U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
Cincinnati, Ohio 45202

HEALTH HAZARD EVALUATION DETERMINATION
Report No. 72-90-107
ARCO POLYMER INCORPORATED
(SINCLAIR-KOPPERS COMPANY, INC.)
MONACA, PA. 15051
February 1974

# I. TOXICITY DETERMINATION

## A. General Statement

This large chemical plant produces styrene monomer by the dehydrogenation of ethyl benzene. Styrene is both sold and utilized in the manufacture of polystyrene plastics (beads, granules, pellets, sheets and meat trays), high temperature styrene plastics, and butadiene-styrene latex. By-products including benzene, xylene, and toluene are recovered. Hydrogen recovered during the reaction is used as a supplementary fuel.

Most processes are highly automated and normally fully enclosed resulting in minimal employee exposure during routine operation. Accidental exposure to high concentrations of toxic materials can occur when leaks, spills, fires, or poorly controlled reactions interrupt normal operation. Maintenance operations may also expose workmen to high levels of toxic substances.

Hazardous exposures to toxic substances and/or noise were determined to exist for employees during routine conditions of production in the following areas: (1) noise and tricalcium phosphate dust in the Dylite-Dylene reactor and screening areas; (2) coal dust in the power house; (3) fly ash in the fly ash silo; and (4) benzene in the styrene laboratory.

A number of plant areas were also identified in which occasional atmospheric samples were found to exceed recommended standards either during normal or abnormal operating conditions or in which poor work practices were utilized. Observation revealed that employee exposure times in these work areas were generally of insufficient duration to exceed time-weighted average standards, but that these areas represent significant potential hazards and warrant the institution of engineering or other changes. Potentially toxic exposures were found with respect to toluene and benzene in the (1) benzene building and (2) styrene cracking building - No. 1 plant; toluene, benzene, and ammonia in the (3) semi-commercial area and to (4) mercury in the instrument repair shop.

B. Basis for Determination

1. The basis for the determination of toxic or potentially toxic concentrations is by comparison of the actual concentration found in the breathing zone of the chemical plant employees (or in their general work area) with that of the OSHA standards. Levels at or above OSHA standards are considered to be potentially toxic.

2. No definite medical evidence of toxic manifestations were found. A review of the plant medical records and mortality experience of plant personnel revealed no significant deviations from national averages.

C. Recommendations

Specific recommendations are suggested in the body of the report by engineering controls, employee work practices, and protective devices to obviate observed or potential hazards.

## II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are available upon request from the Hazard Evaluation Services Branch, NIOSH, U.S. Post Office Building, Room 508, 5th and Walnut Streets, Cincinnati, Ohio 45202. Copies have been sent to:

a. Arco Polymer, Inc., Monaca, Pa.
b. Authorized Representative of Employees
c. U.S. Department of Labor, OSHA - Region III
d. NIOSH - Region III

For the purposes of informing the approximately 600 "affected employees," the employer will promptly "post" the Determination Report in a prominent place(s) near where affected employees work for a period of 30 calendar days.

## III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of employees regarding exposure to noise and twenty-three substances used or found in the plant. Requestor emphasis was placed on these potential hazards: acrylonitrile, styrene, polystyrene, benzene, formaldehyde, diatomaceous earth, asbestos and noise. A primary concern of the employees was whether or not their employment was a threat to their health and longevity.

## IV. HEALTH HAZARD EVALUATION

### A. Description of Processes

#### 1. Styrene Monomer Production

##### A. Styrene Cracking Building - No. 1 Plant

This large chemical plant was built during World War II for the production of synthetic rubber, and many of the buildings and process equipment are still in use. A new and highly automated styrene plant was added in 1969 to enlarge the production of styrene monomer, the basic product. Ethyl benzene (EB) mixed with superheated steam is fed into the reactor. The vaporized EB is passed through a catalyst bed (iron oxide) where the reaction takes place. The effluent is cooled, condensed, and vent gas (containing about 90% hydrogen) is used as fuel. The crude styrene is then forwarded to the purification plant.

Three operators are employed per shift operating a number of reactors.

##### B. Styrene Purification Building - No. 1 Plant

The condensed effluent is transferred (piped) to the styrene purification building where the styrene is purified by distillation. Ethyl benzene, benzene, toluene, and xylene are separated in this process from styrene.

Three operators per shift work in this area and a shift foreman divides his time between the old styrene plant and the purification building.

No particular hazard was noted other than the collection of samples for quality or process control purposes.

C. No. 2 Styrene Plant

This plant was built in 1969 and it utilizes steam superheaters and reactors. EB is dehydrogenated to form styrene as previously described. The effluent is fed through exchangers, condensed, dehydrated and then is purified in distillation columns to separate the remaining ethyl benzene and the benzene, toluene, and xylene from the styrene.

Three employees per shift are required to operate this new, highly automated plant. These men spend most of their time in the control room and are not exposed to the process equipment located outside.

2. Benzene Building

The fraction left from the manufacture of styrene is transferred to the benzene building for separation. Here, the mixture of ethyl benzene, benzene, toluene and xylene is charged into one of two reactors (batch basis), hydrogenated, then distilled to separate the ethyl benzene, benzene, toluene and xylene. Only one operator per shift is required.

3. Dylite-Dylene Area

Polystyrene (or Dylene) is produced and then impregnated with a blowing agent, usually pentane, to make Dylite.

In the north and east areas, styrene is pumped into holding tanks until needed for production. These reactors are filled with styrene, water, suspending agents and a catalyst. This batch reaction produces polystyrene beads. The slurry is dewatered and dried. The product is then placed in storage silos. Operators are exposed to styrene vapors in reactor area.

In the west area, polystyrene is charged to the reactors and impregnated with pentane in a closed system to form Dylite. The screening area is noisy and dusty; however, there is no full time exposure. Recommendations are submitted to control these hazards. Following extrusion, drying, and sizing, the Dylite is packaged or further processed into sheets or made into meat trays.

4. Dylite-2 Plant

This plant, commonly called the D-2 area, manufactures Dylite by impregnating polystyrene with a blowing agent (of which there are several), the principal one being pentane.

Six employees per shift, man this area. No particular hazard was observed, but exposure to hydrochloric acid was investigated by observing the operation. The exposure, which was slight, lasted only for a minute or two each twenty-four hours.

5. Old Polystyrene Area

This area, commonly known as the Old Poly Area, is composed of several divisions. One area is used by R&D engineers for experimental work. An adjoining area, D-1, is used for the production of polystyrene. The D-8 area (a new addition) is used to prepare the rubber in a two-step process. Polybutadiene rubber is dissolved in a closed reactor using heat and a catalyst and subsequently added to polystyrene.

In the Extrusion Area, dyes, different resins, and special additives are mixed in a "boiling mixer," then extruded and cut to size. After drying, the polystyrene is stored in bins for use in blends to meet various specifications. No inherent health hazard was noted in this operation.

6. New Dylark Plant

Dylark, a copolymer of styrene and maleic anhydride, is manufactured by combining styrene and molten (60°C) maleic anhydride.

Start up operations and changing filters may produce some fumes, but respirators are used to control this slight exposure on an interim basis. Five employees per shift are required for this operation.

7. Semi-commercial Area

Approximately 20 people per shift are employed in this area. Butadiene-styrene latex is produced. Butadiene, soaps, water, catalyst, and styrene are mixed, then transferred to a reactor. Water is added and heat applied to polymerize the mixture and form an emulsion. Ammonia is added as a stabilizer and diatomaceous earth is used to form a slurry. The slurry is filtered to complete the process. It is placed in 50-gallon drums or (primarily) pumped into tank cars.

Diatomaceous earth is added by hand from paper shipping bags. The exposure is brief and judged too slight to monitor. Exposure to ammonia, formaldehyde, butadiene, and styrene are either slight and/or of short duration. However, employees are exposed to toluene and benzene while cleaning screens, filter cloths and boiling out the reactors (toluene boil-out). Recommendations are submitted to correct these conditions.

This area is also used as a pilot plant for research and development work. Special forms of Dylite are also made here to customer specifications.

8. Powerhouse

Five high pressure boilers (4 pulverized coal, 1 oil) produce steam for use in the plant. Coal, received by barges or trucks, is transferred from unloading points by belt conveyor to the coal bunkers on the top floor of the powerhouse. One man works full time (day shift) using the tripper car to fill the individual compartments.

Soot is blown daily (usually between midnight to 3:00 a.m.) requiring approximately an hour and a half. Eight men per shift operate the powerhouse. Two additional men work the day shift only. Coal dust and soot are the only hazardous materials encountered here. Recommendations are submitted to control these hazards.

9. Fly-ash

Fly-ash from the powerhouse is conveyed to an adjacent silo. The ash flows by gravity to a hopper (vibrated mechanically) for discharge into trucks for removal from the plant. One full time operator (day shift) performs this extremely dusty task. Recommendations are submitted to control this hazardous dust.

10. Instrument Repair Shop

Instruments, including mercury manometers, are repaired in this building by various maintenance men. Recommendations to control a possible mercury exposure are suggested.

11. Styrene Laboratory

The laboratory is located in a separate building. Normally three technicians work in this building to perform analyses of various process samples. At the time of the survey work was not being performed under a hood.

B. Evaluation Design

The "walk through" or observational survey of May 8, 1973, indicated exposures to benzene, toluene, styrene and xylene could be excessive. This was confirmed by reviewing the plant medical records. Problem areas were observed and noted by the team. Other areas of concern were found by employee interviews and information supplied by the employees' representatives (officials of O.C.A.W.I.U. Local No. 8-74).

Plans were made to return and use detector tubes and other spot air sampling methods to further define the extent of the problem and problem areas. The medical team also indicated that further examination of the medical records and causes of death of several employees required study.

A second survey was made June 26 through June 29, 1973, to complete the remainder of the observational survey. Detector tube samples and breathing zone samples were taken with charcoal tubes. Analysis indicated high concentrations of benzene and toluene in the styrene cracking and benzene buildings. A thorough review of the medical records was also completed. Plans were then made to return for extensive environmental sampling.

A team of industrial hygienists returned to the plant on August 20 and took sixty-two air samples for organic vapors in the breathing zone of operators as they performed their regularly assigned duties. Twelve detector tube samples were also taken as were samples for various dusts such as coal, fly-ash, soot, tricalcium phosphate and cadmium sulfide. One impinger sample for sodium hydroxide was included and a noise survey of the Dylene-Dylite area was completed. Using a list of employees who had died in the past five years, the medical team obtained and analyzed death certificate information on file at the Department of Health in Harrisburg.

C. Evaluation Methods

1. Sampling Methods

Direct reading Drager and MSA detector tubes and pumps were used to collect and determine the levels of ammonia, acrylonitrile, benzene, butadiene, ethylbenzene, formaldehyde, mercury, styrene monomer, toluene and xylene. Breathing zone (BZ) samples were collected with MSA Model G personal monitoring pumps and charcoal tubes placed on individual employees. Sampling time for organic vapors was generally one to two hours when feasible, and the rate was 0.5 cubic feet per hour. Instantaneous dust samples, both total and respirable dust, were taken by the GCA Model RDM-101 Respirable Dust Monitor. Other respirable dust samples were taken using a MSA Model G personal monitoring pump with a 10-mm cyclone and a pre-weighed polyvinyl chloride filter (5 micron pore size) in a 37-mm cassette attached to the employee's lapel. A pre-weighed cellulose membrane (0.8 micron pore size) filter was used to collect the cadmium sulfide dust by holding it in the breathing zone of the operator. Sampling rate for all dusts was two liters per minute. One impinger sample for sodium hydroxide exposure was taken using a MSA Model G personal monitoring pump, sampling at a rate of two liters per minute. The sample was collected using 15 ml. of 0.1N HCl to absorb the vapor while holding the impinger in the breathing zone of the operator.

2. Analytical Methods

The charcoal tubes were labeled, sealed, and returned to the NIOSH Laboratory in Cincinnati for analysis by gas chromatography. The minimum detectable limits for acetone, benzene, toluene, and styrene were approximately 0.04 milligrams while the limit for ethyl benzene was approximately 0.02 mg. The amount of dust was determined by pre-weighing the filters then determining the gross weight and subtracting the tare weight. A sensitive analytical balance was used for these determinations. The amount of sodium hydroxide was determined by titration.

A General Radio Sound Level Meter Type 1565-B which was calibrated prior to the survey was used for this study. A Bacharach Mercury Vapor Detector-Model MV2 was used to survey the instrument shop.

D. Evaluation Criteria

1. Environmental Standards

a. OSHA standards as found in 29 CFR, paragraph 1910.93, "Air Contaminants" were used as criteria for toxic dusts, mists, and vapors. Portions of Tables G-1, G-2, and G-3 applicable to this Hazard Evaluation follow:

TABLE G-1

| Substance | p.p.m[a] | mg/M$^3$ [b] |
|---|---|---|
| Acetone | 1,000 | 2,400 |
| Acrylonitrite | 20 | 45 |
| Ammonia | 50 | 35 |
| Butadiene | 1,000 | 2,200 |
| Ethyl Benzene | 100 | 435 |
| Pentane | 1,000 | 2,950 |
| Sodium Hydroxide | | 2.0 |
| Xylene | 100 | 435 |

a Parts of vapor or gas per million parts of contaminated air by volume at 25°C and 760 mm Hg pressure.

b Approximate milligrams of particulate per cubic meter of air.

TABLE G-2

| Material | 8-Hr. Time-weighted Average | Acceptable Ceiling Concentration | Acceptable Maximum Peak Above the Acceptable Ceiling Concentration for an 8-hr. Shift | |
|---|---|---|---|---|
| | | | Concentration | Maximum Duration |
| Benzene | 10 p.p.m | 25 p.p.m | 50 p.p.m | 10 mins. |
| Formaldehyde | 3 p.p.m | 5 p.p.m | 10 p.p.m | 30 mins. |
| Styrene | 100 p.p.m | 200 p.p.m | 600 p.p.m | 5 mins. in any 3 hrs. |
| Mercury | - | 1 mg/10M$^3$ | - | - |
| Toluene | 200 p.p.m | 300 p.p.m | 500 p.p.m | 10 mins. |
| Cadmium Dust | 0.2 mg./M$^3$ | 0.6 mg./M$^3$ | - | - |

TABLE G-3 MINERAL DUSTS

| Substance | Mg/M$^3$ |
|---|---|
| Coal Dust (Respirable fraction less than 5% $SiO_2$) | 2.4 mg/M$^3$ |
| Inert or Nuisance Dust: Respirable fraction (Tricalcium Phosphate) | 5 mg/M$^3$ |
| Total Dust | 15 mg/M$^3$ |

b. OSHA standards as found in 29 CFR, paragraph 1910.95, "Occupational Noise Exposure."

TABLE G-16--PERMISSIBLE NOISE EXPOSURES[1]

| Duration per day, hours | Sound level dBA slow response |
|---|---|
| 8 | 90 |
| 6 | 92 |
| 4 | 95 |
| 3 | 97 |
| 2 | 100 |
| 1-1/2 | 102 |
| 1 | 105 |
| 1/2 | 110 |
| 1/4 or less | 115 |

[1] When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: $C1/T1+C2/T2 - - + Cn/Tn$ exceeds unity, then, the mixed exposure should be considered to exceed the limit value. Cn indicates the total time of exposure at a specified noise level, and Tn indicates the total time of exposure permitted at that level.

E. Evaluation Results and Discussion

1. Environmental

The sample results for various plant locations are found in tabular form in Section VII of this report.

In general, no plant operation was found where exposures to organic vapors were continually excessive, i.e., at or above OSHA standards. Approximately eighty-eight samples were taken for organic vapors, but only eight detector tube samples and six charcoal tube samples were at or above the OSHA standards. Excessive exposures were usually the result of leaks, spills or similar unusual operations, usually of short duration, with no ill effects noted or reported. Recommendations have been made to correct recurring conditions which could lead to toxic concentrations and possible ill effects.

a. Hazardous Exposures

(1) Dylite-Dylene Area

Noise levels were found to vary from 90 to 106 $dba_s$ which exceed the OSHA standard.

One styrene exposure on August 24, 1973, resulted in a concentration one and a half times the OSHA standard for a one and a half hour period. However, the time-weighted average for this worker was less than half the standard.

Dust, principally tricalcium phosphate, was a continuing problem. The time-weighted average exposure was one and a half times the OSHA standard for respirable nuisance dust.

(2) Power House

Coal dust in the breathing zone of the tripper car operators while filling the bunkers exceeded the OSHA standard by a factor of two on August 24 based on a time-weighted average sample.

(3) Fly Ash Silo

Fly ash was found to exceed the OSHA standard for nuisance dust by a factor of two while loading trucks or cleaning this area.

(4) Styrene Laboratory

One charcoal tube sample of two hours duration resulted in a measurement of four times the OSHA standard for benzene.

b. Potentially Toxic Exposures

(1) Benzene Building

A spill of a benzene-toluene solution occurred in the control room on June 27. Detector tube readings were taken in the area of the spill later that day with these results: one detector tube indicated a concentration of 30 to 60 ppm of benzene; a second detector tube indicated 300-400 ppm of toluene. The following day detector tube measurements indicated the presence of less than 15 ppm of benzene.

(2) Styrene Cracking Building - No. 1 Plant

A single charcoal tube sample (6-28-73) of an hour's duration was three times the benzene eight hour time-weighted OSHA standard. During the follow-up visit, the charcoal tube results were far below (13% or less) the standard.

(3) Semi-commercial Area

Four charcoal tube samples, 7 to 31 minutes in duration, resulted in toluene measurements as much as 30% in excess of the OSHA standard and benzene levels exceeded the standard by a factor of 2-3 times during a toluene boil-out.

(4) Instrument Repair Shop

Globules of mercury were noted on table tops and on the floor during the survey. Although atmospheric measurements failed to detect mercury in the breathing zone, probably due to numerous open doors and windows (summer time conditions), it was felt that a potential for toxic exposure exists either through atmospheric absorption when general ventilation is less optimal or via ingestion. Workmen were noted to be eating, drinking, and smoking in the shop.

2. Medical

a. Methodology

With the assistance of the plant nurse, a relatively complete review of medical records was carried out on June 26-27, 1973. This included all hematology records. Company policy requires that a white blood cell count, hemoglobin, and hematocrit determinations be made every six months for each production employee working in areas where benzene exposure is possible. All hematology results for the past year were scrutinized. For purposes of classification, normal values were assumed to range from 13 to 16 grams of hemoglobin (Hg); 40 to 50% for the hematocrit (Hct), and 4,500 to 12,000 for the white blood count (WBC).

A complete list of all known deceased employees including plant retirees was obtained. Since management was often unsure as to the cause of death, it was decided to review individual death certificates to obtain this information.

It was decided to limit this search to employees dying within the past five years since workers dying prior to that time probably had exposures substantially different from those occurring at the present. Investigation was also limited to those workers living in Pennsylvania although a few deaths occurred in workers residing in West Virginia and Ohio, areas relatively close to Monaca. It was not felt that this selective process would result in any meaningful bias. The age and primary cause of death were obtained from each worker's death certificate on file in the Pennsylvania State Health Department by Mrs. Carolyn Hager, NIOSH Region III nurse, and forwarded to Cincinnati for tabulation and statistical analysis.

b. Results and Discussion

(1) Hematologic Tests

A total of 589 complete blood count reports were examined. In 63 instances abnormal (based on the previously stated criteria) hemoglobin levels were found; 15 elevations and 48 depressions. Of these, only 4 values--more than one gram greater than the criteria--were noted and in only 16 instances were values more than one gram below normal noted.

As expected, hematocrit values tended to parallel hemoglobin values. Seventy-eight abnormal values were noted; 21 increased and 57 decreased. Again the vast majority of high or low values were close to the chosen limits for "normal." The Styrene Laboratory was the only plant area in which a "cluster" of low hemoglobin-hematocrit values were noted. These occurred during February-March 1973. On retesting these individuals had returned to normal.

White blood count values were considered high or low in 54 instances; 23 above 12,000 and 31 below 4,500. In only eight instances were the values of all three tests considered abnormally low. In a single instance, all three values were high. In each of these cases either (1) repeat testing failed to substantiate the original findings, or (2) a logical non-occupational medical explanation was known to account for the anemia and leukopenia. Such explanations included acute traumatic hemorrhage prior to testing and bleeding problems (duodenal ulcer, hemorrhoids). No instances of severe persistent anemia were encountered.

Hematologic values have wide ranges of "normal" depending upon age, sex, and local, religious, cultural or other dietary habits. As with most biologic data the value distribution follows a normal curve with some perfectly normal asymptomatic individuals falling above or below the majority. Many common disease states tend to effect these values but most tend to reduce values (anemia) and relatively few conditions result in increased values. Thus, for any large population group studied, more individuals with low values will be encountered tending to skew the normal distribution curve slightly. In addition, the methods for carrying out these blood tests are subject to a considerable variation or error. This, when combined with the inherent day-to-day biologic variation in these values tend to confer upon these tests a fairly low degree of reproducibility. While chronic low level benzene exposures may cause low hemoglobins and hematocrits (anemia) as well as depressed white blood cell counts (leukopenia) and other blood element changes, these effects do not occur after occasional or episodic exposures. In advanced cases, all the blood elements become depressed in an often irreversible manner, resulting in aplastic anemia. Careful study of the available records revealed no cases of this serious disorder. Leukemia has also been reported as a sequela of chronic benzene exposure but its incidence is expected to be much less than severe anemia or aplastic anemia. Unfortunately, the principal causes of leukemia have not been identified and this not uncommon disorder frequently arises in an apparently spontaneous manner. The review of the hematology tests did not reveal any current values suggesting this disorder.

Thus, careful consideration of this rather large body of data did not reveal an inordinate number of significantly abnormal test results which could not be explained on the basis of non-occupationally related disorders.

(2) Mortality Experience

Forty-six death certificates were available for analysis. Five certificates were not evaluated because death was due to accidents of a non-work nature (4) or suicide (1). The average age at the time of death for the remaining 41 individuals was 63.3 years. At the time these individuals were born (circa 1910), the life expectancy for white males was 50.2 years and this expectancy has been amply exceeded. It is, however, more meaningful to compare their age of demise with that of white males. In 1970, this average age of death was 67 years. The difference between the small sample studied and that for the nation as a whole is thus 3.7 years suggesting that the group under consideration may have a shortened life span. Statistical analysis (P = .35) reveals that this difference is not significant and is probably due to random chance in sampling.

It was also important to learn if a disproportionate number of deaths occurred from any one or group of causes. The 41 deaths under consideration may be classed as follows and compared with causes for the nation as a whole:

| | Plant Workers | | National Data* | |
|---|---|---|---|---|
| Cause | Actual Number | Percent | Actual Number | Percent |
| Coronary Disease | 22 | 53.6 | 52,681 | 49.5 |
| Cancer (all forms) | 13 | 31.7 | 24,122 | 22.7 |
| Cerebral Vascular | 3 | 7.3 | 7,386 | 6.9 |
| Respiratory | 2 | 4.8 | 7,789 | 7.3 |
| Digestive System | 1 | 2.4 | 5,270 | 5.0 |
| All Other | 0 | 0 | 9,134 | 8.6 |
| TOTALS | 41 | 100 | 106,382 | 100 |

* Males, Aged 60-64 Excluding Accidents, etc.

Examination of this data shows that for most categories of disease, the incidence actually experienced by these workers was quite close to that expected based on national data. The most conspicuous discrepancy occurs in cancer deaths, 31.7% of workers died of cancer compared with only 22.7% of men nationally. Statistical analysis, however, showed no significant difference between the observed and expected values. Review of the types of cancer diagnosed also failed to reveal an unusual incidence of any particular type. In fact, ten different types of tumors were observed among the 13 individuals dying of neoplasia. This also strongly suggests that no common factor was operative in the causation of cancer among these individuals. No cases of aplastic anemia were found.

## SUMMARY AND CONCLUSIONS

This medical evaluation has concerned itself with attempting to identify the presence of serious and potentially life threatening health hazards within this large chemical plant which utilizes numerous potentially harmful substances.

Based on the medical information garnered from plant records, there is no evidence of chronic benzene exposure. Hematology tests as carried out appear adequate to detect insidious benzene toxicity.

Data obtained from death certificates were analyzed to determine if workers were experiencing (1) a shorter than normal life span, or (2) experiencing excessive mortality from occupationally associated causes. From this analysis, it appears that neither of these possibilities is tenable and the mortality of this group appears to closely resemble that of the general population.

It is concluded that no serious health or life threatening hazard could be identified as existing in this work place at the time of study.

## RECOMMENDATIONS

A. Benzene Building

1. The packing should be replaced on pump shafts and valves before leaks occur. Leaks must be repaired immediately to avoid excessive concentrations of benzene.

2. The use of approved respirators (for organic vapor) should be continued when minor leaks are noted. Supplied air respirators should be available for major leaks or spills.

B. Dylite-Dylene Reactor and Screening Areas

1. Reactor operators should be provided with approved respirators for organic vapors and wear them when styrene vapors are excessive.

2. Dust respirators approved for nuisance dust should be worn by all employees working in the screening area.

3. Hearing protection should be provided and worn by all employees working in the screening area.

C. Fly-ash Silo

1. Engineering controls are needed to keep the fly-ash confined while loading trucks.

2. The mechanism feeding the hopper should be improved to prevent clogging and depositing excessive dust on the floor. This operation should be made dust free to eliminate exposure during clean-ups.

3. The use of approved respirators for nuisance dust should be continued until improvements have been made.

D. Power House

1. Tripper car operators work continuously in a dusty area. The installation of an enclosed cab with tempered and filtered air is recommended.

2. The continued use of approved respirators should be required as an interim measure.

3. Engineering controls are required to prevent the leakage of soot in the power house while blowing soot.

E. Styrene Cracking Building - No. 1 Plant

Operators should be furnished respirators approved for organic vapor and wear them when taking samples and working in the area of the cracking sump.

F. Styrene Laboratory

Process and quality control samples should be kept in air tight containers or under laboratory (ventilated) hoods until ready for analysis. Analyses should be done under standard laboratory hoods. These should supply an average face velocity of 150 feet per minute.

G. Semi-commercial Area

1. Engineering controls are needed to reduce the exposure to benzene and toluene in the manufacture of butadiene-styrene latex. Toluene "boil out" effuent should be discharged via a closed system into a sump or holding tank pending further processing, recovery or disposal. Until these process modifications are completed, workmen should wear approved respirators for organic vapors.

2. The cleaning of work clothing in open drums of toluene should be prohibited.

H. Instrument Repair Shop

1. All repairs in which there is a likelihood of mercury spillage should be performed on an impervious table top which has a guttered edge. Flowers of sulfur should be placed in the gutter periodically to facilitate the removal of escaped mercury.

2. Eating, drinking, and smoking should be prohibited at this table.

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TABLE 1A

CHARCOAL TUBE SAMPLES

| Date 1973 | Location | Acetone Conc. mg/M$^3$ | Acetone Std. % | Benzene Conc. mg/M$^3$ | Benzene Std. % | Ethyl Benzene Conc. mg/M$^3$ | Ethyl Benzene Std. % | Pentane | Styrene Conc. mg/M$^3$ | Styrene Std. % | Toluene Conc. mg/M$^3$ | Toluene Std. % | Mixture Std. % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6/28 | Benzene Blg. | - | - | 21.8 | 68.2 | 4.44 | 1.0 | - | - | - | 35.2 | 4.7 | 73.9 |
| 8/21 | Benzene Blg. | - | - | 7.07 | 22.1 | < 1.41 | < 0.3 | - | - | - | 32.9 | 4.4 | 26.8 |
| 8/21 | Benzene Blg. | 7.32 | 0.3 | 7.07 | 22.1 | 4.55 | 1.0 | - | 6.06 | 1.4 | 23.5 | 3.1 | 27.9 |
| 8/22 | Styrene Lab. | 21.6 | 0.9 | 137. | 428.1 | 1.41 | 0.3 | - | - | - | 13.1 | 1.7 | 431. |
| 8/22 | Styrene Lab. | 16.6 | 0.7 | 5.65 | 17.7 | < 3.89 | < 0.9 | - | 3.53 | 0.8 | 5.65 | 0.8 | 20.9 |
| 8/22 | Benzene Blg. | < 1.41 | < 0.1 | 18.4 | 57.5 | < 1.41 | < 0.3 | | - | - | 16.9 | 2.3 | 60.2 |
| 8/22 | Styrene Lab. | 17.0 | 0.7 | 1.41 | 4.4 | < 0.71 | < 0.2 | - | 5.65 | 1.3 | 3.53 | 0.5 | 7.1 |
| 8/22 | Styrene Lab. | 25.1 | 1.0 | < 1.41 | < 4.4 | < 1.41 | < 0.3 | - | 9.19 | 2.2 | 7.07 | 0.9 | 8.8 |
| 8/22 | Benzene Blg. | - | - | 6.36 | 19.9 | < 0.71 | < 0.2 | - | < 1.41 | 0.3 | 7.77 | 1.0 | 21.4 |
| 8/22 | Styrene Lab. | 23.6 | 1.0 | < 2.42 | 7.6 | < 1.21 | < 0.3 | - | 14.5 | 3.5 | < 2.42 | < 0.3 | 12.7 |
| 8/22 | Styrene Lab. | 14.5 | 0.6 | 1.49 | 4.7 | < 0.74 | < 0.2 | - | 4.46 | 1.1 | < 1.49 | < 0.2 | 6.8 |
| 8/22 | Benzene Blg. | - | - | 8.57 | 26.8 | < 0.82 | < 0.2 | - | 9.39 | 2.2 | 12.7 | 1.7 | 31. |
| 8/22 | " 1st Flr. | - | - | < 8.51 | < 26.6 | < 4.24 | < 1.0 | - | < 8.47 | < 2.0 | < 8.47 | < 1.1 | 30.7 |
| 8/23 | S.C. Latex Rx | - | - | 1.45 | 4.5 | - | - | Trace | 4.34 | 1.0 | 16.7 | 2.2 | 7.7 |
| 8/23 | " Filter Rm. | - | - | 2.23 | 7.0 | - | - | - | < 1.49 | < 0.4 | 33.1 | 4.4 | 11.8 |
| 8/23 | " Latex Rx. | - | - | 2.88 | 9.0 | - | - | Trace | < 2.88 | < 0.7 | 12.9 | 1.7 | 11.4 |
| 8/23 | " Filter Rm. | - | - | < 2.96 | < 9.2 | < 1.48 | < 0.3 | - | < 2.96 | < 0.7 | 9.63 | 1.3 | 11.5 |
| 8/23 | " Latex Rx. | - | - | < 1.24 | < 3.9 | < 0.62 | < 0.1 | Trace | < 1.24 | < 0.3 | < 10.2 | < 1.4 | 5.7 |
| 8/23 | " Filter Rm | - | - | 2.97 | 9.3 | < 0.46 | < 0.1 | - | < 0.92 | < 0.2 | 18.3 | 2.4 | 12.0 |
| 8/23 | " Latex Rx. | - | - | < 2.92 | 9.1 | < 1.46 | < 0.3 | - | 16.8 | 4.0 | 6.57 | 0.9 | 14.3 |
| 8/24 | Dylark | - | - | < 0.90 | < 2.8 | < 0.45 | < 0.1 | - | < 0.90 | < 0.2 | 1.57 | 0.2 | 3.3 |
| 8/24 | Dylark | - | - | < 0.90 | < 2.8 | < 0.45 | < 0.1 | - | 9.01 | 2.1 | 1.35 | 0.2 | 5.2 |
| 8/24 | " General Area | - | - | < 0.92 | < 2.9 | < 0.46 | < 0.1 | - | < 0.92 | < 0.2 | < 0.92 | < 0.1 | 3.3 |
| 8/24 | " General Area | - | - | < 0.97 | < 3.0 | < 0.48 | < 0.1 | - | < 0.97 | < 0.2 | < 0.97 | < 0.1 | 3.4 |
| 8/24 | " General Area | - | - | < 0.99 | < 3.1 | < 0.50 | < 0.1 | - | 4.01 | 1.0 | 23.8 | 3.2 | 7.4 |
| 8/24 | " General Area | - | - | - | - | - | - | - | < 0.99 | < 0.2 | < 0.99 | < 0.1 | < 0.3 |
| 8/24 | S.C. Latex | - | - | 101. | 315.6 | < 2.73 | < 0.6 | - | < 5.46 | < 1.3 | < 5.46 | < 0.7 | 318. |
| 8/24 | " General Area | - | - | 83.3 | 260.3 | < 2.73 | < 0.6 | - | < 5.46 | 1.3 | 986.3 | 131.5 | 393. |
| 8/24 | " General Area | - | - | 74.2 | 231.9 | < 7.07 | < 1.6 | - | < 14.1 | < 3.4 | 802.1 | 106.9 | 344. |
| 8/24 | " General Area | - | - | 84.8 | 265. | - | - | - | < 24.2 | < 5.8 | 987.9 | 131.7 | 402. |

TABLE 1B

CHARCOAL TUBE SAMPLES

| Date 1973 | Location | Acetone Conc. mg/M³ | Acetone Std. % | Benzene Conc. mg/M³ | Benzene Std. % | Ethyl Benzene Conc. mg/M³ | Ethyl Benzene Std. % | Pentane | Styrene Conc. mg/M³ | Styrene Std. % | Toluene Conc. mg/M³ | Toluene Std. % | Mixture Std. % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6/28 | Styrene #1 Cracking | - | - | 6.34 | 19.8 | 13.38 | 3.1 | - | 16.2 | 3.7 | 8.45 | 1.1 | 27.7 |
| 6/28 | Styrene #1 Cracking | - | - | 95.1 | 297. | 16.2 | 3.7 | - | 20.4 | 4.9 | 8.45 | 1.1 | 307. |
| 8/21 | Styrene Cracking | - | - | 2.80 | 8.8 | 14.0 | 3.2 | - | 7.20 | 1.7 | 9.60 | 1.3 | 15.0 |
| 8/21 | Styrene Cracking | - | - | 2.60 | 8.1 | 5.21 | 1.2 | - | 5.73 | 1.4 | 4.17 | 0.6 | 11.3 |
| 8/21 | Styrene Cracking | - | - | < 1.92 | < 6.0 | 7.69 | 1.8 | - | 3.85 | 0.9 | 2.40 | 0.3 | < 9.0 |
| 8/21 | Styrene Cracking | - | - | 4.14 | 12.9 | 15.5 | 3.6 | - | 9.67 | 2.3 | 6.08 | 0.8 | 19.6 |
| 8/21 | Styrene Cracking | - | - | 1.72 | 5.4 | 12.5 | 2.9 | - | 6.86 | 1.6 | 3.68 | 0.5 | 10.4 |
| 8/21 | Styrene Cracking | - | - | 1.40 | 4.4 | 12.0 | 2.8 | - | 6.70 | 1.6 | 3.35 | 0.4 | 9.2 |
| 8/22 | Styrene Pur #1 | - | - | < 1.19 | < 3.7 | 2.09 | .5 | Trace | 7.16 | 1.7 | < 1.19 | < 0.16 | < 6.0 |
| 8/22 | Styrene Pur #1 | - | - | < 1.64 | 5.1 | 9.43 | 2.2 | Trace | 9.02 | 2.1 | 2.87 | 0.4 | < 9.8 |
| 8/22 | Styrene Pur #1 | - | - | < 1.67 | < 5.2 | 2.08 | 0.5 | Trace | 45.8 | 10.9 | < 1.67 | < 0.2 | < 16.8 |
| 8/22 | Styrene Pur #1 | - | - | 1.64 | 5.1 | 2.96 | 0.7 | Trace | 6.25 | 1.5 | 1.64 | 0.2 | 7.5 |
| 8/22 | Styrene Pur #1 | - | - | < 1.38 | < 4.3 | 13.5 | 3.1 | Trace | 11.1 | 2.6 | 2.08 | 0.3 | <10.3 |
| 8/22 | Styrene Pur #1 | - | - | < 1.40 | < 4.4 | 2.45 | 0.6 | Trace | 33.2 | 7.9 | < 1.40 | < 0.18 | <13.1 |
| 8/22 | Styrene Pur #1 | - | - | < 4.13 | <12.9 | 2.07 | 0.5 | | 6.20 | 1.5 | < 4.13 | < 0.55 | <15.4 |
| 8/22 | Styrene Pur #1 | - | - | < 6.00 | <18.8 | 6.00 | 1.4 | | 7.50 | 1.8 | < 6.0 | < 0.8 | <22.8 |
| 8/22 | Styrene Pur #1 | - | - | < 6.04 | <18.9 | 6.04 | 1.4 | | 13.6 | 3.2 | < 6.04 | < 0.8 | <24.3 |
| 8/23 | Styrene Truck Ldg. | - | - | < 0.94 | < 2.9 | < 0.47 | < 0.1 | - | 3.99 | 1.0 | 0.94 | < 0.12 | < 4.1 |
| 8/23 | Dylite Rx Area | - | - | < 0.99 | < 3.1 | < 0.50 | < 0.1 | - | 3.71 | 0.9 | < 0.99 | < 0.13 | < 4.2 |
| 8/23 | Dylene Rx Area | - | - | < 1.16 | < 3.6 | < 0.58 | < 0.1 | - | 78.0 | 18.6 | < 1.16 | < 0.15 | <22.4 |
| 8/23 | Dylene Rx Area | - | - | < 1.09 | < 3.4 | < 0.55 | < 0.1 | - | 18.0 | 4.3 | < 1.09 | < 0.14 | < 7.9 |
| 8/23 | Dylite Rx Area | - | - | - | - | < 0.75 | < 0.2 | - | 4.89 | 1.2 | < 1.50 | < 0.2 | < 1.6 |
| 8/23 | Dylene Rx Area | - | - | < 1.83 | < 5.7 | < 0.92 | < 0.2 | - | 21.6 | 5.1 | < 1.83 | < 0.24 | <11.2 |
| 8/23 | Dylene Rx Area | - | - | < 1.63 | < 5.1 | < 0.82 | < 0.2 | - | 4.90 | 1.2 | < 1.63 | < 0.21 | < 6.7 |
| 8/23 | Styrene Truck Ldg | - | - | < 1.34 | < 4.2 | < 0.67 | 0.2 | - | 10.7 | 2.5 | < 1.34 | < 0.18 | < 7.1 |
| 8/23 | Dylene Rx Area | - | - | < 1.79 | < 5.6 | < 0.89 | < 0.2 | - | 5.80 | 1.4 | < 1.79 | < 0.24 | < 7.4 |
| 8/23 | Dylene Rx Area | - | - | < 1.83 | < 5.7 | < 0.92 | < 0.2 | Trace | 33.0 | 7.9 | < 1.83 | < 0.24 | <14.0 |
| 8/23 | Dylene Rx Area | - | - | < 1.68 | < 5.3 | < 0.84 | < 0.2 | Trace | 10.5 | 2.5 | < 1.68 | < 0.22 | < 8.2 |
| 8/24 | Dylene Rx Area | - | - | < 1.35 | < 4.2 | < 0.67 | < 0.2 | Trace | 61.6 | 14.7 | < 1.35 | < 0.18 | <19.3 |
| 8/24 | Dylene Rx Area | - | - | < 1.74 | < 5.4 | < 0.87 | < 0.2 | Trace | 23.9 | 5.7 | < 1.74 | < 0.23 | <11.5 |
| 8/24 | Dylene Rx Area | - | - | < 1.40 | < 4.4 | < 0.70 | < 0.2 | - | 76.9 | 18.3 | < 1.40 | < 0.18 | <23.1 |
| 8/24 | Dylene Rx Area | - | - | < 1.64 | < 5.1 | < 0.82 | < 0.2 | | 51.6 | 12.3 | < 1.64 | < 0.21 | <17.8 |
| 8/24 | No. 1 & No. 3 Reactors | | | | | | | | | | | | |
| 8/24 | Dylene Rx Area | - | - | < 1.86 | < 5.8 | < 0.93 | < 0.2 | Trace | 10.2 | 2.4 | < 1.86 | < 0.25 | < 8.6 |
| 8/24 | Dylene Rx Area | - | - | < 2.11 | < 6.6 | < 4.21 | 1.0 | Trace | 606.3 | 144.4 | 2.11 | 0.28 | 152.2 |

TABLE 2

DETECTOR TUBE SAMPLES

| Date | Location | Contaminant | Concentration | Comments |
|---|---|---|---|---|
| 6/27 | Instrument Shop-bench | Mercury | None | Near Sink |
| 6/27 | Instrument Shop-Shelves | Mercury | None | Near Office |
| 6/27 | Styrene Plant #2-Tankpad | Styrene | 50 ppm | #2 Styrene Day Tank |
| 6/27 | Styrene Plant #1-Cracking | Styrene | 50 ppm | General Area |
| 6/27 | Styrene Plant #1-Purification | Styrene | 50 ppm | Pump at #9 Tank |
| 6/27 | Benzene Bldg.-Pump Room | Benzene | 15 ppm | General Area |
| 6/27 | Benzene Bldg.-Pump Room | Benzene | 5 ppm | General Area |
| 6/27 | Benzene Bldg.-Control Room | Toluene | 3-400 ppm | Spill-at Panel Board |
| 6/27 | Benzene Bldg.-Control Room | Benzene | 30-60 ppm | Spill-at Panel Board |
| 6/28 | Benzene Bldg.-Cracking | Styrene | None | At Toggle Valve Leak |
| 6/28 | Benzene Bldg.-Control Room | Benzene | 15 ppm | Spill-at Panel Board |
| 8/21 | Benzene Blg. J.S. | Toluene | 70-100 ppm | Pump leaking toluene |
| 8/21 | Styrene Cracking Sump | Benzene | 13 ppm | |
| 8/22 | Benzene Blg. 2nd Flr. | Benzene | 40 ppm | Motor make-up valve leaking |
| 8/22 | Benzene Blg., S.E. Tank Pad | Benzene | 30 ppm | Benzene transfer pumps leaking |
| 8/22 | Benzene Blg., 1st Flr. Pump Rm. | Benzene | 10-15 ppm | All pumps O.K. no leaks |

TABLE 2

DETECTOR TUBE SAMPLES

| Date | Location | Contaminant | Concentration | Comments |
|---|---|---|---|---|
| 8/22 | Benzene Blg., 2nd Flr. Control Rm. | Benzene | 5-6 ppm | General Area |
| 8/22 | Benzene, Outside, W. Tank Area | Benzene | 0-5 ppm | General Area |
| 8/22 | Styrene Lab | Benzene | 0-10 ppm | General Area |
| 8/23 | Semi-com Filter Rm. or Latex Reactor | Toluene | 20 ppm | Cleaning Filter with water and toluene |
| 8/23 | Semi-com Filter Rm. or Latex Reactor | Toluene | 20 ppm | Cleaning Filter with water and toluene |
| 8/23 | Dylene Reactor Area | Benzene | 5 ppm | No. 6 Reactor |
| 8/23 | Dylene Reactor Area | Styrene | 50 ppm | No. 6 Reactor |
| 8/23 | Semi-commercial Area | Styrene | 50 ppm | Transferring open drum |
| 8/23 | Semi-commercial - Reactor Area | Ammonia | 700 ppm | Ventilation ineffective |
| 8/23 | Semi-commercial - Pouring Toluene into the Sweco | Toluene | 3 ppm | |
| 8/23 | Semi-commercial - Cleaning Filters with Toluene and water | Toluene | 20 ppm | |
| 8/23 | Semi-commercial Area | Formaldehyde | 1 ppm | Transferring formaldehyde from drum |
| 8/23 | Semi-commercial - Modification Tank Area | Ammonia | 20 ppm | |
| 8/23 | Semi-commercial - Modification Platform | Toluene | 20-30 ppm | |

TABLE 2

DETECTOR TUBE SAMPLES

| Date | Location | Contaminant | Concentration | Comments |
|---|---|---|---|---|
| 8/23 | Semi-commercial - Modification Platform | Formaldehyde | 0-2 ppm | General Area |
| 8/23 | Semi-commercial - Modification Platform | Ammonia | 5-20 ppm | General Area |
| 8/24 | Semi-commercial Area - #10 Reactor | Toluene | 800 ppm | Discharge of effuent from boil out |
| 8/24 | Dylark - Changing Filters under 210 Tank | Styrene | 160 ppm | Start up of process |

TABLE 3

INSTANTANEOUS DUST* SAMPLES**

(Dylite-Dylene Screening Area)

| 8/23/73 Time | Location | Concentration (mg/M$^3$) | |
|---|---|---|---|
| 13:59 | Sweco Screens A2,B2,C3,D3 | 5.97 | Total Dust |
| 14:03 | " " " | 2.23 | Respir. Dust |
| 14:08 | " " A1,B1 | 7.57 | Respir. Dust |
| 14:13 | " " " | 9.48<br>5.03 | Total Dust |
| 14:18 | " " ." | 2.03 | Total Dust |
| 14:26 | " " Hoppers | 2.11 | Total Dust |
| 14:31 | " " " " | 0.69 | Respir. Dust |
| 14:59 | " " Tyrock Vibration Screen | 0.74 | Respir. Dust |
| 15:03 | " " " " | 1.87 | Respir. Dust |

* Tricalcium phosphate dust

** GCA Model RDM-101 Respirable Dust Monitor used.

## TABLE 4

## SOUND LEVEL MEASUREMENTS

| Time AM | Area | Location | Reading $dbA_s$ | Comments |
|---|---|---|---|---|
| 10:59 | Dylite/Dylene | #1-2 Reactor | 93-94 | |
| 11:00 | " " | #3-4 Reactor | 95-98 | Steam leak at #3 Reactor |
| 11:02 | " " | #5-6 Reactor | 94-95 | |
| 11:04 | " " | #7-8 Reactor | 98-99 | Steam leak at #7 Reactor |
| 11:06 | " " | #9-10 Reactor | 100-103 | Steam leak at #12 Reactor |
| 11:07 | " " | #11-12 Reactor | 98-100 | Steam leak at #12 Reactor |
| 11:09 | " " | #3 Bird Centrif | 95-97 | |
| 11:11 | " " | #1&2 Awk Tanks | 93-94 | |
| 11:16 | " " | #2 Hold Tank | 90-91 | |
| 11:18 | " " | General Area | 89-91 | |
| 11:20 | " " | Water Treatment Equip | 89-90 | |
| 11:23 | " " | Reactor Area Downstairs | 100-102 | Reactor 7-8 General Area |
| 11:25 | " " | " " " | 105-106 | Reactor 9-10 General Area |
| 11:30 | " " | Screening | 94-96 | Operator Station Level |
| 11:32 | " " | " | 96-97 | Tyrock Vibrating Screens |
| 11:33 | " " | " | 98-99 | Sweco screens A7,B7,C7,D7 |
| 11:36 | " " | " | 99-102 | A7,B7,A4,B4,C4, D4,A6,B6,C6,D6 |
| 11:39 | " " | " | 101 | D4,A6,A3,B3,A5 B5,C5,D5, |
| 11:41 | " " | " | 99-100 | B5,C5,A2,B2 C3,D3 |
| 11:42 | " " | " | 97-98 | C3,D3,A1,B1 |
| 11:44 | " " | " | 97 | $Ca_3(PO_4)_2$ hoppers |

## TABLE 5

## MISCELLANEOUS SAMPLING RESULTS

### COAL DUST

| Date 1973 | Location | Wgt. (mg) | Vol. (L) | Conc. (mg/M$^3$) | Comments |
|---|---|---|---|---|---|
| 8/21 | Power House - BZ | 0.25 | 142 | 1.76 | Tripper car operation |
| 8/22 | Fly Ash Silo - BZ | 1.78 | 150 | 11.9 | Loading truck w/fly ash |
| 8/22 | Power House - 3rd floor | 0.23 | 200 | 1.15 | Blowing Soot |
| 8/24 | Power House - BZ | 0.18 | 36 | 5.0 | Tripper car operation |

### TRICALCIUM PHOSPHATE DUST

| Date | Location | Wgt. | Vol. | Conc.* | Comments |
|---|---|---|---|---|---|
| 8/24 | Dylite-Dylene - BZ | 0.54 | 120.7 | 4.47 | Near sweco screens |
| 8/24 | Dylite-Dylene - BZ | 3.88 | 467.5 | 8.3 | Near sweco screens |

* Respirable dust

### CADMIUM SULFIDE DUST

| Date | Location | Wgt. (ug) | Vol. (L) | Conc. (mg/M$^3$) | Comments |
|---|---|---|---|---|---|
| 8/24 | Old Poly Blg #1-1st Floor - BZ | 0.6 | 26 | 0.023 | Weighing Cds pigment |

### SODIUM HYDROXIDE

| Date | Location | Wgt. (ug) | Vol. (L) | Conc. (mg/M$^3$) | Comments |
|---|---|---|---|---|---|
| 8/23 | Agitator Blg. - BZ | 135.7 | 94 | 1.44 | Filling drums with NaOH |