# Industrial Hygiene Survey Report
of
BASF CORPORATION
COATINGS AND COOLANTS DIVISION
1244 North Lemon Street
Anaheim, CA 92801

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16. Abstract (Limit: 200 words) A visit to the BASF Corporation Coatings and Coolants Division (SIC-2851), Anaheim, California was conducted as part of an effort to locate companies to include in a larger study of the hazards to workers exposed to any of four ethylene glycol ethers. The facility manufactured paint and allied products at this site. The only ethylene glycol ether still used at the site was 2-ethoxyethyl-acetate (2-EEA) (111159); the average concentration in container coatings was 21 percent. Full shift exposures to 2-EEA ranged from 0.07 to 0.43 part per million; the highest short term inhalation exposure measured was 1.85 parts per million. Engineering controls in operation at the site included local exhaust ventilation, a general dilution heating and air conditioning system, floor exhausts and a makeup air supply system. Personal protective equipment supplied to the workers included coveralls, safety glasses, lab coats, disposable gloves, and disposable respirators. Due to the generally low exposures to 2-EEA and the small number of potentially exposed workers at this facility, the authors recommend that this company not be included in the further indepth study.

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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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| SIC Code: | 2851 (Paint and Allied Products) |

## 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 specific results from a survey conducted at a BASF Corporation Coatings and Inks Division facility in Anaheim, CA are presented in this report. At this facility, 2-ethoxyethyl acetate (2-EEA) is present in nine of the container coatings produced. The potential for inhalation and dermal exposure to 2-EEA exists primarily at the following operations: 1) product mixing; 2) product packaging (drum and tank wagon filling); 3) product testing (particularly, roller coat application); 4) QC sample collection and analysis.

The monitoring results from the survey indicated that full-shift exposures to 2-EEA were low (ranging from 0.07 to 0.43 ppm). Measurable short-term inhalation exposures occurred during quality control sampling, mixing activities, and product development testing (ranging from 0.41 to 1.85 ppm). The long-term exposures are lower than the 100 ppm OSHA PEL and the 5 ppm ACGIH TLV, close to the "lowest feasible level" NIOSH REL and are considerably lower than the concentrations in those studies in which exposed workers were observed to have reproductive effects (see [Cook et al. 1982]; [NIOSH 1986]; [Welch and Schrader 1986]). Although protective equipment is provided by BASF to minimize inhalation and dermal exposures, its usage was observed to be minimal.

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®). 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 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 BASF Corporation Coatings and Inks Division facility in Anaheim, CA, during May 23-25, 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 | $C_3H_8O_2$ | $C_5H_{10}O_3$ | $C_4H_{10}O_2$ | $C_6H_{12}O_3$ |
| 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/m3 (25°C,760mmHg) | 3.11 | 4.83 | 3.69 | 5.41 |
| 1 mg/m3=ppm (25°C,760mmHg) | 0.32 | 0.21 | 0.27 | 0.19 |
| Other identifiers: | methyl cellosolve<br>ethylene glycol monomethyl ether<br>Dowanol EM | methyl cellosolve acetate<br>ethylene glycol monomethyl ether acetate | cellosolve<br>ethylene glycol monoethyl ether<br>Dowanol EE | cellosolve acetate<br>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 ethyoxyacetic 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 ($TWA_8$)
[S] Skin notation
* Reduce exposure to lowest feasible level

## HISTORY AND DESCRIPTION OF THE PLANT

The BASF Corporation Coatings and Inks Division is a paint and allied products manufacturer (SIC Code 2851). An ethylene glycol ether is used in only the "container" (e.g. cans, drums, barrels, etc.) coatings that are produced at the Anaheim facility, where approximately 1.3 million gallons of container coatings were produced in 1987 for 25 different customers. 2-ethoxyethyl acetate (2-EEA) is the only ethylene glycol ether still used and only in the production of existing container coating formulations; new formulations are developed without any ethylene glycol ethers. BASF reported that they consumed approximately 717,000 pounds of 2-EEA in 1987.

## PROCESS DESCRIPTION

Production. At present, the BASF Anaheim plant produces nine container coatings that contain an ethylene glycol ether (these represent 4-12 percent of the facilities total production of container coatings). These coatings are made in a batch mode in which 2-EEA is mixed with other solvents to dissolve non-glycol ether resin systems; the average 2-EEA concentration in the product is 21 percent (ranging from 20 to 27 percent). The container coatings produced have a relatively high solids content (41 to 44 percent) which make them desirable for customers.

Approximately four batches (typically 7,000 gallons each) of coatings containing 2-EEA are produced per month. At the time of the survey, the facility reported production at fifty percent of its total capacity. The processing time for each batch spans approximately five shifts from start to final packaging.

2-EEA and other solvents (e.g., xylene and ethyl alcohol) are metered directly into a heated paddle mix tank via pipeline from outside storage tanks. After the material has reached the proper temperature (95°F), 50-pound bags of dry epoxy resin are manually added to the tank of heated solvents. This task usually takes one employee about four hours to perform for a typical 7,000 gallon batch (using approximately 400 bags of resin). The resin-solvent mixture is then agitated in the tank for about 12 hours so that all of the resin has dissolved and the components are thoroughly mixed.

After quality control samples have indicated proper mixing, a portion of the main batch (approximately 150 gallons) is transferred to a 250-gallon side tank in which a crude wax cut is initially made by adding a heated wax-solvent (xylene) mixture. After thorough agitation of this side mixture, it is added back into the main batch and adjustments are made until the final product meets required specifications.

Packaging Operations. Container coatings manufactured at this facility are packaged either indoors into 55-gallon drums or bulk loaded outdoors into 5,000 gallon tanker trucks. When packaged into drums, the liquid coating is first transferred via pipeline from the batch tank through a filter system into a transfer container and finally into grounded drums on a weight scale (see Figure 1). When the drum is full, it is manually capped, removed from the scale, and replaced by a new drum for filling; this complete drum filling process takes approximately three minutes. Normally, it takes about six hours for one employee to fill 30 to 34 drums; however, as many as 90 drums may be filled in one 10-hour shift if the entire 7,000 gallon batch needs to be drummed. The filters in the piping system are changed by the filler operator between batches; additional filter changes may be necessary if the batch becomes contaminated.

One filler operator and one assistant perform the tanker truck (or "tank wagon") filling operations outdoors. Initially, about 60 gallons of the batch material are transferred into a 250-gallon tote tank for final QC sampling before loading. The material is then returned to the original batch tank and then loaded to a tanker truck, which has been checked earlier for any interior contamination. Screens and filters in the transfer lines are visually inspected between tanker loads and manually replaced, as necessary.
Quality Control (QC). Analyses of QC samples collected from the process stream by production personnel are performed at an on-site laboratory. Several QC samples are obtained throughout the coatings manufacturing and packaging operations, the number depending on the extent of adjustments required for each batch. Tests performed on the container coatings during manufacturing include the following: viscosity, weight per gallon, and percent of nonvolatiles.

Quality control technicians also perform "application" tests on the coatings to simulate the performance of the final product. These tests, to determine application properties, drying characteristics and durability, are performed in the coatings laboratory located adjacent to the QC laboratory.

Technical Services Development Operations. The Technical Services Development Department is responsible for developing new product formulations and for assessing customer complaints about a particular batch or product. Batch production of formulations is simulated on a one-quart to 20-gallon scale using the same raw materials as used in the large scale formulation. QC testing and final applications testing (roller coat testing for container coatings) are also performed by the development chemists. 2-EEA is handled in these operations approximately once every two to three weeks.

BASF personnel identified the following process operations as having the greatest potential for exposures to 2-EEA:

- Product mixing
- Product packaging (drum and tank wagon filling)
- Product testing (particularly, roller coat application)
- Quality Control (QC) sample collection and analysis

## DESCRIPTION OF EXPOSURE CONTROLS

A number of controls have been implemented to prevent the release of chemicals into the environment; many of these controls are an integral part of the process equipment, whereas others have been added for a specific purpose. Some controls are designed to reduce worker exposures, whereas others are intended to abate environmental releases. Frequently, the environmental controls also function indirectly to reduce the level of toxic contaminants in the workplace air.

BASF personnel were interviewed to identify those controls that directly or indirectly reduce workplace exposures. Controls identified during the survey are presented herein by the process operation or by the work task that they are designed to control.

Engineering Controls. Several engineering controls are used which directly or indirectly control the release of 2-EEA into the workplace.

(Production). The batch mixing tank is equipped with a local exhaust ventilation system (about 10 years old) for dust collection at the top of the charging chute through which the dry resins are added. The charging chutes at this facility were custom designed to facilitate the task of adding bags of dry resin to the batch tank. An exhaust duct is also provided at the 250-gallon side tank for the mixing of the wax/solvent mixture. The local ventilation system is exhausted to a baghouse; BASF estimated that the baghouse bags and the exhaust system are cleaned every six months. Ceiling exhaust fans and open windows also provide general ventilation for the process areas.

(Quality Control). The QC laboratory is equipped with a general dilution heating and air conditioning system. Analyses and tests are performed at counters without local exhaust ventilation in the laboratory area; two exhaust ducts near the floor of the laboratory are designed to remove solvent vapors for fire protection purposes. A spray paint booth equipped with exhaust ventilation is also located in the QC laboratory.

The coatings laboratory where application tests are performed is equipped with floor exhausts and a make-up air supply system that is separate from the facilities general air supply. Local exhaust is provided at the 20-gallon mixing tank stations in the coatings laboratory which are used by the Technical Services Development chemists.

## PERSONAL PROTECTIVE EQUIPMENT

BASF requires all process workers to wear company-supplied and laundered coveralls. Production specialists in the process and loading areas wear additional personal protective equipment when performing the following activities:

| Task | Protective Equipment |
|---|---|
| ° Addition of resins to batch tank and wax cut operation | 3M Organic Vapor 8712 disposable respirator, cloth gloves, (arm length rubber gloves and apron during liquid resin addition), and safety glasses |
| ° Drum filling operation | safety glasses, heavy cotton gloves |
| ° Tank wagon loading | safety glasses, Tyvek® apron, neoprene gloves |

QC and Technical Services Development laboratory personnel wear safety glasses and lab coats. Playtex #835 industrial gloves and disposable vinyl gloves are also available in the laboratory and are worn during spill cleanup operations. Organic vapor disposable respirators are also available in the laboratory, if needed.

## DESCRIPTION OF THE WORKFORCE

The BASF Anaheim facility operates two 10-hour shifts per day, five days per week. A total of 120 of the 4800 employees of the BASF Corporation are employed at this facility. There are about 30 employees at this facility (including six supervisory personnel) potentially exposed to the only ethylene glycol ether (2-EEA) used at this plant; they can be grouped into the following job classifications:

Production Specialists - This job category includes process operators who are designated as either a "mixer" or a filler". There are a total of eight production specialists per shift. The 16 production specialists at the plant

are trained to perform all process operations; however, mixers and fillers are specifically designated for each shift. The mixer's job duties include preparing the mixing tank for a batch, transferring the raw materials into the tank, collecting quality control samples, and extracting and adjusting the 250 gallon test aliquot of the batch. Any additions for adjusting the batch are made by a mixer designated as the "add man". QC samples are collected by mixers at the end of the initial mixing phase of the batch and after each adjustment to the batch. The fillers are responsible for preparing drums prior to filling, inspecting tank wagons, and actual filling operations; fillers also collect QC samples before transferring the coating product to the tank wagon.

Quality Control Technician - A total of six quality control technicians work in the QC laboratory (four on the first shift and two on the second) in addition to one laboratory supervisor. Typically, one laboratory technician is assigned to conduct the analyses on all QC samples obtained for a particular batch; however, all QC technicians work in the same general area and, therefore, may be exposed to environmental concentrations of 2-EEA during analyses of the QC samples.

Technical Services Development - Two development chemists and one supervisor work in the Technical Services Development laboratory during the first shift only. Processing of a development batch takes approximately three to four hours.

Table 5 provides a breakdown (by job title, gender, and age) of the number of workers at the BASF Anaheim plant who may be exposed to 2-EEA.

TABLE 5

NUMBER OF WORKERS POTENTIALLY EXPOSED TO
2-ETHOXYETHYL ACETATE AT
BASF ANAHEIM PLANT

| Job Title | Number of Workers Exposed | | | |
|---|---|---|---|---|
| | Males All | Males < age 45 | Females All | Females < age 45 |
| Production Specialist | 13 | 12 | 3 | 2 |
| QC Technician | 5 | 4 | 1 | 1 |
| Technical Services Development | 3 | 1 | 0 | 0 |
| Supervisory | 6 | 2 | 0 | 0 |

## MEDICAL AND INDUSTRIAL HYGIENE PROGRAMS

Pre-employment physicals are the only form of medical monitoring required by BASF; these include blood tests, x-rays and physical examination.

The Anaheim plant's health and safety program is the responsibility of the BASF corporate industrial hygienist located in New Jersey. Limited exposure sampling (charcoal tubes-GC/MS) is conducted periodically. Exposure monitoring of the Production Specialist job category for 2-EEA is conducted on approximately a quarterly basis (about two samples per quarter). In addition, two samples per year may be collected for the QC Laboratory Technician job category. BASF reported that all historical monitoring data had shown non-detectable levels of 2-EEA.

## SAMPLING STRATEGY AND METHODS

The sampling survey was conducted over three shifts during May 23-25, 1988 at the BASF facility to measure the extent of exposures associated with the manufacture of coatings containing 2-EEA. Both personal and area long-term (5- to 8-hour) and short-term (3- to 15-minute) samples were collected. Long-term samples evaluated full-shift exposures, whereas short-term samples measured peak exposures of relatively short duration.

Coating formulations containing any of the four subject ethylene glycol ethers (2-ethoxyethanol, 2-methoxyethanol, 2-ethoxyethyl acetate, and 2-methoxyethyl acetate) were initially identified by company personnel and later confirmed from material safety data sheets; only 2-ethoxyethyl acetate (2-EEA) was found to be currently used at this plant.

Long-term personal samples were collected on production specialists (both mixers and fillers), and quality control (QC) technicians who directly handled 2-EEA or any coating containing this compound during the survey period; short-term samples were collected on workers during actual mixing, filling, and QC sampling activities.

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 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

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

| Analytical Limits (mg/sample) | | Sampling Limits (ppm/sample) | | | |
|---|---|---|---|---|---|
| | | TWA8[a] | | Peak[b] | |
| LOD | LOQ | 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 13 field samples were collected and analyzed for 2-EEA. All sample results indicated the presence of 2-EEA above 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 LODs vary according the sampling duration for each sample). Individual sample results are reported in Table 7 as time-weighted averages (TWAs) over the respective sampling duration.

TABLE 7

MONITORING RESULTS FOR 2-ETHOXYETHANOL ACETATE (2-EEA)
BASF CORPORATION, COATINGS AND INKS DIVISION, ANAHEIM, CA
May 23-25, 1988

| Sample ID | Job/area | Time Start-Stop | Flow (cc/min) | Duration (min) | Air volume, (L) | Concentration (ppm)[a] 2-EEA |
|---|---|---|---|---|---|---|
| BA-23 | Mixer/dry resin | 15:25-23:55 | 106.0 | 510 | 54.1 | 0.34 |
| BA-17 | QC technician | 6:25-14:46 | 102.0 | 501 | 51.1 | 0.11[b] |
| BA-18 | QC technician | 6:52-14:51 | 103.0 | 479 | 49.3 | 0.08[b] |
| BA-5 | QC technician | 7:02-15:02 | 104.5 | 480 | 49.9 | 0.07[b] |
| BA-15 | QC technician[c] | 8:11- 8:24 | 1050.0 | 13 | 13.7 | 0.41[b] |
| BA-16 | QC technician[c] | 14:29-14:45 | 1050.0 | 16 | 16.8 | 0.88 |
| BA-29 | Mixer/wax cutting | 8:31-15:26 | 102.0 | 415 | 42.3 | 0.26 |
| BA-7 | R&D Chemist[c] | 14:49-15:09 | 1050.0 | 20 | 21.0 | 1.85 |
| BA-24 | Mixer/dry resin | 6:14-14:16 | 99.0 | 482 | 47.7 | 0.35 |
| BA-21 | Mixer/+dry resin[c] | 7:37- 8:04 | 1020.0 | 27 | 27.5 | 0.67 |
| BA-28 | Filler/drum[c] | 21:19- 1:30 | 104.0 | 251 | 26.1 | 0.43 |
| BA-27 | Filler/drum[c] | 21:50-22:05 | 1020.0 | 15 | 15.3 | 1.21 |
| BA-4 | Filler/tank wagon[c] | 7:43- 8:05 | 1030.0 | 22 | 22.7 | 0.49 |

[a]Samples were not time-weighted to 8-hour concentrations.
[b]Sample result was less than the analytical limit of quantitation (0.03 mg/sample).
[c]Short-term sample

Long-term Sampling. A total of seven long-term (5-8 hours) samples (all personal) were collected during the monitored workshifts. Sample results for the three samples collected on mixers ranged from 0.26 ppm to 0.35 ppm; the arithmetic mean for three samples was 0.32 ppm. The one sample collected on a filler (drum) was 0.43 ppm. Results from the three samples on QC technicians ranged from 0.07-0.11 ppm (average = 0.09 ppm).

Short-term Sampling. Two short-term personal samples were collected on mixers to evaluate peak exposures; a concentration of 0.67 ppm was measured while adding dry resin to the mixing tank and 1.85 ppm was found during the wax cutting process. The two samples collected during drum and tank filling were 1.21 and 0.49 ppm, respectively. And the two samples taken during QC activities were 0.41 ppm (while performing a lab test on a side-mix sample) and 0.88 ppm (during a roller application test).

## SUBSTITUTES

Only one ethylene glycol ether, 2-EEA, is currently used and only in a small amount (4-12%) of the container coatings manufactured at the Anaheim facility. BASF reports that 2-EEA could be substituted with a 95% propylene glycol monomethyl ether acetate/5% butyl cellosolve mixture; however, such substitution would result in a lower solids content of the product than is currently achievable with 2-EEA. BASF suggested that such a product would not meet the current specification requirements and therefore adversely affect its consumer market.

In the past, this facility also used 2-EEA in some lacquer blending operations. This use has been discontinued and replaced by propylene glycol monomethyl ether acetate and other ether/ester solvents. Also, 2-ethoxyethanol (2-EE) has been used previously in the manufacture of automotive paints; however, propylene glycol monomethyl ether has been totally substituted for 2-EE in these paints.

## DISCUSSION

Sampling results clearly indicate that exposures to 2-EEA are occurring at the BASF Anaheim facility during manufacturing of coatings which contain this glycol ether as an ingredient. All field samples had detectable results with two short-term samples exceeding 1.0 ppm.

While some controls have been implemented by BASF to prevent the release of chemicals into the workplace, several areas are lacking adequate ventilation which would better minimize inhalation exposures. For example, there is no local exhaust ventilation at the solvent discharge connection points in the mixing area nor in the drum or the tank wagon filling operations. Also, QC analyses are performed at counters without local exhaust ventilation in the laboratory area; two exhaust ducts near the floor of the laboratory are designed to remove solvent vapors basically for fire protection purposes.

Although BASF requires all process workers to wear coveralls and some workers to use additional personal protective equipment when performing certain activities, adherence to this policy was sporadic during our survey period.

Also, the effectiveness of the cloth coveralls provided by BASF in preventing penetration of any liquid chemical (i.e. 2-EEA) is less than if replaced with an impermeable covering.

## CONCLUSIONS AND RECOMMENDATIONS

The potential for inhalation and dermal exposure to 2-EEA at the BASF Anaheim Plant exists primarily during: 1) product mixing; 2) drum and tank wagon filling; 3) product testing (particularly, roller coat application); 4) QC sample handling.

Sampling results indicated that full-shift exposures to 2-EEA were relatively low (ranging from 0.07 to 0.43 ppm). Higher short-term inhalation exposures occurred during QC sampling, mixing activities, and product testing testing (ranging from 0.41 to 1.85 ppm). Although protective equipment is provided by BASF to minimize inhalation and dermal exposures, its usage was observed to be minimal.

While the long-term exposures are lower than current OSHA PELs and ACGIH TLVs, exposures may be further minimized by: 1) modifying local exhaust ventilation and/or employee work practices in the product mixing, packaging and testing areas; 2) providing impermeable coveralls and gloves to all workers who handle glycol ether-containing coatings and encouraging better usage of the respirators and gloves provided. NIOSH recommends that engineering controls be applied prior to resorting to personal protective equipment for adequating reducing employee exposures in the workplace.

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