EPICHLOROHYDRIN

Industrial Hygiene Survey Report
Dow Chemical, U.S.A.
Texas Division
Freeport, Texas

Survey Date: July 12-14, 1976
Contract No. 210-75-0064

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Worker exposures to epichlorohydrin (106898), allyl-chloride ( ), benzene (71432), methyl-ethyl-ketone ( ) (MEK), methylene-chloride ( ) and toluene (108883) were investigated at the Texas Division of the Dow Chemical Company (SIC-286) in Freeport, Texas, from July 12 to 14, 1976. The company employed about 7,000 persons. The medical department was located next to the community hospital and health center. Pre-employment, termination and periodic medication examinations were provided, and an industrial hygiene program existed. Personnel records were complete and detailed. Production units were enclosed and the operation was entirely automated and monitored from a control room. Concentrations of epichlorohydrin and allyl-chloride ranged from undetectable to 0.41 and 0.68 parts per million (ppm), respectively. Benzene and MEK concentrations were not detectable. Concentrations of methylene-chloride and toluene ranged from 1.0 to 10.6 and 0.6 to 6.8ppm, respectively. OSHA standards for epichlorohydrin, allyl-chloride, MEK, methylene-chloride and toluene were 5, 1, 200, 500 and 200ppm, respectively. The author concludes that all exposures at this company are within acceptable limits, but recommends improvements to reduce allyl-chloride exposures.

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CONTENTS

TABLES

FIGURES

ABSTRACT

An industrial hygiene study was conducted at the Texas Division, Dow Chemical U.S.A., Freeport, Texas, July 12-15, 1976. This study was preceeded by a walk-through survey in November, 1975. This report presents findings of the industrial hygiene study and selected information from the walk-through survey such as descriptions of the occupational medical and industrial hygiene programs, and the availability of personnel records.

The industrial hygiene study was limited to the synthesis of epichlorohydrin and the production of epoxy resins. Atmospheric samples were taken and analyzed to assess the exposures to epichlorohydrin and associated airborne substances. Additionally, observations were made of control measures and work practices. Job titles and descriptions are included for workers having a potential exposure to epichlorohydrin.

Primary control methods employed in the synthesis of epichlorohydrin and the production of epoxy resins were isolation, enclosure, and remote control combined with good work practices and environmental and biological monitoring.

Results of the study showed that the TWA exposure to epichlorohydrin for all workers in the synthesis process ranged from non-detectable to 0.39 ppm and exposure to allyl chloride ranged from non-detectable to 0.68 ppm. All concentrations for epichlorohydrin and allyl chloride were below the permissible concentration. Calculated TWA exposure levels for mixtures of epichlorohydrin and allyl chloride did not exceed the present standard; however, if the recommended standard for epichlorohydrin were promulgated some exposures to the mixture would be in excess of the exposure index.

In the manufacture of epoxy resins a limited number of workers were exposed to epichlorohydrin, methyl ethyl ketone, methylene chloride, and toluene. Of the six samples collected for these substances, five indicated non-detectable concentrations of epichlorohydrin and one was 0.48 ppm. Although there were measurable concentrations of methyl ethyl ketone, methylene chloride, and toluene, the exposure index for combinations of these substances was not exceeded.

The only recommendation offered was the need for better control of allyl chloride. This would be essential if the recommended standard for epichlorohydrin were promulgated.

INTRODUCTION

Under the broad authority of the Occupational Safety and Health Act of 1970, the National Institute for Occupational Safety and Health is charged with responsibility for conducting research, experiments, and demonstrations pertaining to occupational safety and health (1). There are many chemicals used in industry for which there is insufficient data and experience to determine 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 to identify work practices and other control methods which would limit worker exposures to the lowest possible level.

In July, 1975, Tracor Jitco, Inc., was awarded a contract to investigate three agents newly suspected as occupational health hazards. The first of the three agents specified by NIOSH was epichlorohydrin. The first phase of the project consisted of a literature search and compilation of copies of all relevant literature. By agreement with the Project Officer, the field investigation consisted of walk-through surveys of epichlorohydrin production sites and selected user sites, and industrial hygiene surveys of these facilities. The primary purpose of the industrial hygiene survey was to determine exposure of workers to epichlorohydrin and to document engineering controls, work practices, administrative controls, and biological and environmental monitoring procedures being used by the companies.

Under the contract, Tracor Jitco was also to evaluate medical records and occupational histories of exposed workers with the purpose of duplicating such records so that they would be available to NIOSH for a possible retrospective epidemiological study. However, plant management was reluctant to permit these records to be duplicated because they contained confidential information. Dow Chemical has initiated an epidemiologic study of former and active employees exposed to epichlorohydrin. When completed, the findings of these studies will be made available to NIOSH.

During the industrial hygiene study at Dow Chemical U.S.A., Texas Division, air samples were collected to determine current worker exposures to epichlorohydrin and several other associated air contaminants. This report includes a description of the Dow plant areas where epichlorohydrin is manufactured and used, the medical and industrial hygiene programs, air sampling and analytical methods, sample results, and conclusions and recommendations for improvements. The walk-through report was separately submitted. (2)

FACILITY DESCRIPTION

The Texas Division of Dow Chemical U.S.A., Freeport, Texas, is located near the Gulf of Mexico and adjacent to the Brazos River which serves as a source of fresh water. The manufacturing complex was built shortly after World War II and presently comprises over 1,000 acres and houses a multiplicity of chemical manufacturing plants. Over 600 chemicals are produced with over 1,000 separate chemical items. The entire facility employs about 7,000 persons. Practically all products are synthesized from petroleum products and/or sea water. The production complex is broken into blocks, and with a few exceptions, each block houses a distinct manufacturing facility.

The Texas Division has been producing epichlorohydrin since 1956. The plant was designed to minimize worker exposure to epichlorohydrin and other process chemicals and there have been no substantial design changes since the plant has been on stream. However, there have been constant programs for equipment updating and increased use of automatic control equipment as new technology became available. The plant has a design capacity of 260 million pounds of epichlorohydrin per year. Epichlorohydrin and glycerine are produced in a block designated as Glycerine Unit #1. (See Figure 1.) Glycerine Unit #2 which produces glycerine from the epichlorohydrin produced in Glycerine Unit #1 was closed at the time of the study due to decreased market demand for glycerine.

The greater portion of the epichlorohydrin produced is for captive use in the production of glycerine and epoxy resins; some of the production is shipped for customer use in tank cars, tank trucks, or drums.

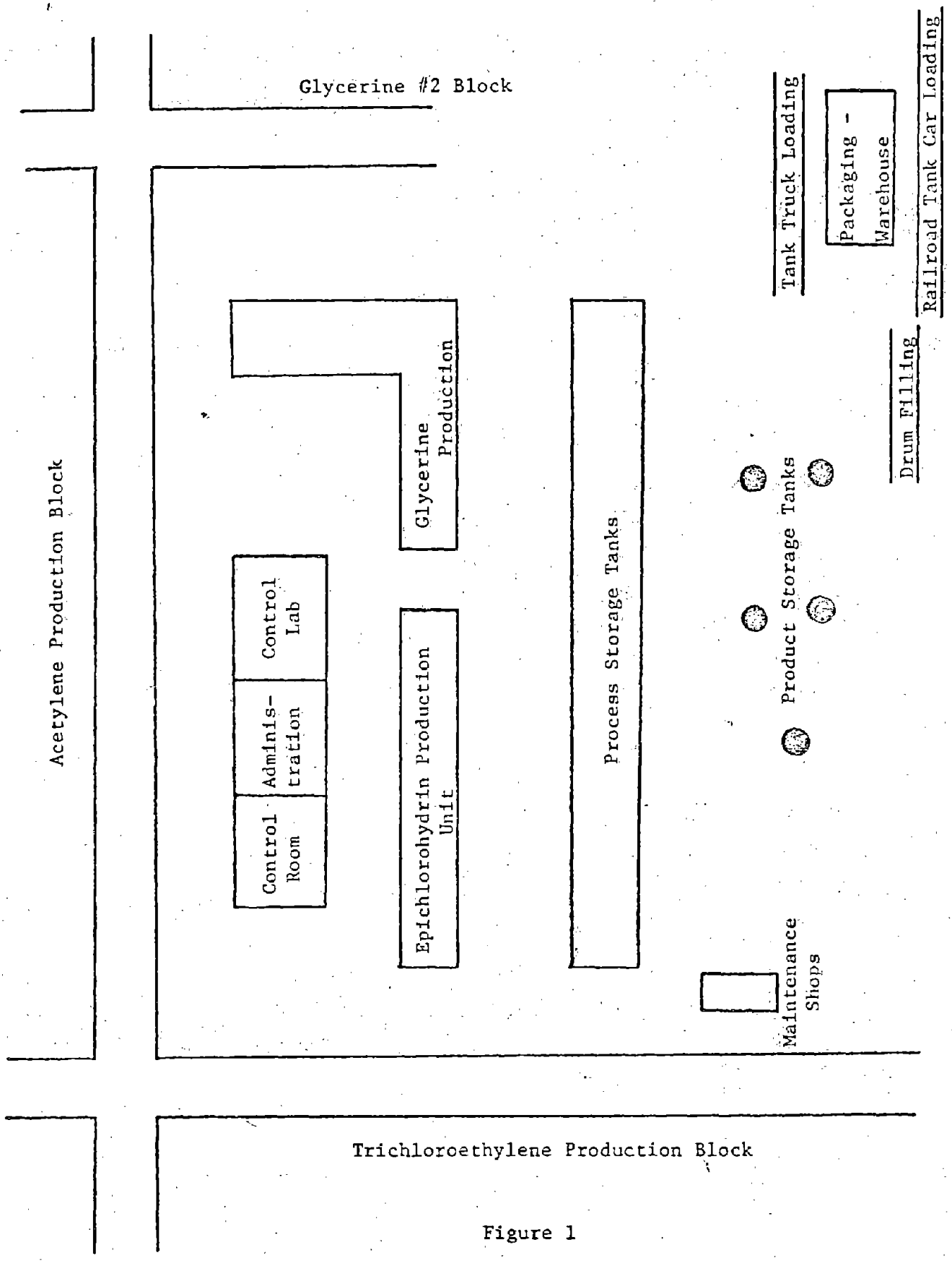


Figure 1

Glycerine Unit #1 (not to scale)

MEDICAL AND INDUSTRIAL HYGIENE PROGRAMS

OCCUPATIONAL MEDICINE

The Medical Department which serves the Texas Division is located outside the plant area and is adjacent to a community hospital and health center. All major occupational accident and illness victims are hospitalized in the community hospital. The basic medical staff consists of a Medical Director, Dr. D. J. Killian; three staff physicians; and a research biologist; 14 staff nurses cover all production shifts. The Medical Department performs the usual function of an occupational medical service including pre-placement, termination, and periodic medical examinations.

INDUSTRIAL HYGIENE

Industrial hygiene is a function of the Environmental Health Department which was organized in 1973. The Department, which serves the entire Texas Division, is directed by Mr. R. L. Daniel who is assisted by three staff industrial hygienists. Between 1956 and 1973, industrial hygiene personnel were on the staff of the medical or safety department.

In addition to service provided by the Department, each major production unit has an environmental chemist on its staff who provides certain industrial hygiene services to the unit including area and personnel monitoring. The environmental chemist is responsible to the superintendent of the unit but works closely with the Environmental Health Department.

The Environmental Health Department personnel serve as consultants and advisors to plant superintendents by providing advice on hazards and controls, and recommending monitoring programs. Additionally the Department performs special services and independent audits. All exposure data are reported to the Environmental Health Department. A system is presently being developed to maintain these records on an ADP system. The Department has a chemical laboratory but most of the analytical work is performed by the Central Research Laboratory.

EPIDEMIOLOGIC STUDY

The Texas Division has contracted with Stanford University to conduct an epidemiology study of present and former employees exposed to epichlorohydrin. The senior investigator for Stanford is Dr. Charles Hines. The cohort includes 831 persons; of these, 389 were employed when the study began and 442 were former employees. In July, 1976, a draft report was submitted to the Texas Division; a copy of the final report will be made available to NIOSH.

AVAILABILITY OF RECORDS

The personnel records at Dow were complete and detailed, and included the pre-employment application form, changes in status, work stations, personal data, and related information. The records would be sufficient to provide the information required by NIOSH such as name of employee, social security number, date of birth, place of birth, last known adress, and an occupational history. The records would also provide some of the other information identified by NIOSH as helpful but not essential such as a prior occupational history and address of next of kin.

The 1946-1952 records of employees who have retired, resigned, or died, are converted to "microcard". This is an obsolete microfilm system utilizing an opaque card with the miniaturized data photographically imprinted on the card. The cards must be read by a printer equipped with a reverse mirror system. Duplication of the cards is not practical. The remainder of the records of employees no longer with the plant are also on microfilm but are maintained in transparent microfiche. The early part of this collection (1953 to approximately 1963) utilize a heavy microfiche jacket which also makes it difficult to reproduce the material. The remainder of the collection of records of employees no longer with the plant are on modern microfiche which can be duplicated quickly and economically using the diazo method.

Records of employees currently on the job are maintained in paper form which could either be microfilmed or duplicated by fast-copy process.

Dow intends to retain all of the present and past personnel records. Thus, data on specific individuals required for an epidemiologic study may be obtained at a later time. Since an epidemiologic study has been initiated and a report is being prepared, it may be prudent to await these findings. Should NIOSH conduct an epidemiologic study on its own, Dow would recommend that the required data be transcribed because of the difficulty in duplicating the required records and securing employee permission for the release of privileged information.

PROCESS DESCRIPTION

EPICHLOROHYDRIN PRODUCTION

Allyl chloride, the starting base from which epichlorohydrin is synthesized, is produced in an adjacent block and delivered to Glycerine Unit #1 by pipe line. Allyl chloride, chlorine, and water are fed to a reactor which yields a mixture of 70% 1,3-dichlorohydrin and 30% 1,2-dichlorohydrin. These products are washed with a cold dilute alkali solution to remove hydrochloric acid and yields an impure epichlorohydrin. The impure epichlorohydrin is steam distilled to produce crude epichlorohydrin; in the process the light ends are removed and flared. Crude epichlorohydrin is distilled in a fractionating column to produce epichlorohydrin of 99+% purity. The residue from the distillation column are the heavy ends. (See Figure 2.)

EPOXY RESINS

Epoxy resins are manufactured in Epoxy Unit #1 (Figure 3) which is located about 1 mile from Glycerine Unite #1. Epichlorohydrin is pumped from Glycerine Unit #1 and stored in closed tanks. There are two methods for producing epoxy resins: Continuous and batch.

In the continous process, epichlorohydrin is condensed with bis-phenol to form a liquid epoxy resin. The entire system is closed so that worker exposure is minimal. Excess epichlorohydrin is stripped from the reacted mixture and returned to the storage tank. There are no exposures to epichlorohydrin after the stripping operation.

In the batch method, various epoxy resins are made in kettles by condensation of epichlorohydrin and other substances to form a novalac resin. All kettles are sealed and discharged into a closed system. Excess epichlorohydrin is stripped from the mixture and returned to the storage tank. No exposure to epichlorohydrin occurs after the stripping operation. Solvents used in the production of resins include toluene, methyl ethyl ketone, and methyl isobutyl ketone.

Resins are pumped to the resin finishing area also located in Epoxy Unit #1. Most of the workers employed in Epoxy Unit #1 are concerned with resin finishing and shipping. When the resin reaches the finishing area it contains no free epichlorohydrin.

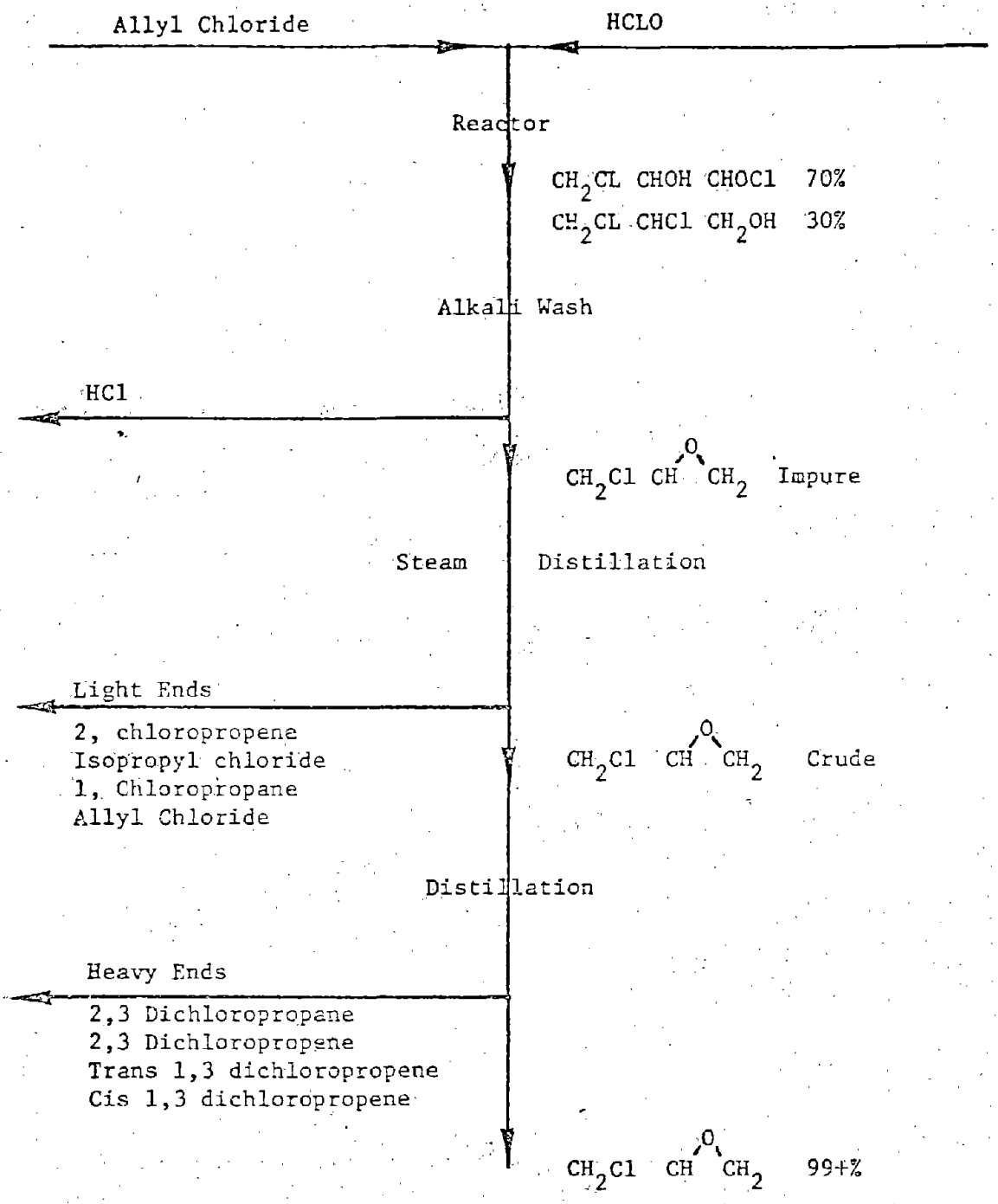


Figure 2

Flow Diagram for Synthesis of Epichlorohydrin

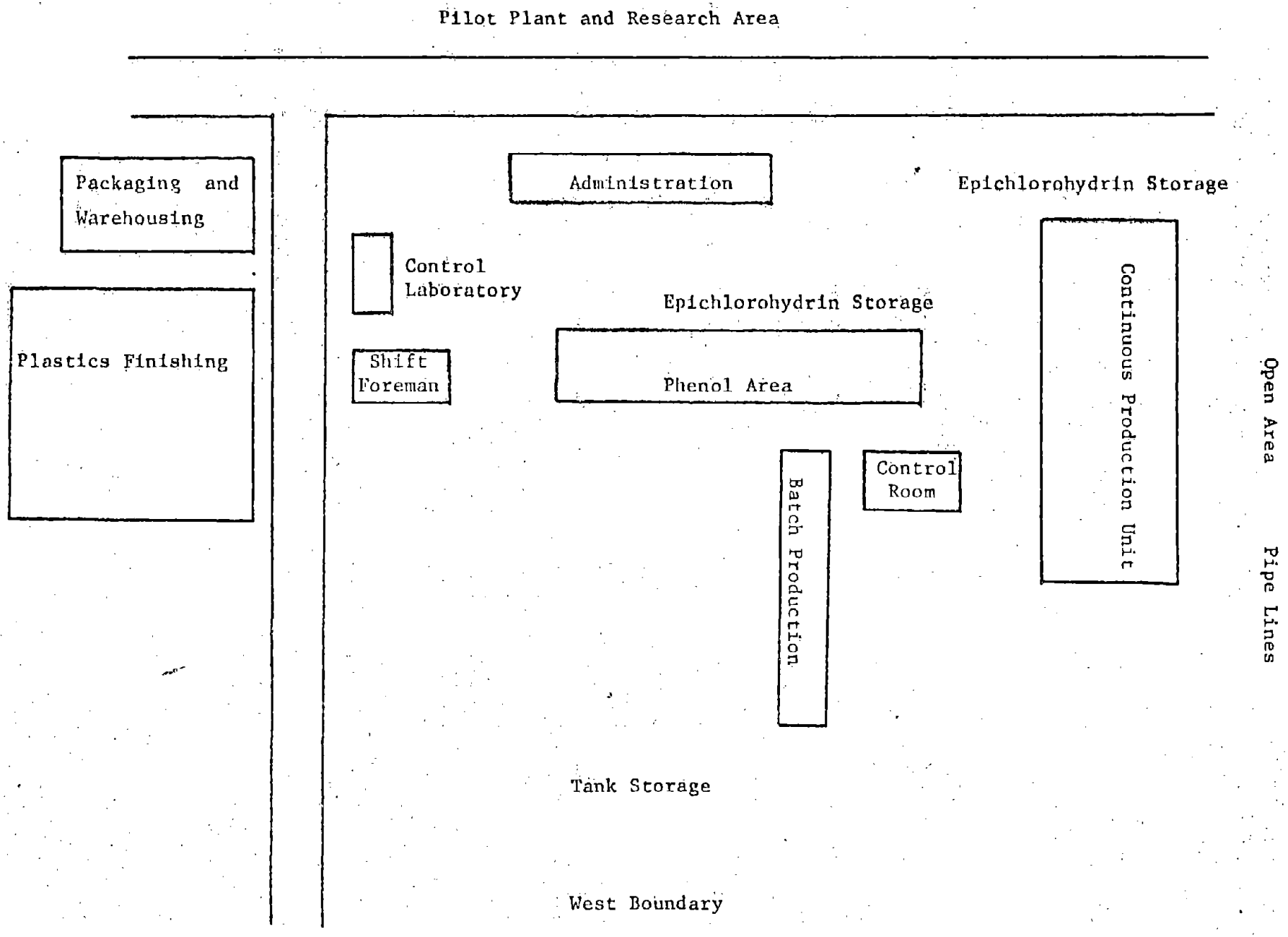


Figure 3
Epoxy Unit #1 (not to scale)

POTENTIAL EXPOSURES

GLYCERINE UNIT #1

In this unit there are potential respiratory and skin exposures to a variety of chemical substances including allyl chloride, epichlorohydrin, and glycerine. Benzene is a low level area contaminant which originates in another production area. The light and heavy ends resulting from the production of epichlorohydrin are handled in such a manner that exposure to these substances would only result if an unusual emergency occurred. In the event of an emergency, there are potential exposures to chlorine or hydrochloric acid fumes. Workers engaged in the loading of epichlorohydrin are exposed only to epichlorohydrin.

EPOXY UNIT #1

During normal operations only the operators engaged in the formulation of epoxy resins are exposed to epichlorohydrin. Here the exposure is largely respiratory, but occasionally the operators may have skin contact with epichlorohydrin. There is also the possibility of skin contact with phenol, but extensive safety precautions are taken to prevent any contact with this agent. Methyl ethyl ketone and toluene are also present as area contaminants. Methylene chloride is used to remove spilled resins; this procedure presents a limited hazard through skin contact with the solvent or inhalation of fumes.

PAST EXPOSURES

Exposure data has been collected for epichlorohydrin and allyl chloride since the sampling program began in 1974. Even before this date, however, industrial hygiene services were provided by the central staff of the Texas Division and corporate headquarters. Exposure records are maintained by the Environmental Health Department and the operating units. Examples of summary data collected in 1975 are contained in the Appendix.

EXPOSURE CONTROL

EPICHLOROHYDRIN

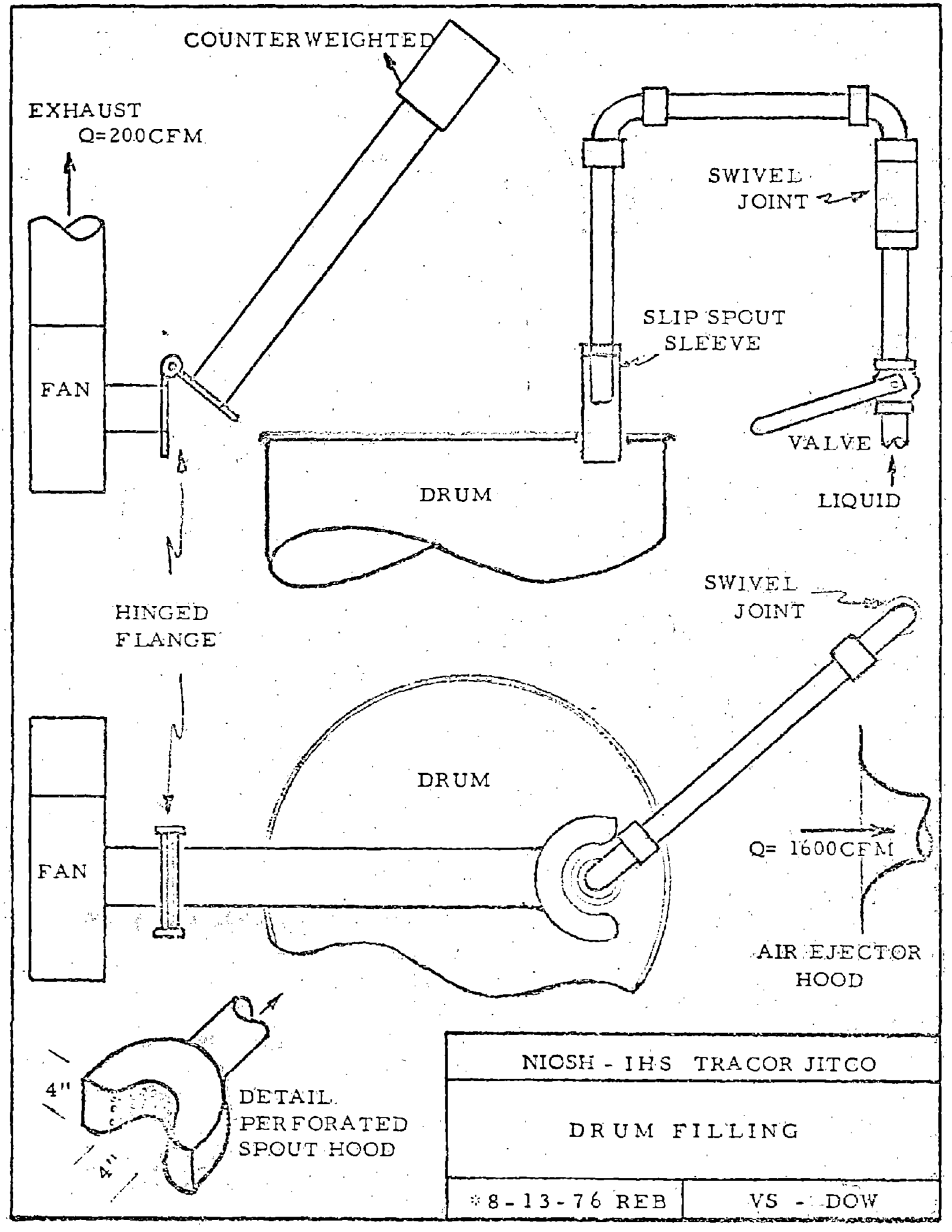
The epichlorohydrin production unit is located out of doors and all production units are enclosed. The operation is entirely automated and monitored from a control room located on the west periphery of the block. During normal operations it is not necessary for any unit in the process to be manned. However, workers are often in the production area for routine inspection of equipment, sampling, and on-stream maintenance. Because pumps and pipe flange seals are kept tight, leakage is normally minimal.

All personnel entering the production area are required to wear long sleeve jackets, gloves, and eye shields, and must have an organic vapor respirator for emergency use. In the event of a production emergency, a warning signal is sounded and area evacuation is required.

Work practices are in effect for on-stream maintenance and maintenance work is supervised by the shift foreman. For major on-site repairs the production unit is either by-passed or the process shut down. Equipment to be repaired or serviced cannot be opened until it has been declared safe by a person authorized to make this decision. Major repairs are usually made on the day shift when the environmental chemist is available to test for epichlorohydrin and other atmospheric contaminants.

Drumming operations are conducted out of doors. Epichlorohydrin is pumped directly from storage tanks and introduced into the drum through a retractable pipe with a cut off valve immediately above the drum. During the filling operation the drum opening is surrounded by a hinged exhaust ventilation hood. Exhaust is discharged to the atmosphere about 25 feet from the loading operation and about 10 feet above ground level. Immediately adjacent to the drumming operation is a Lamb air mover; between drum loading, the epichlorohydrin loading pipe is directly in front of the intake to the air mover. As an additional precaution, workers wear an organic vapor respirator during the drumming operation. See ventilation specification print and measured ventilation rates for this control (local exhaust) system (Figure 4).

Some shipments are made in 10,000 gallon railroad tank cars. Before being received at the loading dock, each car is cleaned and inspected. A second visual inspection is made at the loading dock by removing the dome and observing the interior of the tank. Entry into the tank at the loading dock is prohibited. The tank car is top loaded and vented back to the storage tank. During the loading operation, the operator is at the control site some distance from the car. The only time that the


COUNTERWEIGHTED
EXHAUST
Q=200CFM
SWIVEL
JOINT
SLIP SPOUT
SLEEVE
FAN
VALVE
LIQUID
DRUM
HINGED
FLANGE
SWIVEL
JOINT
DRUM
FAN
Q= 1600CFM
AIR EJECTOR
HOOD
4"
4"
DETAIL
PERFORATED
SPOUT HOOD
NIOSH - IHS TRACOR JITCO
DRUM FILLING
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VS - DOW

operator may be significantly exposed to epichlorohydrin is during the disconnect procedure. Procedures for truck tank loading are similar to tank car loading. See the Appendix for Dow's Glycerine Department Chemical Hazards Guide which is posted at all work stations.

EPOXY RESINS

All epoxy resins process equipment is located out of doors and controlled from a central air-conditioned control room. During normal operations, only operators have a potential exposure to epichlorohydrin. When operators are in the production area they are required to wear long sleeve jackets, gloves, and eye shields, and must have an organic vapor respirator for emergency use.

BIOLOGICAL MONITORING

All workers assigned to allyl chloride, epichlorohydrin, and resin production receive a pre- and post-employment medical examination consisting of the following:

Blood and urine analysis
General physical examination and health history
Chest X-ray
Pulmonary function-FVC and FEV_1
Electrocardiogram
Vision test

Workers assigned to allyl chloride, epichlorohydrin, and resin production are examined on the following schedule:

Blood and urine analysis	Annually
General physical examination	Over 40 years of age-every two years
Pulmonary Function	
Chest X-ray	Under 40 years of age every four years
Electrocardiogram	Over 40 years of age only-every two years
Vision	

ENVIRONMENTAL MONITORING

The environmental chemist assigned full time to Glycerine Unit #1 is required to monitor all production areas once per month. Other monitoring is conducted as required when leaks are suspected or when equipment is being repaired or placed on-stream. Each worker is monitored each two years using the charcoal adsorption procedure. All substances absorbed by the charcoal are determined. Based on these values, each worker is assigned an exposure index determined by dividing

the TWA by the TLV for each substance and summing these values. If the index is over 1, corrective measures are taken; workers with an index between 0.5 and 1.0 are monitored each year. Exposure records are kept by Glycerine Unit #1 and the Environmental Health Department. If the worker transfers to another production area his exposure record goes with him.

HOUSEKEEPING

The plant facilities are maintained in a safe and orderly manner. This is especially true of Glycerine Unit #1. Epoxy Unit #1, by comparison, had more difficulty preventing leakage and spillage; therefore, a variety of materials, primarily resins, was evident throughout the work area because of accumulation and tracking. In spite of this, the work area was in good order and did not represent a safety or health hazard.

JOB TITLES AND DESCRIPTIONS

Glycerine Unit #1 employs 50 persons including supervisory staff, engineering, laboratory, and production workers. The breakdown of this staff is shown in Table 1.

Table 1
Staff of Glycerine Unit #1

Supervisory and Technical Staff		Production Staff	
Superintendent	1	Production Foreman	2
Engineers	4	Shift Foreman	4
Laboratory	9	Operators	13
Secretary	1	Packaging	5
		Maintenance	11
Totals	15		35

Although all employees in the unit may have an occasional exposure to epichlorohydrin, production workers have the greater potential. All supervisory and technical staff are housed in the administrative area which is air conditioned. The control room, immediately adjacent to the administrative area, is also air conditioned.

PRODUCTION WORKERS

Production Foreman (2)

Production foremen are housed in the administrative area and act as assistants to the superintendent. They supervise production and coordinate activities of the shift foremen.

Shift Foreman (4)

The shift foremen have supervisory responsibility for production and maintenance. Shift foremen are housed in the control room, but, depending on operational problems, may spend from 50% to 100% of their work shift in the production area.

Operators (13)

There are two classes of operators: Control A and Control C. Control A is the senior operator and is responsible for monitoring control instruments and making necessary adjustments to maintain production. Normally an operator spends more than 80% of the work shift in the control room. Each Control A Operator will inspect the production area at least twice during the shift and will investigate or correct operational problems in the production area.

The Control C Operator spends about 50% of the work shift in the production area; one of his major duties is the collecting and analysis of the process samples. During the sampling operation he is required to wear an organic vapor respirator. At the time of the study, automatic sampling and analysis equipment was being installed which will relieve the Control C Operator of the sampling responsibility.

Operator C Trainee (1)

During the study there was an Operator C trainee for two work shifts. The trainee performed the same duties as the Control C Operator.

Maintenance (11)

Maintenance personnel are primarily mechanics and pipe-fitters. Maintenance of electronic instruments and electrical equipment is provided by other units of the Texas Division. Maintenance personnel serve the entire block, thus, exposure to epichlorohydrin is a function of the time spent in repairing and servicing epichlorohydrin units.

Packaging (5)

There is one Head Packaging Operator and four general operators. The Head Packaging Operator spends most of his time in supervisory and administrative duties. The four general operators are responsible for loading epichlorohydrin into railroad tank cars, tank trucks, and drums. In addition, they maintain the warehouse and load trucks with filled drums.

Epoxy Operators (4)

During normal operations there are two operators in the epoxy resin area: Control B Operator who controls the batch operation and Control C Operator who controls the continuous operation. The two operators spend about 80% of the work shift in the control room and about 20% in the production area. The shift foreman spends most of his time in the resin finishing area; his office is separate from the control room.

STUDY METHODS

STUDY PROCEDURES

The industrial hygiene study of the Dow epichlorohydrin facility was conducted between July 11 and 15, 1976. During this period, air samples were collected to evaluate exposures to epichlorohydrin, allyl chloride, and benzene. Benzene is an area contaminant and not a by-product of the epichlorohydrin process. Samples were collected on all three shifts for all production workers on duty for the shift sampled. In practically all cases, the sample duration was for a significant portion of the full working shift and represented a TWA. In a few cases, the sampling was only for the duration of the exposure such as the loading of a tank car and drums with epichlorohydrin. The purpose of these samples was to determine exposure for intermittent operations which could be excessive and to evaluate effectiveness of control methods in use. Four maintenance workers were sampled during the only maintenance operation occurring during the study.

In Epoxy Unit #1 only the two operators concerned with the formulation of resins were sampled. These are the only two employees of the unit that have a potential exposure to epichlorohydrin except in emergency situations which did not exist at the time of the study.

The sampling and analytical method used by Tracor Jitco in the study was developed under NIOSH contract by Stanford Research Institute specifically for use by NIOSH in conducting evaluations of atmospheres containing epichlorohydrin (3). Analytical services were provided by the Kettering Laboratory of the University of Cincinnati. SKC (SKC, Inc., Environmental Science Division, P.O. Box 55, Venetia, Pa., 15367) charcoal adsorption tubes were used for all samples. The air sampling pumps were SKC Model 222-351 Air Check Personal Pump and DuPont (E.I. DuPont de Nemours & Co., Inc., Applied Technology Division, Wilmington, Delaware, 19898) Model P-200 Constant Flow Sampler.

STUDY LIMITATIONS

This industrial hygiene study represents a one point in time evaluation of exposures to epichlorohydrin and therefore does not reflect possible variations in exposure due to seasonal or operational changes. An attempt was made to evaluate exposures for each job type during all work shifts. These studies were made during a period of normal production procedures; if an emergency or abnormal situation occurred during the work shift, the higher exposure level should be reflected in the sample. Encountering an emergency during production in a short sampling period was remote; therefore, the resulting exposure measurements are considered to represent the normal operating conditions.

Generally, the samples also do not reflect exposures during maintenance operations. Routine maintenance is usually accomplished at specified times during the year. On these occasions, safety procedures which are designed to minimize exposure are followed. However, on-stream maintenance may result in significant short term exposure unless very strict emergency procedures are used. When such operations were scheduled during the sampling period, exposure measurements were included in the sampling scheme. Whenever there were potential significant exposures to other chemical agents associated with epichlorohydrin these were also evaluated.

RESULTS OF THE STUDY

Glycerine Unit # 1

A summary of all atmospheric samples for glycerine unit #1 is shown in Table 2.

Control A Operator

Three samples were taken for this job classification, one on each of the shifts. Each was a full shift sample and the results represent a time-weighted average exposure level (TWA-ppm).

Table 3
Control A Operator Exposure Levels

Shift	Date	Epichlorohydrin ppm	Allyl Chloride ppm	Benzene ppm
1	7/13/76	0.38	0.24	N.D.
2	7/12/76	N.D.	N.D.	N.D.
3	7/14/76	0.23	N.D.	N.D.

The exposure may be less than the TWA since the Control A operator is equipped with an organic vapor respirator which should be used when there is a suspected exposure to epichlorohydrin. The extent to which the respirators were used was not determined.

Control C Operator

Three samples were taken for this job classification, one on each of the shifts. Each was a full shift sample and the results represent TWA exposures. A major function of this job classification is process sampling and analysis. While sampling, the operator is required to wear an organic vapor respirator. On two of the three shifts the Control C Operator was accompanied by a trainee. Since they were performing the same duties the exposure should have been approximately the same which was the case when based on the sampling data.

Table 2

Summary of Atmospheric Samples for Epichlorohydrin and Allyl Chloride

Glycerin Unit #1

Date Collected	Shift	Worker Sampled	Type or Duration of Sample	Atmospheric Concentration (ppm) Epichlorohydrin	Allyl Chloride	Benzene
7/13	1	Control A Operator	TWA	0.38	0.24	N.D
7/12	2	" " "	TWA	N.D*	N.D	N.D
7/14	3	" " "	TWA	0.23	N.D	N.D
7/13	1	Control C Operator	TWA	0.33	0.68	N.D
7/12	2	" " "	TWA	N.D	N.D	N.D
7/14	3	" " "	TWA	0.39	0.11	N.D
7/13	1	Control C Trainee	TWA	0.41	0.11	N.D
7/14	2	" " "	TWA	N.D	0.26	
7/13	1	Shift Foreman	TWA	0.17	0.3	
7/12	2	" "	TWA	0.1	0.17	
7/14	3	" "	TWA	0.14	N.D	
7/14	1	Pipefitter 1	5 hrs	N.D	N.D	
7/14	1	" " 2	" "	N.D	N.D	
7/14	1	" " 3	" "	N.D	N.D	
7/13	1	Packing Op. 1 - Drum	4 hrs, 20 min	N.D.		
7/13	1	" " 2 - "	" "	N.D		
7/14	1	Packing Op. 1 - Tank Car	3 hrs, 10 min	0.28		

*Not detectable based on the limit of the analytical method

Table 4
Control C Operator Exposure Levels

Shift	Date	Epichlorohydrin ppm	Allyl chloride ppm	Benzene ppm
1	7/13/76	0.33	0.68	N.D.
2	7/12/76	N.D.	N.D.	N.D.
3	7/14/76	0.39	N.D.	N.D.

Control C Trainee Exposure Levels

1	7/12/76	0.41	0.11
2	7/12/76	N.D.	0.26

Exposure may have been less than the TWA since each operator was required to wear an organic vapor respirator during sampling. A short term (20 minute) sample was collected while one sampling circuit was made by the Control C operator. The air concentration for this period was non-detectable.

Shift Foreman

Three samples were taken for this job classification, one each on the 1st, 2nd, and 3rd shifts. Each was a full shift sample and the results represent a TWA.

Table 5
Shift Foreman Exposure Levels

Shift	Date	Epichlorohydrin ppm	Allyl chloride ppm	Benzene+ ppm
1	7/13/76	0.17	0.03	--
2	7/12/76	N.D.	0.17	--
3	7/14/76	0.14	N.D.	--

+ not determined

Pipefitters

On July 15, three maintenance workers were repairing and servicing a condenser for the distillation column which removed light ends from crude epichlorohydrin. During this operation production of epichlorohydrin was continued and the product was put into storage tanks, but the finishing end of the process was closed down. The sample was limited to the 5 hour duration of the repair procedure. Before opening the condenser, the usual safety precaution were taken.

Table 6
Pipefitters Exposure Levels

Shift	Date	Pipefitter #	Epichlorohydrin ppm	Ally Chloride ppm
1	7/15/76	1	N.D.	N.D.
1	7/15/76	2	N.D.	N.D.
1	7/15/76	3	N.D.	N.D.

Packaging

Packaging is an intermittent operation which depends upon customer orders for epichlorohydrin. During the time of the study no packaging operations were scheduled, however, two special packaging runs were made to assist in the sampling program. On Tuesday, July 14, a special drumming run was made which lasted four hours during which forty-three 535 pound drums were filled. On July 14, a 10,000 gallon railroad tank car was loaded in 3 hours and 10 minutes.

Table 7
Drumming Operator Exposure Levels

Shift	Operator	Epichlorohydrin ppm
1	1	N.D.
1	2	N.D.

Tank Car Loading Operator Exposure Levels

1	1	0.28

Epoxy Resin Unit # 1

Epoxy resin operators do not have an exposure to allyl chloride but do have a potential exposure to methyl ethyl ketone, methylene chloride, and toluene. A summary of all sampling taken in Epoxy Unit #1 is shown in Table 8.

Table 8

Summary of Atmospheric Samples for Epichlorohydrin and Other Contaminants

Epoxy #1

Date Collected	Shift	Worker Samples	Type or Duration of Sample	Atmospheric Concentration (ppm) Epichlorohydrin	MEK	Methylene Chloride	Toluene
7/13	1	Control B Operator	TWA	N.D	N.D	1.0	6.8
7/12	2	" " "	TWA	N.D	N.D	4.7	1.7
7/14	3	" " "	TWA	N.D	N.D	7.4	0.6
7/13	1	Control C Operation	TWA	N.D	N.D	3.8	0.6
7/12	2	" " "	TWA	N.D	N.D	4.0	1.0
7/14	3	" " "	TWA	N.D	N.D	10.6	6.5

Table 9

Control B Operator Exposure Levels

Shift	Date	Epichlorohydrin ppm	MEK ppm	Methylene Chloride ppm	Toluene ppm
1	7/13/76	N.D.	N.D.	1.0	6.8
2	7/12/76	N.D.	N.D.	4.7	1.7
3	7/15/76	N.D.	N.D.	7.4	0.6

Control C Operator Exposure Levels

1	7/13/76	N.D.	N.D.	4.0	1.0
2	7/12/76	N.D.	N.D.	3.8	0.6
3	7/15/76	0.43	N.D.	10.6	6.5

DATA ANALYSIS AND EVALUATION

EVALUATION CRITERIA

The permissible concentration for epichlorohydrin is 5 ppm or 19 mg/m^3 as a TWA (4). This is identical to the present TLV recommended by the American Conference of Governmental Industrial Hygienists (5). The Criteria for a Recommended Standard...Occupational Exposure to Epichlorohydrin published by NIOSH, September, 1976, recommends a permissible concentration for epichlorohydrin of 0.5 ppm (1.9 mg/m^3) as a TWA with a ceiling concentration of 5 ppm (19 mg/m^3) for a 15 minute period during the work shift (6). Permissible concentration for allyl chloride is 1 ppm (4).

EVALUATION OF EXPOSURES

Glycerine Unit #1

Based on these data it is apparent that all exposures are well below the present permissible concentration of 5 ppm for epichlorohydrin. An analysis of the exposures is shown in Table 10.

Table 10
Distribution of Samples by Range of Concentration of Epichlorohydrin

Exposure Range ppm	No. of Samples	% of Total
N.D.	13	56.5
0.1-0.19	3	13.0
0.2-0.29	2	8.7
0.3-0.39	3	13.0
0.4-0.49	2	8.7
0.5	0	0.0
Total	23	100.0

In terms of exposure to allyl chloride the exposures were significantly closer to the permissible concentration of 1.0 ppm, ranging from non-detectable to 0.68 ppm as shown in Table 11.

Table 11

Distribution of Samples by Range of Concentration of Allyl Chloride

Exposure Range ppm	No. of Samples	% of Total
N.D.	7	50
0.1-0.19	3	21.4
0.2-0.29	2	14.3
0.3-0.39	1	7.1
0.4-0.49	0	0.0
0.5-0.59	0	0.0
0.6-0.69	1	7.1
0.7	0	0.0
Total	14	100.0

Since the OSHA standard requires an evaluation of mixed exposures, it is necessary to consider the combined exposure for epichlorohydrin and allyl chloride. For this purpose the potential exposure to benzene was excluded since all were non-detectable or at the lower limit of the analytical method. Mixed exposures were considered to have possible significance in four cases:

Case 1	Epichlorohydrin 0.33 ppm	allyl chloride 0.68 ppm
Case 2	Epichlorohydrin 0.41 ppm	allyl chloride 0.11 ppm
Case 3	Epichlorohydrin 0.38 ppm	allyl chloride 0.24 ppm
Case 4	Epichlorohydrin 0.17 ppm	allyl chloride 0.30 ppm

Using the mixed exposure formula $\frac{C_1}{T_1} + \frac{C_2}{T_2} = 1$ the following exposure indexes were developed for the above cases:

Case 1	0.746
Case 2	0.192
Case 3	0.316
Case 4	0.334

For all exposures to epichlorohydrin and allyl chloride the mixed exposure index did not exceed 1, but one exposure approached the limit with a value of 0.75.

The NIOSH criteria document for epichlorohydrin proposes a permissible concentration of 0.5 ppm TWA with a ceiling limit of 5 ppm for 15 minutes (6). Based on the data collected in this study, all TWA's were less than the proposed TWA; however, the data will not permit an assessment of the ceiling concentration. The probability of having exceeded the ceiling limit, however, can be determined from the TWA.

If the concentration had been at the ceiling for 15 minutes, the daily dose contributed by this exposure would have been 1.25 ppm hours. Therefore, any daily dose in excess of 5.125 ppm hours could have an exposure of 15 minutes at 5 ppm. None of the non-detectable exposures could have had a 15 minute period of 5 ppm since the total daily dose was less than 0.8 ppm hours. This represented 56.5% of all samples. At a TWA of 0.2 ppm it would have been possible to have had an exposure of 15 minutes at 5 ppm since the total daily dose was slightly in excess of the permitted dose at the ceiling concentration (1.6 ppm hours as compared to 1.25 ppm hours). Since this condition means that the exposure, except for the 15 minute period, would have to be close to zero, the probability of the ceiling concentration being exceeded is almost zero. By pursuing this logic through other TWA concentrations it is apparent that there is only a slight probability of the ceiling value being exceeded at 0.3 ppm TWA. There is a greater probability, however, when the TWA is 0.4 ppm or greater.

In terms of mixed exposures, however, the index could have been exceeded if the permissible concentration for epichlorohydrin had been 0.5 ppm, the level of the proposed standard. Using the four cases previously developed, the mixed exposure would have been exceeded in two of the four cases and very close to 1 in another case.

Case 1	1.34
Case 2	0.93
Case 3	1.0
Case 4	0.64

Epoxy Resin Unit #1

All operator exposures in epoxy resin production were significantly less than the permissible concentration for epichlorohydrin, MEK (PC 200 ppm), methylene chloride (PC 500 ppm), and toluene (PC 200 ppm). In all cases the mixed exposure index is far less than 1. In one case it is possible that the proposed ceiling concentration was exceeded (Epoxy Control C Operator for the third shift on July 15).

CONCLUSIONS AND RECOMMENDATIONS

Measured exposure levels are less than present standards. However, the company should maintain its present surveillance program and continue to test the control systems for deficiencies.

Should the permissible concentration of epichlorohydrin be lowered to 0.5 ppm with a ceiling concentration of 5 ppm for 15 minutes the process would still be in compliance for epichlorohydrin except that on occasions it may be possible for the ceiling concentration to be exceeded.

The exposure to allyl chloride, however, presents a problem since some exposures to this substance are close to the permissible concentration and at present concentrations the exposure index for a mixture of allyl chloride and epichlorohydrin will be exceeded on occasions. For this reason the company should explore methods for reducing the exposures to allyl chloride. Although levels found in this study are within existing Federal Standards, there exists the potential for acute irritant health effects. The NIOSH recommended standard for epichlorohydrin has been lowered and the combined irritant effect may present health problems.

REFERENCES

1. Public Law 91-596, Sec. 20(a)(1). Occupational Safety and Health Act. 1970.

2. Plant Visit to Dow (Texas Division), Corrected Copy. Tracor Jitco, Inc. Nov. 25, 1975.

2. Phase One Report, Epichlorohydrin. Investigation of Agents Which Are Newly Suspected as Occupational Health Hazards. Contract No. 210-75-00064. Tracor Jitco, Inc. August 20, 1975.

4. 20 CFR 1910.1000

5. American Conference of Governmental Industrial Hygienists. Threshold Limit Values for 1976. ACGIH, 1976.

6. Criteria for a Recommended Standard...Occupational Exposure to Epichlorohydrin. September, 1976. National Institute for Occupational Safety and Health. HEW Publication No. (NIOSH) 76-206.

APPENDIX

ALLYL CHLORIDE #3
PERSONNEL MONITORING (1975)

JOB CLASSIFICATION	NUMBER OF SAMPLES	ALLYL CHLORIDE (PPM VOLUME) HIGH	LOW	AVG.	E P I (PPM VOLUME) HIGH	LOW	AVG.
Control "A"	6	.91	.19	.45	<.01	<.01	<.01
Control "C"	8	.94	.24	.57	<.01	<.01	<.01
Instrument	4	*4.72	.12	2.16	<.01	<.01	<.01
Lab	4	.71	.23	.40	<.01	<.01	<.01
Shift Foreman	4	*4.03	.12	1.30	<.01	<.01	<.01
Maintenance	4	*6.09	.78	3.05	<.01	<.01	<.01

NOTE: High values for allyl chloride could possibly be due to acetone interference. Analytical technique has been corrected.

* Represents potential exposure. Operators wear protective equipment during sampling operations and process upsets.

Avg. represents numerical average between high and low value, not the time weighted average.

EPOXY PLANT
1973 AIR MONITORING

JOB CLASSIFICATION	NUMBER OF SAMPLES	EPI(PPM VOLUME) HIGH	LOW	AVG
RESIN HELPER	1	.03	.03	.03
400 PLANT OPERATOR	1	.03	.03	.03
300 PLANT OPERATOR	1	.03	.03	.03
CONTROL PLANT OPERATOR	1	.03	.03	.03
GRAB SAMPLES	78	13	<.60	3.17

1974 AIR MONITORING

WAREHOUSE OPERATOR	4	<.30	<.30	<.30
MACHINIST	1	<.10	<.10	<.10
PIPEFITTER	2	<.30	<.30	<.30
CONTROL C OPERATOR	3	.90	.40	.66
2nd CLASS OPERATOR BIS	1	<.10	<.10	<.10
GRAB SAMPLES	25	15	.60	2.02
STATIONARY MONITORING	23	1	<.10	.26

DOW CHEMICAL U.S.A.
TEXAS DIVISION
GLYCERINE DEPARTMENT - CHEMICAL HAZARDS GUIDE

COMMON NAME	CHEMICAL NAME	PHYSICAL STATE	EYES	SKIN	BREATHING OF VAPORS	FIRE	REMARKS	TYPE GAS MASK
TONE	ACETONE	LIQUID	[redacted]	[redacted]	(1)	[redacted]		OVAG
ETYLENE	ACETYLENE	GAS	[redacted]	[redacted]	(1)	[redacted]		OVAG
ETONITRILE	METHYL CYANIDE	LIQUID		[redacted]	[redacted]	[redacted]	POOR WARNING PROPERTIES	OVAG
ID INHIBITOR	DOWELL A-120	LIQUID	[redacted]			[redacted]		OVAG
LYL CHLORIDE	3-CHLOROPROPENE	LIQUID	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	OVAG
LYL CHLORIDE TARS	MIXED RCL'S	LIQUID	[redacted]	[redacted]	[redacted]	[redacted]		OVAG
MMONIUM HYDROXIDE	AMMONIUM HYDROXIDE	LIQUID	[redacted]		[redacted]	[redacted]		AMMONIA
RINE	SODIUM CHLORIDE	LIQUID	[redacted]	[redacted]	[redacted]	[redacted]		NONE
ARBON DIOXIDE	CARBON DIOXIDE	LIQUID	[redacted]	[redacted]	[redacted]	[redacted]	FROSTBITE OF SKIN POSSIBLE	CO_2 SUPPLIED
AUSTIC AND ELL EFFLUENT	SODIUM HYDROXIDE	LIQUID	[redacted]	[redacted]	[redacted]	[redacted]		NONE
HLORINE	CHLORINE	GAS		[redacted]	[redacted]	[redacted]		CHLORINE
-CHLOROPROPENE MIX	2-CHLOROPROPENES ISOPROPYL CHLORIDE	LIQUID			[redacted]	[redacted]	[redacted]	OVAG
ICHLOROHYDRIN	DICHLOROHYDRIN	LIQUID		(2)	[redacted]	[redacted]		OVAG
3 DICHLOROPROPENE	2,3 DICHLOROPROPENE	LIQUID		[redacted] (2)	[redacted] (1)	[redacted]	MAY BE ABSORBED THROUGH THE SKIN	OVAG
DIETHOXYTHETHYL ORMATE & GLYCERINE	SAME	LIQUID	[redacted]	[redacted]	[redacted]	[redacted]	[redacted] & SKIN SENSITIZED	OVAG
EPI	EPICHLOROHYDRIN	LIQUID	[redacted]	[redacted]	[redacted] (1)	[redacted]	MAY BE ABSORBED THROUGH THE SKIN WILL PENETRATE RUBBER OR NEOPRENE	OVAG
EPI LIGHTS	2,3 DICHLOROPROPENE ISOPROPYL CHLORIDE [redacted]	LIQUID	[redacted]	[redacted]	[redacted]	[redacted]		OVAG
EDC PASTE	TETRACHLOROETHANE BETA TRICHLORO-ETHANE EDC	LIQUID	[redacted]	[redacted] (2)	[redacted] (1)	[redacted]		OVAG

COMMON NAME	CHEMICAL NAME	PHYSICAL STATE	EYES	SKIN	BREATHING OF VAPORS	FIRE	REMARKS	TYPE GAS MASK
EDC	ETHYLENE DICHLORIDE	LIQUID		[redacted] (2)	[redacted] (1)	[redacted]	[redacted] BURNS IF TRAPPED UNDER SHOES, BELTS, WATCHBANDS, ETC.	OVAG
GLYCERINE	GLYCEROL	LIQUID	[redacted]	[redacted]	[redacted]	[redacted]		NONE
GLYCERINE ML	POLY GLYCERINES	LIQUID	[redacted]	[redacted]	[redacted]	[redacted]	IN PROCESS, VERY HOT (180°C)	NONE
HELIUM	HELIUM	GAS	[redacted]	[redacted]	[redacted]	[redacted]		
HCL	HYDROCHLORIC ACID	LIQUID	[redacted]	[redacted]	[redacted]	[redacted]		OVAG
FISCHER REAGENT	FISCHER REAGENT	LIQUID	[redacted]		(1)	[redacted]		OVAG
MAPP GAS	METHYLENE ACETYLENE	GAS	[redacted]	[redacted]	(1)	[redacted]		OVAG
METHANOL	METHANOL	LIQUID	[redacted]	[redacted]	[redacted]	[redacted]	POOR WARNING PROPERTIES	OVAG
METHANE	METHANE	GAS	[redacted]	[redacted]	(1)	[redacted]		OVAG
NITROGEN	NITROGEN	GAS	[redacted]	[redacted]	[redacted]	[redacted]	FROSTBITE OF SKIN POSSIBLE	N_2 SUPPLIED
OXYGEN	OXYGEN	GAS	[redacted]	[redacted]	[redacted]	[redacted]	INCREASES FLAMMABILITY OF OTHER ORGANIC	NONE
PENTENE	2-4-4 TRIMETHYL PENTENE-1	LIQUID		[redacted]		[redacted]		OVAG
POLYOL	80% GLYCEROL	LIQUID	[redacted]	[redacted]	[redacted]	[redacted]		NONE
PDC	PROPYLENE DICHLORIDE	LIQUID		[redacted] (2)	[redacted] (1)	[redacted]	[redacted]	OVAG
PROPYLENE	PROPYLENE	LIQUID GAS	[redacted]	[redacted]	(1)	[redacted]	FROSTBITE OF SKIN POSSIBLE	OVAG
PYRIDINE	PYRIDINE	LIQUID		(2)		[redacted]		OVAG
TELONE	1,3 DICHLOROPROPENE	LIQUID	[redacted]	[redacted]	[redacted] (1)	[redacted]	[redacted] MAY BE ABSORBED THROUGH THE SKIN	OVAG
TITRATION SOLUTION FOR OIL	TOLUENE ISO-PROPYL ALCOHOL	LIQUID			[redacted]	[redacted]		OVAG
1,2,3 TRICHLORO-PROPANE	1,2,3 TRICHLORO-PROPANE	LIQUID	[redacted]	[redacted] (2)	[redacted]	[redacted]	[redacted]	OVAG
VIDDEN D	1, 3 DICHLORO-PROPENE	LIQUID	[redacted]	[redacted] (2)	[redacted] (1)	[redacted]	[redacted] MAY BE ABSORBED THROUGH THE SKIN	OVAG
ZIMMITE	[redacted] (QUATERNARY AMMONIUM COMPLEX BIOCIDE)	LIQUID	[redacted]	[redacted]	[redacted]	[redacted]		OVAG

LEGEND:

[redacted] — SERIOUSLY EFFECTS THE EXPOSED PART OF THE BODY PERMANENT INJURY POSSIBLE
MAY BE A SERIOUS FIRE AND/OR EXPLOSION HAZARD
→ TAKE ALL POSSIBLE SAFETY PRECAUTIONS TO PREVENT FIRE AND TO PREVENT EXPOSURE TO THE EYES, SKIN AND LUNGS
→ IMMEDIATE AND PROLONGED IRRIGATION OF THE EYES AND/OR SKIN IS ESSENTIAL
→ IMMEDIATE MEDICAL ATTENTION IS NECESSARY

MODERATE OR TEMPORARY EFFECTS TO THE EXPOSED PART OF THE BODY PERMANENT INJURY POSSIBLE BUT NOT LIKELY.
→ APPROPRIATE SAFETY PRECAUTIONS NEEDED IN HANDLING AND IN PREVENTING EXPOSURE TO VAPORS.
→ IMMEDIATE AND STANDARD IRRIGATION OF THE EYES AND/OR SKIN SHOULD BE UNDERTAKEN
→ MEDICAL ATTENTION SHOULD BE OBTAINED.

[redacted] — MILD EFFECTS TO THE EXPOSED PART OF THE BODY POSSIBLE DISCOMFORT AND IRRITATION BUT NO SERIOUS EFFECTS EXPECTED.
IT WILL BURN BUT DOES NOT PRESENT A FIRE HAZARD UNDER NORMAL CONDITIONS
→ OBSERVE PRACTICAL PROTECTION RULES AND REGULATIONS.
→ FOLLOW STANDARD IRRIGATION PRACTICES
→ REPORT TO THE MEDICAL DEPARTMENT OR FIRST AID IF ANY EFFECT IS NOTED.

[redacted] — NO EFFECTS EXPECTED FROM EXPOSURE.
NO FIRE HAZARD
→ OBSERVE GENERAL PLANT AND DEPARTMENT RULES ON HANDLING PRECAUTIONS AND PROTECTIVE EQUIPMENT

(1) — BREATHING VAPORS MAY CAUSE DROWSINESS OR DIZZINESS.

(2) — BURNS IF TRAPPED UNDER ITEMS SUCH AS BELTS, SHOES, WATCHBANDS, BANDAIDS.

[redacted] — DANGEROUSLY TOXIC FUMES LIKELY IF MATERIAL CONTACTS WELDING OPERATIONS OR IS SUBJECTED TO TEMPERATURES SUFFICIENT FOR DECOMPOSITION TO OCCUR

REQUESTED BY	GLYCERINE DEPARTMENT SUPERVISION
PREPARED BY	SUPERVISION AND TEXAS DIVISION MEDICAL DEPARTMENT
DRAWN BY	[redacted] Dow 10-12-73

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TEXAS DIVISION
GLYCERINE DEPARTMENT - CHEMICAL HAZARDS GUIDE

COMMON NAME	CHEMICAL NAME	PHYSICAL STATE	EYES	SKIN	BREATHING OF VAPORS	FIRE	REMARKS	TYPE GAS CLASS
ACETONE	ACETONE	LIQUID			(1)			OVAC
ACETYLENE	ACETYLENE	GAS			(1)			OVAG
ACETONITRILE	METHYL CYANIDE	LIQUID					POOR WARNING PROPERTIES	OVAG
ACID INHIBITOR	DOWELL A-120	LIQUID						OVAG
ALLYL CHLORIDE	3, CHLOROPROPENE	LIQUID						OVAG
ALLYL CHLORIDE TARS	MIXED RCL'S	LIQUID						OVAG
AMMONIUM HYDROXIDE	AMMONIUM HYDROXIDE	LIQUID						AMMONIA
BRINE	SODIUM CHLORIDE	LIQUID						NONE
CARBON DIOXIDE	CARBON DIOXIDE	LIQUID					FROSTBITE OF SKIN POSSIBLE	CO_2
CAUSTIC AND CELL EFFLUENT	SODIUM HYDROXIDE	LIQUID						NONE
CHLORINE	CHLORINE	GAS						CHLORINE
3, CHLOROPROPENE MIX	2, CHLOROPROPENES ISOPROPYL CHLORIDE	LIQUID						OVAG
DICHLOROHYDRIN	DICHLOROHYDRIN	LIQUID		(2)				OVAG
2,3 DICHLOROPROPENE	2,3 DICHLOROPROPENE	LIQUID		(2)	(1)		MAY BE ABSORBED THROUGH THE SKIN	OVAG
DIHYDROXYMETHYL DIOXANE IN GLYCERINE	SAME	LIQUID						OVAG
EPI	EPICHLOROHYDRIN	LIQUID			(1)		A SKIN SENSITIZER MAY BE ABSORBED THROUGH THE SKIN WILL PENETRATE RUBBER OR NEOPRENE	OVAG
EPI LIGHTS	2,3 DICHLOROPROPYL ISOPROPYL CHLORIDE 1,3 DICHLOROPROPYL ISOPROPYL CHLORIDE	LIQUID						OVAG
EDC WASTE	TETRACHLOROETHANE BETA TRICHLOROETHANE EDC	LIQUID		(2)	(1)			OVAG

COMMON NAME	CHEMICAL NAME	PHYSICAL STATE	EYES	SKIN	BREATHING OF VAPORS	FIRE	REMARKS	TYPE GAS CLASS
EDC	ETHYLENE DICHLORIDE	LIQUID		(2)	(1)		BURNS IF TRAPPED UNDER SHOES, BELTS, WATCHBANDS, ETC.	OVAG
GLYCERINE	GLYCEROL	LIQUID						NONE
GLYCERINE ML	POLY GLYCERINES	LIQUID					IN PROCESS, VERY HOT (180°C)	NONE
HELIUM	HELIUM	GAS						
HCL	HYDROCHLORIC ACID	LIQUID						OVAG
FISCHER REAGENT	FISCHER REAGENT	LIQUID			(1)			OVAG
MAPP GAS	METHYLENE ACETYLENE	GAS			(1)			OVAG
METHANOL	METHANOL	LIQUID					POOR WARNING PROPERTIES	OVAG
METHANE	METHANE	GAS			(1)			OVAG
NITROGEN	NITROGEN	GAS					FROSTBITE OF SKIN POSSIBLE	N_2
OXYGEN	OXYGEN	GAS					INCREASES FLAMMABILITY OF OTHER ORGANIC	NONE
PENTENE	2-4-4 TRIMETHYL PENTENE-1	LIQUID						OVAG
POLPOL	80% GLYCEROL	LIQUID						NONE
POC	PROPYLENE DICHLORIDE	LIQUID		(2)	(1)			OVAG
PROPYLENE	PROPYLENE	LIQUID GAS			(1)		FROSTBITE OF SKIN POSSIBLE	OVAG
PYRIDINE	PYRIDINE	LIQUID		(2)				OVAG
TCLONE	1,3 DICHLOROPROPENE	LIQUID			(1)		MAY BE ABSORBED THROUGH THE SKIN	OVAG
TITRATION SOLUTION FOR OIL	TOLUENE ISO-PROPYL ALCOHOL	LIQUID						OVAG
1,2,3-TRICHLORO-PROPANE	1,2,3 TRICHLORO-PROPANE	LIQUID		(2)				OVAG
VIODEN D	1, 3 DICHLORO-PROPENE	LIQUID		(2)	(1)		MAY BE ABSORBED THROUGH THE SKIN	OVAG
ZIMMITE	QUATERNARY AMMONIUM COMPLEX (BIOCIDE)	LIQUID			(1)			OVAG

LEGEND:

- SERIOUSLY EFFECTS THE EXPOSED PART OF THE BODY PERMANENT INJURY POSSIBLE
- MAY BE A SERIOUS FIRE AND/OR EXPLOSION HAZARD.

→ TAKE ALL POSSIBLE SAFETY PRECAUTIONS TO PREVENT FIRE AND TO PREVENT EXPOSURE TO THE EYES, SKIN AND LUNGS
→ IMMEDIATE AND PROLONGED IRRIGATION OF THE EYES AND/OR SKIN IS ESSENTIAL
→ IMMEDIATE MEDICAL ATTENTION IS NECESSARY

- MODERATE OR TEMPORARY EFFECTS TO THE EXPOSED PART OF THE BODY PERMANENT INJURY POSSIBLE BUT NOT LIKELY.

→ APPROPRIATE SAFETY PRECAUTIONS NEEDED IN HANDLING AND IN PREVENTING EXPOSURE TO VAPORS.
→ IMMEDIATE AND STANDARD IRRIGATION OF THE EYES AND/OR SKIN SHOULD BE UNDERTAKEN
→ MEDICAL ATTENTION SHOULD BE OBTAINED.

- MILD EFFECTS TO THE EXPOSED PART OF THE BODY POSSIBLE DISCOMFORT AND IRRITATION BUT NO SERIOUS EFFECTS EXPECTED.
- IT WILL BURN BUT DOES NOT PRESENT A FIRE HAZARD UNDER NORMAL CONDITIONS

→ OBSERVE PRACTICAL PROTECTION RULES AND REGULATIONS.
→ FOLLOW STANDARD IRRIGATION PRACTICES.
→ REPORT TO THE MEDICAL DEPARTMENT OR FIRST AID IF ANY EFFECT IS NOTED

- NO EFFECTS EXPECTED FROM EXPOSURE.
- NO FIRE HAZARD

→ OBSERVE GENERAL PLANT AND DEPARTMENT RULES ON HANDLING PRECAUTIONS AND PROTECTIVE EQUIPMENT

(1) — BREATHING VAPORS MAY CAUSE DROWSINESS OR DIZZINESS.

(2) — BURNS IF TRAPPED UNDER ITEMS SUCH AS BELTS, SHOES, WATCHBANDS, BANDAIDS.

— DANGEROUSLY TOXIC FUMES LIKELY IF MATERIAL CONTACTS WELDING OPERATIONS OR IS SUBJECTED TO TEMPERATURES SUFFICIENT FOR DECOMPOSITION TO OCCUR.

REQUESTED BY	GLYCERINE DEPARTMENT
PREPARED BY	SUPERVISION AND TEXAS DIVISION MEDICAL DEPARTMENT
DRAWN BY	Date 10-16-73