INDEPTH INDUSTRIAL HYGIENE REPORT OF ETHYLENE OXIDE EXPOSURE AT UNION CARBIDE CORPORATION SOUTH CHARLESTON, WEST VIRGINIA

SURVEY CONDUCTED BY:
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DATE OF SURVEY

May 30 - June 1, 1978

REPORT WRITTEN BY

James L. Oser

DATE OF REPORT

August 17, 1979

Industrial Hygiene Section
Industry-wide Studies Branch
Division of Surveillance, Hazard Evaluations and Field Studies
National Institute for Occupational Safety and Health
Cincinnati, Ohio

PURPOSE OF SURVEY:	The purpose of this survey is to evaluate worker exposure to ethylene oxide and other potential exposures in the work environment. This study was conducted as part of the NIOSH project to conduct mortality studies of ethylene oxide at Union Carbide.
EMPLOYER REPRESENTATIVE CONTACTED:	Mr. Robert W. Cope C & P Industrial Hygiene Manager (304) 747-2346 Mr. John R. Soice Senior Engineer (304) 747-2125 Mr. W.C. Young Senior Industrial Hygienist (304) 747-2434
EMPLOYEE REPRESENTATIVE CONTACTED:	Mr. J.C. Copenhaver Local 598 International Association of Machinists and Aerospace Workers 200 7th Ave. South Charleston, West Virginia
ACKNOWLEDGEMENTS:	Karen Stephenson, Chemist Utah Biomedical Test Laboratory Charles Geraci, Ph.D., Coordinating Chemist, NIOSH
STANDARD INDUSTRIAL CLASSIFICATION OF PLANT:	2869

INTRODUCTION

Authority

NIOSH has been granted the authority and responsibility under the "Occupational Safety and Health Act of 1970" to conduct field research studies in industry, evaluate findings and report on these findings. Section 20(a)7 states that NIOSH shall conduct and publish industrywide studies of the effects of chronic or low-level exposure to industrial materials, processes, and stresses on the potential for illness, disease or loss of functional capacity in aging adults.

Purpose of the Study

There are many chemicals used in industry for which there are insufficient data and experience to determine the exent of worker exposure and the long-term biological effects on exposed workers. Additionally, there is a need to determine the effectiveness of control measures presently in use by industry, and identify work practices and other control methods which would limit worker exposures. The primary purposes of the industrial hygiene study are to determine worker exposure and to document existing engineering controls, work practices, administrative controls, and biological and environmental sampling requirements and control procedures.

Field studies of industrial exposure to ethylene oxide resulted from NIOSH and industry concern demonstrated by reports of sterility and mutagenistic testing. Ethylene oxide was identified by NIOSH as a chemical agent for study under the contract Investigation of Industries with Agents which are newly Suspected as Occupational Health Hazards. A preliminary survey of the Institute plant was conducted by SRI, Industries under NIOSH contract on June 13-14, 1977. NIOSH is presently engaged in an ethylene oxide mortality study of workers at the Institute and South Charleston plants. This industrial hygiene study was conducted to complement these efforts.

Limitations of Study

The industrial hygiene surveys represent singular evaluations of worker exposures and do not reflect possible variations in exposure due to seasonal or operational changes. An attempt was made to evaluate exposures for each job type as encountered during all work shifts. These studies were made during periods of normal production. Ethylene oxide is highly soluble with water. Rain occurred several times during the course of the survey, which could have an effect on the reported exposure levels.

Generally, the samples do not reflect exposures during maintenance operations. Routine maintenance is often accomplished at specified times during the year. On these occasions, safety procedures which are designed to minimize exposure are followed. On-stream maintenance or repair work is common and may result in short-term exposure.

DESCRIPTION OF THE FACILITY

The Union Carbide Institute Plant is located in the Kanawha Valley in South Charleston, West Virginia. Operations at this site commenced in 1925 and has undergone continual change and expansion. The plant site occupies 230 acres and 36 major buildings. There are four major production areas where ethylene oxide are presently used in the production of chemical products. Ethylene oxide was produced from 1929 to 1937 by the Chlorohydrin process and from 1937-1973 by the direct oxidation process. Presently, ethylene oxide is pumped from Union Carbide Institute plant for storage and subsequent use in manufacture of a variety of ethylene oxide derivatives at South Charleston plant. These are: (1) Flexible Polyols Unit, Bldg. 216 and 225, (2) Polymer Polyols Unit, Bldg. 103, (3) Oxide Adducts, Mainland Chemical Complex, Bldg. 36, and (4) Alkanolamines & Glycol Ether Production Mainland Chemical Complex, Bldg. 42. The Alkanolamines and Glycol Ether Unit was using ethylene oxide at the time of this study.

Ethylene oxide was produced in the South Charleston Plant in Units IV and VI between 1937 and 1973 by direct oxidation method and earlier by the chlorohydrin process. Through 1960, the operation was manned during each shift by one chief operator or foreman who spent part of his time in the units, and four operators. After 1960, two and one-half operators and a part-time chief operator or foreman per shift worked in ethylene oxide production. All the workers spent the major part of their time inside the control room (not closed or air-conditioned) with the exception of the relief man who was outside most of the time. The process employed the direct oxidation of ethylene and reached a peak production of ethylene oxide of 40 million pounds per year.

Since its beginning in 1925, the South Charleston Plant has been engaged in the manufacture of many derivatives of ethylene that have since been terminated. Ethylene chlorohydrin production began in 1925 and ended in 1940; ethylene glycol ran from 1929 until 1960; aminoethylethanolamine was produced on an intermittent basis between 1952 and 1961; and alkylamines from 1954 to 1963. CELLOSIZE^{R}, certain UCON^{R} fluids and lubricants methyl and ethyl CELLOSOLVE^{R} solvents methyl and ethyl CARBITOL^{R}, certain alkanolamines, CARBOWAX^{R} polyethylene and glycols, TERGITOL^{R} surfactant, butyl CARBIT L^{R}, and butyl CELLOSOLVE^{R} were all made at the South Charleston plant.

DESCRIPTION OF THE WORKFORCE

The present plant employs about 1700 and operates 24 hours per day, 7 days per week, with four rotating shifts.

The potential for ethylene oxide exposure to occur presently exists, in the Flexible Polyols Unit with about 17 workers, Polymer Bolyol Unit with about 22 workers, Oxide Adducts Unit with about 31 workers, and Alkanolamines and Glycol Ether Unit with about 15 workers. The job titles and number of workers exposed for each job title is presented in the Appendix. The primary job titles involved with exposure to ethylene oxide are the chemical operators, particularly the outside operators responsible for making transfers from reactors and taking quality control samples. Laboratory personnel can experience significant short term exposures in handling and testing samples but were not included in the South Charleston Plant study. Job descriptions are presented in the Appendix.

DESCRIPTION OF PROCESSES

E.O. Distribution System

Ethylene oxide is delivered via a pipeline from the Institute Plant to a 44,000 gallon underground storage tank at the South Charleston Plant. A flame arrestor is installed on the inlet and outlet of the storage tank. Ethylene oxide is distributed to the use areas in closed system pipelines; one pipeline feeds the Mainland Chemical Complex (Buildings 36 and 42) and the other pipeline feeds the Polyols areas (Buildings 103, 196, & 216). Quantities of ethylene oxide are routed off the main pipeline as required by the individual derivative producers. The pressure in the line is maintained at 225 psig until it reaches the feed valves into the reaction systems at which point it is reduced to approximately 75 psig. Throughout the system, a series of back-flow regulators and double valves are placed in-line to prevent backflow from the reactors into the ethylene oxide distribution system. Also, safety valves are installed in the pipelines to prevent overpressuring.

Flexible Polyols

The Flexible Polyol Unit extends into several buildings including 103, 196, 216 and 225. The sampling survey was conducted out of buildings 216 and 225. The flexible polyols are polymer feed products that are marketed as a variety of polymer chemicals under the trade name of NIAX. The basic process involves reacting ethylene oxide or propylene oxide with glycerine or propylene glycol and a potassium hydroxide catalyst. The oxides are totally consumed by the reaction. Isopropyl alcohol and allyl alcohol may be used as dilutants.

Ethylene oxide is contained in a closed system including storage tank, feed tank and reactor. Exposure to ethylene oxide would occur from system leaks or accidental spills.

Oxide Adducts

The Mainland Chemical Complex is involved in the production of fire-safe hydraulic fluids, specialty heat transfer fluids, hydraulic lubricants, specialty glycol-ethers (CELLOSOLVE^{R} Solvents) and alkanolamines. All of these include adducts of ethylene oxide. The various hydraulic fluids and lubricants are made in Building 36 in batch reactors. Ethylene oxide or propylene oxide or a mixture of the two is added at a controlled rate to the reactor which contains a heated mixture of a monohydric or dihydric starting alcohol and catalyst. Normal venting of the reactor is allowed only after a complete reaction of all contained oxides.

A variety of oxide adducts have been produced at the South Charleston Plant since 1943, the nature and quantities of each is dependent upon customer needs. There are 5 batch reactors in which ethylene oxide and/or propylene oxide are reacted to produce about 40 different products. Processing is computer controlled. The reaction systems are totally enclosed, allowing very little escape of gas. Routine industrial hygiene measurements taken in the area indicate personnel exposure to be less than 5 ppm ethylene oxide.

Quality control sampling of the main storage tank is performed by the operator of the Oxide Adduct Unit about once per week.

Alkanolamines and Glycol Ether

In Building 42, Mainland Chemical Complex, there are two reactors; the alkanolamines reactor, which reacts ethylene oxide and amines to produce alkanolamines, and the glycol-ethers reactor, which reacts a monohydric alcohol with either ethylene oxide to produce ethoxylates (such as hexyl CELLOSOLVE^{R}) or with propylene oxide to produce propoxylates such as PROPASOL B. Again, the oxides are totally consumed by the reaction.

DESCRIPTION OF PAST EXPOSURES

Air monitoring for ethylene oxide levels was conducted by Union Carbide between December of 1975 to present for various locations and job classifications at the South Charleston facility. A summation of data provided by management for personal sampling is presented in the Appendix. These data provide extensive information on the personal exposure levels (TWA's) to plant operators in all the operating units considered in this evaluation.

DESCRIPTION OF INDUSTRIAL HYGIENE MEDICAL AND SAFETY PROGRAMS

The Industrial Hygiene Program is under the direction of Mr. J. L. Worstell, Department Head, Environmental Protection/Occupational Health, and includes two full-time industrial hygienists. They are responsible for the monitoring of operations involving toxic chemicals and for providing assistance to production units. Support for this group is available from the UCC Chemical

and Plastics Division Technical Center, where Mr. Cope is located. The program is supported by the Quality Assurance Laboratory which performs the analysis on samples collected by the industrial hygiene personnel.

The Medical Program includes two full-time physicians, Drs. R.W. Holland, and B.A. Foster. They have a staff of seven licensed registered nurses and there are at least five persons per shift who have received formal emergency medical training.

All new employees are required to take a pre-employment medical examination. Periodic examinations are offered. Chest x-rays, hearing, visual, and lung function tests are performed, in addition to biological tests on blood and urine.

The Safety Program is directed by Mr. W.B. Troutman, and involves twenty professionals and technical personnel. During 1976, the South Charleston Plant had six disabling injury accidents. Meetings between employees and management personnel are conducted on a regular basis to discuss and work on problems involving safety.

Union Carbide requires that every employee wear a safety hat and safety glasses in the production areas. In specialized operations in which additional equipment may be necessary, the plant provides appropriate protective clothing and gloves, safety shoes, and respirators. Change rooms, lockers and showers are available for the employees. Smoking in the production areas is strictly prohibited.

INSPECTION OF THE PLANT

Ethylene oxide is recognized to be extremely flammable and a highly reactive material. Plant design in storage, transfer and reacting ethylene oxide is such as to perclude fire danger and runaway reactions. Thus, all handling, storage, transfer reaction processes are performed outdoors in a tightly closed process system. All pumps, connections and seals are periodically checked and maintained to prevent accidents or leakage. Several other hazardous and dangerous chemicals are handled and/or processed in the ethylene oxide production units or in adjacent units.

Union Carbide has a plant wide alert alarm system designed to inform all employees when leaks are located or accidents result anywhere in the plant. Routine maintenance of process equipment is performed by Union Carbide employees. Construction of new processes or installation of new equipment may be done by outside contractors.

Potential health exposures in the ethylene oxide processing areas given consideration in this survey are presented in the Appendix for each unit. Sampling was conducted for ethylene oxide, propylene oxide and isopropyl alcohol and allyl alcohol.

DISCUSSION OF SURVEY METHODS

Personal air monitoring was conducted over the three working shifts for each unit. Ethylene oxide sampling was conducted in accordance with the NIOSH sampling data sheet No. 5286 except that a special type charcoal, Columbia JXC, was used in two 600 mg tubes in series. Sampling methods for propylene oxide and isopropyl alcohol are NIOSH #575 and 565 respectively. These methods used the standard 150 mg, 20/40 mesh, charcoal tubes. All samples were taken for approximately 6 hours at about 50 cc per minute. Relative humidity determinations were recorded at various locations using the standard wet bulb and dry bulb therometer readings. These air samples were analysed by NIOSH under contract with Utah Biomedical Test Laboratory in Salt Lake City. Analysis was performed by gas chromatograph according to appropriate NIOSH analytical methods. The limit of analytical detection was determined to be 0.02 mg per tube for ethylene oxide and isopropal alcohol. The existing Federal air standard for ethylene oxide is 50 ppm; for propylene oxide is 100 ppm; and, for isopropyl alcohol is 400 ppm based on an eight hour time weighted average exposure level.

RESULTS

The results of ethylene oxide personal air monitoring data for the operating units are presented in the Appendix, Table 1. Similarly, results for propylene oxide are presented in Table 2 and isopropyl alcohol and allyl alcohol in Table 3. Table 4 presents the results of relative humidity readings.

Ethylene oxide exposure levels were determined to be below the analytical detection limit of 0.02 mg per sample for all but five sample results. Four of these samples were in Oxide Adducts with reportable levels of 11 and 23 ppm for outside operators and 1.5 and 3.5 for the utility mechanic.

Propylene Oxide samples that were taken indicated low levels and low exposure (0.2 to 2.5 for 5 reportable samples in PP and OA). Results were determined to be not detectable based on the analytical limit of 0.01 mg per sample for all samples collected in the Flexible Polyol Unit. A level of 1.5 ppm propylene oxide is reported for an inside operator at the Flexible Polyol Unit.

Isopropyl alcohol and allyl alcohol samples were taken for operators. Reportable samples varied from 0.2 to 1.2 ppm for all isopropyl alcohol samples and from 0.4 to 4.5 ppm for allyl alcohol.

Weather conditions during the survey period were intermittent rain; cloudy with periods of sunshine and temperatures in the 70°F. The relative humidity readings varied inside operating units 50 to 60% and outside 60 to 80%.

ANALYSIS AND DISCUSSION

The intermittent rain during the survey period may have effectively reduced ethylene oxide exposure levels for outside operators. However, the past exposure data supplied by Union Carbide confirms that personnel exposures in operating units is generally low.

CONCLUSIONS AND RECOMMENDATIONS

Results of personal sampling for ethylene oxide and other chemicals sampled at the South Charleston facility were low or generally below the limits of analytical detection for the methods employed. The Alkanolamines and Glycol Ethers Unit was down and not sampled.

Additional environmental studies should be considered if the ongoing NIOSH mortality study of workers presents positive findings.

REFERENCES

1. NIOSH Manual of Analytical Methods, 2nd Edition, Vol. 1, 2 & 3, 1977. (NIOSH Publication No. 77-157, A, B, C).

2. NIOSH Manual of Sampling Data Sheets, 1977 Edition (NIOSH Publication No. 77-159). Supplement to the 1977 Edition, August 1978 (NIOSH Publication No. 77-189).

3. Special Occupational Hazard Review with Control Recommendations for the Use of Ethylene Oxide as a Sterilant in the Medical Facilities, prepared by Zorack R. Glaser, August 1977, (NIOSH Publication No. 77-200).

APPENDIX

TABLE 1

Ethylene Oxide
Personal Air Monitoring Data
Union Carbide
South Charles, West Virginia
May 30 - June 1, 1978

Department: Job Title	Date - Shift		Sample Volume Liters	Result mg/sample	ppm
Flexible Polyol:					
Inside Operator	5/30	2	21.6	N.D.*	
Outside Operator	"	2	23.0	N.D.	
Production Foreman	"	2	17.8	N.D.	
Inside Day Relief	5/31	1	18.7	N.D.	
Outside Operator	"	1	12.6	N.D.	
Production Supervisor	"	1	17.7	N.D.	
Inside Operator	6/1	3	11.8	N.D.	
Outside Operator	"	3	10.6	N.D.	
Polymer Polyol:					
Inside Operator	5/30	2	19.4	N.D.	
Inside Operator	"	2	17.3	N.D.	
Outside Operator	"	2	19.7	N.D.	
Pumper	"	2	19.5	N.D.	
Production Foreman	5/31	1	18.6	N.D.	
Production Foreman	"	1	16.7	N.D.	
Inside Operator	"	1	16.6	N.D.	
Inside Operator	"	1	18.7	N.D.	
Outside Operator	"	1	20.6	N.D.	
Pumper	"	1	15.7	N.D.	

Table 1 (Continued)

Department Job Title	Date - Shift		Sample Volume Liters	Results mg/sample	ppm
Production Foreman	6/1	3	16.5	N.D.	
Outside Operator	"	3	20.9	N.D.	
Inside Operator	"	3	17.3	0.05	1.6
Inside Operator	"	3	18.1	N.D.	
Oxide Adducts:					
Outside Operator	5/30	2	18.5	N.D.	
Outside Operator	"	2	20.4	N.D.	
Inside Operator	"	2	7.0	N.D.	
Production Supervisor	"	2	12.2	N.D.	
Outside Operator	5/31	1	15.6	N.D.	
Outside Operator	"	1	15.6	N.D.	
Pumper	"	1	13.0	N.D.	
Inside Operator	"	1	9.8	N.D.	
Outside Operator	"	1	12.3	0.24	11
Maintenance	"	1	18.0	N.D.	
Electrician	"	1	16.4	N.D.	
Production Supervisor	"	1	13.3	N.D.	
Instrument Person	"	1	10.8	N.D.	
Outside Operator	6/1	3	16.3	0.66	23
Outside Operator	"	3	15.9	N.D.	

Table 1 (Continued)

Department Job Title	Date - Shift	Sample Volume Liters	Results mg/sample	ppm
Production Supervisor	6/1 3	15.8	N.D.	
Inside Operator	" 3	15.9	N.D.	
Utility Mechanic	" 3	18.7	0.05	1.5
Utility Mechanic	" 3	17.4	0.11	3.5

* N.D. - Not detected based on analytical limit of 0.02 mg per sample

Table 2
Propylene Oxide
Personal Air Monitoring Data
Union Carbide
South Charleston, West Virginia
May 30 - June 1, 1978

Department: Job Title	Date - Shift		Sample Volume Liters	Results mg/sample	ppm
Flexible Polyol:					
Outside Operator	5/30	2	22.1	N.D.*	
Inside Day Relief	5/31	1	18.7	N.D.	
Outside Operator	5/31	1	19.1	N.D.	
Outside Operator	6/1	3	18.7	N.D.	
Polymer Polyol:					
Outside Operator	5/30	2	20.5	0.01	0.2
Inside Operator	5/31	1	15.7	0.03	0.8
Outside Operator	5/31	1	3.4	0.02	2.5
Outside Operator	6/1	3	18.8	0.07	1.5
Oxide Adducts:					
Outside Operator	5/30	2	22.3	0.01	0.2
Outside Operator	5/31	1	17.8	N.D.	
Pumper	5/31	1	8.5	N.D.	
Outside Operator	5/31	1	17.5	0.01	0.2
Outside Operator	6/1	3	24.0	0.03	0.5
Outside Operator	6/1	3	18.1	0.01	0.2

* N.D. = Not detected based on analytical limit of 0.01 mg per sample

Table 3
Isopropyl Alcohol and Allyl Alcohol
Personal Air Monitoring Data
Union Carbide
South Charleston, West Virginia
May 30 - June 1, 1978

Department: Job Title	Date - Shift	Sample Volume Liters	mg/sample IA	mg/sample AA	ppm IA	ppm AA
Flexible Polyol:						
Outside Operator	5/30 2	22.1	0.01	0.02	0.2	0.4
Inside Day Relief	5/31 1	18.7	0.01	0.04	0.2	0.9
Outside Operator	5/31 1	19.1	0.01	0.03	0.2	0.6
Outside Operator	6/1 1	18.7	0.01	0.03	0.2	0.6
Polymer Polyol:						
Outside Operator	5/30 2	20.5	0.01	0.03	0.2	0.6
Inside Operator	5/31 1	15.7	0.02	0.04	0.5	1.0
Outside Operator	5/31 1	3.4	0.01	0.04	1.2	4.7
Outside Operator	6/1 3	18.8	0.01	0.02	0.2	0.4
Oxide Adducts:						
Outside Operator	5/30 2	22.3	0.03	0.04	0.5	0.7
Outside Operator	5/30 2	20.4	0.01	0.02	0.2	0.4
Outside Operator	5/31 1	17.8	N.D.*	0.04		0.9
Pumper	5/31 1	8.5	N.D.	0.04		1.9
Outside Operator	5/31 1	17.5	0.01	0.04	0.2	0.9
Outside Operator	6/1 3	24.0	N.D.	N.D.		
Outside Operator	6/1 3	18.1	N.D.	N.D.		

*N.D. - Not detected based on the analytical limit of 0.01 mg per sample.

Table 4
Relative Humidity Date

Location	Date	Time - Shift	% R. H. Inside	Outside
Oxide Adducts	5/30	2200 - 2	60	77
Oxide Adducts	5/30	0715 - 1	58	70
Oxide Adducts	6/1	2400 - 3	50	60

Table 5
Union Carbide, South Charleston Plant
Present Employment Schedule

Location/Job Title	Day	Rotating	Total
Flexible Polyol:			
Inside Operator		1	4
Outside Operator		1	4
Foreman		1	4
Day Relief	1		1
Production Supervisor	1		1
Production Specialist	1		1
Production Engineer	1		1
Instrument Person (shared)	1		1
Polymer Polyol:			
Inside Operator		2	8
Outside Operator		2	8
Foreman		1	4
Production Supervisor	1		1
Instrument Person (shared)	1		1
Oxide Adducts:			
Inside Operator		1	4
Outside Operator (north & south)	1	2	9
Foreman		1	4
Instrument Person (shared)	1		1
Electrician (shared)	1		1

Table 5
(continued)

Location/Job Title	Day	Rotating	Total
Oxide Adducts:			
Maintenance	2		2
Day Relief	1		1
Miscellaneous (Technical Staff)	9		9
Alkanolamine & G.E.:			
Inside Operator		1	4
Outside Operator		1	4
Foreman		1	4
Miscellaneous (Technical Staff)	3		3

Table 6
Potential Health Exposures
In
Ethylene Oxide Processing Units
Union Carbide
South Charleston, W.Va.

Process or Unit	Potential Exposure Chemical	Number of Workers
Flexible Polyol	Ethylene Oxide Propylene Oxide Glycerine Potassium Hydroxide Isopropyl Alcohol	17
Polymer Polyols	Ethylene Oxide Propylene Oxide Isopropyl Alcohol Styrene Acrylonitrile	22
Oxide Adducts	Ethylene Oxide Propylene Oxide Allyl Alcohol Isopropyl Alcohol Isopropyl Ether Sulfuric Acid Potassium Hydroxide	31

E.O. Past Sampling Data (1976) reported by Union Carbide,
South Charleston, West Virginia

PLANT: 514 PROCESS AND/OR BUILDING NO.: Mainland Chemical Complex
Alkanolamines Unit - Bldg. 42

Job Title - Tasks	No. Of Samples	PPM Range			Time Weighted Average (8-Ho	
		Low	High	Mean	PPM Range	
-I Foreman	3 - Ct	0.10	0.21	0.14		0.08
-I AA Operator***	12 - Ct	0.18	66*	7.23		4.3
-II Pumper	10 - Ct	0.08	0.27	0.28		0.16
-I Instrument Mechanic	1 - Ct		0.08			0.08
-I AA Operator	3 - G	2.8	179**	75.2		0.53

*A Carbon Tube (CT) sample for 285 minutes sampling time.

**Grab (G) samples - 2.8 ppm - Operator opening ETOX vent line - 42-2 NE
179 ppm - Operator checking vent line at pump - 42-1 N
43.8 - Operator collecting liquid sample at GE-reactor

TWA based on 1 minute exposure time for these tasks.

***Re-evaluated October 1976

A - Operator 10/76 7 - Ct 0.08 2.2 1.0 0.46

PLANT: 514 PROCESS AND/OR BUILDING NO.: Oxide Adducts - Building 36

Job Title - Tasks	No. Of Samples	PPM Range			Time Weighted Average (8-Hou
		Low	High	Mean	PPM Range
P-II Control Board Operator	3 - Ct	ND	4.3	1.48	0.90
P-III North Side Operator	6 - Ct	ND	2.7	0.51	0.51
P-IV South Side Operator	10 - Ct	ND	1.1	0.25	0.25
P-IV Pumper	6 - Ct	ND	0.40	0.14	0.14
M-II Instrument Mechanic	7 - Ct	ND	0.30	0.10	0.05
M-III Electrician	1 - Ct		0.1		0.001
M-IV Rigger	1 - Ct		38.9*		2.4
*Remove filter housing lid, filters, purges with N_2 to remove H_2O, replaces filters					
A-II Foreman	5 - Ct	ND	0.30	0.14	0.14
P-III North Side Operator					
Washing Turbine Meter	1 - Ct	43.3			1.4
Collecting Sample No. 7 Reactor			5.6		0.01
Collecting Sample Tk. 9653	2 - Ct	522	512**	392	0.82
Washing Filters (LI)	1 - Ct		5.4		0.45
P-IV South Side Operator	1 - Ct		6.8		0.01
**Based on one minute samples		(TWA)	$\frac{392}{480}$ = 0.82		
			20		

PLANT: 514 PROCESS AND/OR BUILDING NO.: Flexible Polyol Building 103

Job Title - Tasks	No. Of Samples	PPM Range			Time Weighted Average (8-Hou
		Low	High	Mean	PPM Range
-V Instrument Mechanic	3 - Ct	0.13	0.64	0.44	0.18
-V Outside Operator	9 - Ct	0.1	63	8.	2.5
-VIII Flexible Operator	7 - Ct	0.1	4.0	0.45	0.27
-I Weighmaster	2 - Ct	<.1	<.1	<.1	< .1
-III Foreman	3 - Ct	< .1	1.0	1.0	0.50
-VI Still Operator	4 - Ct	<0.1	0.9	0.23	0.13
-VIII Flexible Polyol Operator	4 - G	<0.05	0.63	0.38	0.38

PLANT: 514 PROCESS AND/OR BUILDING NO.: Flexible Polyol - Bldg. 196

Job Title - Tasks	No. Of Samples	PPM Range			Time Weighted Average (8-Hou PPM Range
		Low	High	Mean	
--IX Reactor Operator	3 - Ct	0.1	4.3	2	1.2
--VI Instrument Mechanic	1 - Ct		<0.1		< 0.1
--IV Supervisor	1 - Ct		0.1		0.06

*A 287 minute carbon tube sample - routine operation - specific job task not defined.

PLANT: 514 PROCESS AND/OR BUILDING NO.: Chemical Mixing, Building 303

Job Title - Tasks	No. Of Samples	PPM Range			Time Weighted Average (8-Ho
		Low	High	Mean	PPM Range
—I Weighmaster	4 - Ct	ND	15.9	4.39	0.14
—II Supervisor	1 - Ct	-	6.0	-	0.19
—I Weighmaster	3 - G	0.03	0.98	0.35	0.04

PLANT: 514 PROCESS AND/OR BUILDING NO.: Plant Laboratory, Building 105 Room 209 (Shipments)

Job Title - Tasks	No. Of Samples	PPM Range			Time Weighted Average (8-Ho PPM Ran
		Low	High	Mean	
L-I Lab Analyst	1 - Ct		100*		2.7
L-II Q.C. Analyst	1 - Ct		122*		1.8
L-I Analyst	1 - G		59*		0.61
L-II Q.C. Analyst	2 - G	2.31	4.62	3.46	0.10

*Analytical work performed outside of a chemical fume hood.