

Industrial Hygiene Survey Report  
of  
FORD MOTOR COMPANY  
KANSAS CITY ASSEMBLY PLANT  
P.O. Box 11009, Antioch Station  
Kansas City, Missouri 64119

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16. Abstract (Limit: 200 words) A study was made of working conditions at the Ford Motor Company Kansas City Assembly Plant (SIC-3711), Kansas City, Missouri as part of a larger study of worker exposure to ethylene glycol ethers. During the time of the survey, 27 different types of paints/coatings were used at the facility. 2-Ethoxyethyl-acetate (111159) (2-EEA) was used in three paints for passenger car painting and in four paints for trucks. Approximately 12 and 22 gallons of 2-EEA containing paints were used for passenger cars and trucks, respectively, during the 2 week period preceding the study. The paints and coatings were either delivered daily or pumped through a recirculating system to the spray booths from the Paint Kitchen at the site. Various solvents were blended with the incoming paints in the Paint Kitchen. Spray painters wore cloth coveralls, rubber boots, nylon gloves and surgical or baseball caps. Health screening includes audiograms, vision tests, blood tests, and urine tests and were performed annually. The authors conclude that, due to the small number of workers with potential exposure to 2-EEA and the low exposure levels in general at this facility, that this site should not be included in an indepth study of ethylene glycol ether exposures.				
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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 and 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 results from a survey conducted at the Ford Motor Company Assembly Plant in Kansas City, MO during August 2-3, 1988 are presented in this report. At this facility, some of the paints and coatings applied on newly-built cars and trucks contain an ethylene glycol ether, 2-ethoxyethyl acetate (2-EEA).

Monitoring results indicate that full-shift exposures to 2-EEA are mostly non-detectable in both the vehicle painting and paint lab areas; only two of the 14 samples collected had any detectable amount of 2-EEA and both were at levels below the limit of quantitation. These exposures were well 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 limited use of the glycol ether-containing paints, the effective work practices, and the presence of adequate engineering controls.

Due to the generally low exposures to 2-EEA 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<sup>®</sup>). The TLVs<sup>®</sup> 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 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 Ford Motor Company Assembly Plant in Kansas City, MO during August 2-3, 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 adverse effects in the peripheral blood of rats [Werner et al. 1943b], mice [Nagano et al. 1979], and dogs [Werner et al. 1943a].

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 <sub>3</sub> H <sub>8</sub> O <sub>2</sub>	C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>	C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>	C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>
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 <sup>3</sup> (25°C,760mmHg)	3.11	4.83	3.69	5.41
1 mg/m <sup>3</sup> =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

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 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<sup>®</sup> established for the targeted glycol ethers are summarized in Table 4.

TABLE 4  
APPLICABLE STANDARDS AND RECOMMENDED LIMITS

Compound	Exposure Limit <sup>a</sup> (ppm)		
	NIOSH REL	OSHA PEL	ACGIH TLV <sup>®</sup>
2-ME	*	25 <sup>S</sup>	5 <sup>S</sup>
2-MEA	*	25 <sup>S</sup>	5 <sup>S</sup>
2-EE	*	200 <sup>S</sup>	5 <sup>S</sup>
2-EEA	*	100 <sup>S</sup>	5 <sup>S</sup>

CFR 1984; ACGIH 1987

<sup>a</sup> 8-hour time-weighted-average (TWA<sub>8</sub>)

<sup>S</sup> Skin notation

\* Reduce exposure to lowest feasible level

#### HISTORY AND DESCRIPTION OF THE PLANT

The Ford Motor Company Kansas City Plant Assembly Plant, which is one of 16 Ford plants in the United States, is located in the village of Claycmo, Missouri. Automotive production began at this plant in January, 1957; the site covers an area of 115 acres with 65 acres under roof.

The Kansas City plant is essentially a combination of two separate plants with cars built on one assembly line and trucks on another line. Vehicles being built at the plant at the time of the survey included the Tempo and Topaz cars and the F-Series trucks. The plant has a design capacity to produce 55 cars and 39 trucks per hour.

Twenty-seven different types of paints/coatings (16 for passenger cars and 11 for trucks) were being used at the assembly plant during the time of the survey; DuPont and BASF are the two major paint suppliers at the plant. An ethylene glycol ether, 2-ethoxyethyl acetate (2-EEA), is contained in three paints used in the passenger car painting area, and in four paints used in the truck painting area. Approximately 12 and 22 gallons of 2-EEA containing paints for passenger cars and trucks, respectively, were used during the two-week period preceding the survey. The composition of 2-EEA in these paints is reported by the supplier to be between one and five weight percent.

Two of the truck paints which contain 2-EEA also contain propylene glycol monomethyl ether (PGME) in low concentrations (one to five weight percent). Another truck paint contains five to ten weight percent of PGME, but no 2-EEA.

#### PROCESS DESCRIPTION

Prior to painting any car or truck, there are several stages which every vehicle at the assembly plant undergoes: 1) alkaline cleaning, 2) hot water rinse, 3) phosphatizing, 4) cold water rinse, 5) chromic/phosphoric acid rinse, and 6) electrocoating. An electrocoat ("E-Coat") primer is applied for corrosion protection by dipping the vehicle by conveyor into separate enclosed tanks containing the liquid primer. Ovens are then used for curing the electrocoat onto the vehicles. Quality control (QC) samples of the electrocoat primer are collected once per shift for both the passenger car and truck E-Coat assembly lines. While the electrocoat primer had originally contained 2-EE, it was reformulated by DuPont in 1987 and no longer contains any ethylene glycol ether.

After the E-Coat application, the passenger cars and trucks are hand-wiped with a naphtha solution (Wipe Solvent<sup>®</sup>) to remove any residue prior to subsequent painting. Passenger cars only are then sprayed with a paint primer and then top coated with either a basecoat/clearcoat color or a non-metallic enamel color. The primer is applied by automatic spray guns in enclosed spray booths. The color coat and clear coat are also applied automatically in spray booths. Trucks receive only the exterior color paint.

The paints and coatings are either delivered daily or pumped through a recirculating system to the passenger car and truck spray booths from the Paint Kitchen at the plant. There are a series of tanks of varying capacities (e.g., 750 gal, 7500 gal) in the paint kitchen, which are used for blending various solvents with incoming paints. Solvents consist of thinners, accelerators, and retarders. The type and quantity of solvent used depends upon the evaporation rate and the volatile organic compound (VOC) concentration of the paint. On average, paints are blended with 5 to 15 weight percent of solvent.

A solvent containing up to 30 weight percent of 2-EEA has previously been used as a retarder for the paints at the Kansas City Assembly Plant; this has recently been replaced with another solvent containing 50 weight percent of ethylene glycol monobutyl ether acetate (2-BEA). The Paint Lab supervisor at the plant reported that a lesser quantity of the 2-BEA-containing solvent (compared to the 2-EEA containing solvent) was required for paint blending purposes. Another solvent used at the Ford plant also contains 2-BEA (ten weight percent). Several non-glycol ether solvents are also used at the Ford plant.

#### DESCRIPTION OF THE WORKFORCE

There are approximately 4,300 hourly employees and 440 salaried employees at the Ford Kansas City Assembly Plant. The plant normally operates two ten-hour production shifts, five days per week, with a two-hour break between the

shifts. There are approximately 35 employees per shift with a potential for exposure to 2-EEA at this facility who can be grouped into the following job classifications:

Spray Painter (Passenger Car) - There are approximately 14 spray painters per shift in the passenger car spray booths. Their duties consist of spray painting passenger cars with the clear coat or color paints.

Spray Painter (Truck) - There are approximately 18 spray painters per shift in the truck spray booths. They spray trucks with color paint only.

Lab Technician - There is one lab technician in the paint kitchen. There are three paint kitchen paint mixers whose duties include blending of paints with solvents in different tanks. Most of this blending is done automatically (i.e. by opening/closing valves) but special order mixing is performed.

#### ENGINEERING CONTROLS

The spray painting areas and paint lab present the only potential exposure to 2-EEA. The primer coat (used only for passenger cars) is applied by automatic spray guns in enclosed spray booths. Both passenger cars and trucks are painted with enamels (both clear coat and exterior color on cars) using hand-operated electrostatic spray paint guns in spray booths equipped with down-draft flow-through ventilation. Only general dilution was provided in the paint lab.

#### PERSONAL PROTECTIVE EQUIPMENT

Spray painters in the passenger car spray booths wear cloth coveralls, rubber boots, nylon gloves, and surgical caps. Spray Painters in the truck spray booths wear coveralls, safety shoes with shoe covers, cotton gloves, and baseball caps. Coveralls are the only type of personal protective equipment worn by the Technicians in the paint lab.

#### MEDICAL AND INDUSTRIAL HYGIENE PROGRAMS

Pre-employment physicals are required for all employees at the Kansas City Assembly Plant. Health screenings, which include audiograms, vision tests, blood tests, and urine tests, are performed annually at the plant. Medical records are computerized and maintained at the corporate location in Dearborn, Michigan.

The corporate industrial hygienists conduct personal and area monitoring at the plant on an "as-needed" basis. No monitoring for glycol ethers has been conducted at the plant since 1984, at which time the usage of ethylene glycol ether-containing coatings was discontinued or significantly reduced. For recently conducted a monitoring program at the Kansas City Assembly Plant to evaluate exposures to the following chemicals in the truck spray booths: methyl amyl ketone, isopropyl alcohol, acetone, and toluene.

## SAMPLING STRATEGY AND METHODS

A one shift sampling survey was conducted at the Ford Kansas City Assembly Plant to measure the extent of exposures associated with the typical usage of formulations containing 2-EEA. Personal long-term (5- to 7-hour) and short-term (3- to 10-minute) samples were collected. Long-term samples are used to measure full-shift exposures, whereas short-term samples measure peak exposures of relatively short duration.

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 5 presents the analytical limit of detection (LOD) and limit of quantitation (LOQ) for the ethylene glycol ether sampled at the BASF facility. 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

MONITORING RESULTS FOR 2-ETHOXYETHANOL ACETATE (2-EEA)  
 FORD MOTOR COMPANY (Kansas City Assembly Plant)  
 August 3, 1988

Sample ID	Job/(Activity)	Time Start-Stop	Flow (cc/min)	Duration (min)	Air volume (L)	Concentration (ppm) <sup>a</sup> 2-EEA
FM-32	Spray Painter (truck)	6:49-12:36	100.4	347	34.8	<0.05 <sup>b</sup>
FM-14	Spray Painter (truck)	6:57-12:43	100.6	346	34.8	0.05 <sup>c</sup>
FM-15	Spray Painter (truck)	6:54-12:40	103.0	346	35.6	<0.05 <sup>b</sup>
FM-09	Spray Painter (car)	6:33-12:59	101.9	386	39.3	<0.05 <sup>b</sup>
FM-16	Spray Painter (car)	6:35-13:02	102.6	387	39.7	<0.05 <sup>b</sup>
FM-36	Spray Painter (car)	6:32-12:55	100.0	383	39.3	<0.05 <sup>b</sup>
FM-18	Spray Painter (car)	6:37-12:58	98.5	381	37.5	<0.25 <sup>b</sup>
FM-17	Spray Painter (car)	6:25-12:50	98.6	385	38.1	<0.05 <sup>b</sup>
FM-11	Spray Painter (truck)	7:05-12:28	100.6	323	32.5	<0.06 <sup>b</sup>
FM-26	E-Coat Attendant	6:17-13:13	203.5	416	84.7	<0.02 <sup>b</sup>
FM-08	E-Coat Attendant	7:19-12:11	200.8	292	58.6	<0.03 <sup>b</sup>
FM-25	Lab Technician	7:34-14:05	205.5	391	80.4	0.05 <sup>c</sup>
FM-20	E-Coat Attendant <sup>d</sup>	8:54- 8:57	1010.0	3	3.0	<0.61 <sup>b</sup>
FM-29	E-Coat Attendant <sup>d</sup>	11:28-11:38	1010.0	10	10.1	<0.18 <sup>b</sup>

<sup>a</sup>Samples were not time-weighted to 8-hour concentrations.

<sup>b</sup>Sample result was less than the analytical limit of quantitation (0.03 mg/sample).

<sup>c</sup>Sample result was less than the analytical limit of quantitation (0.03 mg/sample).

<sup>d</sup>Short-term sample.

TABLE 5

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 <sup>a</sup>		Peak <sup>b</sup>	
		LOD	LOQ	LOD	LOQ
0.01	0.03	0.02	0.06	0.12	0.37

<sup>a</sup> 8-hour time-weighted average sample collected at 0.2 Lpm.

<sup>b</sup> 15-minute short-term sample collected at 1.0 Lpm.

#### MONITORING RESULTS

A total of 14 samples were collected and analyzed for ethylene glycol ethers. Only two samples indicated the presence of 2-EEA and these results were between the limit of detection (0.01 milligrams per sample) and the limit of quantitation (0.03 milligrams per sample) of the analytical method. Note that the actual sampling LODs and LOQs vary according to the sampling duration for each sample). The sampling results of all samples are shown in Table 6.

(Note: Because the E-Coat primer was originally identified by Ford personnel as containing 2-EE, four samples (two long-term and two short-term) were collected on workers in the E-Coat application area. Subsequently, DuPont confirmed that 2-EE had been eliminated from the primer in 1987 and no longer contains any ethylene glycol ether. While the results of the four samples are shown in Table 6 for completeness, they are not included in the discussion below).

Long-term Sampling. A total of twelve long-term samples (all personal) were collected during the monitored workshifts. Only two samples (one on a car sprayer and the other on a paint lab technician) indicated any presence of 2-EEA, both at 0.05 ppm which is below the sampling limit of quantitation (0.15 ppm in each case).

Short-term Sampling. Only two short-term samples were collected, both on E-Coat attendants. 2-EEA was not detected on either sample.

#### DISCUSSION

Sampling results suggest that personal exposures to 2-EEA are not occurring at during routine activities at the Ford Kansas City Assembly Plant. Only two samples indicated any exposure to 2-EEA (for a spray painter and a paint technician)--at full shift concentrations which were well below the limit of quantitation.

## SUBSTITUTES

Ford has recently substituted formulations containing 2-BEA (instead of 2-EEA) as solvents for some of the paints. It was reported that this substitution resulted in material savings.

An ethylene glycol ether (i.e., 2-EEA) is still contained only in approximately 25 percent of the paints used in the passenger car and truck spray booths. Most of the other paints used at the plant do not contain any glycol ethers. One paint used in the truck spray painting booths contains five to ten weight percent of propylene glycol monomethyl ether.

## CONCLUSIONS AND RECOMMENDATIONS

At the Ford Kansas City Assembly Plant, paints containing 2-EEA are used for spray painting of passenger cars and trucks. During the survey, the potential for inhalation and dermal exposure to 2-EEA existed primarily during: the painting of passenger cars and trucks; and the blending/handling of paints in the paint lab.

Monitoring results indicated that full-shift exposures to 2-EEA are mostly non-detectable; only two of the 14 samples collected had any detectable amount of 2-EEA and both were at levels below the limit of quantitation. The long-term exposures compare to the 100 ppm OSHA PEL, the 5 ppm ACGIH TLV, and the "lowest feasible level" NIOSH REL. The measured exposures are considerably lower than the concentrations in those few studies in which exposed workers were observed to have reproductive effects (see [Cook et al. 1982]; [NIOSH 1986]; [Welch and Schrader 1986]).

Efforts to further minimize exposures at the Ford plant could focus on encouraging strict adherence to wearing respirators and impermeable gloves whenever handling the glycol ether-containing paints.

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