~~for Ethyl Corp Federal~~

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Centers for Disease Control
National Institute for
Occupational Safety & Health
Robert A. Taft Laboratories
4676 Columbia Parkway
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February 16, 1983

Alan Johnson ✓

G. B. MEYERS, M. D.

FEB 24 1983

F.Y. Attention

file: Houston

Mr. Gilbert B. Meyers
Ethyl Corporation
Corporate Medical Department
451 Florida Boulevard
Baton Rouge, Louisiana 70801

Dear Mr. Meyers:

Enclosed is a copy of the draft report of the industrial hygiene survey conducted during the tetraethyl lead study at the Ethyl Corporation in Pasadena, Texas, on April 7-10, 1980. A copy has also been forwarded to the Plant Manager of the Pasadena plant for review and comments.

If you have any questions, you may contact me at (513) 684-3255.

Sincerely yours,

Virginia Ringenburg

Virginia Ringenburg
Industrial Hygienist
Industrial Hygiene Section
Industrywide Studies Branch
Division of Surveillance, Hazard
Evaluations and Field Studies

1 Enclosure

EC 3005

# SURVEY REPORT OF
# ETHYL CORPORATION
# PASADENA, TEXAS 77501

SURVEY CONDUCTED BY:
Michael S. Crandall
Charles McCammon

DATE OF SURVEY:
April 7-10, 1980

REPORT WRITTEN BY:
Virginia L. Ringenburg

DATE OF REPORT:
January 19, 1983

REPORT #:
115.10

Industrial Hygiene Section
Industrywide Studies Branch
Division of Surveillance, Hazard Evaluations and Field Studies
National Institute for Occupational Safety and Health
Centers for Disease Control
Cincinnati, Ohio

| | |
|---|---|
| Purpose of Survey: | The purpose of the industrial hygiene survey was to determine the Ethyl Corporation employees' exposure to tetraethel lead (TEL), inorganic lead (Pb), ethylene dibromide (EDB), ethylene dichloride (EDC), and ethyl chloride. |
| Employer Representative Contacted: | Dr. D.B. Johns, Pasadena Plant Physician, Ethyl Corp.<br>Mr. Jonathan Jacoby, Industrial Hygienist, Ethyl Corp. |
| Employee Representative Contacted: | Mr. Ron Guinn, Safety Representative, OCAW, Local 16000 |
| Standard Industrial Classification of Company: | 2869 |

## Disclaimer

Mention of company names or products does not constitute endorsement by NIOSH.

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Abstract

An industrial hygiene survey was conducted at the Ethyl Corporation to estimate worker exposure to tetraethyl lead (TEL) and other air contaminants in the TEL manufacturing and blending units. Personal and area samples were collected for tetraethyl lead, inorganic lead, ethylene dibromide, ethylene dichloride and ethyl chloride.

Tetraethyl lead sampling results ranged from 0.011 to 0.159 $mg/m^3$, and inorganic lead (Pb) sampling results ranged from 0.0027 to 0.869 $mg/m^3$. Ten percent of the TEL and inorganic lead personal samples were above the OSHA Permissible Exposure Limit (PEL) of 0.075 milligrams per cubic meter ($mg/m^3$) for TEL and 0.05 $mg/m^3$ for inorganic lead. Approximately 6.5% of the inorganic Pb samples were above the NIOSH recommended standard of 0.10 $mg/m^3$. However, Ethyl employees wore protective clothing and respirators which had been quantitatively fit tested. Levels of ethylene dibromide (EDB), ethylene dichloride (EDC), and ethyl chloride personal samples averaged 0.064, 0.068, and 0.295 $mg/m^3$; the OSHA standards are 154, 202, and 2600 $mg/m^3$, respectively. NIOSH recommended standards are 1 $mg/m^3$ as a ceiling level for EDB and 20 $mg/m^3$ as a Time Weighted Average (TWA) for EDC.

## Introduction

Under the Occupational Safety and Health Act of 1970 (set forth by the 91st Congress, S.9123, Public Law 91-596) the National Institute for Occupational Safety and Health (NIOSH) was given the authority and responsibility for conducting and reporting on field research studies in industry. Section 20(a)7 states that NIOSH shall conduct and publish industrywide studies of the effects of chronic low level exposure to industrial materials, processes, and stresses n the potential for illness, disease or loss of functional capacity in the aging adult.

Manufacture of tetraethyl lead for use as a gasoline additive began in 1923. By 1924, commercial activities were stopped due to TEL intoxication of workers.[2] An extensive investigation conducted by the U.S. Public Health Service revealed that if adequate precautions were taken in TEL's manufacture and addition to gasoline, the use of TEL should not endanger workers' health.[3] Industry developed more hygienic work practices and better technology, began clinical surveillance of TEL workers, and resumed production of TEL in 1926.[2] Several years later (and as late as the 1970's), TEL intoxication was observed in employees engaged in cleaning and repairing large gasoline storage tanks. It was discovered that most of these cases were due to laxness in wearing of safety apparel, especially air supplied respirators.[1]

In June, 1978, NIOSH responded to a Health Hazard Evaluation (HHE) request at the Ethyl Corporation plant in Pasadena, Texas. The request was prompted by the occurrence of three cases of multiple myeloma among long-term plant employees who had been exposed to TEL. These cases were diagnosed between 1971 and 1976.

To assist in the Health Hazard Evaluation, an investigation was conducted by NIOSH epidemiologists. The incidence of multiple myeloma among workers at the Pasadena plant was determined to be approximately 15 times that expected by using race-specific data from the Third National Cancer Survey (1969-1971) and the State of Connecticut (1970), and the person-years calculated for workers employed a minimum of one year. These results prompted NIOSH to undertake a combined retrospective cohort mortality study and industrial hygiene evaluation of workers at the Ethyl Corporation plant in Pasadena, Texas.

This industrial hygiene survey was performed on April 7-10, 1980, to determine the TEL plant employees' exposure to TEL, inorganic lead (Pb), ethylene dibromide (EDB), ethylene dichloride (EDC), and ethyl chloride. The exposure data will be used in conjunction with the ongoing epidemiological retrospective cohort mortality study. This data represents exposure at the time of this survey and may not be indicative of past exposure.

## Plant Description

The Ethyl Corporation is comprised of eight buildings on 400 acres of land in Pasadena, Texas. (The major plant buildings and processes may be seen in Figure A-1.) The plant was built in 1952 principally for production of the motor fuel antiknock compound tetraethyl lead (TEL). Several other processes operating at the facility produced linear alcohols, linear olefins, diethyl aniline, ethyl chloride, ethylene dichloride, and aluminum alkyls. Production of vinyl chloride monomer was begun in 1965 and terminated in 1975.

Much of the Pasadena plant and its operations were open to the environment. The TEL process, however, was enclosed, and laminar flow ventilation systems and air sampling monitors were added to the process areas to reduce worker exposures. The TEL building contained four floors. The alloy area occupied part of the first three floors on the southwest end of the building. The lead-sodium alloy and ethyl chloride were charged from the fourth floor to the autoclaves on the third floor. The steam stills were located on the second floor, the blending area occupied a three floor area on the north end of the building, and the recovery furnaces were located on the ground floor along the east side of the building.

The entire TEL process was manually operated until 1960 when half of the process was automated. This included automatic charge pot filling and conveying to the autoclave charging station; however, manual operations were still required in the actual autoclave charging. The TEL production at this plant was closed down in 1981.

## Description of Industrial Hygiene, Safety and Medical Programs

### Industrial Hygiene

Ethyl Corporation employed a staff of seven industrial hygienists at corporate headquarters in Baton Rouge, Louisiana, with one hygienist located at the Pasadena plant. The hygienists conducted a comprehensive quarterly monitoring program to check for exposures to physical agents, TEL, and chemicals used in the TEL and other processes. All process areas were provided with forced air (general) ventilation and local exhaust ventilation.

### Safety Program

A formal safety program in which all employees were involved, was under the direction of the Safety and Health Supervisor, Robert Mack. Under this program, descriptive literature on Ethyl's products was provided as well as protective clothing such as slicker suits, gloves, chemically impervious safety boots, goggles, hard hats, and respirators (which included quarter-face, half-face, and full-face). Ethyl also had a quantitative respirator fit testing (QNFT) program.

Facilities for changing clothes and taking showers were provided and use of these facilities was mandatory. The change area consisted of clean and "dirty" sides with showers in between. Laundry facilities were also provided by the company, and personal respirators were cleaned in that area. Safety sh wers were installed throughout the TEL building as well as a kerosene shower in the clothes change area for personnel exposed to TEL liquid.

### Medical Program

The Ethyl Corporation, Pasadena plant, employed one full-time physician and a full-time licensed nurse. There was also an employee on each shift with formal first aid training; these employees were designated to provide emergency medical treatment. Preplacement (which replaced preemployment) and annual physical examinations were required for all employees and included a chest x-ray, hearing and visual acuity tests, lung function test, urinalysis, blood chemistry analysis, and an electrocardiogram (ECG) for those 40 years of age and over.

In addition, urine samples were collected approximately every 2-6 months and blood samples collected every 6 months; these samples were analyzed for total lead. If an employee's lead level was elevated (above 40 ug/100g of blood), the individual was removed from the TEL area until his lead level returned to an acceptable level (below 40 ug/100g of blood).

Past analyses have revealed increased blood and urine lead levels with lead intoxication symptoms in some employees. These results as well as any injuries (10 lost-time accidents during 1979), complaints, and other examinations handled by the plant clinic were noted in the employees' medical records. These medical records have been retained from the time the plant opened in 1952 for all employees who have worked at the Pasadena facility.

## Description of the Workforce

This plant employed 1200 people at the time of this survey; 1000 in production and 200 in administration. As of 1978, 14% of these employees were black, 5% of Hispanic origin, and 4% female. Women with child bearing potential were not permitted to work in the TEL area due to the possible harmful effects of inorganic lead on the fetus. Production was continuous over three shifts; with 125 employees per shift in the TEL plant. The union representing the Ethyl employees was the Oil, Chemical, and Atomic Workers Union (OCAW), Local 16000.

The main area evaluated during this survey was the TEL manufacturing and blending unit. Fourteen people, excluding maintenance employees, worked in this unit on each shift. Variations in numbers were caused by addition or deletion of trainees per shift. The breakdown of workers by area per shift during the survey was as follows:

| Area | Number of Workers |
|---|---|
| Furnaces | 3 furnace operators<br>1 relief man<br>1 furnace foreman |
| Alloy area | 1 hopper booth operator<br>1 charge pot operator |
| Main Building | 1 4th floor operator<br>1 3rd floor operator<br>2 2nd floor operators |
| Blender area | 2 blender operators<br>1 blender foreman |

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## Process Description

Tetraethyl lead is generally made by reacting a lead-sodium alloy with ethyl chloride in an autoclave. (See Appendix, Figures A-1 and A-2 for a description of the TEL process.) The crude product is purified by vacuum distillation and water washing.[4]

The Ethyl TEL process, a multireactor continuous batch operation, was housed in a four story enclosed structure. The alloy area occupied part of the first three floors on the southwest end of the TEL building where the lead-sodium alloy [90% lead (Pb) and 10% sodium (Na)] was prepared in an alloy pot. The liquid alloy was transferred to a drum caster where it was cast, oil cooled to solidify, and crushed. All operations were carried out in a nitrogen atmosphere. The crushed alloy (in flake form) was moved by a vibrating conveyor to a hopper on the fourth floor. The hopper was purged with nitrogen and filled with the flaked alloy by either the manual "A" or automated "B" process. From there the crushed alloy was charged into a horizontal autoclave (with approximately 100 pounds per square inch (psi) of pressure and safety valve) which was located on the third floor. After the autoclave was charged with the alloy, ethyl chloride was fed slowly into the autoclave where part of it was vaporized by heat evolved from the reaction. The vaporized ethyl chloride was condensed in a reflux condenser and returned to the autoclave. Vaporization supplemented by circulation of a coolant in the autoclave jacket kept the reactants at 65-75°C and 50-60 psi. Any gaseous by-products were vented through the reflux condenser. Various catalysts, such as aldehydes, acids, ketones, esters, etc., were used in concentrations of 1 to 2% to speed up the reaction.

When the reaction was completed, the autoclave was vented into a steam still located on the second floor. (Each still was opened and checked prior to loading and before dumping bottoms.) Caustics, fatty acid, and hot water were used in the stills to vaporize the last traces of ethyl chloride, to decrease the surface tension, and to distill the TEL from the spongy metallic mass. (Sodium sulfide, sulfur, and caustic were combined to produce sodium thiosulfate which when mixed with ferric chloride and added to the stills prevents "balling" of the solid material). The tetraethyl lead and water were removed from the top of the stills and placed in a settling tank where the water was drawn off the top.

The lead-salt sludge and water remaining in the stills were dumped out the bottom to a sludge pit. The slurry from the still was washed free of sodium chloride and passed (under slight vacuum) through the dryer twice before being resmelted in three recovery furnaces located on the east side of the ground floor. In the furnaces, impurities were skimmed off before going to the melting pot. Seventy-five percent of the Pb used was recovered (and reused) since only about 25% of the lead fed into the autoclave was consumed in the process reaction.

The crude TEL from the still was aereated, washed, filtered, and pumped to the blending area which was located on three floors on the north side of the building. There, under a nitrogen blanket, the ethylene dibromide, ethylene dichloride, and kerosene were automatically metered into the blender and the dyes, Automate orange-2 (oil soluble) and Ethyl red 105 (granular), were manually added through a chute to the crude TEL.

Mixed lead alkyls (MLA) and tetramethyl lead are also manufactured; these compounds and TEL are mixed according to customer specifications and shipped to refineries for use as gasoline additives.

## Potential Exposures and Controls Used

The TEL process could be divided into ~~five~~ three main areas: alloy, autoclave, steam still, recovery, and blending areas, among which the exposure potential varied. Elemental lead (Pb) exposure was possible throughout the TEL process by inhalation or skin absorption; however, the potential for Pb exposure was greatest in the alloy and recovery (furnace) areas. If system leaks occurred in the autoclave or steam stills, exposure (by inhalation) to lead, ethyl chloride, catalysts, and TEL was possible. Exposure to ethylene dibromide, ethylene dichloride, kerosene, and dyes such as Automate orange-2 and Ethyl red 105 was also possible (by inhalation) in the blending area. Potential exposure was reduced by ventilation systems, protective clothing, and respirators used as control measures in the various TEL process areas.

## Production and Toxicity of Substances Monitored

### Tetraethyl Lead (TEL)

Tetraethyl lead is an antiknock compound that has been manufactured and used as an additive for gasoline since 1923.[1] Only very small quantities (i.e. approximately 2 cubic centimeters per gallon of gasoline) are needed to raise the efficiency of the fuel so that it burns more evenly.[5]

TEL, a colorless oily liquid, is a slightly volatile organic Pb compound that is insoluble in water but soluble in fats and their solvents. The solubility factor allows TEL to be absorbed into the blood stream via contact with skin, inhalation of vapors or ingestion of the liquid. TEL is then deposited in the fatty tissues of the body, especially the central nervous system (CNS). (A study by Cremer[1] showed that TEL was readily converted in the liver to triethyl lead, and that triethyl lead, not TEL, caused the CNS effects.) Early signs and symptoms associated with TEL intoxication may include: insomnia, disturbing dreams, anorexia (loss of appetite), nausea, vomiting, metallic taste in the mouth, headache, irritability and nervous anxiety, palor, tremors, slow pulse, low temperature, exaggerated reflexes, change in bowel habits, and weight loss. As the state of TEL intoxication increases, the signs and symptoms are exaggerated and the subject may suffer an acute anxiety state progressing to a state of mania typical of acute toxic psychosis; coma and death may follow.[5,6,7]

Although the lead content of the blood is the best indicator of inorganic Pb poisoning, the concentration of Pb in the blood may be only slightly elevated or within normal range when TEL intoxication occurs. Urine levels, however, may be elevated in both cases; but urine levels usually are appreciably higher in TEL intoxication since lead, absorbed in this form, is more rapidly excreted.[8]

The Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for TEL is 0.075 milligrams per cubic meter ($mg/m^3$) for an 8-hour time weighted average (TWA). The Immediately Dangerous to Life or Health (IDLH) level set by OSHA is 40 $mg/m^3$.[9] The American Conference of Governmental Hygienists (ACGIH) recommends a Threshold Limit Value (TLV) of 0.1 $mg/m^3$ for an 8-hour TWA.[9] (See Appendix, Table A-1.)

## Lead

Inorganic Pb is ubiquitous in the environment and can be found in measurable amounts in all adult body tissues and fluids. Lead is used in many industrial processes, one of which is tetraethyl lead. In most of these processes the main routes of occupational exposure to Pb are inhalation and ingestion. Either type of exposure may result in Pb absorption (5-10% of ingested Pb; 30-50% of inhaled Pb)[10] and distribution throughout the body. The effects of Pb absorption have been described by Mayers [11] as follows: loss of appetite, metallic taste in the mouth, constipation, anemia, pallor, malaise, weakness, insomnia, headache, nervous irritability, muscle and joint pains, fine tremors, encephalopathy, and colic. Other effects include damage to the reproductive system and inhibition of heme synthesis (which would decrease oxygen ($O_2$) transport in the body).[12]

An indirect indicator of Pb exposure is the blood lead (PbB) level. Prevention of adverse health effects from exposure to Pb throughout a working lifetime requires that the PbB level be maintained at or below 40 ug/100g of blood. Average PbB levels are < 20 ug Pb/100g of blood for 50% of the population and < 35 ug Pb/100g of blood for 98% of the population.[12] Urinalysis may also be used to indirectly determine the amount of Pb exposure. Under certain circumstances, although not a regular procedure, analysis of feces may be conducted to give an approximate measurement of the amount of Pb ingested (including that from the upper respiratory tract).

The OSHA Standard (PEL) for Pb is 0.05 mg/$m^3$; NIOSH recommends a TWA of 0.1 mg/$m^3$; and ACGIH recommends a TLV of 0.15 mg/$m^3$ and a Short Term Exposure Limit (STEL, up to 15 minutes) of 0.45 mg/$m^3$.[9,13] (See Appendix, Table A-1.)

## Ethylene dibromide (EDB) and Ethylene dichloride (EDC)

Ethylene dibromide and Ethylene dichloride are added to TEL in order to prevent the deposition of lead in the exhaust sections of the engine. The ethylene halide converts the lead oxide formed during combustion into the volatile lead halide.[14]

Both EDB and EDC are toxic by inhalation, ingestion, and skin absorption, and are strong irritants to the eyes and skin.[15] Exposure to EDB vapor concentrations above the standard may cause injury to the lungs, liver, and kidneys as well as CNS depression and death (due to pneumonia resulting from injury to the lungs).[16] NIOSH recommends that EDB be treated as a potential carcinogen.[17] Exposure to EDC vapor concentrations above the standard may cause mental confusion, dizziness, nausea, and vomiting. Liver, kidney, and adrenal injuries may also occur.[16]

The OSHA standards for EDB are: 20 parts per million (ppm) PEL, 30 ppm as a ceiling level, 50 ppm maximum peak for five minutes, and 400 ppm IDLH level.[18,9] (See Appendix, Table A-1.) NIOSH recommends a 15 minute ceiling limit of 1 $mg/m^3$.[9] ACGIH lists EDB as a substance that is suspect of inducing cancer in man; however, environmental conditions have not been sufficiently defined to assign a TLV.[13]

The OSHA standards for EDC are: 50 ppm PEL, 100 ppm as a ceiling concentration, 200 ppm maximum duration for 5 minutes in any 3 hours, and 1000 ppm IDLH level.[18,9] NIOSH recommends that the PEL be reduced to 5 ppm per 10-hour workday and the ceiling level be reduced to 15 ppm averaged over a 15 minute period.[9] ACGIH recommends a TLV of 10 ppm and a STEL of 15 ppm.[13] (See Appendix, Table A-1.)

Ethyl chloride

Ethyl chloride and a lead-sodium alloy are fed into an autoclave; the resultant chemical reaction produces TEL. Afterwards, any remaining trace of ethyl chloride is vaporized and removed.[4]

The major problems involved in handling ethyl chloride are fire and explosion.[19] Healthwise, it may cause eye irritation, stomach cramps, dizziness and incoordination, liver and kidney damage, cardiac arrhythmias, and cardiac arrest.[9,20]

The OSHA standards for ethyl chloride are 1000 ppm (2600 $mg/m^3$) PEL and 20,000 ppm IDLH level.[18,9] ACGIH recommends a TLV of 1000 ppm and a STEL of 1,250 ppm (3,250 $mg/m^3$).[13] (See Appendix, Table A-1.)

## Survey Methods

### General

Area and personal air samples were collected at the TEL (process) plant over the four following work shifts:

| | |
|---|---|
| 4-8-80 | 7:30am to 3:30pm |
| 4-8/9-80 | 11:30pm to 7:30am |
| 4-9-80 | 3:30pm to 11:30pm |
| 4-10-80 | 7:30am to 3:30pm |

Only the automated half of the process was in operation at the time of the survey; monitoring for inorganic lead and TEL was conducted in all areas of this process. However, monitoring of ethyl chloride was conducted only in the TEL manufacturing area and monitoring of EDB and EDC was conducted only in the blending area.

### Tetraethyl lead (TEL)

Area and personal TEL samples were collected at a flow rate of approximately 1.25 liters per minute (Lpm) for 6-8 hours per shift using MSA Model G pumps. Sampling media were changed at least once during each shift and consisted of an 0.8 micron AA Millipore filter backed up with an XAD-2 resin tube. The filter collected the inorganic lead fraction and the XAD-2 resin tube collected the TEL (organic lead) fraction.

Chemical analysis for TEL was performed using NIOSH Method No. S383.[21] TEL was desorbed from the resin with pentane, separated, and analyzed by using a gas chromatograph with a photoionization detector.

### Inorganic Lead (Pb)

Personal and area Pb samples were collected on 0.8 micron AA Millipore filters in line with MSA Model G pumps. The flow rate was 1.0 Lpm with a collection time of 6-8 hours per shift.

Analysis of lead was performed using NIOSH Method SCP No. S-341.[22] The sample filters were wet ashed with nitric and perchloric acids to insure their complete oxidation. The ashed samples were diluted to a final volume of 25 milliliters (mL) and analyzed by atomic absorption spectrophotometry.

Ethylene dibromide (EDB) and Ethylene dichloride (EDC)

Area and personal EDB and EDC samples were obtained using standard 150 milligram (mg) charcoal tubes in line with MDA Accuhaler (Model 808) low-flow pumps [20 cubic centimeters minute (cc/min) limiting orifice]. Samples were collected for a period of 6-8 hours per shift.

The samples were analyzed for EDB and EDC by using a modification of NIOSH Method S-104.[23] Each sample was separated into A and B sections and each section was desorbed with 1 mL of carbon disulfide containing 1 microliter per milliliter (ul/mL) dodecane as an internal standard. Each section was analyzed by using a gas chromatograph.

Ethyl chloride

Area and personal ethyl chloride samples were collected using charcoal tubes (600 mg) in line with MDA Accuhaler (Model 808) low-flow pumps (20 cc/min limiting orifice). Sampling was conducted for 6-8 hours per shift.

The charcoal tube samples were analyzed for ethyl chloride by using a modification of NIOSH Method S-105.[24] Ethyl chloride was desorbed from the charcoal with 2 mLs of carbon disulfide containing 1 uL/mL octane as an internal standard. The sample analysis was completed on a gas chromatograph by flame i nization detection.

## Statistical Methods

Summary statistics such as arithmetic mean, standard deviation, geometric mean, geometric standard deviation, and 95% confidence limits of geometric means were calculated by different job titles for TEL, Pb, EDB, EDC and ethyl chloride.

Due to the small number of samples in each statistical grouping, the statistical analysis was judged not to be descriptive of the exposure data. This analysis may be seen in the Appendix, Tables A-2 through A-6.

## Results and Discussion

All 8-hour TWA area TEL sample results and most 8-hour TWA personal TEL sample results were below the OSHA standard of 0.075 $mg/m^3$ and ACGIH TLV of 0.15 $mg/m^3$. However, 6 of 60 TEL personal samples were above the OSHA standard and ranged from 0.092 to 0.159 $mg/m^3$; five were above the ACGIH TLV. (See Table 1 and Appendix, Table A-8.) Although these levels were above the OSHA standard, the employees were required to wear respirators and protective clothing, which if properly used and maintained would decrease the actual exposure level.

For lead, the 8-hour TWA area sampling results ranged from 0.003 to 0.006 $mg/m^3$ which is below the OSHA standard of 0.05 $mg/m^3$, the NIOSH recommended standard of 0.1 $mg/m^3$, and ACGIH TLV of 0.15 $mg/m^3$. Four of 60 TWA personal sampling results were above the NIOSH recommended standard and ranged from 0.118 to 0.869 $mg/m^3$; six were above the OSHA standard and ranged from 0.057 to 0.869 $mg/m^3$. (See Table 2 and Appendix, Table A-9.)

All area and personal EDB and EDC sample results were below the analytical limit of detection of 0.01 mg/sample. (See Appendix, Tables A-10 and A-11.) For ethyl chloride, all 8-hour TWA area and personal sampling results were well below the OSHA standard and ACGIH TLV of 2600 $mg/m^3$ and ranged from 0.138 to 0.572 $mg/m^3$. (See Appendix, Table A-12.)

## Conclusions

Worker exposure to TEL, Pb, EDB, EDC, and ethyl chloride was assessed at the Ethyl Corporation. The employees' exposure to EDB, EDC and ethyl chloride was judged not to constitute a health hazard since all area and personal levels found were well below the OSHA standards and NIOSH recommended standards (for EDB and EDC).

Due to physical contact with TEL and Pb containing substances and to malfunctioning of equipment (e.g. system leaks), the potential existed for an appreciable exposure to TEL and/or Pb. However, since the employees wore protective equipment, their actual personal exposure was probably below the OSHA standards of 0.075 $mg/m^3$ for TEL and 0.05 $mg/m^3$ for Pb.

TABLE 1

Worker Exposure Levels for Tetraethyl Lead (TEL)
Greater Than the OSHA Standard [a] (0.075 $mg/m^3$) 4/8-10/80

| Date | Shift | Job Title | TEL TWA Concentration ($mg/m^3$) |
|---|---|---|---|
| 4/8 | 1 | 3rd Floor Operator | 0.141 |
| 4/8 | 3 | 4th Floor Operator | 0.109 |
| 4/9 | 2 | Blender Operator | >0.094 |
| 4/9 | 2 | 4th Floor Operator | 0.159 |
| 4/9 | 2 | Furnace Operator | 0.137 |
| 4/10 | 1 | 2nd Floor Operator | 0.092 |

a) Data have not been corrected for temperature and pressure variation; maximum deviation would be within $\pm$ 1% of actual values.

TABLE 2

Worker Exposure Levels for Lead (Pb)
Greater Than the OSHA Standard [a] (0.050 $mg/m^3$) 4/8-10/80

| Date | Shift | Job Title | Pb TWA Concentration ($mg/m^3$) |
|---|---|---|---|
| 4/8 | 1 | Carpenter (Sludge pit) | 0.118 |
| 4/8 | 3 | Alloy Charge Pot Operator | 0.869 |
| 4/8 | 3 | B-2 Furnace Operator | 0.198* |
| 4/9 | 2 | Chief Operator | 0.091 |
| 4/9 | 2 | Alloy Charge Pot Operator | 0.167 |
| 4/10 | 1 | Alloy Charge Pot Operator | 0.057 |

a) Data have not been corrected for temperature and pressure variation; maximum deviation would be within $\pm$ 1% of actual values.

* Furnace B-2 started leaking Pb resulting in Pb fumes.



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## Recommendations

1. Continue to emphasize the respirator fit testing program.

2. Continue the industrial hygiene and biological monitoring programs.

3. Better maintain equipment to reduce system leaks.

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24. NIOSH Manual of Analytical Methods, U.S. DHEW Publication No. 78-175, 4: S-105, 1978.

# APPENDIX A

FIGURE A-1

Flow Chart of Ethyl Corp.

Tetraethyl Lead, Process and Plants

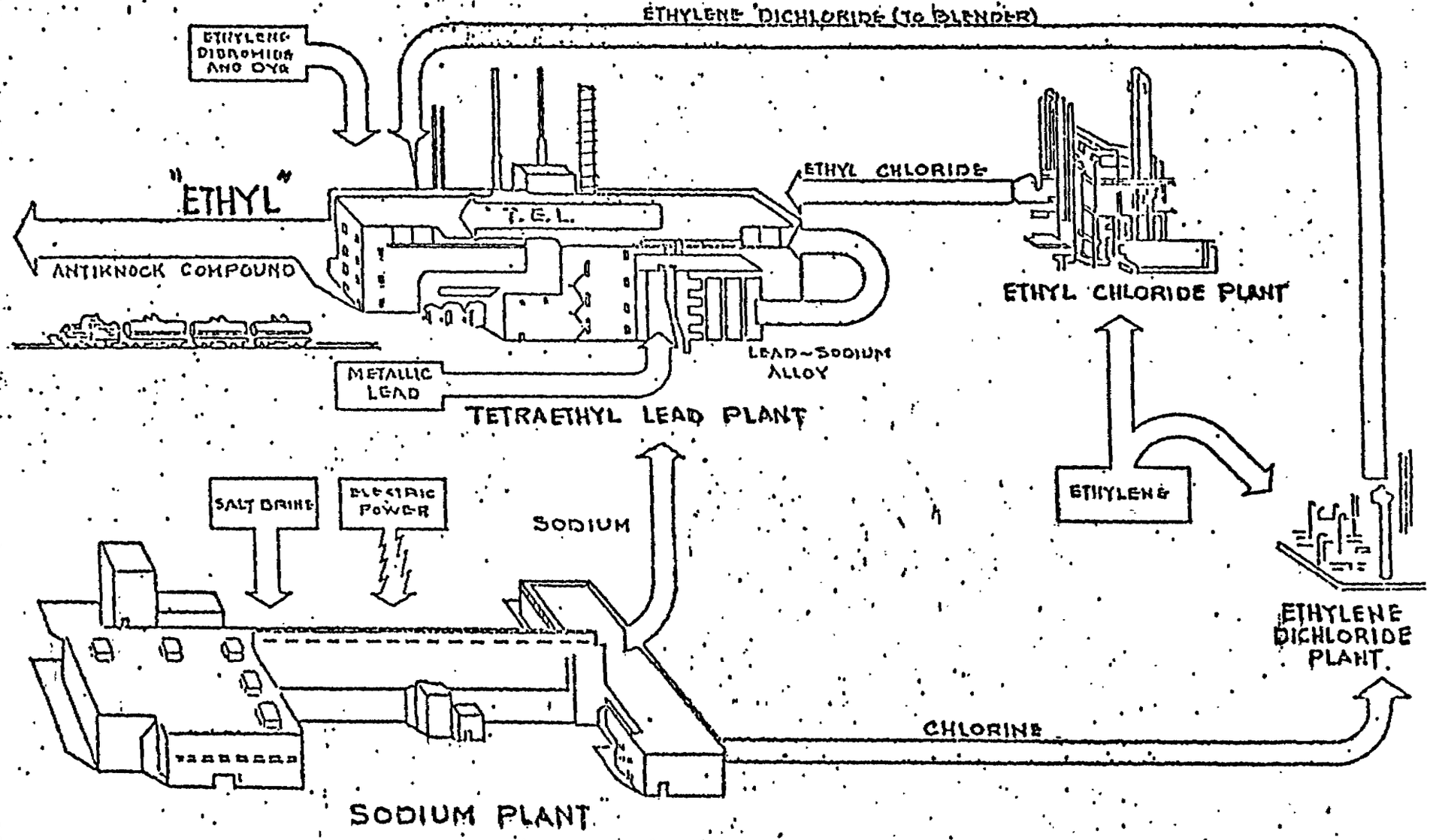


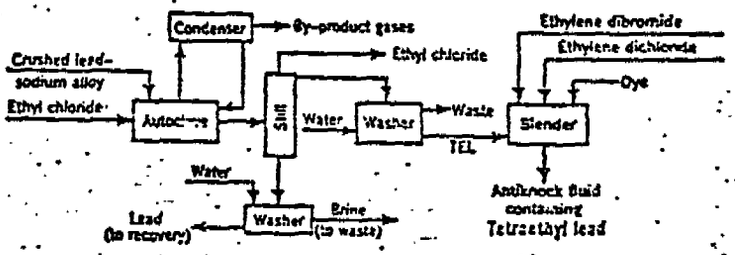
FIGURE A-2

Process Flow, Reaction, and Material Requirements

# TETRAETHYLLEAD
# (LEAD TETRAETHYL, TEL)

$Pb(C_2H_5)_4$

## From Ethyl Chloride and Lead-Sodium Alloy




## Reaction

$$4NaPb + 4C_2H_5Cl \rightarrow Pb(C_2H_5)_4 + 3Pb + 4NaCl$$

85-90% yield (based on sodium)

## Material Requirements

Basis—1 metric ton tetraethyllead

| | |
|---|---|
| Sodium | 325 kg |
| Lead (theoretical) | 640 kg |
| Ethyl chloride (theoretical) | 798 kg |
| Catalyst | 7.5 to 25 kg |
| Ferric chloride | Small |
| Sodium thiosulfate | Small |

TABLE A-1

Applicable Standards of Substances Monitored

On April 8-10, 1980

| Substance Monitored | OSHA Standard | | NIOSH Recommended Standard | | ACGIH Recommended Standard | |
|---|---|---|---|---|---|---|
| | PEL | IDLH | TWA | Ceiling | TLV | STEL |
| TEL | 0.075 mg/m$^3$ | 40 mg/m$^3$ | | | 0.1 mg/m$^3$ | |
| Pb | 0.05 mg/m$^3$ | Variable | 0.1 mg/m$^3$ | | 0.15 mg/m$^3$ | 0.45 mg/m$^3$ |
| EDB | 20 ppm<br>154 mg/m$^3$<br>(30 ppm ceiling) | 400 ppm | | 0.13 ppm<br>1 mg/m$^3$ | * | |
| EDC | 50 ppm<br>202 mg/m$^3$<br>(100 ppm ceiling)<br>** | 1000 ppm | 5 ppm/<br>10 hr<br>shift | 15 ppm/<br>(15 min.) | 40 mg/m$^3$ | 60 mg/m$^3$ |
| Ethyl chloride | 1000 ppm<br>2600 mg/m$^3$ | 20,000 ppm | | | 1000 ppm<br>2600 mg/m$^3$ | 1250 ppm<br>3250 mg/m$^3$ |

* Is suspect of inducing cancer in man; environmental conditions have not been sufficiently defined to assign a TLV.

** 200 ppm for five minute - peak for any three hour period.

TABLE A-2

SUMMARY STATISTICS
ETHYL CORPORATION
PASADENA, TX
APRIL 8-10,1980

REAGENT TETRA ETHYL LEAD

| | JOB TITLE | N | MAX | MIN | MEAN | STANDARD DEVIATION | STANDARD ERROR | GEOMETRIC MEAN | GEOMETRIC STANDARD DEVIATION | 95% LOWER CONFIDENCE LIMIT | 95% UPPER CONFIDENCE LIMIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CHIEF OPERATOR | 3 | 0.030 | 0.011 | 0.018 | 0.010 | 0.006 | 0.016 | 1.705 | 0.004 | 0.062 |
| + | 2ND FLOOR OPERATOR | 8 | 0.092 | 0.023 | 0.039 | 0.024 | 0.008 | 0.034 | 1.624 | 0.023 | 0.051 |
| + | 3RD FLOOR OPERATOR | 4 | 0.141 | 0.025 | 0.056 | 0.057 | 0.028 | 0.041 | 2.280 | 0.011 | 0.152 |
| | 4TH FLOOR OPERATOR | 5 | 0.159 | 0.024 | 0.076 | 0.058 | 0.026 | 0.057 | 2.381 | 0.020 | 0.169 |
| + | BLENDER OPERATOR | 6 | 0.108 | 0.018 | 0.055 | 0.034 | 0.014 | 0.046 | 1.935 | 0.023 | 0.092 |
| + | ALLOY CHARGE POT OPERATOR | 4 | 0.039 | 0.017 | 0.027 | 0.009 | 0.005 | 0.026 | 1.402 | 0.015 | 0.044 |
| + | ALLOY HOPPER BOOTH OPERATOR | 3 | 0.027 | 0.017 | 0.022 | 0.005 | 0.003 | 0.022 | 1.290 | 0.012 | 0.041 |
| + | A FURNACE OPERATOR | 4 | 0.137 | 0.025 | 0.055 | 0.054 | 0.027 | 0.042 | 2.212 | 0.012 | 0.148 |
| + | B-1 FURNACE OPERATOR | 3 | 0.082 | 0.026 | 0.048 | 0.030 | 0.017 | 0.042 | 1.801 | 0.010 | 0.182 |
| + | FURNACE RELIEF OPERATOR | 2 | 0.030 | 0.024 | 0.027 | 0.004 | 0.003 | 0.027 | 1.178 | 0.006 | 0.118 |
| + | FURNACE BREAKER | 1 | 0.018 | 0.018 | 0.018 | . | . | 0.018 | . | . | . |
| + | PIPEFITTER (FURNACE AREA) | 3 | 0.027 | 0.023 | 0.025 | 0.002 | 0.001 | 0.025 | 1.093 | 0.020 | 0.031 |
| | CARPENTER (SLUDGE PIT) | 1 | 0.030 | 0.030 | 0.030 | . | . | 0.030 | . | . | . |
| + | 2ND FLOOR OPERATOR (TRAINEE) | 1 | 0.024 | 0.024 | 0.024 | . | . | 0.024 | . | . | . |
| + | BLENDER FOREMAN | 2 | 0.032 | 0.027 | 0.030 | 0.004 | 0.003 | 0.029 | 1.128 | 0.010 | 0.087 |
| + | B-2 FURNACE OPERATOR | 2 | 0.082 | 0.023 | 0.053 | 0.041 | 0.029 | 0.044 | 2.418 | 0.000 | 122.084 |
| + | FURNACE SWINGMAN | 1 | 0.027 | 0.027 | 0.027 | . | . | 0.027 | . | . | . |
| + | ELECTRICIAN | 2 | 0.024 | 0.012 | 0.018 | 0.008 | 0.006 | 0.017 | 1.627 | 0.000 | 1.348 |

NOTE: UNITS FOR THIS TABLE ARE IN: MILLIGRAMS PER CUBIC METER
+ MORE THAN 50% OF THE VALUES USED TO COMPUTE THIS STATISTIC WERE BELOW THE LIMIT OF DETECTION

TABLE A-(2 (cont)

SUMMARY STATISTICS
ETHYL CORPORATION
PASADENA, TX
APRIL 8-10,1980

REAGENT TETRA ETHYL LEAD

| JOB TITLE | N | MAX | MIN | MEAN | STANDARD DEVIATION | STANDARD ERROR | GEOMETRIC MEAN | GEOMETRIC STANDARD DEVIATION | 95% LOWER CONFIDENCE LIMIT | 95% UPPER CONFIDENCE LIMIT |
|---|---|---|---|---|---|---|---|---|---|---|
| + MACHINIST | 1 | 0.024 | 0.024 | 0.024 | . | . | 0.024 | . | . | . |
| + OUTSIDE MACHINIST (FURNACE AREA) | 2 | 0.057 | 0.026 | 0.041 | 0.021 | 0.015 | 0.039 | 1.722 | 0.000 | 5.077 |
| + OUTSIDE MACHINIST (1ST FLOOR ALLOY) | 1 | 0.035 | 0.035 | 0.035 | . | . | 0.035 | . | . | . |
| + BLENDER TRAINEE | 1 | 0.042 | 0.042 | 0.042 | . | . | 0.042 | . | . | . |
| + MLA OPERATOR | 1 | 0.027 | 0.027 | 0.027 | . | . | 0.027 | . | . | . |
| + TEL OFFICE | 1 | 0.013 | 0.013 | 0.013 | . | . | 0.013 | . | . | . |
| + CHANGE ROOM (CONTAMINATED SIDE) | 1 | 0.017 | 0.017 | 0.017 | . | . | 0.017 | . | . | . |
| + CHANGE ROON (CLEAN SIDE) | 1 | 0.015 | 0.015 | 0.015 | . | . | 0.015 | . | . | . |
| + IH OFFICE | 1 | 0.015 | 0.015 | 0.015 | . | . | 0.015 | . | . | . |
| + BREAK AREA | 1 | 0.013 | 0.013 | 0.013 | . | . | 0.013 | . | . | . |

NOTE: UNITS FOR THIS TABLE ARE IN: MILLIGRAMS PER CUBIC METER
+ MORE THAN 50% OF THE VALUES USED TO COMPUTE THIS STATISTIC WERE BELOW THE LIMIT OF DETECTION

EC 3034

TABLE A-3

SUMMARY STATISTICS
ETHYL CORPORATION
PASADENA, TX
APRIL 8-10,1980

REAGENT LEAD

| | JOB TITLE | N | MAX | MIN | MEAN | STANDARD DEVIATION | STANDARD ERROR | GEOMETRIC MEAN | GEOMETRIC STANDARD DEVIATION | 95% LOWER CONFIDENCE LIMIT | 95% UPPER CONFIDENCE LIMIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| + | 2ND FLOOR OPERATOR | 8 | 12.876 | 2.576 | 6.093 | 4.130 | 1.460 | 5.024 | 1.926 | 2.905 | 8.689 |
| + | 3RD FLOOR OPERATOR | 4 | 5.590 | 3.048 | 4.406 | 1.061 | 0.530 | 4.303 | 1.292 | 2.864 | 6.466 |
| + | 4TH FLOOR OPERATOR | 5 | 5.427 | 3.004 | 4.107 | 1.015 | 0.454 | 4.005 | 1.287 | 2.927 | 5.481 |
| + | BLENDER OPERATOR | 6 | 11.445 | 3.218 | 6.350 | 3.020 | 1.233 | 5.807 | 1.583 | 3.587 | 9.402 |
| | ALLOY CHARGE POT OPERATOR | 4 | 869.499 | 3.936 | 274.214 | 402.625 | 201.313 | 75.379 | 9.645 | 2.047 | 2775.283 |
| | ALLOY HOPPER BOOTH OPERATOR | 3 | 18.322 | 3.740 | 12.001 | 7.482 | 4.320 | 9.849 | 2.339 | 1.193 | 81.286 |
| | A FURNACE OPERATOR | 4 | 30.661 | 14.485 | 23.901 | 6.792 | 3.396 | 23.056 | 1.382 | 13.777 | 38.585 |
| | B-1 FURNACE OPERATOR | 3 | 32.771 | 6.580 | 17.755 | 13.512 | 7.801 | 14.423 | 2.233 | 1.960 | 106.135 |
| | FURNACE RELIEF OPERATOR | 2 | 46.895 | 25.017 | 35.956 | 15.470 | 10.939 | 34.252 | 1.559 | 0.632 | 1854.942 |
| | FURNACE BREAKER | 1 | 37.111 | 37.111 | 37.111 | . | . | 37.111 | . | . | . |
| | PIPEFITTER (FURNACE AREA) | 2 | 24.727 | 9.137 | 16.932 | 11.024 | 7.795 | 15.031 | 2.022 | 0.027 | 8391.651 |
| | CARPENTER (SLUDGE PIT) | 1 | 118.296 | 118.296 | 118.296 | . | . | 118.296 | . | . | . |
| | 2ND FLOOR OPERATOR (TRAINEE) | 1 | 5.414 | 5.414 | 5.414 | . | . | 5.414 | . | . | . |
| + | BLENDER FOREMAN | 2 | 3.617 | 3.051 | 3.334 | 0.400 | 0.283 | 3.322 | 1.128 | 1.127 | 9.789 |
| | B-2 FURNACE OPERATOR | 2 | 198.268 | 45.558 | 121.913 | 107.982 | 76.355 | 95.040 | 2.829 | 0.008 | 1085191.324 |
| | FURNACE SWINGMAN | 1 | 20.075 | 20.075 | 20.075 | . | . | 20.075 | . | . | . |
| | ELECTRICIAN | 2 | 21.584 | 4.516 | 13.050 | 12.068 | 8.534 | 9.873 | 3.022 | 0.000 | 204307.023 |
| | MACHINIST | 1 | 12.804 | 12.804 | 12.804 | . | . | 12.804 | . | . | . |

NOTE: UNITS FOR THIS TABLE ARE IN: MICROGRAMS PER CUBIC METER
+ MORE THAN 50% OF THE VALUES USED TO COMPUTE THIS STATISTIC
WERE BELOW THE LIMIT OF DETECTION

EC 3035

TABLE A-3 (cont)

SUMMARY STATISTICS
ETHYL CORPORATION
PASADENA, TX
APRIL 8-10,1980

H REAGENT LEAD

| JOB TITLE | N | MAX | MIN | MEAN | STANDARD DEVIATION | STANDARD ERROR | GEOMETRIC MEAN | GEOMETRIC STANDARD DEVIATION | 95% LOWER CONFIDENCE LIMIT | 95% UPPER CONFIDENCE LIMIT |
|---|---|---|---|---|---|---|---|---|---|---|
| OUTSIDE MACHINIST (FURNACE AREA) | 2 | 24.728 | 4.928 | 14.828 | 14.000 | 9.900 | 11.039 | 3.128 | 0.000 | 311304.352 |
| OUTSIDE MACHINIST (1ST FLOOR ALLOY) | 1 | 12.372 | 12.372 | 12.372 | . | . | 12.372 | . | . | . |
| + BLENDER TRAINEE | 1 | 4.316 | 4.316 | 4.316 | . | . | 4.316 | . | . | . |
| MLA OPERATOR | 1 | 12.302 | 12.302 | 12.302 | . | . | 12.302 | . | . | . |
| + TEL OFFICE | 1 | 4.827 | 4.827 | 4.827 | . | . | 4.827 | . | . | . |
| + CHANGE ROOM (CONTAMINATED SIDE) | 1 | 6.249 | 6.249 | 6.249 | . | . | 6.249 | . | . | . |
| + CHANGE ROOM (CLEAN SIDE) | 1 | 5.687 | 5.687 | 5.687 | . | . | 5.687 | . | . | . |
| + IH OFFICE | 1 | 5.462 | 5.462 | 5.462 | . | . | 5.462 | . | . | . |

NOTE: UNITS FOR THIS TABLE ARE IN: MICROGRAMS PER CUBIC METER
+ MORE THAN 50% OF THE VALUES USED TO COMPUTE THIS STATISTIC WERE BELOW THE LIMIT OF DETECTION

EC 3036

TABLE A-4

SUMMARY STATISTICS
ETHYL CORPORATION
PASADENA, TX
APRIL 8-10,1980

REAGENT ETHYLENE DIBROMIDE

| JOB TITLE | N | MAX | MIN | MEAN | STANDARD DEVIATION | STANDARD ERROR | GEOMETRIC MEAN | GEOMETRIC STANDARD DEVIATION | 95% LOWER CONFIDENCE LIMIT | 95% UPPER CONFIDENCE LIMIT |
|---|---|---|---|---|---|---|---|---|---|---|
| + BLENDER TRAINEE | 1 | 0.054 | 0.054 | 0.054 | . | . | 0.054 | . | . | . |
| + MLA OPERATOR | 1 | 0.062 | 0.062 | 0.062 | . | . | 0.062 | . | . | . |
| + 2ND FLOOR BLENDING | 3 | 0.065 | 0.056 | 0.061 | 0.005 | 0.003 | 0.061 | 1.080 | 0.050 | 0.073 |
| + 3RD FLOOR BLENDING | 3 | 0.070 | 0.054 | 0.060 | 0.008 | 0.005 | 0.060 | 1.143 | 0.043 | 0.083 |
| + 1ST FLOOR BLENDING | 3 | 0.072 | 0.049 | 0.058 | 0.012 | 0.007 | 0.057 | 1.228 | 0.034 | 0.096 |
| + EDB | 1 | 0.123 | 0.123 | 0.123 | . | . | 0.123 | . | . | . |
| + EDC | 1 | 0.055 | 0.055 | 0.055 | . | . | 0.055 | . | . | . |

NOTE: UNITS FOR THIS TABLE ARE IN: MILLIGRAMS PER CUBIC METER
+ MORE THAN 50% OF THE VALUES USED TO COMPUTE THIS STATISTIC WERE BELOW THE LIMIT OF DETECTION

EC 3037

TABLE A-5

SUMMARY STATISTICS
ETHYL CORPORATION
PASADENA, TX
APRIL 8-10,1980

EC 3038

REAGENT ETHYLENE DICHLORIDE

| JOB TITLE | N | MAX | MIN | MEAN | STANDARD DEVIATION | STANDARD ERROR | GEOMETRIC MEAN | GEOMETRIC STANDARD DEVIATION | 95% LOWER CONFIDENCE LIMIT | 95% UPPER CONFIDENCE LIMIT |
|---|---|---|---|---|---|---|---|---|---|---|
| + BLENDER TRAINEE. | 1 | 0.054 | 0.054 | 0.054 | . | . | 0.054 | . | . | . |
| + MLA OPERATOR | 1 | 0.062 | 0.062 | 0.062 | . | . | 0.062 | . | . | . |
| + 2ND FLOOR BLENDING | 3 | 0.065 | 0.056 | 0.061 | 0.005 | 0.003 | 0.061 | 1.080 | 0.050 | 0.073 |
| + 3RD FLOOR BLENDING | 3 | 0.070 | 0.054 | 0.060 | 0.008 | 0.005 | 0.060 | 1.143 | 0.043 | 0.083 |
| + 1ST FLOOR BLENDING | 3 | 0.072 | 0.049 | 0.058 | 0.012 | 0.007 | 0.057 | 1.228 | 0.034 | 0.096 |
| + EDB | 1 | 0.123 | 0.123 | 0.123 | . | . | 0.123 | . | . | . |
| + EDC | 1 | 0.055 | 0.055 | 0.055 | . | . | 0.055 | . | . | . |
| + BLENDER OPERATOR | 1 | 0.073 | 0.073 | 0.073 | . | . | 0.073 | . | . | . |

NOTE: UNITS FOR THIS TABLE ARE IN: MICROGRAMS PER CUBIC METER
+ MORE THAN 50% OF THE VALUES USED TO COMPUTE THIS STATISTIC WERE BELOW THE LIMIT OF DETECTION

TABLE A-6

SUMMARY STATISTICS
ETHYL CORPORATION
PASADENA, TX
APRIL 8-10,1980

REAGENT ETHYL CHLORIDE

| JOB TITLE | N | MAX | MIN | MEAN | STANDARD DEVIATION | STANDARD ERROR | GEOMETRIC MEAN | GEOMETRIC STANDARD DEVIATION | 95% LOWER CONFIDENCE LIMIT | 95% UPPER CONFIDENCE LIMIT |
|---|---|---|---|---|---|---|---|---|---|---|
| + B-7 | 1 | 0.198 | 0.198 | 0.198 | . | . | 0.198 | . | . | . |
| + B-15 | 1 | 0.265 | 0.265 | 0.265 | . | . | 0.265 | . | . | . |
| + B-1 | 1 | 0.299 | 0.299 | 0.299 | . | . | 0.299 | . | . | . |
| + B-8 | 2 | 0.208 | 0.142 | 0.175 | 0.047 | 0.033 | 0.172 | 1.310 | 0.015 | 1.941 |
| + B-12 | 1 | 0.239 | 0.239 | 0.239 | . | . | 0.239 | . | . | . |
| + B-9 | 2 | 0.488 | 0.166 | 0.327 | 0.227 | 0.161 | 0.285 | 2.139 | 0.000 | 264.100 |
| + B-4 | 2 | 0.280 | 0.180 | 0.230 | 0.071 | 0.050 | 0.224 | 1.367 | 0.013 | 3.730 |
| + B-3 | 1 | 0.206 | 0.206 | 0.206 | . | . | 0.206 | . | . | . |
| + B-13 | 1 | 0.138 | 0.138 | 0.138 | . | . | 0.138 | . | . | . |
| + B-6 | 1 | 0.317 | 0.317 | 0.317 | . | . | 0.317 | . | . | . |
| + B-2 | 1 | 0.572 | 0.572 | 0.572 | . | . | 0.572 | . | . | . |
| + B-5 | 1 | 0.239 | 0.239 | 0.239 | . | . | 0.239 | . | . | . |

NOTE: UNITS FOR THIS TABLE ARE IN: MILLIGRAMS PER CUBIC METER
+ MORE THAN 50% OF THE VALUES USED TO COMPUTE THIS STATISTIC WERE BELOW THE LIMIT OF DETECTION

EC 3039

TABLE A-7

Notation for the following sample data tables:

Data have not been corrected for temperature and pressure variation; maximum deviation would be within ± 1% of actual values.

TABLE A-8

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

REAGENT TETRA ETHYL LEAD

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | ANALYTICAL RESULTS (MG) | CONCENTRATION (MG/CU.M.) | TWA CONCENTRATION (MG/CU.M.) |
|---|---|---|---|---|---|---|---|---|
| 3281 | CHIEF OPERATOR | 08 | 1 | 115 | 160.991 | < 0.013 | < 0.083 | |
| 3361 | CHIEF OPERATOR | 08 | 1 | 200 | 279.984 | < 0.013 | < 0.048 | |
| | | | | | | | | < 0.030 |
| 3441 | 3RD FLOOR OPERATOR | 08 | 1 | 136 | 139.079 | 0.015 | 0.109 | |
| 3521 | 3RD FLOOR OPERATOR | 08 | 1 | 209 | 213.731 | 0.035 | 0.162 | |
| | | | | | | | | 0.141 |
| 3781 | 4TH FLOOR OPERATOR | 08 | 1 | 140 | 184.869 | 0.017 | 0.091 | |
| 3861 | 4TH FLOOR OPERATOR | 08 | 1 | 214 | 286.835 | 0.013 | 0.046 | |
| | | | | | | | | 0.064 |
| 3770 | 4TH FLOOR OPERATOR | 10 | 1 | 265 | 357.824 | < 0.013 | < 0.037 | |
| 3850 | 4TH FLOOR OPERATOR | 10 | 1 | 150 | 202.542 | < 0.013 | < 0.066 | |
| | | | | | | | | < 0.024 |
| 4171 | 2ND FLOOR OPERATOR | 08 | 1 | 159 | 200.487 | < 0.013 | < 0.066 | |
| | | | | | | | | < 0.033 |
| 4251 | PIPEFITTER (FURNACE AREA) | 08 | 1 | 201 | 259.432 | < 0.013 | < 0.051 | |
| 4331 | PIPEFITTER (FURNACE AREA) | 08 | 1 | 175 | 225.874 | < 0.013 | < 0.059 | |
| | | | | | | | | < 0.027 |
| 4671 | CARPENTER (SLUDGE PIT) | 08 | 1 | 314 | 439.575 | 0.013 | 0.030 | |
| | | | | | | | | 0.030 |
| 4751 | BLENDER OPERATOR | 08 | 1 | 301 | 364.595 | < 0.013 | < 0.036 | |
| | | | | | | | | < 0.018 |
| 5221 | ALLOY CHARGE POT OPERATOR | 08 | 1 | 293 | 381.087 | < 0.013 | < 0.035 | |
| | | | | | | | | < 0.017 |
| 5301 | FURNACE BREAKER | 08 | 1 | 322 | 377.244 | < 0.013 | < 0.035 | |
| | | | | | | | | < 0.018 |
| 5481 | ALLOY HOPPER BOOTH OPERATOR | 08 | 1 | 297 | 401.033 | < 0.013 | < 0.033 | |
| | | | | | | | | < 0.017 |
| 5561 | FURNACE RELIEF OPERATOR | 08 | 1 | 207 | 250.735 | < 0.013 | < 0.053 | |
| 5641 | FURNACE RELIEF OPERATOR | 08 | 1 | 156 | 188.960 | < 0.013 | < 0.070 | |
| | | | | | | | | < 0.030 |

EC 3041

TABLE (A-[illegible] cont)

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

REAGENT TETRA ETHYL LEAD

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | ANALYTICAL RESULTS (MG) | CONCENTRATION (MG/CU.M.) | TWA CONCENTRATION (MG/CU.M.) |
|---|---|---|---|---|---|---|---|---|
| 5721 | A FURNACE OPERATOR | 08 | 1 | 215 | 268.964 | < 0.013 | < 0.049 | |
| 5801 | A FURNACE OPERATOR | 08 | 1 | 150 | 187.649 | < 0.013 | < 0.071 | < 0.029 |
| 6111 | B-1 FURNACE OPERATOR | 08 | 1 | 210 | 264.794 | 0.031 | 0.116 | |
| 6031 | B-1 FURNACE OPERATOR | 08 | 1 | 153 | 192.921 | < 0.013 | < 0.069 | < 0.082 |
| 2620 | A FURNACE OPERATOR | 10 | 1 | 226 | 271.505 | < 0.013 | < 0.049 | |
| 2700 | A FURNACE OPERATOR | 10 | 1 | 162 | 194.619 | < 0.013 | < 0.068 | |
| 2720 | A FURNACE OPERATOR | 10 | 1 | 162 | 194.619 | < 0.013 | < 0.068 | < 0.030 |
| 6371 | 2ND FLOOR OPERATOR | 08 | 1 | 111 | 128.942 | < 0.013 | < 0.103 | |
| 6451 | 2ND FLOOR OPERATOR | 08 | 1 | 222 | 257.883 | < 0.013 | < 0.052 | < 0.034 |
| 4660 | 2ND FLOOR OPERATOR | 10 | 1 | 229 | 331.950 | 0.025 | 0.077 | |
| 4580 | 2ND FLOOR OPERATOR | 10 | 1 | 188 | 272.518 | < 0.013 | < 0.049 | < 0.053 |
| 6611 | BLENDER OPERATOR | 08 | 1 | 221 | 243.557 | 0.024 | 0.098 | |
| 6531 | BLENDER OPERATOR | 08 | 1 | 110 | 121.227 | < 0.013 | < 0.110 | < 0.084 |
| 8720 | 2ND FLOOR OPERATOR | 08 | 3 | 280 | 386.418 | < 0.013 | < 0.034 | |
| 8800 | 2ND FLOOR OPERATOR | 08 | 3 | 142 | 195.969 | < 0.013 | < 0.068 | < 0.023 |
| 0011 | 4TH FLOOR OPERATOR | 08 | 3 | 254 | 320.274 | 0.040 | 0.125 | |
| 0271 | 4TH FLOOR OPERATOR | 08 | 3 | 142 | 179.051 | 0.014 | 0.080 | 0.109 |
| 0351 | BLENDER OPERATOR | 08 | 3 | 122 | 146.565 | < 0.013 | < 0.091 | |
| 0431 | BLENDER OPERATOR | 08 | 3 | 266 | 319.559 | < 0.013 | < 0.042 | < 0.029 |
| 0511 | CHIEF OPERATOR | 08 | 3 | 412 | 597.221 | < 0.013 | < 0.022 | < 0.011 |
| 0771 | 3RD FLOOR OPERATOR | 08 | 3 | 252 | 300.239 | < 0.013 | < 0.044 | |
| 0851 | 3RD FLOOR OPERATOR | 08 | 3 | 161 | 191.819 | < 0.013 | < 0.069 | < 0.027 |
| 1081 | 2ND FLOOR OPERATOR (TRAINEE) | 08 | 3 | 257 | 334.264 | < 0.013 | < 0.040 | |
| 1161 | 2ND FLOOR OPERATOR (TRAINEE) | 08 | 3 | 169 | 219.808 | < 0.013 | < 0.061 | |

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TABLE A-8 (cont)

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

REAGENT TETRA ETHYL LEAD

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | ANALYTICAL RESULTS (MG) | CONCENTRATION (MG/CU.M.) | TWA CONCENTRATION (MG/CU.M.) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | < 0.024 |
| 1241 | 2ND FLOOR OPERATOR | 08 | 3 | 253 | 329.061 | < 0.013 | < 0.040 | |
| 1321 | 2ND FLOOR OPERATOR | 08 | 3 | 174 | 226.311 | < 0.013 | < 0.059 | |
| | | | | | | | | < 0.024 |
| 1401 | MLA OPERATOR | 08 | 3 | 183 | 238.016 | < 0.013 | < 0.056 | |
| 1581 | MLA OPERATOR | 08 | 3 | 192 | 249.722 | < 0.013 | < 0.053 | |
| | | | | | | | | < 0.027 |
| 1661 | BLENDER FOREMAN | 08 | 3 | 126 | 163.880 | < 0.013 | < 0.081 | |
| 1741 | BLENDER FOREMAN | 08 | 3 | 252 | 327.760 | < 0.013 | < 0.041 | |
| | | | | | | | | < 0.027 |
| 1821 | ALLOY CHARGE POT OPERATOR | 08 | 3 | 204 | 267.355 | < 0.013 | < 0.050 | |
| 2051 | ALLOY CHARGE POT OPERATOR | 08 | 3 | 226 | 296.188 | < 0.013 | < 0.045 | |
| | | | | | | | | < 0.024 |
| 2131 | B-2 FURNACE OPERATOR | 08 | 3 | 204 | 257.228 | < 0.013 | < 0.052 | |
| 2211 | B-2 FURNACE OPERATOR | 08 | 3 | 245 | 308.926 | < 0.013 | < 0.043 | |
| | | | | | | | | < 0.023 |
| 2471 | A FURNACE OPERATOR | 08 | 3 | 258 | 302.264 | < 0.013 | < 0.044 | |
| 2551 | A FURNACE OPERATOR | 08 | 3 | 191 | 223.769 | < 0.013 | < 0.059 | |
| | | | | | | | | < 0.025 |
| 2631 | ALLOY HOPPER BOOTH OPERATOR | 08 | 3 | 172 | 215.171 | < 0.013 | < 0.062 | |
| 2711 | ALLOY HOPPER BOOTH OPERATOR | 08 | 3 | 274 | 342.772 | < 0.013 | < 0.039 | |
| | | | | | | | | < 0.024 |
| 3021 | FURNACE RELIEF OPERATOR | 08 | 3 | 201 | 245.463 | < 0.013 | < 0.054 | |
| 3101 | FURNACE RELIEF OPERATOR | 08 | 3 | 253 | 308.966 | < 0.013 | < 0.043 | |
| | | | | | | | | < 0.024 |
| 4740 | CHIEF OPERATOR | 09 | 2 | 417 | 505.104 | < 0.013 | < 0.026 | |
| | | | | | | | | < 0.013 |
| 4820 | 2ND FLOOR OPERATOR | 09 | 2 | 197 | 254.269 | < 0.013 | < 0.052 | |
| 5050 | 2ND FLOOR OPERATOR | 09 | 2 | 226 | 291.700 | < 0.013 | < 0.046 | |
| | | | | | | | | < 0.024 |
| 5130 | BLENDER FOREMAN | 09 | 2 | 121 | 141.759 | < 0.013 | < 0.094 | |

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TABLE A-8 (cont)

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

REAGENT TETRA ETHYL LEAD

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | ANALYTICAL RESULTS (MG) | CONCENTRATION (MG/CU.M.) | TWA CONCENTRATION (MG/CU.M.) |
|---|---|---|---|---|---|---|---|---|
| 5210 | BLENDER FOREMAN | 09 | 2 | 233 | 272.975 | < 0.013 | < 0.049 | |
| | | | | | | | | < 0.032 |
| 5470 | 3RD FLOOR OPERATOR | 09 | 2 | 194 | 206.096 | < 0.013 | < 0.065 | |
| 5550 | 3RD FLOOR OPERATOR | 09 | 2 | 227 | 241.154 | < 0.013 | < 0.055 | |
| | | | | | | | | < 0.030 |
| 5630 | BLENDER OPERATOR | 09 | 2 | 177 | 196.823 | 0.014 | 0.069 | |
| 5710 | BLENDER OPERATOR | 09 | 2 | 225 | 250.199 | < 0.013 | < 0.053 | |
| | | | | | | | | < 0.045 |
| 6020 | 2ND FLOOR OPERATOR | 09 | 2 | 206 | 247.478 | < 0.013 | < 0.054 | |
| 6100 | 2ND FLOOR OPERATOR | 09 | 2 | 218 | 261.895 | < 0.013 | < 0.051 | |
| | | | | | | | | < 0.026 |
| 6280 | ALLOY CHARGE POT OPERATOR | 09 | 2 | 191 | 267.385 | 0.017 | 0.064 | |
| 6360 | ALLOY CHARGE POT OPERATOR | 09 | 2 | 237 | 331.781 | < 0.013 | < 0.040 | |
| | | | | | | | | < 0.039 |
| 6440 | BLENDER OPERATOR | 09 | 2 | 111 | 135.554 | 0.043 | 0.314 | |
| 6520 | BLENDER OPERATOR | 09 | 2 | 261 | 318.735 | < 0.013 | < 0.042 | |
| | | | | | | | | < 0.108 |
| 6600 | 4TH FLOOR OPERATOR | 09 | 2 | 157 | 210.435 | < 0.013 | < 0.063 | |
| 6780 | 4TH FLOOR OPERATOR | 09 | 2 | 259 | 347.151 | < 0.013 | < 0.038 | |
| | | | | | | | | < 0.024 |
| 6860 | ALLOY HOPPER BOOTH OPERATOR | 09 | 2 | 217 | 245.612 | < 0.013 | < 0.054 | |
| 7170 | ALLOY HOPPER BOOTH OPERATOR | 09 | 2 | 217 | 245.612 | < 0.013 | < 0.054 | |
| | | | | | | | | < 0.027 |
| 7250 | 4TH FLOOR OPERATOR | 09 | 2 | 191 | 210.495 | 0.058 | 0.276 | |
| 7330 | 4TH FLOOR OPERATOR | 09 | 2 | 227 | 250.169 | 0.015 | 0.060 | |
| | | | | | | | | 0.159 |
| 7670 | D-2 FURNACE OPERATOR | 09 | 2 | 184 | 158.936 | 0.024 | 0.150 | |
| 7410 | D-2 FURNACE OPERATOR | 09 | 2 | 248 | 214.218 | < 0.013 | < 0.062 | |
| | | | | | | | | < 0.082 |
| 7750 | A FURNACE OPERATOR | 09 | 2 | 252 | 317.752 | 0.069 | 0.217 | |
| 7830 | A FURNACE OPERATOR | 09 | 2 | 186 | 234.532 | < 0.013 | < 0.057 | |
| | | | | | | | | 0.137 |
| 8060 | B-1 FURNACE | 09 | 2 | 203 | 173.332 | < 0.013 | < 0.077 | |

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TABLE A-6 (cont)

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

REAGENT TETRA ETHYL LEAD

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | ANALYTICAL RESULTS (MG) | CONCENTRATION (MG/CU.M.) | TWA CONCENTRATION (MG/CU.M.) |
|---|---|---|---|---|---|---|---|---|
| | OPERATOR | | | | | | | |
| 8140 | B-1 FURNACE OPERATOR | 09 | 2 | 242 | 206.632 | < 0.013 | < 0.064 | |
| | | | | | | | | < 0.035 |
| 0000 | PIPEFITTER (FURNACE AREA) | 10 | 1 | 196 | 247.141 | < 0.013 | < 0.054 | |
| 0180 | PIPEFITTER (FURNACE AREA) | 10 | 1 | 238 | 300.100 | < 0.013 | < 0.044 | |
| | | | | | | | | < 0.024 |
| 0260 | MACHINIST | 10 | 1 | 199 | 248.948 | < 0.013 | < 0.053 | |
| 0340 | MACHINIST | 10 | 1 | 238 | 297.737 | < 0.013 | < 0.045 | |
| | | | | | | | | < 0.024 |
| 0500 | B-1 FURNACE OPERATOR | 10 | 1 | 139 | 175.268 | < 0.013 | < 0.076 | |
| 0680 | B-1 FURNACE OPERATOR | 10 | 1 | 260 | 327.840 | < 0.013 | < 0.041 | |
| | | | | | | | | < 0.026 |
| 0760 | 3RD FLOOR OPERATOR | 10 | 1 | 187 | 243.219 | < 0.013 | < 0.055 | |
| 0840 | 3RD FLOOR OPERATOR | 10 | 1 | 219 | 284.839 | < 0.013 | < 0.047 | |
| | | | | | | | | < 0.025 |
| 1070 | ELECTRICIAN | 10 | 1 | 273 | 330.679 | < 0.013 | < 0.040 | |
| 1150 | ELECTRICIAN | 10 | 1 | 186 | 225.298 | < 0.013 | < 0.059 | |
| | | | | | | | | < 0.024 |
| 1230 | OUTSIDE MACHINIST (FURNACE AREA) | 10 | 1 | 197 | 230.798 | < 0.013 | < 0.058 | |
| 1310 | OUTSIDE MACHINIST (FURNACE AREA) | 10 | 1 | 236 | 276.490 | < 0.013 | < 0.048 | |
| | | | | | | | | < 0.026 |
| 1570 | PIPEFITTER (FURNACE AREA) | 10 | 1 | 191 | 256.007 | < 0.013 | < 0.052 | |
| 1650 | PIPEFITTER (FURNACE AREA) | 10 | 1 | 240 | 321.684 | < 0.013 | < 0.041 | |
| | | | | | | | | < 0.023 |
| 1730 | ALLOY CHARGE POT OPERATOR | 10 | 1 | 152 | 190.151 | < 0.013 | < 0.070 | |
| 1810 | ALLOY CHARGE POT OPERATOR | 10 | 1 | 244 | 305.243 | < 0.013 | < 0.044 | |
| | | | | | | | | < 0.027 |
| 2040 | OUTSIDE MACHINIST (FURNACE AREA) | 10 | 1 | 199 | 203.505 | 0.018 | 0.091 | |
| 2120 | OUTSIDE MACHINIST | 10 | 1 | 236 | 241.343 | < 0.013 | < 0.055 | |

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TABLE A-8 (cont)

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

REAGENT TETRA ETHYL LEAD

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | ANALYTICAL RESULTS (MG) | CONCENTRATION (MG/CU.M.) | TWA CONCENTRATION (MG/CU.M.) |
|---|---|---|---|---|---|---|---|---|
| | (FURNACE AREA) | | | | | | | < 0.057 |
| 2200 | OUTSIDE MACHINIST (1ST FLOOR ALLOY) | 10 | 1 | 202 | 262.729 | 0.013 | 0.051 | |
| 2380 | OUTSIDE MACHINIST (1ST FLOOR ALLOY) | 10 | 1 | 233 | 303.048 | < 0.013 | < 0.044 | |
| | | | | | | | | < 0.035 |
| 2880 | FURNACE SWINGMAN | 10 | 1 | 222 | 288.741 | < 0.013 | < 0.046 | |
| 3010 | FURNACE SWINGMAN | 10 | 1 | 161 | 209.402 | < 0.013 | < 0.064 | |
| | | 10 | | | | | | < 0.027 |
| 3270 | 2ND FLOOR OPERATOR | 10 | 1 | 197 | 256.225 | 0.031 | 0.121 | |
| 3350 | 2ND FLOOR OPERATOR | 10 | 1 | 221 | 287.441 | 0.019 | 0.066 | |
| | | | | | | | | 0.092 |
| 4160 | BLENDER OPERATOR | 10 | 1 | 174 | 207.308 | 0.017 | 0.080 | |
| 4080 | BLENDER OPERATOR | 10 | 1 | 266 | 316.918 | < 0.013 | < 0.042 | |
| | | | | | | | | < 0.044 |
| 4320 | BLENDER TRAINEE | 10 | 1 | 250 | 327.641 | 0.017 | 0.053 | |
| 4240 | BLENDER TRAINEE | 10 | 1 | 192 | 251.629 | < 0.013 | < 0.053 | |
| | | | | | | | | < 0.042 |
| 4400 | ELECTRICIAN | 10 | 1 | 439 | 553.545 | < 0.013 | < 0.024 | |
| | | | | | | | | < 0.012 |
| 0420 | TEL OFFICE | 10 | 1 | 370 | 517.971 | < 0.013 | < 0.026 | |
| | | | | | | | | < 0.013 |
| 2460 | CHANGE ROOM (CONTAMINATED SIDE) | 10 | 1 | 363 | 400.050 | < 0.013 | < 0.033 | |
| | | | | | | | | < 0.017 |
| 2540 | CHANGE ROOM (CLEAN SIDE) | 10 | 1 | 360 | 439.635 | < 0.013 | < 0.030 | |
| | | | | | | | | < 0.015 |
| 3430 | IH OFFICE | 10 | 1 | 394 | 457.685 | < 0.013 | < 0.029 | |
| | | | | | | | | < 0.015 |
| 3510 | BREAK AREA | 10 | 1 | 357 | 492.683 | < 0.013 | < 0.027 | |
| | | | | | | | | < 0.013 |

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TABLE A-9

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

H REAGENT LEAD

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | ANALYTICAL RESULTS (UG) | CONCENTRATION (UG/CU.M.) | TWA CONCENTRATION (UG/CU.M.) |
|---|---|---|---|---|---|---|---|---|
| 4773 | CHIEF OPERATOR | 08 | 1 | 315 | 440.975 | < 3.000 | < 6.803 | < 3.402 |
| 4853 | 3RD FLOOR OPERATOR | 08 | 1 | 345 | 352.810 | < 3.000 | < 8.503 | < 4.252 |
| 2313 | 4TH FLOOR OPERATOR | 10 | 1 | 415 | 560.366 | < 5.000 | < 8.923 | < 4.461 |
| 5243 | 2ND FLOOR OPERATOR | 08 | 1 | 159 | 200.487 | < 3.000 | < 14.964 | < 7.482 |
| 5323 | PIPEFITTER (FURNACE AREA) | 08 | 1 | 376 | 485.306 | 12.000 | 24.727 | 24.727 |
| 5583 | CARPENTER (SLUDGE PIT) | 08 | 1 | 314 | 439.575 | 52.000 | 118.296 | 118.296 |
| 5663 | BLENDER OPERATOR | 08 | 1 | 301 | 364.595 | 3.000 | 8.228 | 8.228 |
| 6133 | ALLOY CHARGE POT OPERATOR | 08 | 1 | 293 | 381.087 | < 3.000 | < 7.872 | < 3.936 |
| 6213 | FURNACE BREAKER | 08 | 1 | 322 | 377.244 | 14.000 | 37.111 | 37.111 |
| 6473 | ALLOY HOPPER BOOTH OPERATOR | 08 | 1 | 297 | 401.033 | < 3.000 | < 7.481 | < 3.740 |
| 6553 | FURNACE RELIEF OPERATOR | 08 | 1 | 363 | 439.695 | 11.000 | 25.017 | 25.017 |
| 6633 | A FURNACE OPERATOR | 08 | 1 | 365 | 456.613 | 14.000 | 30.661 | 30.661 |
| 6713 | B-1 FURNACE OPERATOR | 08 | 1 | 363 | 457.715 | 15.000 | 32.771 | 32.771 |
| 1763 | A FURNACE OPERATOR | 10 | 1 | 388 | 466.124 | 12.000 | 25.744 | 25.744 |
| 7023 | 2ND FLOOR OPERATOR | 08 | 1 | 333 | 386.825 | < 3.000 | < 7.755 | |

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TABLE A-9 (cont)

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

REAGENT LEAD

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | ANALYTICAL RESULTS (UG) | CONCENTRATION (UG/CU.M.) | TWA CONCENTRATION (UG/CU.M.) |
|---|---|---|---|---|---|---|---|---|
| 2813 | 2ND FLOOR OPERATOR | 10 | 1 | 417 | 604.468 | 7.000 | 11.580 | < 3.878<br>11.580 |
| 7103 | BLENDER OPERATOR | 08 | 1 | 331 | 364.784 | < 3.000 | < 8.224 | < 4.112 |
| 3043 | 2ND FLOOR OPERATOR | 08 | 3 | 422 | 582.387 | < 3.000 | < 5.151 | < 2.576 |
| 3123 | 4TH FLOOR OPERATOR | 08 | 3 | 396 | 499.325 | < 3.000 | < 6.008 | < 3.004 |
| 3203 | BLENDER OPERATOR | 08 | 3 | 388 | 466.124 | < 3.000 | < 6.436 | < 3.218 |
| 3383 | CHIEF OPERATOR | 08 | 3 | 412 | 597.221 | 5.000 | 8.372 | 8.372 |
| 3463 | 3RD FLOOR OPERATOR | 08 | 3 | 413 | 492.058 | < 3.000 | < 6.097 | < 3.048 |
| 3543 | 2ND FLOOR OPERATOR (TRAINEE) | 08 | 3 | 426 | 554.071 | 3.000 | 5.414 | 5.414 |
| 3623 | 2ND FLOOR OPERATOR | 08 | 3 | 427 | 555.372 | < 3.000 | < 5.402 | < 2.701 |
| 3703 | MLA OPERATOR | 08 | 3 | 375 | 487.739 | 6.000 | 12.302 | 12.302 |
| 3883 | BLENDER FOREMAN | 08 | 3 | 378 | 491.641 | < 3.000 | < 6.102 | < 3.051 |
| 4013 | ALLOY CHARGE POT OPERATOR | 08 | 3 | 430 | 563.543 | 490.000 | 869.499 | 869.499 |
| 4273 | B-2 FURNACE OPERATOR | 08 | 3 | 204 | 257.228 | 51.000 | 198.268 | 198.268 |
| 4353 | A FURNACE OPERATOR | 08 | 3 | 449 | 526.033 | 13.000 | 24.713 | 24.713 |
| 4433 | ALLOY HOPPER BOOTH OPERATOR | 08 | 3 | 172 | 215.171 | 3.000 | 13.942 | 13.942 |

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TABLE A-9 (cont)

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

REAGENT LEAD

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | ANALYTICAL RESULTS (UG) | CONCENTRATION (UG/CU.M.) | TWA CONCENTRATION (UG/CU.M.) |
|---|---|---|---|---|---|---|---|---|
| 4513 | FURNACE RELIEF OPERATOR | 08 | 3 | 454 | 554.429 | 26.000 | 46.895 | 46.895 |
| 7432 | CHIEF OPERATOR | 09 | 2 | 417 | 505.104 | 46.000 | 91.070 | 91.070 |
| 7512 | 2ND FLOOR OPERATOR | 09 | 2 | 423 | 545.970 | < 3.000 | < 5.495 | < 2.747 |
| 7772 | BLENDER FOREMAN | 09 | 2 | 354 | 414.734 | < 3.000 | < 7.234 | < 3.617 |
| 7852 | 3RD FLOOR OPERATOR | 09 | 2 | 421 | 447.250 | < 5.000 | < 11.179 | < 5.590 |
| 8082 | BLENDER OPERATOR | 09 | 2 | 402 | 447.022 | < 5.000 | < 11.185 | < 5.593 |
| 8162 | 2ND FLOOR OPERATOR | 09 | 2 | 424 | 509.373 | < 5.000 | < 9.816 | < 4.908 |
| 8242 | ALLOY CHARGE POT OPERATOR | 09 | 2 | 428 | 599.167 | 100.000 | 166.899 | 166.899 |
| 8322 | BLENDER OPERATOR | 09 | 2 | 372 | 454.290 | < 5.000 | < 11.006 | < 5.503 |
| 8402 | 4TH FLOOR OPERATOR | 09 | 2 | 416 | 557.586 | < 5.000 | < 8.967 | < 4.484 |
| 8582 | ALLOY HOPPER BOOTH OPERATOR | 09 | 2 | 434 | 491.224 | 9.000 | 18.322 | 18.322 |
| 8662 | 4TH FLOOR OPERATOR | 09 | 2 | 418 | 460.664 | < 5.000 | < 10.854 | < 5.427 |
| 8742 | B-2 FURNACE OPERATOR | 09 | 2 | 432 | 373.154 | 17.000 | 45.558 | 45.558 |
| 8822 | A FURNACE OPERATOR | 09 | 2 | 438 | 552.284 | 8.000 | 14.485 | 14.485 |
| 0033 | B-1 FURNACE OPERATOR | 09 | 2 | 445 | 379.965 | < 5.000 | < 13.159 | < 6.580 |

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TABLE A-9 (cont)

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

REAGENT: LEAD

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | ANALYTICAL RESULTS (UG) | CONCENTRATION (UG/CU.M.) | TWA CONCENTRATION (UG/CU.M.) |
|---|---|---|---|---|---|---|---|---|
| 0113 | PIPEFITTER (FURNACE AREA) | 10 | 1 | 434 | 547.240 | 5.000 | 9.137 | 9.137 |
| 0373 | MACHINIST..... | 10 | 1 | 437 | 546.684 | 7.000 | 12.804 | 12.804 |
| 0533 | B-1 FURNACE OPERATOR | 10 | 1 | 399 | 503.108 | 7.000 | 13.914 | 13.914 |
| 0613 | 3RD FLOOR OPERATOR | 10 | 1 | 406 | 528.058 | < 5.000 | < 9.469 | < 4.734 |
| 0873 | ELECTRICIAN | 16 | 1 | 459 | 555.977 | 12.000 | 21.584 | 21.584 |
| 1003 | OUTSIDE MACHINIST (FURNACE AREA) | 10 | 1 | 433 | 507.288 | < 5.000 | < 9.856 | < 4.928 |
| 1343 | ALLOY CHARGE POT OPERATOR | 10 | 1 | 396 | 495.394 | 28.000 | 56.521 | 56.521 |
| 1263 | OUTSIDE MACHINIST (FURNACE AREA) | 10 | 1 | 435 | 444.848 | 11.000 | 24.728 | 24.728 |
| 1423 | OUTSIDE MACHINIST (1ST FLOOR ALLOY) | 10 | 1 | 435 | 565.777 | 7.000 | 12.372 | 12.372 |
| 1843 | FURNACE SWINGMAN | 10 | 1 | 383 | 498.144 | 10.000 | 20.075 | 20.075 |
| 2073 | 2ND FLOOR OPERATOR | 10 | 1 | 418 | 543.666 | 7.000 | 12.876 | 12.876 |
| 2573 | BLENDER OPERATOR | 10 | 1 | 440 | 524.226 | 6.000 | 11.445 | 11.445 |
| 2653 | BLENDER TRAINEE | 10 | 1 | 442 | 579.270 | < 5.000 | < 8.632 | < 4.316 |
| 2733 | ELECTRICIAN | 10 | 1 | 439 | 553.545 | < 5.000 | < 9.033 | < 4.516 |
| 0453 | TEL OFFICE | 10 | 1 | 370 | 517.971 | < 5.000 | < 9.653 | |

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TABLE A-9 (cont)

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

H REAGENT LEAD

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | | ANALYTICAL RESULTS (UG) | | CONCENTRATION (UG/CU.M.) | | TWA CONCENTRATION (UG/CU.M.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | < 4.827 |
| 1503 | CHANGE ROOM (CONTAMINATED SIDE) | 10 | 1 | 363 | 400.050 | < | 5.000 | < | 12.498 | | |
| | | | | | | | | | | | < 6.249 |
| 1683 | CHANGE ROOM (CLEAN SIDE) | 10 | 1 | 360 | 439.635 | < | 5.000 | < | 11.373 | | |
| | | | | | | | | | | | < 5.687 |
| 2153 | IH OFFICE | 10 | 1 | 394 | 457.685 | < | 5.000 | < | 10.925 | | |
| | | | | | | | | | | | < 5.462 |
| 5163 | 4TH FLOOR OPERATOR | 08 | 1 | 354 | 474.484 | < | 3.000 | < | 6.323 | | |
| | | | | | | | | | | | < 3.161 |

EC 3051

TABLE A-10

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

REAGENT ETHYLENE DIBROMIDE

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | ANALYTICAL RESULTS (MG) | CONCENTRATION (MG/CU.M.) | TWA CONCENTRATION (MG/CU.M.) |
|---|---|---|---|---|---|---|---|---|
| 8071 | BLENDER OPERATOR | 08 | 1 | 297 | 60.373 | < 0.010 | < 0.166 | < 0.083 |
| 8151 | BLENDER OPERATOR | 08 | 1 | 333 | 32.055 | < 0.010 | < 0.312 | < 0.156 |
| 7421 | BLENDER OPERATOR | 08 | 3 | 387 | 77.021 | < 0.010 | < 0.130 | < 0.065 |
| 7681 | MLA OPERATOR | 08 | 3 | 374 | 80.518 | < 0.010 | < 0.124 | < 0.062 |
| 7603 | BLENDER OPERATOR | 09 | 2 | 396 | 68.368 | < 0.010 | < 0.146 | < 0.073 |
| 7523 | BLENDER OPERATOR | 09 | 2 | 370 | 73.364 | < 0.010 | < 0.136 | < 0.068 |
| 7341 | BLENDER OPERATOR | 10 | 1 | 440 | 115.601 | < 0.010 | < 0.087 | < 0.043 |
| 7001 | BLENDER TRAINEE | 10 | 1 | 441 | 92.341 | < 0.010 | < 0.108 | < 0.054 |
| 8571 | EDB | 08 | 1 | 337 | 40.533 | < 0.010 | < 0.247 | < 0.123 |
| 8311 | EDC | 08 | 1 | 333 | 90.766 | < 0.010 | < 0.110 | < 0.055 |
| 7501 | 2ND FLOOR BLENDING | 08 | 3 | 395 | 81.153 | < 0.010 | < 0.123 | < 0.062 |
| 7761 | 3RD FLOOR BLENDING | 08 | 3 | 400 | 71.866 | < 0.010 | < 0.139 | < 0.070 |
| 7841 | 1ST FLOOR BLENDING | 08 | 3 | 386 | 68.973 | < 0.010 | < 0.145 | < 0.072 |
| 7283 | 2ND FLOOR BLENDING | 09 | 2 | 406 | 89.608 | < 0.010 | < 0.112 | < 0.056 |
| 7443 | 3RD FLOOR BLENDING | 09 | 2 | 409 | 91.837 | < 0.010 | < 0.109 | < 0.054 |
| 7363 | 1ST FLOOR BLENDING | 09 | 2 | 397 | 93.469 | < 0.010 | < 0.107 | < 0.053 |
| 7181 | 2ND FLOOR BLENDING | 10 | 1 | 432 | 77.017 | < 0.010 | < 0.130 | |

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TABLE ( ) (cont)

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

REAGENT ETHYLENE DIBROMIDE

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | ANALYTICAL RESULTS (MG) | CONCENTRATION (MG/CU.M.) | TWA CONCENTRATION (MG/CU.M.) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | < 0.065 |
| 6871 | 3RD FLOOR BLENDING | 10 | 1 | 430 | 88.972 | < 0.010 | < 0.112 | |
| | | | | | | | | < 0.056 |
| 7261 | 1ST FLOOR BLENDING | 10 | 1 | 441 | 102.099 | < 0.010 | < 0.098 | |
| | | | | | | | | < 0.049 |

EC 3053

TABLE A-11

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

REAGENT ETHYLENE DICHLORIDE

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | ANALYTICAL RESULTS (MG) | CONCENTRATION (MG/CU.M.) | TWA CONCENTRATION (MG/CU.M.) |
|---|---|---|---|---|---|---|---|---|
| 8071 | BLENDER OPERATOR | 08 | 1 | 297 | 60.373 | < 0.010 | < 0.166 | < 0.083 |
| 8151 | BLENDER OPERATOR | 08 | 1 | 333 | 32.055 | < 0.010 | < 0.312 | < 0.156 |
| 7421 | BLENDER OPERATOR | 08 | 3 | 387 | 77.021 | < 0.010 | < 0.130 | < 0.065 |
| 7681 | MLA OPERATOR | 08 | 3 | 374 | 80.518 | < 0.010 | < 0.124 | < 0.062 |
| 7603 | BLENDER OPERATOR | 09 | 2 | 396 | 68.368 | < 0.010 | < 0.146 | < 0.073 |
| 7523 | BLENDER OPERATOR | 09 | 2 | 370 | 73.364 | < 0.010 | < 0.136 | < 0.068 |
| 7341 | BLENDER OPERATOR | 10 | 1 | 440 | 115.601 | < 0.010 | < 0.087 | < 0.043 |
| 7001 | BLENDER TRAINEE | 10 | 1 | 441 | 92.341 | < 0.010 | < 0.108 | < 0.054 |
| 8571 | EDB | 08 | 1 | 337 | 40.533 | < 0.010 | < 0.247 | < 0.123 |
| 8311 | EDC | 08 | 1 | 333 | 90.766 | < 0.010 | < 0.110 | < 0.055 |
| 7501 | 2ND FLOOR BLENDING | 08 | 3 | 395 | 81.153 | < 0.010 | < 0.123 | < 0.062 |
| 7761 | 3RD FLOOR BLENDING | 08 | 3 | 400 | 71.866 | < 0.010 | < 0.139 | < 0.070 |
| 7841 | 1ST FLOOR BLENDING | 08 | 3 | 386 | 68.973 | < 0.010 | < 0.145 | < 0.072 |
| 7283 | 2ND FLOOR BLENDING | 09 | 2 | 406 | 89.608 | < 0.010 | < 0.112 | < 0.056 |
| 7443 | 3RD FLOOR BLENDING | 09 | 2 | 409 | 91.837 | < 0.010 | < 0.109 | < 0.054 |
| 7363 | 1ST FLOOR BLENDING | 09 | 2 | 397 | 93.469 | < 0.010 | < 0.107 | < 0.053 |
| 7181 | 2ND FLOOR BLENDING | 10 | 1 | 432 | 77.017 | < 0.010 | < 0.130 | |

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TABLE A-11 (cont)

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

REAGENT ETHYLENE DICHLORIDE

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | ANALYTICAL RESULTS (MG) | CONCENTRATION (MG/CU.M.) | TWA CONCENTRATION (MG/CU.M.) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | < 0.065 |
| 6871 | 3RD FLOOR BLENDING | 10 | 1 | 430 | 88.972 | < 0.010 | < 0.112 | |
| | | | | | | | | < 0.056 |
| 7261 | 1ST FLOOR BLENDING | 10 | 1 | 441 | 102.099 | < 0.010 | < 0.098 | |
| | | | | | | | | < 0.049 |

EC 3055

TABLE A-12

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

REAGENT ETHYL CHLORIDE

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | ANALYTICAL RESULTS (MG) | CONCENTRATION (MG/CU.M.) | TWA CONCENTRATION (MG/CU.M.) |
|---|---|---|---|---|---|---|---|---|
| 6462 | 4TH FLOOR OPERATOR | 08 | 1 | 128 | 26.141 | < 0.010 | < 0.383 | |
| 6542 | 4TH FLOOR OPERATOR | 08 | 1 | 128 | 26.141 | < 0.010 | < 0.383 | |
| 6622 | 4TH FLOOR OPERATOR | 08 | 1 | 213 | 43.626 | < 0.010 | < 0.229 | |
| 6702 | 4TH FLOOR OPERATOR | 08 | 1 | 213 | 43.626 | < 0.010 | < 0.229 | |
| | | | | | | | | < 0.143 |
| 0362 | 4TH FLOOR OPERATOR | 10 | 1 | 415 | 62.412 | 0.020 | 0.320 | |
| 0442 | 4TH FLOOR OPERATOR | 10 | 1 | 415 | 62.412 | < 0.010 | < 0.160 | |
| | | | | | | | | 0.200 |
| 6042 | B-8 | 08 | 1 | 201 | 42.330 | < 0.010 | < 0.236 | |
| 6122 | B-8 | 08 | 1 | 201 | 42.330 | < 0.010 | < 0.236 | |
| 6202 | B-8 | 08 | 1 | 153 | 28.896 | < 0.010 | < 0.346 | |
| 6382 | B-8 | 08 | 1 | 153 | 28.896 | < 0.010 | < 0.346 | |
| | | | | | | | | < 0.142 |
| 6882 | B-9 | 08 | 1 | 200 | 34.693 | < 0.010 | < 0.288 | |
| 7012 | B-9 | 08 | 1 | 200 | 34.693 | < 0.010 | < 0.288 | |
| 7272 | B-9 | 08 | 1 | 151 | 25.520 | < 0.010 | < 0.392 | |
| 7352 | B-9 | 08 | 1 | 151 | 25.520 | < 0.010 | < 0.392 | |
| | | | | | | | | < 0.166 |
| 5572 | B-4 | 08 | 1 | 200 | 30.543 | < 0.010 | < 0.327 | |
| 5652 | B-4 | 08 | 1 | 200 | 30.543 | < 0.010 | < 0.327 | |
| 5732 | B-4 | 08 | 1 | 156 | 24.936 | < 0.010 | < 0.401 | |
| 5812 | B-4 | 08 | 1 | 156 | 24.936 | < 0.010 | < 0.401 | |
| | | | | | | | | < 0.180 |
| 5072 | B-13 | 08 | 1 | 200 | 41.722 | < 0.010 | < 0.240 | |
| 5152 | B-13 | 08 | 1 | 200 | 41.722 | < 0.010 | < 0.240 | |
| 5232 | B-13 | 08 | 1 | 147 | 30.706 | < 0.010 | < 0.326 | |
| 5312 | B-13 | 08 | 1 | 147 | 30.706 | < 0.010 | < 0.326 | |
| | | | | | | | | < 0.138 |
| 2722 | B-9 | 08 | 3 | 243 | 56.137 | 0.050 | 0.891 | |
| 3032 | B-9 | 08 | 3 | 161 | 36.067 | 0.030 | 0.832 | |
| 2802 | B-9 | 08 | 3 | 243 | 56.137 | < 0.010 | < 0.178 | |
| 3112 | B-9 | 08 | 3 | 161 | 36.407 | < 0.010 | < 0.275 | |
| | | | | | | | | < 0.488 |
| 3372 | B-6 | 08 | 3 | 240 | 47.769 | 0.020 | 0.419 | |
| 3532 | B-6 | 08 | 3 | 162 | 31.363 | 0.020 | 0.638 | |
| 3452 | B-6 | 08 | 3 | 240 | 47.769 | < 0.010 | < 0.209 | |
| 3612 | B-6 | 08 | 3 | 162 | 31.363 | < 0.010 | < 0.319 | |
| | | | | | | | | < 0.317 |
| 3872 | B-2 | 08 | 3 | 236 | 28.779 | < 0.010 | < 0.347 | |
| 4002 | B-2 | 08 | 3 | 236 | 28.779 | < 0.010 | < 0.347 | |
| 4182 | B-2 | 08 | 3 | 163 | 4.357 | < 0.010 | < 2.295 | |

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TABLE A-12 (cont)

SUMMARY OF SAMPLES TAKEN ON
APRIL 8-10,1980
ETHYL CORPORATION
PASADENA, TX

REAGENT ETHYL CHLORIDE

| SAMPLE NUMBER | JOB TITLE/LOCATION | DATE | SHIFT | SAMPLE TIME (MINUTES) | SAMPLE VOLUME (LITERS) | ANALYTICAL RESULTS (MG) | CONCENTRATION (MG/CU.M.) | TWA CONCENTRATION (MG/CU.M.) |
|---|---|---|---|---|---|---|---|---|
| 4262 | B-2 | 08 | 3 | 163 | 4.357 | < 0.010 | < 2.295 | |
| | | | | | | | | < 0.572 |
| 4342 | B-5 | 08 | 3 | 238 | 61.422 | 0.020 | 0.326 | |
| 4502 | B-5 | 08 | 3 | 162 | 42.964 | 0.020 | 0.466 | |
| 4422 | B-5 | 08 | 3 | 238 | 61.422 | < 0.010 | < 0.163 | |
| 4682 | B-5 | 08 | 3 | 162 | 42.964 | < 0.010 | < 0.233 | |
| | | | | | | | | < 0.239 |
| 0522 | B-8 | 09 | 2 | 225 | 59.856 | 0.020 | 0.334 | |
| 0782 | B-8 | 09 | 2 | 190 | 48.707 | 0.010 | 0.205 | |
| 0602 | B-8 | 09 | 2 | 225 | 59.856 | < 0.010 | < 0.167 | |
| | | | | | | | | < 0.208 |
| 1172 | B-12 | 09 | 2 | 225 | 45.828 | 0.020 | 0.436 | |
| 1332 | B-12 | 09 | 2 | 188 | 37.874 | 0.010 | 0.264 | |
| 1252 | B-12 | 09 | 2 | 225 | 45.828 | < 0.010 | < 0.218 | |
| 1412 | B-12 | 09 | 2 | 188 | 37.874 | < 0.010 | < 0.264 | |
| | | | | | | | | < 0.239 |
| 2062 | B-4 | 09 | 2 | 223 | 44.656 | 0.020 | 0.448 | |
| 1832 | B-4 | 09 | 2 | 223 | 44.656 | < 0.010 | < 0.224 | |
| | | | | | | | | < 0.280 |
| 2142 | B-3 | 09 | 2 | 223 | 37.675 | 0.010 | 0.265 | |
| 2562 | B-3 | 09 | 2 | 194 | 35.114 | 0.010 | 0.285 | |
| 2222 | B-3 | 09 | 2 | 223 | 37.675 | < 0.010 | < 0.265 | |
| 2642 | B-3 | 09 | 2 | 194 | 35.114 | < 0.010 | < 0.285 | |
| | | | | | | | | < 0.206 |
| 8431 | B-7 | 10 | 1 | 418 | 88.287 | 0.030 | 0.340 | |
| 8731 | B-7 | 10 | 1 | 418 | 88.922 | 0.030 | 0.337 | |
| 8651 | B-7 | 10 | 1 | 418 | 88.287 | < 0.010 | < 0.113 | |
| 8731 | B-7 | 10 | 1 | 418 | 88.922 | < 0.010 | < 0.112 | |
| | | | | | | | | < 0.198 |
| 8811 | B-15 | 10 | 1 | 417 | 84.903 | 0.040 | 0.471 | |
| 0022 | B-15 | 10 | 1 | 417 | 84.903 | < 0.010 | < 0.118 | |
| | | | | | | | | < 0.265 |
| 0102 | B-1 | 10 | 1 | 418 | 58.519 | 0.030 | 0.513 | |
| 0282 | B-1 | 10 | 1 | 418 | 58.519 | < 0.010 | < 0.171 | |
| | | | | | | | | < 0.299 |

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