long-term samples are used to measure full-shift exposures whereas short-term samples are used to measure peak exposures of relatively short duration.

SAMPLING STRATEGY AND METHODS

A one-shift sampling survey was conducted at the TRW facility to measure the extent of exposures associated with the typical usage of formulations containing ethylene glycol ethers. Personal and area long-term (6- to 7-hour) and short-term (13-minute) samples were collected. Long-term samples are used to measure full-shift exposures whereas short-term samples are used to measure peak exposures of relatively short duration.

Sampling and analysis were conducted in accordance with OSHA method 53. Airborne samples were collected on charcoal, desorbed with a methylene chloride/methanol solution and analyzed by a gas chromatograph equipped with a flame ionization detector.

OSHA Method 53 [OSHA 1985] was used for sampling and analysis of all NIOSH samples. Airborne samples were collected on charcoal, desorbed with methylene chloride/methanol and analyzed by gas chromatography using flame ionization detection (GC/FID). A brief description of the sampling and analytical procedures follows:

Long-term samples were taken with Gilian Model LFS-113DC portable low-flow air sampling pumps calibrated at a flow rate between 0.1-0.2 liters per minute (Lpm). Targeted sample volumes were generally between 30-70 liters. Short-term samples were collected with SKC Model 224 sampling pumps calibrated at approximately 1.0 Lpm; sample volumes were nominally 15 liters.

All samples were collected on SKC No. 226-01 coconut charcoal tubes (100 mg primary/50 mg backup sections) connected to sampling pumps with tygon tubing. Personal samples were attached near the breathing zone of the worker while area samples were positioned in the immediate vicinity of typical work stations. Samples were refrigerated between sample collection and analysis.

Sample analyses were performed by DataChem (Salt Lake City, UT). Charcoal tube samples were desorbed with 95/5 (v/v) methylene chloride/methanol and analyzed using a Hewlett-Packard Model 5890A gas chromatograph equipped with a flame ionization detector.

Table 6 presents the analytical limit of detection (LOD) and limit of quantitation (LOQ) for 2-EEA. The LOD is that level at which an instrument response can confidently be attributed (95% probability) to the presence of

the compound being measured; the LOQ indicates the point at which an indicated response is within acceptable confidence limits. Table 6 also shows the equivalent LOD and LOQ concentrations for an 8-hr TWA sample collected at 0.2 Lpm and a 15-minute short-term sample collected at 1.0 Lpm.

TABLE 6
LIMIT OF DETECTION (LOD) AND LIMIT OF QUANTITATION (LOQ)
FOR 2-ETHOXYETHYL ACETATE (2-EEA)

Analytical Limits (mg/sample)		Sampling Limits (ppm/sample)			
LOD	LOQ	TWA8 ^a		Peak ^b	
		LOD	LOQ	LOD	LOQ
0.01	0.03	0.02	0.06	0.12	0.37

^a 8-hour time-weighted average sample collected at 0.2 Lpm.

^b 15-minute short-term sample collected at 1.0 Lpm.

MONITORING RESULTS

A total of ten field samples (eight long-term and two short-term) were collected and analyzed. None showed the presence of 2-EEA. As seen by the results in Table 7, the actual sampling LODs and LOQs vary according to the sampling duration for each sample.

Interestingly, the two short-term area samples indicated the presence of 2-EE and these results were between the limit of detection (0.01 milligram per sample) and the limit of quantitation (0.03 milligram per sample) of the analytical method. 2-EE was not detected on any other samples.

Long-term Sampling Results - A total of eight long-term samples (three personal and five area) were collected during the monitored work shift. Personal samples were obtained on three manufacturing specialists in the marking area. Sample results of all long-term personal and area samples were nondetectable for any of the ethylene glycol ethers.

Short-Term Sampling Results - Two short-term samples were obtained during the blending of the coating (Part A) and catalyst (Part B) components. The results showed concentrations of 0.21 and 0.41 ppm 2-EE which are both below the sampling limit of quantitation (0.54 ppm/sample). Although the specific ethylene glycol ether in the coating and catalyst components was 2-EEA (as indicated by Material Safety Data Sheet (MSDS) information), it is presumed that 2-EE was detected because: (1) 2-EEA may have hydrolyzed to 2-EE; or (2) 2-EEA was incorrectly identified during analysis as 2-EE. The latter is quite plausible considering that past analytical problems of misidentification have been recognized for this method.

TABLE 7

MONITORING RESULTS FOR 2-ETHOXYETHYL ACETATE (2-EEA)
 TRW ELECTRONIC PRODUCTS INC.
 Colorado Springs, CO

September 14, 1988

Sample	ID	Job (Activity)	Time Start-Stop	Flow (cc/min)	Duration (min)	Air volume (L)	Concentration (ppm) ^a 2-EEA
TRW-9	CS-3	Marking Station (area)	06:48-13:48	209.2	420	87.9	<0.02 ^b
TRW-32	CS-3	Marking Station (area)	07:23-13:48	198.5	385	76.4	<0.02 ^b
TRW-23		Soldering Lab (area)	06:50-13:44	204.3	414	84.6	<0.02 ^b
TRW-46	CS-3	Chem Storage (area)	07:03-13:45	202.6	404	81.9	<0.02 ^b
TRW-2	CS-3	Mfg Specialist	07:14-13:52	209.2	398	83.3	<0.02 ^b
TRW-3	CS-3	Mfg Specialist	07:19-13:56	213.1	397	84.6	<0.02 ^b
TRW-31	CS-3	Mfg Specialist	07:17-13:57	194.3	400	77.7	<0.02 ^b
TRW-19	CS-3	Solder Station (area)	07:21-13:49	199.4	388	77.4	<0.02 ^b
TRW-15	CS-3	Blending (area) ^d	12:57-13:10	1010.0	13	13.1	<0.12 ^b
TRW-1	CS-3	Blending (area) ^d	12:57-13:10	1030.0	13	13.4	<0.12 ^b

(Concentrations of 2-Ethoxyethanol)

TRW-15	CS-3	Blending (area) ^d	12:57-13:10	1010.0	13	13.1	0.21 ^c
TRW-1	CS-3	Blending (area) ^d	12:57-13:10	1030.0	13	13.4	0.41 ^c

^aSamples were not time-weighted to 8-hour concentrations.^bSample result was less than the analytical limit of detection (0.01 mg/sample).^cSample result was less than the analytical limit of quantitation (0.03 mg/sample).^dShort-term sample.

DISCUSSION

Sampling results suggest that personal exposures to 2-EEA are not occurring during routine activities at the TRW plant. None of the ten samples collected during a typical workshift indicated the presence of any 2-EEA. However, unexpectedly, 2-EE was found in low concentrations (below the sampling limit of quantitation of 0.54 ppm/sample) on the two short-term samples collected while blending two glycol ether-containing components.

Workers were observed to conscientiously wear gloves and safety glasses whenever working with the glycol ether-containing components/mixture. Good work practices were followed as the components used to make the marking mixture were only opened, poured, weighed, blended, and applied in close vicinity to the side-draft hoods. Dermal contact with the glycol ether-containing liquids is only a remote possibility if the practices observed are typical of normal handling and usage of the glycol ether compounds.

SUBSTITUTES

TRW uses a number of coatings and inks which do not contain any of the four ethylene glycol ethers. Other ethylene glycol ethers (e.g, 2-BE, DEGMEA) as well as propylene glycol ethers are present in many inks used at the plant. A formulator (Lord Co.) has replaced 2-EEA with a propylene glycol ether acetate in one of the coatings (Chemgalze II A 276) being supplied to the TRW plant. TRW mentioned that, for their applications, it was very important that the formulators determine if reformulated products meet the stringent specifications of the Department of Defense.

CONCLUSIONS

Exposures to glycol ethers at the TRW Electronic Products plant in Colorado Springs, CO occur due to the use of one liquid mixture containing 2-EEA for marking printed circuit boards. This mixture consists of two components which both contain low concentrations (25 and 17 weight percent) of 2-EEA. There is a limited potential for short-term inhalation and dermal exposure during the blending of the two components of the coating and while applying this mixture for marking circuit boards.

The monitoring results from the survey indicate that workplace concentrations of 2-EEA were nondetectable. These results were probably due to the very limited use of the glycol ether-containing materials, the effective work practices, and the presence of adequate engineering controls. A previous study by NIOSH had indicated measurable concentrations of 2-EE and 2-EEA, however, process conditions have changed considerably since this earlier survey.

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