IN-DEPTH INDUSTRIAL HYGIENE COMPOSITE REPORT ON EXPOSURE TO STYRENE AND BUTADIENE AT TWO STYRENE-BUTADIENE RUBBER PROCESSING PLANTS

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ABSTRACT

The National Institute for Occupational Safety and Health (NIOSH) selected the styrene-butadine rubber (SBR) process at two adjacent, very similar SBR production facilities in the Port Neches, Texas area for an industrial hygiene and epidemiologic evaluation. This report addresses the industrial hygiene portion of the study.

NIOSH industrial hygienists collected personal and area air samples for the target chemicals, which are styrene, butadiene, and benzene. All concentrations were well below legal and recommended maximum levels of the Occupational Safety and Health Adminstration (OSHA), the American Conference of Governmental Industrial Hygienists (ACGIH), and NIOSH. Samples were also collected for particulates, and concentrations below OSHA standards and ACGIH recommendations were found. Several other organic compounds were also identified.

The low levels of contaminants found could not be linked with any health effects. However, continued attention to routine industrial hygiene surveillance, installation and maintenance of leak-free equipment, training, and personal protective equipment is recommended; also, preemployment physical examinations should be provided.

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INTRODUCTION

The Williams-Steiger "Occupational Safety and Health Act of 1970" (PL 91-596) was passed into law "to assure safe and healthful working conditions for working men and women..." The Act established the National Institute for Occupational and Health (NIOSH) in what is now called the U.S. Department of Health and Human Services. NIOSH has been given authority and responsibility under the Act to conduct field research studies in industry and develop needed information regarding potentially toxic substances or harmful physical agents. Section 20(a)(7) states that NIOSH shall conduct and publish industry-wide studies of the effects of chronic or low-level exposure to industrial materials, processes and stresses on the potential for illness, disease or loss of functional capacity in aging adults.

Styrene-butadiene rubber (SBR) is the most widely used rubber in the world and the most important synthetic rubber. SBR is a copolymer of styrene and butadiene.[1] Upon discovery of eight leukemia cases among the employees at SBR facilities in the Port Neches, Texas area, representatives of the rubber industries requested that NIOSH investigate this occurrence. As a part of their research responsibility, NIOSH then selected the SBR production process for an industrial hygiene and epidemiologic evaluation. A review of current literature revealed the following. It is reported that workers in the SBR industry experience a three-to-five-fold relative risk of dying from lymphatic leukemia.[2,3] Other reports state that there is a significant excess of deaths due to neoplasms of lymphatic and hematopoietic tissue among certain job classes and age groups in the SBR process industry.[4,5] Further substantiation of the hazards of the SBR production process was given in the findings of the joint United Rubber Workers (URW)/industry sponsored epidemiologic investigation of 1976 conducted by McMichael et al.[6] This study reported that workers employed in a facility where synthetic rubber was being manufactured had a 6-fold relative risk of dying from lymphatic and hematopoietic malignancies, and a 4-fold relative risk of dying from lymphatic leukemia as compared to other rubber workers who had not worked in synthetic rubber production.

The current NIOSH study, entitled "Mortality and Industrial Hygiene Study of Styrene Butadiene Rubber", is a retrospective mortality and industrial hygiene study of employees involved in SBR production. The results will be used to determine the nature of the association, if any, between SBR production and leukemia, as well as to isolate critical operations which contribute to the association. This report describes the industrial hygiene portion of the study. The epidemiologic portion of the study is described elsewhere;[7] the relevant epidemiologic findings included a 2-fold excess, which was not statistically significant, of leukemia among workers at one plant, and a significant (0.05 p 0.1) increase (SMR=278) in leukemia among individuals who worked at that same plant during 1943, 1944, and 1945.

Industrial hygiene walk-through surveys were conducted at Plants A and B during the week of April 1, 1976 to assess the feasibility of an epidemiologic investigation. It was determined that a suitable study population existed among these SBR production workers. A preliminary industrial hygiene survey was conducted the week of May 11, 1976, to validate a sampling method for styrene and butadiene to be used during the in-depth investigations. Two in-depth industrial hygiene surveys were then conducted, one July 12-16, 1976 and the other April 11-14, 1977, in order to characterize the environment of the two SBR plants under study with respect to worker exposure to organic chemicals and solvents, specifically styrene and butadiene.

DESCRIPTION OF PLANTS SURVEYED

Plant A and Plant B were both constructed in the early forties, under U.S. Government financing. Production under government ownership continued until 1955 when, under the Rubber Disposal Act, the two plants were acquired separately by private industry.

The two facilities are adjacent and similar in size, construction and arrangement of production areas. A detailed look at the production area is provided by Figure 1, the SBR production area layout. This figure indicates the three main production units as the Reactor Building, the Recovery Building, and the Process Building. In the figure, one of the process "trains" is indicating the flow of the process while the other points out the process equipment that is listed in Table 1. The Reactor and Recovery areas are smaller and more open relative to the Process Building. The tank farm area (not shown in Figure 1) is outside except for the pump houses and operator's office. This arrangement helps to keep exposures to raw chemical products low in this part of the plant.

Production at Plants A and B has continued since their purchase with SBR and emulsion rubbers as the main products. Technological improvements have been made through the years in an effort to improve product quality and versatility, and more recently to improve efficiency and economy. One of the first major improvements on the basic process was the adoption of continuous processing. Another early major improvement arose from the use of more active-radical initiating systems which allowed polymerization at lower temperatures with high conversions.[1]

At the time of the surveys, production at both plants was reported to be at normal capacity. In 1977, production for these two plants was reported to be around 326,000 metric tons annually.[8]

PROCESS DESCRIPTION

The manufacturing process used in Plant A and Plant B consists of three basic steps. The styrene and butadiene are first polymerized in the "Polymerization Unit" which consists of a number of reactor trains. Next, unreacted monomers are recovered in the "Recovery Unit". Finally, in the "Process Unit", the polymer is separated from the latex and dried. The details involved in each "Unit" operation may vary from Plant A to Plant B in that throughput, extent of polymerization, other process variables, and chemical components other than styrene and butadiene are not necessarily the same. Figures 2 and 3 provide a flow chart and simplified material balance for a typical SBR process.

Styrene-butadiene rubber is a copolymer of styrene and butadiene monomers, and is made using a continuous emulsion polymerization process.[1] A typical emulsion system contains water, monomers, an initiator and an emulsifier. An initiator system of organic peroxides is used in combination with a mercaptan (for regulation of polymer chain length) to polymerize butadiene and styrene. The initiator provides free radicals needed to start and sustain the polymerization reaction.

The emulsion charge mixture, containing ingredients in carefully controlled proportions, is charged continously into a series of agitated reactors, maintained at proper conditions such that the required degree of conversion is reached at the exit of the last reactor. The percent of polymerization accomplished in a specific reactor of the train depends primarily on retention time, i.e., the greater the retention time, the greater the percent of polymerization. The rubber quality and rate of reaction both fall off as polymerization proceeds, and it is customary to stop the reaction short of completion. The termination of the reaction is effected by the addition of a "shortstop", a strong reducing agent, which reacts rapidly with free radicals and oxidizing agents, thus destroying any remaining initiator and preventing any further polymerization.

Recovery of unreacted monomers is an essential step in economical synthetic rubber production. Therefore, the polymerized latex emulsions (containing unreacted butadiene and styrene monomers), next flow into "blow down" tanks where they are sparged with steam as the emulsions flow continuously to the Recovery Buildings. Butadiene is permitted to bubble out as the emulsions pass through a series of flash tanks operating at progressively reduced pressures. The butadiene vapors are then compressed, condensed and returned for reuse. Styrene is removed from the essentially butadiene free emulsions by steam stripping, condensation and decantation. The recovered styrene is also returned to the tank farm.

The latex emulsions are then pumped to the processing area. An antioxidant is added to protect the product from oxidation during storage. The latex is finished by blending with oil, partially coagulated with brine, and then fully coagulated with dilute sulfuric acid. The resulting rubber "crumbs" are then washed, dewatered, dried and baled for shipment.

The addition of petroleum oils while processing high molecular weight rubbers renders them extremely tough and results in improvements in quality.[9] Approximately 70% of the SBR produced in the United States is oil-extended.[9]

It should be noted that the equipment used for rubber polymerization is versatile and that different rubber recipes can be used. Many variations and refinements have been developed which make possible improved products with distinct and unique properties, but the underlying procedure is the one described above.

DESCRIPTION OF THE WORKFORCE

During the time of the surveys Plant A employed approximately 650 workers, of which 200 were in the management area. Plant B employment was 475 with

115 being in management. The rest of the employees were considered as working in production, including the laboratory and engineering. A breakdown of hourly workers by collective bargaining unit and the number of employee members is in Tables 2 and 3. Job classifications for Plant A and B and corresponding job descriptions are in Appendix I.

The occupation title, job classification and description give a good indication of which employees are involved in production, either directly or indirectly. Occupational titles can be correlated to the sampling results in Appendix III.

SAMPLING METHODOLOGY AND ANALYTICAL TECHNIQUES

There is a myriad of chemicals used in the production of SBR. This fact made it difficult to pinpoint the one, or ones, that could be responsible for any health problem associated with over-exposures. It is not difficult to imagine that synergistic effects may be present. Styrene and butadiene were chosen as target chemicals for this study, because they are the major components in SBR. Benzene was chosen because of its known leukemogenic activity. Limited sampling was done for the particulates carbon black and OMYA BSH-20 (a calcium carbonate compound substituted for talc); also a limited number of organic vapor samples were subjected to GC/MS analysis for detection of the other organic compounds present. However, characterization of the total production environment with respect to the target chemicals was the primary objective of the study. Personal exposure monitoring was conducted mainly on the first shift employees at both plants. Personal organic vapor (OV) and total particulate (TP) samples were collected at Plant A, while personal and area OV and personal TP samples were collected at Plant B.

Environmental monitoring was accomplished by using sampling pumps to draw air through the collecting substance, such as activated charcoal, or polyvinyl chloride filters. Personal samples were obtained by attaching sample collection apparatuses to the shirt collars or lapels of the employees, in a manner that would least interfere with their job functions or freedom of movement. The sampling pumps were secured to the workers' belts. The pumps and collection apparatuses were connected by plastic Tygon[R] tubing. Area samples were collected in desired locations using the same type of sampling equipment as used for personal samples.

Organic Vapor Sampling

Preliminary sampling was conducted at an SBR facility similar to Plants A and B to validate a sampling method. At that time, two standard 150 mg coconut shell charcoal tubes were used in series for collection. There was no breakthrough of styrene or butadiene upon analysis. Accordingly, the decision was made to use a single tube for collection at Plant A.

Plant A

Sampling was conducted at Plant A on July 12-15, 1976. The sampling train included a single 150 mg coconut shell/charcoal tube and either a Sipin or DuPont sampling pump. The flow rate was calibrated to either 50 or 100 cc/min. Full period consecutive sample measurement, with the average sampling time being four hours, was employed at this plant. Flow rates through the sampling train were determined both before and after sampling.

Directly after sampling, the charcoal tube samples were stored in a refrigerator freezer section until they were sent to the analytical laboratory. A total of 164 individual samples were collected and submitted. Two tubes were lost in transit. The chemist looked for the presence of butadiene, styrene and benzene specifically, using NIOSH method number P&CAM 127. A copy of this method is in Appendix II. This method has a limit of detection of 0.01 mg for all three compounds.

A large percentage (82.6%) of the samples with detectable butadiene concentrations collected at Plant A showed breakthrough or migration of butadiene from the adsorbing section to the backup section. Butadiene was found on the backup sections at very low front section loadings, e.g., 0.02 mg. Due to this problem, monitoring at Plant B was conducted using two charcoal tubes in series to isolate the breakthrough cases and minimize the chance for migration. The entire first tube, called Tube "A", was considered the adsorbing section and the entire second tube, Tube "B" was considered the backup section.

Plant B

Environmental OV sampling was conducted on April 11-14, 1977, at Plant B. A sampling train consisting of an MDA Accuhaler[R] sampling pump operating at a flow-rate of 20 cc/min, determined by a limiting orifice and two 150-mg charcoal tubes in series, was used for personal sample collection. At this lower flow rate and with the tubes in series a full period single sample measurement strategy was employed. A total of 113 breathing zone samples were taken. Sampling time averaged about six hours. Ten area OV samples were collected using Sipin pumps, at a flow rate of 200 cc/min, and two charcoal tubes in series. Area sampling was done in suspected high concentration zones throughout the production area.

After sampling, the charcoal tubes were capped and stored in a refrigerator freezer section. At the end of the survey the personal OV samples were kept in storage and the ten area samples were given to an analytical laboratory for a detailed gas chromatograph/mass spectrometer (GC/MS) analysis. This technique was utilized to identify other substances present in addition to the target chemicals. Of special interest was benzene, because very little was detected in the Plant A samples (only a few samples showed the minimum detectable level).

The GC/MS analysis proceeded as follows. Initially, two "A" charcoal tube and two "B" charcoal tube samples were desorbed with 0.5 ml of carbon disulfide and analyzed by the GC/MS system. Both of the "A" samples showed the presence of some noticeable components while the "B" samples did not show any extraneous peaks. Hence, only "A" portions of the collected samples were investigated after the initial attempt.

Because these area OV samples showed the presence of chemicals in addition to the target chemicals, ten of the breathing zone OV samples were randomly chosen for GC/MS analysis. None of these samples showed any extraneous peaks on the reconstructed total ion chromatogram, and therefore, no other breathing zone samples were tested in this manner. At this point, the rest of the breathing zone samples were sent to the analytical laboratory for analysis according to NIOSH method number P&CAM 127 (See Appendix II).

It should be noted that the personal samples from Plant A had both the front and backup sections desorbed and analyzed. Alternatively, the Plant B personal samples were done by desorbing and analyzing all of the front sections ("A" tube) while only random backup tube ("B" tube) analysis was done.

At each plant two tubes containing charcoal from the same batch as the sample tubes were treated in the same way as the sample tubes, except no air was drawn through them. Both ends of each tube were broken off and the tubes resealed using the plastic caps provided by the manufacturer, and they were stored with the samples. These tubes served as blanks. No blank correction was shown to be necessary in analysis.

Total Particulate Sampling

Plant A

Four TP samples were collected in the process area of Plant A to evaluate exposure to OMYA BSH-20, a white powdery compound which is applied to the finished rubber product in order to prevent adhesion. A chemical analysis of this OMYA BSH-20 showed it to be a calcium carbonate compound. Traditionally, talc is used for this purpose.

Tared MSA FWS-B filters (5- m pore-size) contained in Millipore three-piece cassettes were used. Suction was provided by MSA Model-G sampling pumps at a flow-rate of $1\frac{1}{2}$ liters per minute or greater. A gravimetric analysis of these samples was later performed.

Plant B

Two TP samples were collected at Plant B in the carbon black unit, and were subsequently analyzed for this substance using NIOSH method number S-262. The sensitivity of this method is 0.3 - 2.0 mg for a 200-liter sample, and is enhanced when collecting larger sample volumes. The sampling train consisted of tared Gelman VM-1 PVC-film filters in Millipore three-piece cassettes. MSA Model-G pumps provided a flow rate of at least 1.7 liters per minute.

All TP samples collected at both plants were personal breathing zone type. The cassettes were attached to the collars or lapels with metal clips and to pumps on the workers' belts via rubber tubing.

Blanks were prepared for each of the total particulate sampling instances by placing the appropriate filters in cassettes but drawing no air through them. No blank correction was necessary for these samples.

SAMPLING RESULTS

ORGANIC VAPOR SAMPLING

Standards

The Occupational Safety and Health Administration (OSHA) standard for styrene is presently an 8-hour time-weighted average (TWA) of 100 ppm, a ceiling value of 200 ppm, and a peak excursion value of 600 ppm for 5 minutes during any 3 hours.[10] The American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV) for styrene are currently 100 ppm for an 8-hour TWA and 125 ppm for a Short Term Exposure Limit (STEL) which may be equalled for 15 minutes continuously, 4 times per day, with at least 60 minutes between exposure periods. However, ACGIH has proposed a change in the TLV to 50 ppm TWA and 100 ppm STEL.[11]

The OSHA standard for butadiene is an 8-hour TWA of 1000 ppm,[10] while the ACGIH TLV is 1000 ppm for an 8-hour TWA and 1250 ppm for a STEL.[11]

The OSHA standard for benzene is currently 10 ppm for an 8-hour TWA, with a ceiling of 25 ppm and a peak excusion of 50 ppm for 10 minutes during an 8-hour shift permitted.[10] Similarly, the ACGIH TLV is 10 ppm for an 8-hour TWA and 25 ppm for a STEL.[11] However, NIOSH has recommended a standard of 1 ppm for a 2-hour sample[12].

Plant A

Results of the half-shift styrene and butadiene sample from Plant A can be seen in Table III-1 of Appendix III. It was possible to construct 57 styrene and butadiene full-shift TWA's from this data. These are presented in Table III-2 of Appendix III by occupational title and operation. Statistical summaries comparing Plant A with Plant B by job title are presented for styrene and butadiene TWA's in Table 4 and 5, respectively, in the text. (It should be noted here that for statistical calculations, a value of half the detection limit was used for samples below the detection limit, in accordance with the L/2 method.[13]

Styrene

The styrene TWA's ranged from less than 0.05 to 4.44 ppm; 38 of them were less than 1.00 ppm, 13 ranged from 1.00 to 1.99 and 5 were between 2.0 and 3.99 ppm, inclusive. One TWA was above 4.00 ppm at 4.44 ppm.

Butadiene

The full-shift TWA's for BD ranged between less than 0.10 ppm and 4.82 ppm. Of the 57 TWA's, 39 were less than 1.00 ppm, 11 ranged from 1.00 to 1.99 ppm, 5 ranged from 2.0 to 3.99 ppm, while 2 were above 4.0 ppm. (See Table III-2 of Appendix III.)

In 76 of the half-shift samples with detectable levels, BD was present in the backup section above one-third of the level in the primary adsorbing section.

Benzene

Benzene was detected in only three samples (tube numbers 193, 194, and 309). These samples each contained 0.01 mg benzene and were collected on July 15, 1976. Corresponding atmospheric concentrations were 0.08 ppm, 0.14 ppm and 0.08 ppm, respectively.

Plant B

These results were obtained from an average sampling time of six hours. However, since there were no significant changes in operation and the SBR process is continuous, these are believed to be representative of 8-hour TWA's. Statical summaries presented by job title comparing Plant A to Plant B are in Table 4 for styrene TWA's and in Table 5 for butadiene TWA's. (As in Plant A, the L/2 method[13] of using half the detection limit as a value for samples below the detection limit was incorporated when calculating statistical parameters).

Styrene

Of the 103 personal samples analyzed for styrene, 35 were found to have detectable levels in the "A" tubes. Corresponding styrene concentrations ranged from 0.04 to 12.33 ppm. No styrene was detected in any analyzed "B" tubes. Two-thirds of all detectable samples (23 of them) indicated atmospheric concentrations below 1.0 ppm. Seven ranged from 1.0 to 2.99 ppm and five ranged from 6.0 to 12.33 ppm, with the two highest being tube numbers 30 "A" and 115 "A" at 9.86 and 12.33 ppm, respectively.

Two-thirds of the total number analyzed for styrene (68 samples) were found to be below the limit of detection. These results are presented in Table III-3 of Appendix III by occupational title and date.

Butadiene

Fifty of the 103 personal sample "A" tubes analyzed for BD were found to have detectable levels. Sixty-six percent of these samples indicated atmospheric concentrations less than 2.0 ppm. Thirteen samples indicated concentrations between 2.0 and 50.0 ppm, and four ranged between 50.0 and 175.0 ppm. The two high samples were numbers 1 "A" and 196 "A" indicating 144.55 and 174.14 ppm respectively. (See Table III-3 of Appendix III)

Of the 103 samples analyzed for BD, 53 were BLD. Also, three samples had detectable levels in the "B" tube. The sample numbers were 196, 35 and 45. Corresponding enivronmental concentrations were 174, 102 and 0.899 ppm, respectively.

Other Chemicals

Ten area samples were submitted for GC/MS analysis. Results for these are listed in Table III-4 of Appendix III. This analysis was performed to ascertain the presence of chemicals other than the target chemicals, not for the purpose of obtaining atmospheric concentrations. 4-vinylcyclohex-1-ene (a butadiene dimer), ethyl benzene, toluene and some methanes were the major components found.

TOTAL PARTICULATE SAMPLING

Standards

The OSHA standard for a total dust sample of the nuisance dust type is 15 mg/m^3 for an 8-hour TWA,[10] while the ACGIH TLV is 10 mg/m^3.[11] The OSHA standard for carbon black is 3.5 mg/m^3;[10] similarly, the ACGIH TLV is 3.5 mg/m^3 for an 8-hour TWA and 7 mg/m^3 for a STEL.[11]

Plant A

Four TP samples were collected at this facility. Sample volumes averaged 515 liters. Atmospheric dust concentrations found were 0.62, 0.72, 1.13 and 2.53 mg/m^3. Results are in Table III-5 of Appendix III.

Plant B

Two TP samples were collected at Plant B. Sample volumes were 512 and 602 liters. Sample environmental concentrations were 0.252 and 0.505 mg/m^3. Results are in Table III-6 of Appendix III.

DISCUSSION

Occupational titles have been identified in a survey of two SBR manufacturers for which exposure to styrene and butadiene has been assessed. Full-shift TWA concentrations have been determined for individuals in these occupational titles.

There is not complete uniformity in the duties assigned to each occupational title between the two plants. However, task assignments are not so different as to make comparison of exposure levels between plants invalid. Some general observations are possible based on the results summarized in Tables 4 and 5, as well as in Tables III-2 and III-3 of Appendix III. Styrene exposures are consistently higher in Plant A than in Plant B, by job classification as well as overall. However, BD exposures are consistently higher in Plant B than Plant A. A comparison of the geometric means and 95% confidence limits of Plant A and Plant B "overall" provides striking confirmation of this observation, both for styrene (Table 4) and butadiene (Table 5). These observations could be reflecting differences in engineering controls between the two plants.

In these plants, as in most plants whose processes are of the closed continuous type, the higher exposures were experienced by those whose occupational duties include quality control sampling and analysis and maintenance or repair during system breakdown. Specifically, relatively high styrene exposures were experienced by coag. operators, drier operators, maintenance people, utility people, and laborers, among others, while relatively high butadiene exposures were experienced by electricians, head reactor and recovery operators, instrument men, lab technicians, shift testers, and tank farm operators, among others. There seemed to be no outstanding exposures in either plant; in fact, all exposures in both plants were well below current OSHA standards.

Exposures to dusts and other particulate matter were also below the OSHA standards. At this type of chemical plant there are only a couple of areas where a dust exposure problem might arise. These areas are the packaging area where talc or a similar substance is used, and the carbon black area.

CONCLUSIONS

With recent concern about the possible carcinogenic hazard from exposure to industrial chemicals, it is reasonable to consider control methods that will minimize human exposures in industry. The TWA exposures of workers to styrene and butadiene during normal operations at the two plants surveyed was found to be well below the present OSHA standards of 100 ppm for styrene and 1000 ppm for butadiene, principally for the following reasons:

- The processing is performed mainly in a closed system, which is only opened for repairs and quality control sampling.

- The worker is not required to spend much time in the area except for the rubber baling operations.

- The reactor and recovery processes are in relatively open structures.

Continued and improved industrial hygiene practices are warranted for controlling worker exposures to styrene, butadiene and other chemicals used in the synthetic rubber processing industry.

These industrial hygiene surveys represent evaluations of worker exposure to styrene and butadiene which do not reflect possible variations in exposure due to seasonal or operational changes, but are considered to represent those that are associated with the usual operating conditions.

Because the epidemiologic portion of this study did not find any significant excess of cause-specific mortality in the population exposed to these very low levels of contaminants, no link can be shown between the low levels documented here and any cause of death.

RECOMMENDATIONS

In line with the scope of this study, the following general recommendations are made:

1. Complete pre-employment physicals for all workmen, with periodical physicals for operations personnel, should be provided.

2. The plants should maintain a routine industrial hygiene surveillance program.

3. The design and installation of process sytems that are leak resistant and routine maintenance of process equipment should continue to be the primary control efforts. Regular inspection of all process equipment should be performed.

4. Instruction of employees, especially new employees, in the toxic nature of process materials and the need for proper and timely use of protective equipment and clothing should be conducted periodically. Training is essential to effectively minimize worker exposures.

5. Respiratory protection and protective clothing should be made available to employees and used when exposure and emergency conditions warrant additional protection. Specific instructions for this type of program may be obtained by consulting the Personal Protective Equipment subpart of the OSHA Standards.[14]

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FIGURE 1 PLOT PLANT FOR SBR FACILITIES

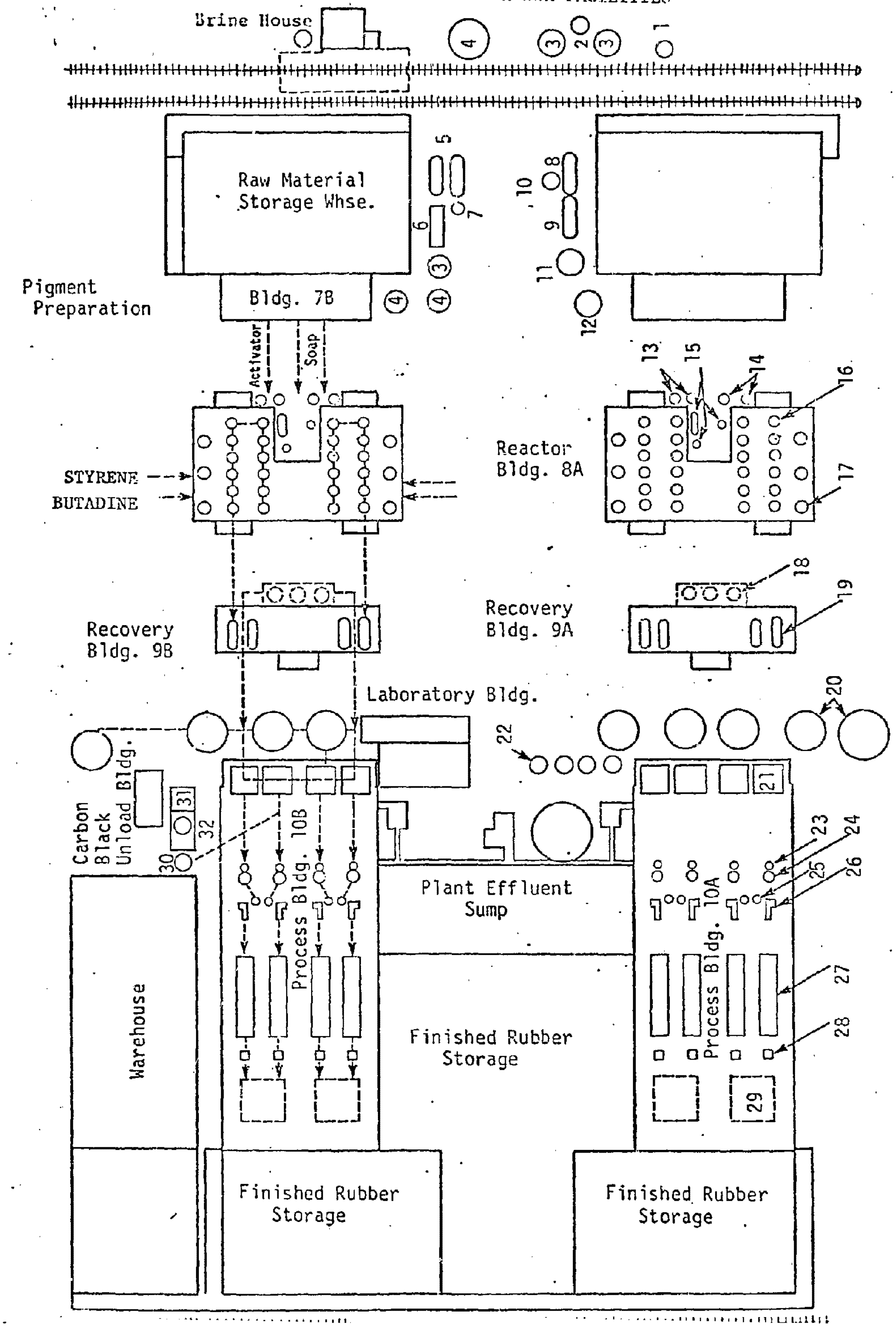


TABLE 1 PLOT PLAN LEGEND

1 - 12	Chemical Additives Storage Tanks
13	Activator Surge Tanks
14	Soap Solution Storage Tanks
15	Shortstop Surge Tanks
16	Continuous Reactors
17	Blowdown Tanks
18	Latex Stripping Columns
19	Butadiene Flash Tanks
20	Latex Storage Tanks
21	Latex Blend Tanks
22	Oil Emulsion Storage Tanks
23	Coagulation Tanks
24	Soap Conversion Tanks
25	Resurrn Tanks
26	Dewatering
27	Driers
28	Balers
29	Packaging Areas
30	Additive Storage Tank
31	Carbon Black Storage Tank
[illegible]	Carbon Black Mix Tank

FIGURE 2.

PROCESS FLOW CHART FOR SBR PROCESS

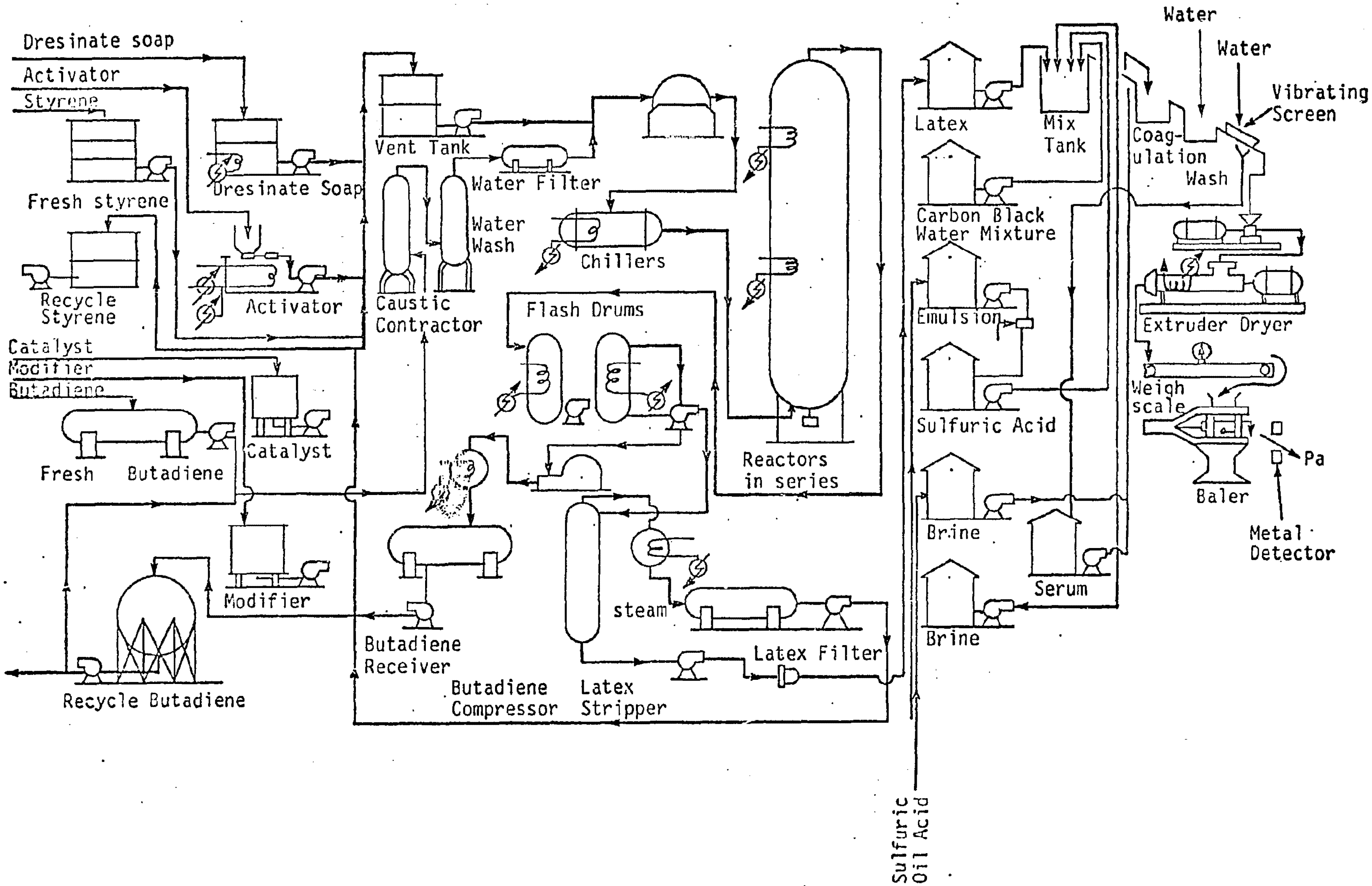
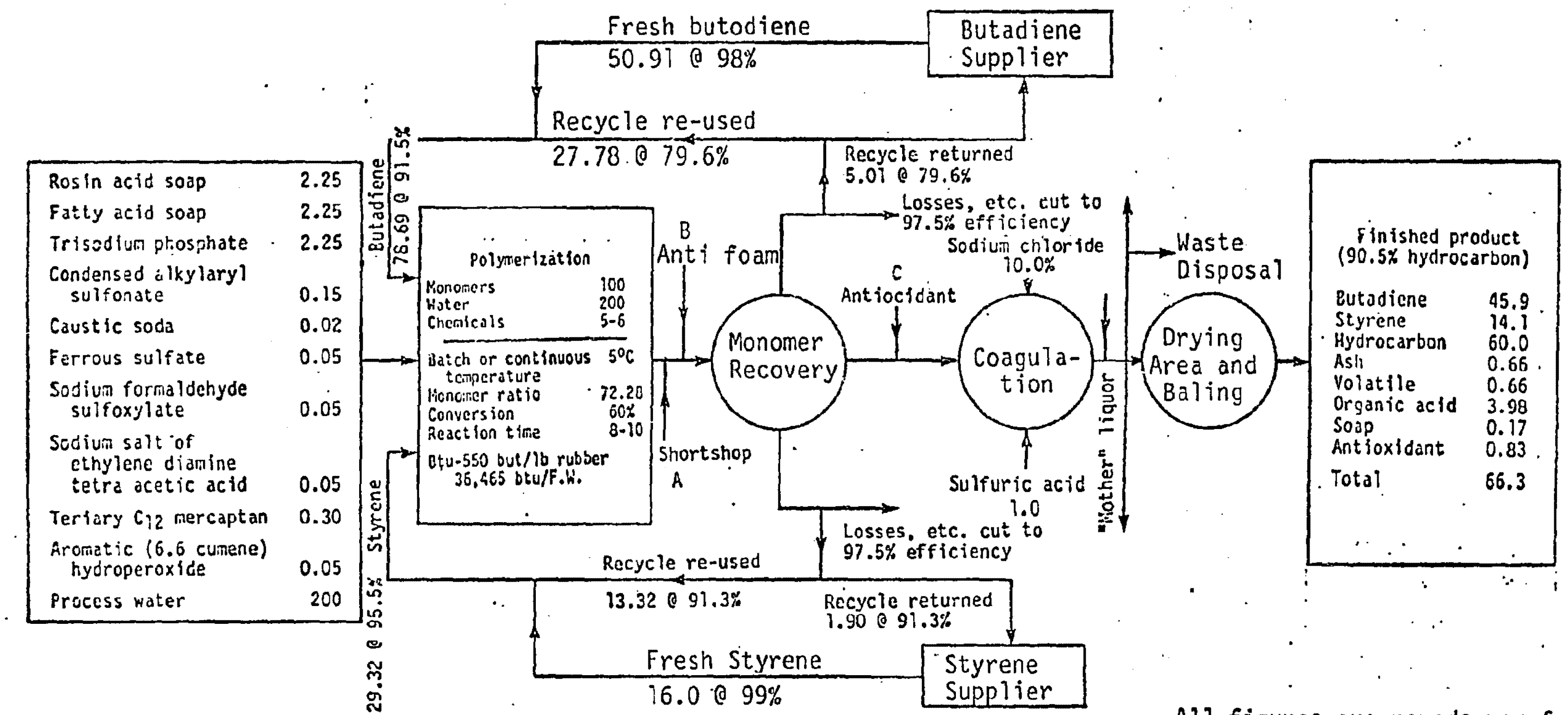


FIGURE 3

MATERIAL BALANCE AND FLOW CHART FOR SBR PROCESS



All figures are pounds per formula weight (100 pounds pure monomer and associated materials). For a 40,000 metric ton per year Rate based on 337 day year

A. Shortstop, sodium dimethyl dithiocarbamate	0.10
Polyamine "H"	0.05
Rosin acid soap	0.05
B. Antifoam - various	0.001
C. Antioxidant	0.83-1.0
choice of several	

NOTE: 100% efficiency shown, losses cut efficiencies and yields to 97.5%, and result in reduced recycle return, etc.

TABLE 2

EMPLOYEE REPRESENTATIVES AT Plant A

	Organization	Members
1.	Oil, Chemical and Atomic Workers	225
2.	United Brotherhood of Carpenters and Joiners of America	9
3.	United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry of the United States and Canada	33
4.	United Brotherhood of Painters, Decorators, and Paperhangers	9
5.	International Association of Machinists and Aerospace Workers	42
6.	International Brotherhood of Electrical Workers	32

TABLE 3

EMPLOYEE REPRESENTATIVES AT PLANT B

	Organization	Members
1.	Local 4-228, Oil, Chemical and Atomic Workers International Union, CIO, Plant Group	236
2.	Local 4-228, Oil, Chemical and Atomic Workers International Union, CIO, Office Group	32
3.	Local No. 610, United Brotherhood of Carpenters and Joiners of America, A. F. of L.	6
4.	Lodge 1792, District 31, International Association of Machinists and Aerospace Workers	39
5.	Local 390, International Brotherhood of Electrical Workers, A. F. of L.	22
6.	Local 328, United Brotherhood of Painters, Decorators, and Paperhangers, A. F. of L.	7
7.	Pipefitters Local 195, United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry of the United States and Canada, A. F. of L.	40
8.	Local 196, Sheet Metal Workers International Association A. F. of L.	6

Employment was approximately 475 divided as follows for Plant B:

120 Production
180 Maintenance
60 Laboratory
115 Management

TABLE 4

ANALYSIS OF STYRENE CONCENTRATION BY JOB, PLANTS A AND B

JOB TITLE	PLANT	NUMBER OF SAMPLES	NUMBER SAMPLES BELOW DETECTION LIMIT	MAXIMUM VALUE	MINIMUM VALUE	MEAN	STANDARD DEVIATION	STANDARD ERROR	GEOMETRIC MEAN	GEOMETRIC STANDARD DEVIATION	UPPER 95% CONFIDENCE LIMIT, GEOMETRIC	LOWER 95% CONFILENCE LIMIT, GEOMETRIC
"A" Operator	A	4	0	1.06	0.21	0.61	0.36	0.18	0.52	1.97	1.52	0.18
Bailer/Dryer	A	1	0	0.16	0.16	-	-	-	-	-	-	-
Bailer	A	1	1^+	0.03	0.03	-	-	-	-	-	-	-
Bailer Operator	B	3	3^+	0.15	0.14	-	-	-	-	-	-	-
Blend Operator	A	4	0	2.02	0.40	1.19	0.74	0.37	1.00	2.08	3.20	0.31
Carpenter	B	4	4^+	0.11	0.10	-	-	-	-	-	-	-
Charge Operator	B	1	1^+	0.14	0.14	-	-	-	-	-	-	-
Cleaner	A	2	0	0.75	0.56	0.66	0.14	0.10	0.65	1.24	4.38	0.10
Coag. Operator	A	6	0	3.65	0.36	1.34	1.20	0.49	0.99	2.34	2.43	0.41
Coag. Operator	B	5	1	0.54	0.05	0.35	0.23	0.10	0.25	2.88	0.94	0.07
Compounder	A	2	0	0.22	0.10	0.16	0.08	0.06	0.15	1.69	16.70	0.00
Dryer Operator	A	4	0	3.38	0.26	2.20	1.35	0.67	1.56	3.32	10.50	0.23
Dryer Operator	B	1	1^+	0.31	0.31	-	-	-	-	-	-	-
E-Line Helper	A	1	0	0.33	0.33	-	-	-	-	-	-	-
Electrician	A	1	0	0.10	0.10	-	-	-	-	-	-	-
Electrician	B	5	5^+	1.05	0.09	-	-	-	-	-	-	-
Finished Prod. Chem. Testing	A	1	0	0.22	0.22	-	-	-	-	-	-	-
Float Aid Oper.	A	1	0	0.36	0.36	-	-	-	-	-	-	-
Foreman	B	1	1^+	0.15	0.15	-	-	-	-	-	-	-
G-H Line Helper	A	1	0	0.72	0.72	-	-	-	-	-	-	-
Head Blend Oper.	A	1	0	0.89	0.89	-	-	-	-	-	-	-
Head Coag. Oper.	B	2	0	2.14	0.26	1.20	1.33	0.94	0.75	4.38	437983.67	0.00
Head Operator	A	12	2	5.90	0.03	1.15	1.60	0.46	0.56	3.90	1.32	0.23
Head Operator	B	1	0	0.55	0.55	-	-	-	-	-	-	-

TABLE 4 (Cont.)

ANALYSIS OF STYRENE CONCENTRATION BY JOB, PLANTS A AND B

JOB TITLE	PLANT	NUMBER OF SAMPLES	NUMBER SAMPLES BELOW DETECTION LIMIT	MAXIMUM VALUE	MINIMUM VALUE	MEAN	STANDARD DEVIATION	STANDARD ERROR	GEOMETRIC MEAN	GEOMETRIC STANDARD DEVIATION	UPPER 95% CONFIDENCE LIMIT, GEOMETRIC	LOWER 95% CONFIDENCE LIMIT, GEOMETRIC
Head Reactor Operator	A	1	0	0.61	0.61	-	-	-	-	-	-	-
Head Reactor Operator	B	4	3^{+}	0.48	0.11	-	-	-	-	-	-	-
Head Recovery Operator	B	4	2^{+}	1.02	0.12	-	-	-	-	-	-	-
Head, Transfer Pump House	B	1	1^{+}	0.15	0.15	-	-	-	-	-	-	-
Hood-Tank Farm Operator	B	1	1^{+}	0.13	0.13	-	-	-	-	-	-	-
Instrument Repair	A	1	0	0.15	0.15	-	-	-	-	-	-	-
Instrument Man	B	3	1	1.44	0.09	0.65	0.71	0.41	0.38	4.01	11.80	0.01
Janitor	B	1	1^{+}	0.11	0.11	-	-	-	-	-	-	-
Lab. Analyst	B	4	0	0.96	0.24	0.55	0.30	0.15	0.49	1.76	1.21	0.20
Lab. Foreman	A	1	0	0.30	0.30	-	-	-	-	-	-	-
Lab. Technician	B	8	4^{+}	2.86	0.09	-	-	-	-	-	-	-
Laborer	A	4	0	1.05	0.42	0.80	0.27	0.14	0.76	1.50	1.44	0.40
Laborer	B	17	6	12.33	0.10	3.00	4.08	0.99	0.83	6.08	2.11	0.33
Lift Truck Driver	B	1	1^{+}	0.14	0.14	-	-	-	-	-	-	-
Machinist	A	2	0	0.53	0.48	0.50	0.03	0.02	0.50	1.07	0.92	0.27
Machinist	B	1	1^{+}	0.12	0.12	-	-	-	-	-	-	-
Maintenance Head Operator	A	3	0	1.01	0.23	0.58	0.40	0.23	0.49	2.09	3.09	0.08
Main Operator	A	1	0	0.37	0.37	-	-	-	-	-	-	-
Maintenance Oper.	A	1	0	0.82	0.82	-	-	-	-	-	-	-
Maintenance	A	2	0	1.52	0.73	1.13	0.56	0.39	1.06	1.67	108.57	0.01
Maintenance	B	4	4^{+}	0.16	0.10	-	-	-	-	-	-	-

TABLE 4 (Cont.)

ANALYSIS OF STYRENE CONCENTRATION BY JOB, PLANTS A AND B

JOB TITLE	PLANT	NUMBER OF SAMPLES	NUMBER SAMPLES BELOW DETECTION LIMIT	MAXIMUM VALUE	MINIMUM VALUE	MEAN	STANDARD DEVIATION	STANDARD ERROR	GEOMETRIC MEAN	GEOMETRIC STANDARD DEVIATION	UPPER 95% CONFIDENCE LIMIT, GEOMETRIC	LOWER 95% CONFIDENCE LIMIT, GEOMETRIC
Mechanic	A	7	0	4.25	0.06	1.11	1.51	0.57	0.49	4.26	1.74	0.14
Mechanic	B	12	10^{+}	0.81	0.09	–	–	–	–	–	–	–
Operator	A	1	0	3.88	3.88	–	–	–	–	–	–	–
Operator Helper	A	3	0	0.50	0.11	0.27	0.20	0.12	0.22	2.12	1.43	0.03
Operator Helper	B	3	3^{+}	0.16	0.14	–	–	–	–	–	–	–
Pipefitter	A	14	1	6.50	0.02	1.85	2.20	0.59	0.73	5.06	1.86	0.29
Pipefitter	B	8	7^{+}	0.23	0.09	–	–	–	–	–	–	–
Reactor Operator	A	7	0	0.50	0.16	0.27	0.12	0.05	0.25	1.51	0.37	0.16
Recovery Operator	A	7	0	3.19	0.18	0.84	1.08	0.41	0.51	2.64	1.22	0.22
Recovery Operator	B	4	3^{+}	0.80	0.12	–	–	–	–	–	–	–
Relief Operator	B	1	1^{+}	0.17	0.17	–	–	–	–	–	–	–
Shift Tester	A	2	0	0.33	0.14	0.23	0.13	0.09	0.21	1.83	49.90	0.00
Tank Farm Oper.	A	6	0	3.35	0.15	0.89	1.23	0.50	0.49	3.06	1.58	0.15
Tank Fram Oper.	B	1	1^{+}	0.14	0.14	–	–	–	–	–	–	–
Tester	A	1	0	0.53	0.53	–	–	–	–	–	–	–
Tester-in-Training	A	1	0	0.37	0.37	–	–	–	–	–	–	–
Tinner	A	1	0	0.30	0.30	–	–	–	–	–	–	–
Transfer Pump House	B	1	1^{+}	0.15	0.15	–	–	–	–	–	–	–
Utility/Coag. Operator	A	1	0	2.19	2.19	–	–	–	–	–	–	–
Utility Operator	A	2	0	3.84	1.18	2.51	1.88	1.33	2.13	2.30	3834.39	0.00
Welder	B	1	1^{+}	0.11	0.11	–	–	–	–	–	–	–

TABLE 4 (Cont.)

ANALYSIS OF STYRENE CONCENTRATION BY JOB, PLANTS A AND B

JOB TITLE	PLANT	NUMBER OF SAMPLES	NUMBER SAMPLES BELOW DETECTION LIMIT	MAXIMUM VALUE	MINIMUM VALUE	MEAN	STANDARD DEVIATION	STANDARD ERROR	GEOMETRIC MEAN	GEOMETRIC STANDARD DEVIATION	UPPER 95% CONFIDENCE LIMIT, GEOMETRIC	LOWER 95% CONFIDENCE LIMIT, GEOMETRIC
OVERALL	A	111	4	6.50	0.03	1.02	1.30	0.12	0.54	3.15	0.67	0.43
OVERALL	B	103	68++	12.33	0.05	0.77	1.95	0.19	0.25	3.31	0.32	0.20

+ At least 50% of samples were below the detection limit, so statistical parameters were not generated. (ref. 13)

++ Statistical parameters may have large error because more than 50% of samples were below the detection limit. (ref. 13)

TABLE 5

ANALYSIS OF BUTADIENE CONCENTRATION BY JOB, PLANT A AND B

JOB TITLE	PLANT	NUMBER OF SAMPLES	NUMBER SAMPLES BELOW DETECTION LIMIT	MAXIMUM VALUE	MINIMUM VALUE	MEAN	STANDARD DEVIATION	STANDARD ERROR	GEOMETRIC MEAN	GEOMETRIC STANDARD DEVIATION	UPPER 95% CONFIDENCE LIMIT, GEOMETRIC	LOWER 95% CONFIDENCE LIMIT, GEOMETRIC
"A" Operator	A	4*	1	1.79	0.06	0.77	0.77	0.39	0.42	4.29	4.25	0.04
Bailer/Dryer	A	1	1+	0.05	0.05	-	-	-	-	-	-	-
Bailer Operator	A	1*	0	0.18	0.18	-	-	-	-	-	-	-
Bailer Operator	B	3	3+	0.29	0.27	-	-	-	-	-	-	-
Blend Operator	A	4	4+	0.07	0.05	-	-	-	-	-	-	-
Carpenter	B	4	3+	30.60	0.20	-	-	-	-	-	-	-
Charge Operator	B	1	0	1.10	1.10	-	-	-	-	-	-	-
Cleaner	A	2	2+	0.13	0.10	-	-	-	-	-	-	-
Coag. Operator	A	6*	4+	0.18	0.05	-	-	-	-	-	-	-
Coag. Operator	B	5	2	0.52	0.23	0.41	0.13	0.06	0.39	1.43	0.60	0.25
Compounder	A	2*	0	1.95	1.40	1.67	0.39	0.28	1.65	1.26	13.56	0.20
Dryer Operator	A	4	2+	0.26	0.05	-	-	-	-	-	-	-
Dryer Operator	B	1	1+	0.60	0.60	-	-	-	-	-	-	-
E-Line Helper	A	1	0	0.11	0.11	-	-	-	-	-	-	-
Electrician	A	1	0	2.14	2.14	-	-	-	-	-	-	-
Electrician	B	5	5+	2.02	0.18	-	-	-	-	-	-	-
Finished Prod. Chem. Testing	A	1*	0	0.36	0.36	-	-	-	-	-	-	-
Float Aid Oper.	A	1*	0	0.71	0.71	-	-	-	-	-	-	-
Foreman	B	1	0	1.16	1.16	-	-	-	-	-	-	-
G-H Line Helper	A	1	1+	0.06	0.06	-	-	-	-	-	-	-
Head Blend Oper.	A	1	1+	0.06	0.06	-	-	-	-	-	-	-
Head Coag. Oper.	B	2	2+	0.26	0.26	-	-	-	-	-	-	-
Head Operator	A	12*	5	5.14	0.05	0.96	1.53	0.44	0.32	4.87	0.89	0.12
Head Operator	B	1	1+	0.27	0.27	-	-	-	-	-	-	-

TABLE 5 (Cont.)

ANALYSIS OF BUTADIENE CONCENTRATION BY JOB, PLANTS A AND B

JOB TITLE	PLANT	NUMBER OF SAMPLES	NUMBER SAMPLES BELOW DETECTION LIMIT	MAXIMUM VALUE	MINIMUM VALUE	MEAN	STANDARD DEVIATION	STANDARD ERROR	GEOMETRIC MEAN	GEOMETRIC STANDARD DEVIATION	UPPER 95% CONFIDENCE LIMIT, GEOMETRIC	LOWER 95% CONFIDENCE LIMIT, GEOMETRIC
Head Reactor Operator	A	1*	0	4.55	4.55	-	-	-	-	-	-	-
Head Reactor Operator	B	4	2+	69.61	0.25	-	-	-	-	-	-	-
Head Recovery Operator	B	4	1	33.21	0.23	11.10	15.37	7.68	3.02	9.20	103.03	0.09
Head, Transfer Pump House	B	1	0	25.01	25.01	-	-	-	-	-	-	-
Hood-Tank Farm Operator	B	1	0	0.51	0.51	-	-	-	-	-	-	-
Instrument Repair	A	1*	0	0.18	0.18	-	-	-	-	-	-	-
Instrument Man	B	3*	1	276.03	0.17	92.59	158.87	91.72	4.22	44.02	51065.72	0.00
Janitor	B	1	1+	0.20	0.20	-	-	-	-	-	-	-
Lab. Analyst	B	4	2+	1.33	0.23	-	-	-	-	-	-	-
Lab. Foreman	A	1*	0	2.45	2.45	-	-	-	-	-	-	-
Lab. Technician	B	8	3	144.55	0.22	33.27	53.86	19.04	3.51	14.03	31.94	0.39
Laborer	A	4	4+	0.13	0.08	-	-	-	-	-	-	-
Laborer	B	17	7	8.22	0.17	1.54	2.29	0.56	0.66	3.58	1.27	0.34
Lift Truck Driver	B	1	0	0.54	0.54	-	-	-	-	-	-	-
Machinist	A	2	0	0.55	0.39	0.47	0.12	0.08	0.46	1.29	4.45	0.05
Machinist	B	1	0	0.46	0.46	-	-	-	-	-	-	-
Maintenance Head Operator	A	3*	1	0.53	0.06	0.29	0.24	0.14	0.21	3.03	3.21	0.01
Main Operator	A	1*	0	1.91	1.91	-	-	-	-	-	-	-
Maintenance Oper.	A	1*	0	1.30	1.30	-	-	-	-	-	-	-
Maintenance	A	2	2+	0.10	0.08	-	-	-	-	-	-	-
Maintenance	B	4	3+	0.63	0.20	-	-	-	-	-	-	-

TABLE 5 (Cont.)

ANALYSIS OF BUTADIENE CONCENTRATION BY JOB, PLANTS A AND B

JOB TITLE	PLANT	NUMBER OF SAMPLES	NUMBER SAMPLES BELOW DETECTION LIMIT	MAXIMUM VALUE	MINIMUM VALUE	MEAN	STANDARD DEVIATION	STANDARD ERROR	GEOMETRIC MEAN	GEOMETRIC STANDARD DEVIATION	UPPER 95% CONFIDENCE LIMIT, GEOMETRIC	LOWER 95% CONFILENCE LIMIT, GEOMETRIC
Mechanic	A	7	3	1.68	0.09	0.42	0.60	0.23	0.22	3.14	0.59	0.08
Mechanic	B	12	5	44.38	0.19	4.08	12.69	3.66	0.53	4.47	1.37	0.21
Operator	A	1	0	0.63	0.63	-	-	-	-	-	-	-
Operator Helper	A	3	3[+]	0.16	0.05	-	-	-	-	-	-	-
Operator Helper	B	3	2[+]	1.81	0.26	-	-	-	-	-	-	-
Pipefitter	A	14	6	4.17	0.05	0.92	1.34	0.36	0.32	4.69	0.79	0.13
Pipefitter	B	8[*]	4[+]	3.12	0.18	-	-	-	-	-	-	-
Reactor Operator	A	7[*]	0	4.08	0.24	1.93	1.52	0.58	1.27	3.03	3.74	0.43
Recovery Operator	A	7[*]	1	4.45	0.06	0.90	1.58	0.60	0.37	3.81	1.21	0.11
Recovery Operator	B	4	2[+]	2.33	0.24	-	-	-	-	-	-	-
Relief Operator	B	1	1[+]	0.31	0.31	-	-	-	-	-	-	-
Shift Tester	A	2[*]	0	4.82	1.00	2.91	2.70	1.91	2.20	3.04	47964.66	0.00
Tank Farm Operator	A	6[*]	0	3.94	0.94	2.50	1.34	0.55	2.14	1.92	4.23	1.08
Tank Farm Operator	B	1	1[+]	0.26	0.26	-	-	-	-	-	-	-
Tester	A	1[*]	0	1.35	1.35	-	-	-	-	-	-	-
Tester-in Training	A	1[*]	0	1.11	1.11	-	-	-	-	-	-	-
Tinner	A	1	1[+]	0.10	0.10	-	-	-	-	-	-	-
Transfer Pump House	B	1	1[+]	0.29	0.29	-	-	-	-	-	-	-
Utility/Coag. Operator	A	1	1[+]	0.06	0.06	-	-	-	-	-	-	-
Utility Operator	A	2[*]	0	0.39	0.16	0.27	0.16	0.12	0.25	1.88	71.75	0.00
Welder	B	1	1[+]	0.21	0.21	-	-	-	-	-	-	-

TABLE 5 (Cont.)

ANALYSIS OF BUTADIENE CONCENTRATION BY JOB, PLANT A AND B

JOB TITLE	PLANT	NUMBER OF SAMPLES	NUMBER SAMPLES BELOW DETECTION LIMIT	MAXIMUM VALUE	MINIMUM VALUE	MEAN	STANDARD DEVIATION	STANDARD ERROR	GEOMETRIC MEAN	GEOMETRIC STANDARD DEVIATION	UPPER 95% CONFIDENCE LIMIT, GEOMETRIC	LOWER 95% CONFIDENCE LIMIT, GEOMETRIC
OVERALL	A	111	43	5.14	0.05	0.87	1.26	0.12	0.31	4.31	0.41	0.24
OVERALL	B	103	54[++]	276.03	0.17	8.03	32.62	3.21	0.71	5.35	0.99	0.52

* At least one of the samples had styrene on the B tube or B section above one-third the level found on the A tube or A section.

\+ At least 50% of the samples were below the detection limit, so statistical parameters were not generated. (ref. 13)

++ Statistical parameters may have large error because more than 50% of samples were below the detection limit. (ref. 13)

APPENDIX I

APPENDIX I

JOB CLASSIFICATIONS

Plant A	Plant B	
01	01	Laboratory - Technical
03		
05	03	Laboratory Technician: Compound rubber samples, cure rubber samples, pull tensile, mix BPI samples in Banbury. Determine compound viscosities and BPI's on Mooney Viscometer, clean and calibrate Mooney Viscometer and Scott Testers. Make up solvents, order and handle laboratory supplies, record, check, and report testing results. Make up coagulant used in Shift Control Laboratory, determine torque curves of compounded rubber using Monsanto Rheometer, cut up standard rubber bales.
02	05	Tank Farm - Production
07	08	Head Operator: Receives recycle butadiene from Recovery units and with fresh butadiene received from Neches Butane make blends which are pumped to the Reactor units. Samples all butadiene day tanks for laboratory tests. Caustic treats butadiene pumped to the Reactor units. Samples caustic for laboratory tests. Receives and unloads caustic and acid cars to storage tanks. Samples these cars for laboratory tests. Requests maintenance be done on all tank farm equipment.
08	09	A Operator: Assists Head Operator as needed. Receives and unloads fresh styrene trucks. Makes styrene blends for recycle styrene received from the Recovery units and available fresh styrene in storage. Pumps blended styrene to the Reactor units. Samples styrene received and blends for laboratory tests.

Plant A	Plant B	
03	05	Reactor - Production
07	08	Head Operator: Receives charge ingredients, butadiene, styrene, soap solution, PMHP, activator, modifier and shortstop. Directs charge ingredients through Reactor train for latex production. Pumps latex to Recovery. Assists Reactor charge operator with his duties. Samples latex for laboratory tests. Requests maintenance to be done on Reactor area equipment. Performs specific housekeeping duties and completes Reactor logs.
	09	A Operator: Assist the Reactor Head Operator in the performance of his duties. Receives charge ingredients into surge tanks and calibrates minor stream flows to the train. Samples latex for laboratory tests. Analyzes the reactor charge stream for oxygen content by a syringe titration method. Completes reactor charge and calibration log.
04	05	Recovery - Production
07	08	Head Operator: Operates recovery unit equipment to remove unreacted butadiene and styrene from latex received from reactor units. Pumps these monomers to the Tank Farm. Pumps stripped latex to the Process storage tanks. Makes up sodium nitrite solution for use in pump seal water. Makes up defoamer used in the flash tanks and stripping columns. Samples latex, seal H_2O and vent gas for laboratory tests. Requests maintenance on equipment in this unit. Performs specific housekeeping duties and completes the recovery log.

Plant A	Plant B	
08	09	A Operator: Assists the Head Operator as needed in the performance of his duties.
05	05	Process - Production

Foremen - all categories:

Process: Supervises all operations in the process area excluding specific solutions operations which are supervised by the General Shift Foreman. Reports to General Shift Foreman.

Poly: Directs activities in the utility, reactor, recovery, pigment, brinehouse and tank farm areas. Reports to General Shift Foreman.

Plant A	Plant B	
07	08	Head Operator - Process Area: Reports to the process foreman for instructions on shift operations in the finishing area and coordinates activities of operations in all process areas toward completion of these instructions. These areas include solutions, coagulation, dryers, balers, packaging, scale and fork truck operation. Makes maintenance requests on equipment in the various areas. Maintains raw materials inventories. Assists operators as needed and provides temporary relief to these operators as required. Additionally, the Process A Head Operator checks the affluent pumping and treatment system for proper control and pH control.

Plant A	Plant B	
08	09	A Operator - Pigment: Makes up soap, activator, antioxidant, shortstop, and oil emulsion for use in the reactor and solutions area. Pumps these chemicals along with PMHP and modifier to designated storage and surge tanks. Samples made-up chemical solutions for laboratory tests. Adds water treating chemicals to hot water circulating systems in pigment tank farm area. Samples water for analysis at the utility cooling water test house.
09	09	Blend Operator: Receives latex from the recovery units and directs to storage tanks as instructed by the General Shift Foreman. Receives oil emulsion and antioxidant from the pigment areas and directs to storage. Makes latex blends and directs latex from one tank to another as required. Pumps latex to coagulation. Samples latex, oil emulsion and antioxidant for laboratory tests. Completes blend logs and performs certain housekeeping duties.
10-12	09	Coagulation Operator: Coagulates latex received from solution blend tanks, washes and dewaters rubber crumb for transfer to the dryers. Receives concentrated acid from the tank farm to coagulation surge tank. Makes up coagulant aid and TPP solutions and pumps to the coagulation tanks. Receives raw brine and pumps to the coagulatio tank. Performs certain housekeeping duties and completes coagulation log.
11	09	Dryer Operator: Receives rubber crumb into the dryers and operates dryers as detailed. Delivers rubber samples to laboratory for test Cleans dryer fines in designated areas and maintains general house-

Plant A	Plant B	
		keeping in the area. Samples silicone dryer spray solutions after makeup for laboratory tests, Completes dryer log.
14	09	Baler Operator: Receives dried rubber crumb to the baler scale for weighing and baling. Operates baler conveyors and film wrapper. Assist operator helper in bale packaging. Performs general and specific housekeeping duties. Completes baler log.
	09	Valve Greaser: Lubricates and exercises all plug cock valves in the plant. Requests maintenance on valves and grease gun equipment.
15	17	Lift Truck Driver: Removes packaged rubber by lift truck, weighs and stores rubber in warehouse. Delivers raw materials and packaging parts to various process areas. Completes warehouse inventory log.
16	12	Operator Helper: Packages rubber bales. Assists baler operator in baler and wrapper operation. Performs general housekeeping and completes packaging log.
06	09	Carbon Black:
	09	Floating A Operator: Removes dryer fines and samples rubber for laboratory tests. Assists coagulation, dryer and black hou operators as needed.
08	09	Black House Operator: Receives and unloads carbon black seald bi with hoist truck. Operates black house. Makes up carbon bla slurry and pumps to coagulation. Samples carbon black slurr for laboratory tests. Completes carbon black receiving and unloading log.

Plant A	Plant B	
02	10	Shift Breaker-Head Operator: Provide shift relief for process, recovery, reactor, utility and tank farm Head Operators.
02	10	Shift Breaker-A Operator: Provides shift relief for the floating Lift Truck Driver and the regular Lift Truck Drivers. Also, all A Operators in Process and Polymerization areas.
02	10	Shift Breaker-Vacation Relief: Provides vacation relief for all day shift operators. Performs other duties as directed.
07	07	Maintenance
01	01	Foreman: Directs and supervises activities of craftsmen and Laborers assigned to him, to perform the various maintenance repair jobs throughout the plant. He directs and instructs employees in the proper methods and techniques of work, including safety. Performs certain administrative duties such as time keeping, personnel record ordering of materials, etc.
19	20	Pipefitter - plantwide: Performs maintenance upkeep, troubleshooting and repair of all piping systems, vessels and condensers within the plant. He cuts, threads and fits pipe. Makes pipe sketches for welder fabrication. Removes, cleans and installs pipe, valves, etc. Unheads and heads up non-agitated vessels and stripping volumns, installs and removes relief valves.
20	21	Welder-plantwide: Performs welding such as electric arc, gas metal arc, oxy-acetylene and soldering on piping systems, structural steel, pipe hangers and brackets and equipment repair, as he may be directed. Also does own cutting, fitting and grinding of various materials he works with.

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Plant A	Plant B	
21	22	Sheetmetal-plantwide: (Same as BFG).
23	24	Electrician-plantwide: (Same as BFG).
24	25	Painter-plantwide: (Same as BFG).
25	26	Machinists-Inside-plantwide: Fabricates necessary parts to keep equipment in plant in operation. Operates lathes, mills, drill presses, shaper, grinders, etc., to make or repair machine equipment, such as shafts, bearing housing, pump and compressor parts and housings, etc.
22	26	Machinists-Outside-plantwide: Performs maintenance upkeep, troubleshooting and repair and installation of mechanical systems throughout the plant such as pumps, gear boxes, agitators, conveying systems, mechanical drives such as sprockets and sheaves, compressors and gasoline, gas and diesel engine driven equipment
26	27	Oiler (Poly & Process): Provides lubrication on pre-determined schedule for all machinery requiring lubrication. Checks such machines on daily basis.
27	28	Carpenter-plantwide: (Same as BFG).
28	29	Instrument Repairman-plantwide: (Same as BFG).
11/18	36	Truck Driver-plantwide:
		Trash Truck: Makes interplant deliveries. Hauls waste materials from plant to disposal sites. Assisted by Laborers assigned to trash truck when hauling.
		Winch Truck: Makes interplant deliveries. Assisted by plant craftmen. Operates winch when needed.

Plant A	Plant B	
11/33	37	Labor Leaderman-tank, dryer, yard: Leader on common labor jobs in assigned areas.
11/34	38	Common Labor-Special Crews:

Dryer Crew: Performs cleaning on dryers, coagulation tanks and blend tanks in process area. Cleans floors and trenches in process area.

Tank Crew: Performs cleaning on all vessels in poly area. Cleans floors and trenches in poly area.

Yard Crew (plant-wide).

Lawn mowers: Maintains yard and grounds. Operates all mowi[ng] machinery including tractor, hand mowers and edgers.

Trash Truck: Places plant garbage into dumpsters in specified areas for pickup by contract waste disposal. Assists truck driver in disposal of plant wastes.

Common Labor: Cleans column trays, strainers, screens, dryer fligh[ts] at salvage yard. Use for housekeeping plantwide.

Laborer-Cement Finisher: Pours and finishes all concrete. Applies grout where needed. Lays bricks.

Laborer-Cement Cutter Buster: Operates pneumatic concrete busting tools.

Water Blaster-plantwide: Performs high pressure water cleaning as needed.

11/35	39	Building Laborers and Janitors: Maintains buildings, offices and restrooms in a clean and sanitary condition.

Plant A	Plant B	
10	05	Utilities
07	08	Head Operator: Operates compressor house providing refrigeration for the reactor units using NH_z as a refrigerant. Recieves anhydrous NH_z by tank truck to storage. Lubricates equipment in this area. Adds water treating chemicals to engine and compressor cooling water and samples water for tests at the cooling tower test bench. Performs specific housekeeping duties and completes refrigeration l
16	09	Operator A: Assist utility head operator when needed. Operates coolin tower. Receives and adds concentrated acid to control pH of circulation plant cooling water. Adds water treating chemical to cooling water. Receives chlorine by cylinder and adds to the cooling water periodically thru a chlorinator. Samples cooling water and perform required analysis. Operates water pump house. Lubricates equipment. Performs specific housekeeping duties and completes water pumphouse log.
02	19	Relief Operator: Takes the place of any of the above listed Operators when they are absent. Performs duties of that particular operator relieved.
12	10	Storeroom - Stockroom
2 3	41	Storeroom Clerks: . Issues materials in storeroom and inserts legible and accurate numbers on stores requisitions for EDP use. Uses working knowledge of stores catalog printed by ED to find approximately 15,000 individual items for instruments, pum equipment, electrical, pipefitting and miscellaneous craftsman's j Uses his knowledge of 1,000 tools in EDP catalog and follows pro-

Plant A	Plant B	
		cedures for issuing correctly and accurately. Unloads, receives and stores any materials received by storeroom. Makes annual inventory on selective check cards prepunched in EDP section. Issues coveralls and towels as authorized. Assists in inventory control and report loses or mutilation.
		Head Storeroom Clerk: Performs all duties as listed for Storeroom Clerk. Supervises all Storeroom Clerks during the vacation and illness of the Storeroom Foreman.
12	13	Supply & Distribution:
15	17	Lift Truck Driver: Loading rubber into box cars and trucks, storing rubber cartons in warehouse after being filled at packaging station.
	50	Rubber Loaders: Sweep warehouse, prepare box cars for loading, clos boxcar doors after loading, cut samples of finished rubber for laboratory, prepare sample shipments, prepare special and export packaging, recoup broken and spilled boxes of rubber.

APPENDIX II

ORGANIC SOLVENTS IN AIR

Physical and Chemical Analysis Branch

Analytical Method *

Analyte:	Organic Solvents (See Table 1)	**Method No.:**	P&CAM 127
Matrix:	Air	**Range:**	For the specific compound, refer to Table 1
Procedure:	Adsorption on charcoal desorption with carbon disulfide, GC		
Date Issued:	9/15/72	**Precision:**	10.5% RSD
Date Revised:	2/15/77	**Classification:**	See Table 1

1. Principle of the Method

1.1 A known volume of air is drawn through a charcoal tube to trap the organic vapors present.

1.2 The charcoal in the tube is transferred to a small, graduated test tube and desorbed with carbon disulfide.

1.3 An aliquot of the desorbed sample is injected into a gas chromatograph.

1.4 The area of the resulting peak is determined and compared with areas obtained from the injection of standards.

2. Range and Sensitivity

The lower limit in mg/sample for the specific compound at 16 × 1 attenuation on a gas chromatograph fitted with a 10:1 splitter is shown in Table 1. This value can be lowered by reducing the attenuation or by eliminating the 10:1 splitter.

3. Interferences

3.1 When the amount of water in the air is so great that condensation actually occurs in the tube, organic vapors will not be trapped. Preliminary experiments indicate that high humidity severely decreases the breakthrough volume.

3.2 When two or more solvents are known or suspected to be present in the air, such information (including their suspected identities), should be transmitted with the sample, since with differences in polarity, one may displace another from the charcoal.

3.3 It must be emphasized that any compound which has the same retention time as the specific compound under study at the operating conditions described in this method is an interference. Hence, retention time data on a single column, or even on a number of columns, cannot be considered as proof of chemical identity. For this reason it is important that a sample of the bulk solvent(s) be submitted at the same time so that identity(ies) can be established by other means.

* from NIOSH Manual of Analytical Methods, Second Edition, Volume 1. David G. Taylor, Manual Coordinator. DHEW(NIOSH) Publication No. 77-157-A, 1977.

3.4 If the possibility of interference exists, separation conditions (column packing, temperatures, etc.) must be changed to circumvent the problem.

4. Precision and Accuracy

4.1 The mean relative standard deviation of the analytical method is 8% (11.4).

4.2 The mean relative standard deviation of the analytical method plus field sampling using an approved personal sampling pump is 10% (11.4). Part of the error associated with the method is related to uncertainties in the sample volume collected. If a more powerful vacuum pump with associated gas-volume integrating equipment is used, sampling precision can be improved.

4.3 The accuracy of the overall sampling and analytical method is 10% (NIOSH–unpublished data) when the personal sampling pump is calibrated with a charcoal tube in the line.

5. Advantages and Disadvantages of the Method

5.1 The sampling device is small, portable, and involves no liquids. Interferences are minimal, and most of those which do occur can be eliminated by altering chromatographic conditions. The tubes are analyzed by means of a quick, instrumental method. The method can also be used for the simultaneous analysis of two or more solvents suspected to be present in the same sample by simply changing gas chromatographic conditions from isothermal to a temperature-programmed mode of operation.

5.2 One disadvantage of the method is that the amount of sample which can be taken is limited by the number of milligrams that the tube will hold before overloading. When the sample value obtained for the backup section of the charcoal tube exceeds 25% of that found on the front section, the possibility of sample loss exists. During sample storage, the more volatile compounds will migrate throughout the tube until equilibrium is reached (33% of the sample on the backup section).

5.3 Furthermore, the precision of the method is limited by the reproducibility of the pressure drop across the tubes. This drop will affect the flow rate and cause the volume to be imprecise, because the pump is usually calibrated for one tube only.

6. Apparatus

6.1 An approved and calibrated personal sampling pump for personal samples. For an area sample, any vacuum pump whose flow can be determined accurately at 1 liter per minute or less.

6.2 Charcoal tubes: glass tube with both ends flame sealed, 7 cm long with a 6-mm O.D. and a 4-mm I.D., containing 2 sections of 20/40 mesh activated charcoal separated by a 2-mm portion of urethane foam. The activated charcoal is prepared from coconut shells and is fired at 600°C prior to packing. The absorbing section contains 100 mg of charcoal, the backup section 50 mg. A 3-mm portion of urethane foam is placed between the outlet end of the tube and the backup section. A plug of silylated glass wool is placed in front of the absorbing section. The pressure drop across the tube must be less than one inch of mercury at a flow rate of 1 lpm.

6.3 Gas chromatograph equipped with a flame ionization detector.

6.4 Column (20 ft × ⅛ in) with 10% FFAP stationary phase on 80/100 mesh, acid-washed DMCS Chromosorb W solid support. Other columns capable of performing the required separations may be used.

6.5 A mechanical or electronic integrator or a recorder and some method for determining peak area.

6.6 Microcentrifuge tubes, 2.5 ml, graduated.

6.7 Hamilton syringes: 10 μl, and convenient sizes for making standards.

6.8 Pipets: 0.5-ml delivery pipets or 1.0-ml type graduated in 0.1-ml increments.

6.9 Volumetric flasks: 10 ml or convenient sizes for making standard solutions.

7. Reagents

7.1 Spectroquality carbon disulfide (Matheson Coleman and Bell).

7.2 Sample of the specific compound under study, preferably chromatoquality grade.

7.3 Bureau of Mines Grade A helium.

7.4 Prepurified hydrogen.

7.5 Filtered compressed air.

8. Procedure

8.1 Cleaning of Equipment: All glassware used for the laboratory analysis should be detergent washed and thoroughly rinsed with tap water and distilled water.

8.2 Calibration of Personal Pumps. Each personal pump must be calibrated with a representative charcoal tube in the line. This will minimize errors associated with uncertainties in the sample volume collected.

8.3 Collection and Shipping of Samples

8.3.1 Immediately before sampling, the ends of the tube should be broken to provide an opening at least one-half the internal diameter of the tube (2 mm).

8.3.2 The small section of charcoal is used as a back-up and should be positioned nearest the sampling pump.

8.3.3 The charcoal tube should be vertical during sampling to reduce channeling through the charcoal.

8.3.4 Air being sampled should not be passed through any hose or tubing before entering the charcoal tube.

8.3.5 The flow, time, and/or volume must be measured as accurately as possible. The sample should be taken at a flow rate of 1 lpm or less to attain the total sample volume required. The minimum and maximum sample volumes that should be collected for each solvent are shown in Table 1. The minimum volume quoted must be collected if the desired sensitivity is to be achieved.

8.3.6 The temperature and pressure of the atmosphere being sampled should be measured and recorded.

8.3.7 The charcoal tubes should be capped with the supplied plastic caps immediately after sampling. Under no circumstances should rubber caps be used.

8.3.8 One tube should be handled in the same manner as the sample tube (break, seal, and transport), except that no air is sampled through this tube. This tube should be labeled as a blank.

8.3.9 Capped tubes should be packed tightly before they are shipped to minimize tube breakage during shipping.

8.3.10 Samples of the suspected solvent(s) should be submitted to the laboratory for qualitative characterization. These liquid bulk samples should not be transported in the same container as the samples or blank tube. If possible, a bulk air sample (at least 50 l air drawn through tube) should be shipped for qualitative identification purposes.

8.4 Analysis of Samples

8.4.1 Preparation of Samples. In preparation for analysis, each charcoal tube is scored with a file in front of the first section of charcoal and broken open. The glass wool is removed and discarded. The charcoal in the first (larger) section is transferred to a small stoppered test tube. The separating section of foam is removed and discarded; the second section is transferred to another test tube. These two sections are analyzed separately.

8.4.2 Desorption of Samples. Prior to analysis, one-half ml of carbon disulfide is pipetted into each test tube. (All work with carbon disulfide should be performed in a hood because of its high toxicity.) Tests indicate that desorption is complete in 30 minutes if the sample is stirred occasionally during this period.

8.4.3 GC Conditions. The typical operating conditions for the gas chromatograph are:

1. 85 cc/min. (70 psig) helium carrier gas flow.
2. 65 cc/min. (24 psig) hydrogen gas flow to detector.
3. 500 cc/min. (50 psig) air flow to detector.
4. 200°C injector temperature.
5. 200°C manifold temperature (detector).
6. Isothermal oven or column temperature — refer to Table 1 for specific compounds.

8.4.4 Injection. The first step in the analysis is the injection of the sample into the gas chromatograph. To eliminate difficulties arising from blowback or distillation within the syringe needle, one should employ the solvent flush injection technique. The 10 μl syringe is first flushed with solvent several times to wet the barrel and plunger. Three microliters of solvent are drawn into the syringe to increase the accuracy and reproducibility of the injected sample volume. The needle is removed from the solvent, and the plunger is pulled back about 0.2 μl to separate the solvent flush from the sample with a pocket of air to be used as a marker. The needle is then immersed in the sample, and a 5-μl aliquot is withdrawn, taking into consideration the volume of the needle, since the sample in the needle will be completely injected. After the needle is removed from the sample and prior to injection, the plunger is pulled back a short distance to minimize evaporation of the sample from the tip of the needle. Duplicate injections of each sample and standard should be made. No more than a 3% difference in area is to be expected.

8.4.5 Measurement of area. The area of the sample peak is measured by an electronic integrator or some other suitable form of area measurement, and preliminary results are read from a standard curve prepared as discussed below.

8.5 Determination of Desorption Efficiency

8.5.1 Importance of determination. The desorption efficiency of a particular compound can vary from one laboratory to another and also from one batch of charcoal to another. Thus, it is necessary to determine at least once the percentage of the specific compound that is removed in the desorption process for a given compound, provided the same batch of charcoal is used. NIOSH has found that the desorption efficiencies for the compounds in Table 1 are between 81% and 100% and vary with each batch of charcoal.

8.5.2 Procedure for determining desorption efficiency. Activated charcoal equivalent to the amount in the first section of the sampling tube (100 mg) is measured into a 5-cm, 4-mm I.D. glass tube, flame-sealed at one end (similar to commercially available culture tubes). This charcoal must be from the same batch as that used in obtaining the samples and can be obtained from unused charcoal tubes. The open end is capped with Parafilm. A known amount of the compound is injected directly into the activated charcoal with a microliter syringe, and the tube is capped with more Parafilm. The amount injected is usually equivalent to that present in a 10-liter sample at a concentration equal to the federal standard.

At least five tubes are prepared in this manner and allowed to stand for at least overnight to assure complete absorption of the specific compound onto the charcoal. These five tubes are referred to as the samples. A parallel blank tube should be treated in the same manner except that no sample is added to it. The sample and blank tubes are desorbed and analyzed in exactly the same manner as the sampling tube described in Section 8.4.

Two or three standards are prepared by injecting the same volume of compound into 0.5 ml of CS_2 with the same syringe used in the preparation of the sample. These are analyzed with the samples.

The desorption efficiency equals the difference between the average peak area of the samples and the peak area of the blank divided by the average peak area of the standards, or

$$\text{desorption efficiency} = \frac{\text{Area sample} - \text{Area blank}}{\text{Area standard}}$$

9. Calibration and Standards

It is convenient to express concentration of standards in terms of mg/0.5 ml CS_2 because samples are desorbed in this amount of CS_2. To minimize error due to the volatility of carbon disulfide, one can inject 20 times the weight into 10 ml of CS_2. For example, to prepare a 0.3 mg/0.5 ml standard, one would inject 6.0 mg into exactly 10 ml of CS_2 in a glass-stoppered flask. The density of the specific compound is used to convert 6.0 mg into microliters for easy measurement with a microliter syringe. A series of standards, varying in concentration over the range of interest, is prepared and analyzed under the same GC conditions and during the same time period as the unknown samples. Curves are established by plotting concentration in mg/0.5 ml versus peak area.

NOTE: Since no internal standard is used in the method, standard solutions must be analyzed at the same time that the sample analysis is done. This will minimize the effect of known day-to-day variations and variations during the same day of the FID response.

10. Calculations

10.1 The weight, in mg. corresponding to each peak area is read from the standard curve for the particular compound. No volume corrections are needed, because the standard curve is based on mg/0.5 ml CS_2 and the volume of sample injected is identical to the volume of the standards injected.

10.2 Corrections for the blank must be made for each sample.

$$\text{Correct mg} = mg_s - mg_b$$

where:

mg_a = mg found in front section of sample tube

mg_b = mg found in front section of blank tube

A similar procedure is followed for the backup sections.

10.3 The corrected amounts present in the front and backup sections of the same sample tube are added to determine the total measured amount in the sample.

10.4 This total weight is divided by the determined desorption efficiency to obtain the corrected mg per sample.

10.5 The concentration of the analyte in the air sampled can be expressed in mg per m^3.

$$mg/m^3 = \frac{\text{Corrected mg (Section 10.4)} \times 1000\ (\text{liters}/m^3)}{\text{Air volume sampled (liters)}}$$

10.6 Another method of expressing concentration is ppm (corrected to standard conditions of 25°C and 760 mm Hg).

$$ppm = mg/m^3 \times \frac{24.45}{MW} \times \frac{760}{P} \times \frac{(T + 273)}{298}$$

where:

P = pressure (mm Hg) of air sampled

T = temperature (°C) of air sampled

24.45 = molar volume (liter/mole) at 25°C and 760 mm Hg

MW = molecular weight

760 = standard pressure (mm Hg)

298 = standard temperature (°K)

11. References

11.1 White, L. D., D. G. Taylor, P. A. Mauer, and R. E. Kupel, "A Convenient Optimized Method for the Analysis of Selected Solvent Vapors in the Industrial Atmosphere", Am Ind Hyg Assoc J 31:225, 1970.

11.2 Young, D. M. and A. D. Crowell, Physical Adsorption of Gases, pp. 137-146, Butterworths, London, 1962.

11.3 Federal Register, 37:202:22139-22142, October 18, 1972.

11.4 NIOSH Contract HSM-99-72-98, Scott Research Laboratories, Inc., "Collaborative Testing of Activated Charcoal Sampling Tubes for Seven Organic Solvents", pp. 4-22, 4-27, 1973.

TABLE 1

Parameters Associated With P&CAB Analytical Method No. 127

Organic Solvent	Method Classification	Detection limit (mg/sample)	Sample Volume (liters) Minimum(a)	Sample Volume (liters) Maximum(b)	GC Column Temp.(°C)	Molecular Weight
Acetone	D	—	0.5	7.7	60	58.1
Benzene	A	0.01	0.5	55	90	78.1
Carbon tetrachloride	A	0.20	10	60	60	154.0
Chloroform	A	0.10	0.5	13	80	119
Dichloromethane	D	0.05	0.5	3.8	85	84.9
p-Dioxane	A	0.05	1	18	100	88.1
Ethylene dichloride	D	0.05	1	12	90	99.0
Methyl ethyl ketone	B	0.01	0.5	13	80	72.1
Styrene	D	0.10	1.5	34	150	104
Tetrachloroethylene	B	0.06	1	25	130	166
1,1,2-trichloroethane	B	0.05	10	97	150	133
1,1,1-trichloroethane (methyl chloroform)	B	0.05	0.5	13	150	133
Trichloroethylene	A	0.05	1	17	90	131
Toluene	B	0.01	0.5	22	120	92.1
Xylene	A	0.02	0.5	31	100	106

(a) Minimum volume, in liters, required to measure 0.1 times the OSHA standard

(b) These are breakthrough volumes calculated with data derived from a potential plot (11.2) for activated coconut charcoal. Concentrations of vapor in air at 5 times the OSHA standard (11.3) or 500 ppm, whichever is lower, 25°C, and 760 torr were assumed. These values will be as much as 50% lower for atmospheres of high humidity. The effects of multiple contaminants have not been investigated, but it is suspected that less volatile compounds may displace more volatile compounds (See 3.1 and 3.2)

APPENDIX III

Table III-1

INDIVIDUAL PERSONAL SAMPLE RESULTS -- JULY 12, 1976

Occupational Title	Operation	Tube No.	Time On	Time Off	Vol., ℓ	Styrene, mg	Butadiene, mg	Styrene conc., ppm	Butadiene conc., ppm
Reactor Operator	8CC	56	6:57	10:40	42.34	0.01	0.13*	0.05	1.39*
Reactor Operator	8CC	8	3:19	6:56	43.53	0.05	0.23*	0.28	2.39*
Reactor Operator	8D	58	6:50	10:44	54.86	0.04	0.41*	0.17	3.39*
Reactor Operator	8D	39	3:10	6:48	51.53	0.19	0.55*	0.86	4.82*
Tank Farm Operator	Pump Room	7	6:38	10:33	47.00	0.06	0.29*	0.30	2.79*
Tank Farm Operator	Pump Room	83	3:00	6:37	43.40	0.04	0.49*	0.21	5.10*
Tank Farm Operator	Outside	29	3:09	6:33	40.8	0.02	0.24*	0.11	2.66*
Tank Farm Operator	Outside	35	6:35	10:33	46.4	0.21	0.20*	1.05	1.95*
Recovery Operator	7D	70	3:50	7:12	42.94	0.07	0.08*	0.39	0.84*
Recovery Operator	7D	93	7:14	10:29	39.90	0.06	<0.01	0.36	<0.10
Float Aid Operator	7D	81	3:52	7:08	43.49	0.10	0.07*	0.54	0.73*
Float Aid Operator	7D	64	7:10	10:28	39.30	0.03	0.06*	0.18	0.69*
Pipefitter	Main	84	3:16	6:41	42.11	0.02	< 0.01	0.11	<0.10
Pipefitter	Main	53	6:43	10:27	45.75	0.04	<0.01	0.20	<0.10
Pipefitter	Main	80	3:20	6:28	40.20	<0.01	<0.01	<0.06	<0.11
Pipefitter	Main	30	6:29	10:27	49.35	<0.01	0.01	<0.05	<0.09
Instrument Repair	Main	55	3:08	6:39	42.69	0.05	0.03*	0.28	0.32*
Instrument Repair	Main	22	6:40	10:27	45.68	<0.01	<0.01	<0.05	<0.10
Mechanic	Main	5	3:10	6:29	43.45	0.03	0.02	0.16	0.21
Mechanic	Main	37	6:31	10:27	51.32	0.03	<0.01	0.14	<0.09
Mechanic	Main	88	3:12	6:31	43.40	0.02	0.02	0.11	0.21

Table III-1 (continued)

Occupational Title	Operation	Tube No.	Time On	Time Off	Vol., ℓ	Styrene, mg	Butadiene, mg	Styrene conc., ppm	Butadiene conc., ppm
Mechanic	Main	67	6:32	10:27	50.80	<0.01	<0.01	<0.05	<0.09
Electrician	Main	91	3:14	6:45	44.46	0.02	0.21*	0.10	2.14*
Utility Operator	6CC Blend	87	3:31	6:33	41.17	0.14	0.01	0.80	0.11
Utility Operator	6CC Blend	40	6:35	9:59	44.78	0.29	0.02	1.52	0.21
Utility Operator	6CC Coag.	63	3:36	6:35	39.90	0.63	0.06*	3.71	0.35*
Utility Operator	6CC Coag.	86	6:38	10:05	43.39	0.73	0.04*	3.95	0.42*
Dryer Operator	I & J Lines	52	3:42	6:43	35.25	0.39	0.02	2.60	0.26
Coag. Operator	6C Bldg.	41	4:00	6:50	33.82	0.19	<0.01	1.32	<0.13
Coag. Operator	6C Bldg.	47	6:53	10:09	39.12	0.15	<0.01	0.90	<0.12
Operator Helper	6C Bldg.	23	4:07	6:56	35.07	0.03	<0.01	0.20	<0.13
Operator Helper	6C Bldg.	75	6:59	10:12	39.81	0.03	<0.01	0.17	<0.11
Recovery Operator	7C	60	3:40	7:04	46.98	0.06	0.02*	0.30	0.19*
Recovery Operator	7C	38	7:06	10:24	45.50	0.05	0.02*	0.25	0.20*
Recovery Operator	7CC	78	3:39	7:01	43.11	0.06	0.04*	0.33	0.22*
Recovery Operator	7CC	2	7:04	10:23	41.98	0.07	0.03*	0.39	0.32*
Coag. Operator	6D	45	4:16	7:07	35.37	0.05	0.01	0.34	0.13
Coag. Operator	6D	48	7:09	10:20	38.57	0.06	0.02	0.37	0.23
Blend Operator	6D	34	4:27	7:14	29.31	0.05	<0.01	0.40	<0.15
Baler Operator	6D	73	4:20	7:18	39.34	<0.01	0.02*	<0.06	0.23*
Baler Operator	6D	27	7:22	10:16	38.75	<0.01	0.01*	<0.06	0.12*
Reactor Operator	8C	24	6:18	10:20	50.77	0.04	0.34*	0.18	3.03*

Table III-1 (continued)

INDIVIDUAL PERSONAL SAMPLE RESULTS -- JULY 13, 1976

Occupational Title	Operation	Tube No.	Time On	Time Off	Vol., ℓ	Styrene, mg	Butadiene, mg	Styrene conc., ppm	Butadiene conc., ppm
Mechanic	Main	110	8:15	3:01	22.9	0.03	<0.01	0.31	<0.19
Tank Farm Operator	Pump Room	13	7:28	10:37	37.8	0.09	0.22	0.56	2.63
Recovery Operator	8D	76	7:50	10:53	36.6	0.06	0.36*	0.38	4.45*
Tank Farm Operator	Pump Room	42	10:37	2:08	42.2	0.16	0.31*	0.89	3.30*
Reac. Head Oper.	8D Reactor	124	7:48	10:42	34.8	0.09	0.35*	0.61	4.55*
Tank Farm Oper.	Outside	120	7:42	10:39	35.4	0.82	0.11*	5.44	1.40*
Reactor Operator	8CC	71	11:09	2:27	45.54	0.05	0.10*	0.26	0.99*
Blend Operator	6CC	100	10:34	2:13	43.10	0.37	< 0.01	2.02	<0.10
Recovery Operator	6C	125	10:59	2:25	41.2	0.56	0.06*	3.19	0.65*
Recovery Operator	7C	9	11:02	2:27	41.0	0.19	0.02*	1.09	0.22*
Coag. Operator	6C	44	10:50	2:18	44.30	0.20	<0.01	1.06	<0.10
Coag. Operator	6CC	79	10:38	2:16	43.51	0.62	<0.01	3.34	<0.10
Dryer Operator	6CC	102	10:45	2:15	44.33	0.56	<0.01	2.96	<0.10
Mechanic	Main	112	8:05	2:31	17.20	0.14	<0.01	1.90	<0.26
Dryer Operator		97	8:09	3:14	18.08	0.02	<0.01	0.26	<0.25
Coag. Operator	6CC	141	7:38	10:37	35.47	0.59	0.02*	3.90	0.26*
Dryer Operator	6CC	109	7:43	10:44	37.68	0.34	<0.01	2.12	<0.12
Head/Blend Operator	6CC	101	7:34	10:33	34.21	0.13	<0.01	0.89	<0.13
Operator Helper	6C	62	11:27	2:42	41.37	0.02	<0.01	0.11	<0.11
Coag. Operator	6D	43	11:50	2:31	31.30	0.05	<0.01	0.38	<0.14
Tank Farm Operator	Outside	121	10:34	2:07	42.6	0.06	0.12*	0.33	1.27*

Table III-1 (continued)

Occupational Title	Operation	Tube No.	Time On	Time Off	Vol., ℓ	Styrene, mg	Butadiene, mg	Styrene conc., ppm	Butadiene conc., ppm
Coag. Operator	6C	90	10:55	2:24	44.82	0.15	<0.01	0.79	<0.10
Head Operator	6C Process	108	10:58	2:18	43.91	0.09	<0.01	0.48	<0.10
E Line Helper	6C Process	61	11:11	2:40	42.68	0.06	0.01*	0.33	0.11*
Tank Farm Operator	Outside	99 +	7:30	10:26	35.2	0.02	0.05	0.13	0.65
Reactor Operator	8CC	51	8:23	11:08	24.15	0.03	0.02*	0.29	0.37*
Head Operator	6C Recovery	10	8:00	10:57	35.4	0.89	0.04*	5.90	0.51*
Operator	7CC Recovery	85	8:06	10:56	35.7	0.59	0.05*	3.88	0.63*
Coag. Operator	6C	98	8:00	10:47	36.21	0.24	<0.01	1.55	<0.12
Coag. Operator	6C	104	7:53	10:53	40.68	0.30	<0.01	1.73	<0.11
Blend Operator	6D Process	96	8:18	11:42	42.55	0.14	<0.01	0.77	<0.11
Head Operator	6D Process	123	8:08	11:36	40.53	0.13	0.01	0.75	0.11
Maintenance	Clean Blend Tank	114	7:57	3:07	25.62	0.08	<0.01	0.73	<0.18
Head Operator	6C Process	3	7:55	10:57	39.64	0.10	<0.01	0.59	<0.11
Coag. Operator	6D Process	65	8:13	11:47	47.79	0.09	<0.01	0.44	<0.10
Pipefitter	Main	140	7:46	3:18	29.29	0.21	0.04*	1.68	0.62*
Maint. Head Op.	7C Recovery	0	8:04	11:00	34.8	0.15	0.02	1.01	0.26
Pipefitter	Main	113	7:44	3:36	30.45	0.03	<0.01	0.23	<0.15
Reactor Operator	8D	122	10:45	2:19	42.8	0.06	0.30*	0.33	3.17*
Tank Farm Operator	Outside	12	10:40	2:09	41.8	0.28	0.05*	1.57	0.54*
Pipefitter	Routine 6D	133	7:48	3:01	23.34	0.02	<0.01	0.20	<0.19
Maintenance	Clean Blend Tank	132	7:50	3:07	21.66	0.14	<0.01	1.52	<0.20
Mechanic	Main	129	8:02	2:55	24.28	0.44	0.09*	4.25	1.68*

Table III-1 (continued)

INDIVIDUAL PERSONAL SAMPLE RESULTS -- JULY 14, 1976

Occupational Title	Operation	Tube No.	Time On	Time Off	Vol., ℓ	Styrene, mg	Butadiene, mg	Styrene conc., ppm	Butadiene conc., ppm
Reactor Operator	8C & 8CC	130	8:25	11:34	37.74	0.04	0.02*	0.25	0.24*
Recovery Operator	7C	177	8:09	11:27	38.31	0.03	<0.01	0.18	<0.12
Reactor Operator	8C	152	8:14	11:30	41.68	0.03	0.04*	0.17	0.43*
"A" Operator	7C Recovery	151	8:03	11:24	35.15	0.07	<0.01	0.47	<0.13
Head Operator	7C Recovery	131	8:01	11:23	41.79	0.03	<0.01	0.17	<0.09
Maintenance Op.	7D Recovery	137	7:56	11:20	42.39	0.18	0.14*	1.00	1.49*
Tank Farm Operator		72	11:45	2:23	32.11	0.02	0.28*	0.15	3.94*
Head Operator	Tank Farm	18	7:38	11:08	47.25	0.05	0.06*	0.25	0.57*
Maint. Head Op.	Tank Farm	115	7:35	11:43	50.76	0.05	0.06*	0.23	0.53*
"A" Operator	Tank Farm	183	11:08	2:25	43.49	0.28	0.14*	1.51	1.46*
Head Operator	Tank Farm	180	11:10	2:21	40.96	0.05	0.18*	0.29	1.99*
Maintenance Op.	7D Recovery	185	11:21	2:35	41.06	0.11	0.10*	0.63	1.10*
Head Operator	7C Recovery	127	11:25	2:39	40.57	0.44	0.09*	2.54	1.00*
Mechanic	Main	176	7:44	3:12	18.78	0.04	0.03*	0.50	0.72*
Pipefitter	Main	25	7:46	3:04	23.41	0.07	0.07	0.70	1.35
Cleaner	Blend Tank	199	7:50	3:10	21.78	0.07	<0.01	0.76	<0.21
Cleaner	Blend Tank	150	7:53	3:06	16.80	0.04	<0.01	0.56	<0.27
Laborer	Cleaning a Dryer	144	7:59	2:51	27.47	0.11	<0.01	0.94	<0.16
Pipefitter	Main	157	8:03	3:01	20.11	0.03	<0.01	0.35	<0.22
"A" Operator	7D Recovery	155	11:17	2:36	43.15	0.13	<0.01	0.71	<0.10
Pipefitter		184	7:41	3:16	24.60	0.47	0.04*	4.49	0.18*
Pipefitter		198	7:39	3:02	27.75	0.04	0.07*	0.34	0.16*

Table III-1 (continued)

Occupational Title	Operation	Tube No.	Time On	Time Off	Vol., ℓ	Styrene, mg	Butadiene, mg	Styrene conc., ppm	Butadiene conc., ppm
Maint. Head Op.	7C Recovery	153	11:28	2:39	36.90	0.08	<0.01	0.51	<0.12
Head Operator	8C Recovery	128	11:31	2:45	42.09	0.05	0.03*	0.28	0.32*
Main Operator	8C & 8CC Reactor	147	11:35	2:44	37.82	0.06	0.16*	0.37	1.91*
Head Operator	8CC Reactor	182	8:27	11:37	38.0	<0.01	<0.01	<0.06	<0.12
Head Operator	8D Reactor	197	7:48	11:12	43.48	0.03	0.27*	0.16	2.81*
Head Operator	7D Recovery	187	7:52	11:12	43.56	0.11	0.10*	0.59	1.04*
"A" Operator	7D Recovery	172	7:54	11:16	43.12	0.12	0.05*	0.65	0.52*
"A" Operator	8D Reactor	181	7:48	11:11	40.46	0.04	0.28*	0.23	3.13*
"A" Operator	8D Reactor	16	11:14	2:31	5.53	<0.01	<0.01	<0.42	<0.82
Head Operator	8D Reactor	134	11:14	2:28	41.34	<0.01	0.47*	<0.57	5.14*
Head Operator	7D Recovery	95	11:18	2:24	22.60	0.15	<0.01	1.56	<0.20
"A" Operator	Tank Farm	146	7:41	11:07	44.82	0.12	0.04*	0.63	0.40*

Table III-1 (continued)

INDIVIDUAL PERSONAL SAMPLE RESULTS -- JULY 15, 1976

Occupational Title	Operation	Tube No.	Time On	Time Off	Vol., ℓ	Styrene, mg	Butadiene, mg	Styrene conc., ppm	Butadiene conc., ppm
Tinner	6D	171	8:16	3:08	23.27	0.03	< 0.01	0.30	< 0.19
Operator Helper	6C	196	11:17	2:34	14.10	0.03	< 0.01	0.50	< 0.32
Baler/Dryer Operator	6D	1	11:13	2:43	44.43	<0.01	< 0.01	< 0.05	< 0.10
Blend Operator	6C	304	11:21	2:31	38.0	0.33	< 0.01	2.04	< 0.12
Utility/Coag. Op.	6CC	154	8:28	11:31	36.6	0.31	< 0.01	1.99	< 0.12
Lab Foreman	Sample Lab	139	7:28	10:56	43.64	0.06	0.24*	0.32	2.48*
Compounder		178	7:30	10:53	42.09	0.05	0.26*	0.28	2.79*
	Finish Prod. Chem. Testing	173	7:35	11:08	40.65	0.05	0.01*	0.29	0.11*
Shift Tester	Carbon Black	193	7:41	10:58	40.59	0.03	0.09*	0.17	1.00*
Shift Tester	Lab Tech. A	167	7:45	11:00	38.68	0.06	0.34*	0.36	3.97*
Tester	Sample Lab	159	7:48	10:45	40.02	0.09	0.12*	0.53	1.36*
Compounder		169	7:50	10:50	29.95	0.02	0.20	0.16	3.02
	Finish Prod. Chem. Testing	311	11:09	2:15	34.76	0.02	0.05	0.14	0.65
Shift Tester	Carbon Black	309	10:59	3:17	40.80	0.02	0.09*	0.12	1.00*
Shift Tester	Lab Tech. A	117	11:04	3:19	38.85	0.04	0.47*	0.30	5.47*
Tester in Training		301	10:47	2:13	44.65	0.07	0.11*	0.37	1.11*
Compounder		156	10:52	3:18	15.34	≤0.01	0.01	< 0.15	0.30
Compounder		307	10:55	3:18	41.84	0.03	0.12*	0.17	1.30*
Lab Foreman		303	10:57	3:16	42.99	0.05	0.23*	0.27	2.42*
Dryer Operator	6CC Process	161	8:24	11:35	38.2	0.55	0.02	3.38	0.24

Table III-1 (continued)

Occupational Title	Operation	Tube No.	Time On	Time Off	Vol., ℓ	Styrene, mg	Butadiene, mg	Styrene conc., ppm	Butadiene conc., ppm
Head Operator	6CC Process	118	8:22	11:26	36.8	0.31	<0.01	1.98	<0.12
Head Operator	6C Process	191	8:15	11:22	37.4	0.23	<0.01	1.444	<0.12
Blender Operator	6C Process	166	8:11	11:20	37.8	0.18	<0.01	1.12	<0.12
G-H Line Helper	6C Process	54	8:06	11:15	38.92	0.12	<0.01	0.72	<0.12
C & D Baler/Dryer	6D Process	160	7:43	11:10	44.10	0.01	<0.01	0.05	<0.10
Utility/Coag. Oper.	6CC Process	310	11:32	2:24	34.4	0.35	<0.01	2.39	<0.13
Head Operator	6CC Process	302	11:30	2:27	35.4	0.24	BLD	1.59	<0.13
Head Operator	6C Process	200	11:23	2:39	39.2	0.23	BLD	1.38	<0.12
Pipefitter	7CC Latex Line	32	7:36	2:46	24.94	0.69	0.23*	6.50	4.17*
Pipefitter	7CC Condenser	186	7:39	2:54	21.03	0.31	0.07*	3.46	1.50*
Machinist	C2B Blowdown Tank	168	7:43	2:56	26.70	0.06	0.02	0.53	0.39
Pipefitter	Upper Vac. Condenser	194	7:46	2:52	22.96	0.19	0.04*	1.94	0.79*
Machinist	C2B Blowdown	165	7:54	2:39	24.48	0.05	0.03	0.48	0.55
Pipefitter	Clean Latex Lines	175	7:52	2:47	26.61	0.61	0.21*	5.38	3.57*
Laborer	D6 & C16 Blend	163	7:56	2:42	22.26	0.04	<0.01	0.42	<0.20
Laborer	D6 & C16 Blend	192	8:00	2:41	20.10	0.09	<0.01	1.05	<0.22
Laborer	Dryer Cleaning	195	8:03	2:59	17.94	0.06	<0.01	0.78	<0.25
Mechanic	Routine Main 6C	105	8:05	2:57	22.25	0.06	<0.01	0.63	<0.20
Pipefitter	Routine 6C	36	8:08	3:04	15.52	0.03	<0.01	0.45	<0.29

* Butadiene present in B section of charcoal tube above one-third the level of that found in A section.
‡ Tube broke when removed from holder.

Table III - 2

COMBINED SAMPLE TIME WEIGHTED AVERAGE CONCENTRATIONS OF STYRENE AND BUTADIENE

Occupational Title	Operation	Date	Tube Nos.	Styrene TWA, ppm	Butadiene TWA, ppm
Reactor Operator	8CC	7/12	8;56	0.16	1.88*
Reactor Operator	8D	7/12	58;39	0.50	4.08*
Tank Farm Operator	Control Room	7/12	7;83	0.26	3.90*
Tank Farm Operator	Control Room	7/12	29;35	0.62	2.28*
Recovery Operator	7D	7/12	70;93	0.38	0.45*
Float Aid Operator	7D	7/12	81;64	0.36	0.71*
Pipefitter	Main	7/12	84;53	0.16	<0.10
Pipefitter	Main	7/12	80;30	0.05	<0.10
Instrument Repair	Main	7/12	55;22	0.15	0.18*
Mechanic	Main	7/12	5;37	0.15	0.12
Mechanic	Main	7/12	88;67	0.06	0.12
Utility Operator	6CC Bend	7/12	87;40	1.18	0.16
Utility Operator	6CC Coag	7/12	63;86	3.84	0.39*
Coag. Operator	6C Bldg.	7/12	41;47	1.13	<0.12
Operator Helper	6C Bldg.	7/12	23;75	0.19	<0.12
Recovery Operator	7C	7/12	60;38	0.28	0.19*
Recovery Operator	7CC	7/12	78;2	0.36	0.27*
Coag. Operator	6D	7/12	45;48	0.36	0.18
Baler Operator	6D	7/12	73;27	<0.06	0.18*
Tank Farm Operator	Pump Room	7/13	13;42	0.71	2.95*
Reactor Operator	8C	7/13	51;71	0.27	0.71*
Head/Blend Operator	6CC	7/13	101;100	1.51	<0.11

Table III - 2 (continued)

Occupational Title	Operation	Date	Tube Nos.	Styrene TWA, ppm	Butadiene TWA, ppm
Recovery Operator/Head Oper.	6C	7/13	10;125	4.44	0.59*
Recovery Operator/Maint. Head Oper.	7C	7/13	0;9	1.05	0.24*
Coag. Operator	6C	7/13	98;44	1.28	<0.12
Coag. Operator	6CC	7/13	79;141	3.65	0.16*
Dryer Operator	6CC	7/13	102;109	2.57	<0.11
Coag. Operator	6D	7/13	65;43	0.41	<0.11
Tank Farm Operator	Outside	7/13	99;121	0.24	0.99*
Coag. Operator	6C	7/13	90;104	1.22	<0.11
Head Operator	6C Process	7/13	3;108	0.53	<0.11
Tank Farm Operator	Outside	7/13	12;120	3.35	0.94*
Reactor Operator/Reactor Head Oper.	8D	7/13	124;122	0.45	3.79*
Reactor Operator/Main Oper.	8C, 8CC	7/14	130;147	0.31	1.08*
Recovery Operator/Maint. Head Oper.	7C	7/14	177;153	0.34	<0.12
Reactor Operator/Head Oper.	8C	7/14	152;128	0.23	0.38*
Head Operator	7C	7/14	131;127	1.33	0.52*
Maintenance Operator	7D	7/14	137;185	0.82	1.30*
Tank Farm Operator/Main. Head Oper.	Tank Farm	7/14	72;115	0.20	1.86*
Head Operator	Tank Farm	7/14	18;180	0.27	1.25*
"A" Operator	Tank Farm	7/14	183;146	1.06	0.92*
"A" Operator	7D	7/14	155;172	0.68	0.29*
Head Operator	7D	7/14	187;95	1.05	0.61*
"A" Operator	8D	7/14	181;16	0.22	1.79*
Operator Helper/G-H Line Helper	6C	7/15	196;54	0.61	<0.32

Table III - 2 (continued)

Occupational Title	Operation	Date	Tube Nos.	Styrene TWA, ppm	Butadiene TWA, ppm
Baler/Dryer Operator	6D	7/15	1;160	0.16	<0.10
Blend Operator	6C	7/15	304;166	1.58	<0.12
Utility/Coag. Op.	6CC	7/15	154;310	2.19	<0.12
Lab Foreman	Sample Lab	7/15	139;303	0.30	2.45*
Compounder		7/15	178;307	0.22	1.95*
Finished Prod. Chem.	Testing	7/15	173;311	0.22	0.36*
Shift Tester	Carbon Black	7/15	193;309	0.14	1.00*
Shift Tester	Lab A	7/15	167;117	0.33	4.82*
Tester/Tester in Training	Sample Lab	7/15	159;301	0.44	1.23*
Compounder		7/15	169;156	0.10	1.40
Head Operator	6CC	7/15	118;302	1.79	<0.13
Head Operator	6C	7/15	191;200	1.41	<0.12

* In one or both charcoal tubes, butadiene was present in the B section above one-third the level of that found in the A section of the same tube.

Table III - 3

INDIVIDUAL PERSONAL SAMPLE RESULTS

Occupational Title	Date	Tube No.	Time On	Time Off	Vol., ℓ	Styrene conc., ppm	Butadiene A conc., ppm	Butadiene B conc., ppm
Head Recovery Operator	4/11	84 A&B	15:57	21:55	8.27	<0.28	1.09	BLD
Head Recovery Operator	4/11	77 A&B	15:57	21:55	9.76	<0.24	<0.46	---
Recovery Operator	4/11	107 A&B	15:54	21:56	8.60	<0.27	<0.53	---
Recovery Operator	4/11	66 A&B	15:54	21:58	8.75	<0.27	1.03	---
Head Reactor Operator	4/11	70 A&B	15:44	21:50	9.06	<0.26	<0.50	---
Head Reactor Operator	4/11	73 A&B	15:49	21:53	9.74	0.48	69.61	BLD
Transfer Pump House Head	4/11	104 A&B	16:55	22:22	7.77	<0.30	25.02	BLD
Transfer Pump House	4/11	108 A&B	16:58	22:21	7.72	<0.30	<0.29	---
Head Coag Operator	4/11	137 A&B	16:11	22:05	8.85	0.26	<0.51	---
Coag Operator	4/11	75 A&B	16:06	22:03	9.62	0.05	<0.47	---
Coag Operator	4/11	71 A&B	16:07	22:01	7.50	<0.31	<0.30	---
Bailer Operator	4/11	133 A&B	16:45	22:09	8.27	<0.28	<0.55	---
Bailer Operator	4/11	82 A&B	16:34	22:09	8.10	<0.29	<0.56	BLD
Relief Operator	4/11	68 A&B	16:32	22:07	7.23	<0.32	<0.63	---
Operator Helper	4/11	61 A&B	16:27	22:11	7.58	<0.31	<0.60	---
Operator Helper	4/11	64 A&B	16:21	22:08	8.58	<0.27	<0.53	---
Operator Helper	4/11	63 A&B	16:32	21:59	7.51	<0.31	1.81	---
Foreman	4/11	106 A&B	16:17	22:15	7.76	<0.30	1.16	---
Head Operator	4/11	79 A&B	16:21	22:05	8.48	0.55	<0.53	---
Lift Truck Driver	4/11	67 A&B	16:38	22:12	8.36	<0.28	0.54	---
Bailer Operator	4/11	62 A&B	16:16	21:59	7.77	<0.30	<0.58	BLD

Table III - 3 (Cont.)

INDIVIDUAL PERSONAL SAMPLE RESULTS

Occupational Title	Date	Tube No.	Time On	Time Off	Vol., ℓ	Styrene conc., ppm	Butadiene A conc., ppm	Butadiene B conc., ppm
Recovery Operator	4/12	15 A&B	8:09	14:38	9.47	<0.25	<0.48	---
Head Recovery Operator	4/12	25 A&B	8:06	14:57	9.12	0.52	33.21	BLD
Head Reactor Operator	4/12	86 A&B	7:59	14:39	10.80	<0.22	7.12	BLD
Head Coag Operator	4/12	134 A&B	8:23	14:31	8.77	2.14	<0.52	---
Coag Operator	4/12	18 A&B	8:17	14:31	9.52	0.49	0.48	---
Coag Operator	4/12	17 A&B	8:20	14:28	8.98	0.52	0.50	---
Coag Operator	4/12	13 A&B	8:18	14:28	8.74	0.54	0.52	---
Laborer	4/12	138 A&B	7:52	15:32	11.82	7.55	1.15	BLD
Laborer	4/12	120 A&B	8:06	15:36	11.44	1.03	<0.40	---
Laborer	4/12	118 A&B	7:35	15:30	11.29	6.86	3.60	BLD
Laborer	4/12	115 A&B	8:08	15:34	10.85	12:33	0.83	---
Laborer	4/12	90 A&B	7:32	15:39	11.28	0.42	5.61	---
Laborer	4/12	88 A&B	8:13	15:35	13.36	0.35	<0.34	---
Laborer	4/12	85 A&B	7:50	15:38	11.24	0.84	<0.40	---
Laborer	4/12	81 A&B	7:43	15:37	12.67	7.41	<0.36	---
Laborer	4/12	54 A&B	7:58	15:14	10.55	<0.22	0.43	---
Laborer	4/12	53 A&B	7:40	15:40	11.55	0.61	8.22	BLD
Laborer	4/12	49 A&B	8:05	15:36	11.43	<0.21	<0.40	---
Laborer	4/12	30 A&B	8:12	15:17	9.29	9.86	0.49	---
Laborer	4/12	28 A&B	7:54	14:50	9.43	2.99	2.88	BLD

Table III - 3 (Cont.)

INDIVIDUAL PERSONAL SAMPLE RESULTS

Occupational Title	Date	Tube No.	Time On	Time Off	Vol., ℓ	Styrene conc., ppm	Butadiene A conc., ppm	Butadiene B conc., ppm
Drier Operator	4/12	74 A&B	8:25	14:31	3.74	<0.63	<1.21	---
Hood Tank Farm Operator	4/12	29 A&B	9:03	14:50	8.84	<0.27	0.51	---
Tank Farm Operator	4/12	27 A&B	9:05	14:52	8.56	<0.27	<0.53	---
Maintenance	4/12	78 A&B	7:45	14:25	8.88	<0.26	<0.25	---
Maintenance	4/12	69 A&B	7:38	14:24	11.43	<0.21	<0.20	---
Maintenance	4/12	16 A&B	7:37	14:23	9.75	<0.24	<0.23	---
Maintenance	4/12	14 A&B	7:42	14:24	7.13	<0.33	0.63	---
Janitor	4/12	116 A&B	7:36	15:15	11.06	<0.21	<0.41	---
Laborer	4/13	114 A&B	11:49	14:50	4.76	<0.49	<0.95	---
Laborer	4/13	111 A&B	7:51	14:56	10.09	<0.23	<0.45	---
Laborer	4/13	26 A&B	7:48	14:52	10.23	<0.23	0.44	---
Laborer	4/13	10 A&B	7:49	14:56	10.79	<0.23	0.84	---
Mechanic	4/13	147 A&B	7:31	14:54	10.91	<0.22	<0.41	---
Mechanic	4/13	60 A&B	7:45	14:55	10.09	<0.23	<0.45	---
Mechanic	4/13	57 A&B	7:21	15:17	11.66	<0.20	<0.39	---
Mechanic	4/13	56 A&B	7:40	15:03	9.77	<0.24	0.46	---
Mechanic	4/13	44 A&B	7:44	14:57	10.74	<0.22	<0.42	---
Mechanic	4/13	42 A	7:32	14:57	11.69	<0.20	0.39	---
Mechanic	4/13	40 A&B	7:39	14:59	10.59	<0.22	0.43	---
Mechanic	4/13	39 A&B	7:29	15:26	11.61	0.81	44.38	BLD

Table III - 3 (Cont.)

INDIVIDUAL PERSONAL SAMPLE RESULTS

Occupational Title	Date	Tube No.	Time On	Time Off	Vol., ℓ	Styrene conc., ppm	Butadiene A conc., ppm	Butadiene B conc., ppm
Mechanic	4/13	12 A&B	7:38	14:58	13.79	<0.17	0.66	---
Mechanic	4/13	9 A&B	7:35	15:28	8.07	<0.29	<0.56	---
Mechanic	4/13	8 A&B	7:42	15:12	10.88	0.41	1.25	BLD
Mechanic	4/13	7 A&B	7:37	15:07	13.25	<0.18	0.34	---
Machinist	4/13	38 A&B	7:40	15:22	9.76	<0.24	0.46	---
Welder	4/13	110 A&B	7:54	15:06	10.57	<0.23	<0.42	---
Pipefitter	4/13	37 A&B	7:35	14:58	10.06	<0.23	0.90*	0.90*
Pipefitter	4/13	11 A&B	7:31	15:16	10.86	<0.22	0.42	---
Pipefitter	4/13	45 A&B	7:22	14:58	11.59	<0.20	1.17*	1.95*
Pipefitter	4/13	43 A&B	7:37	15:13	10.90	<0.22	<0.21	---
Pipefitter	4/13	55 A&B	7:25	15:14	11.08	0.20	1.52	---
Pipefitter	4/13	59 A&B	7:33	15:25	12.70	<0.18	<0.36	---
Pipefitter	4/13	146 A&B	7:32	15:16	5.20	<0.45	<0.87	---
Pipefitter	4/13	148 A&B	7:28	15:15	11.10	<0.21	<0.41	---
Head Recovery Operator	4/14	112 A&B	9:21	14:58	6.88	1.02	9.86	BLD
Recovery Operator	4/14	123 A&B	9:18	15:02	5.83	0.80	2.33	BLD
Charge Operator	4/14	2 A&B	9:13	15:06	8.25	<0.28	1.10	---
Head Reactor Operator	4/14	151 A&B	9:15	15:05	8.47	<0.28	<0.53	---
Instrument Man	4/14	200 A&B	7:26	15:02	11.57	0.41	1.56	BLD
Instrument Man	4/14	196 A&B	7:24	15:05	9.76	1.44	174.14*	101.89*
Instrument	4/14	180 A&B	7:20	15:07	13.02	<0.18	<0.35	---
Lab Analyst	4/14	145 A&B	8:08	14:54	9.70	0.24	<0.47	---

Table III - 3 (Cont.)

INDIVIDUAL PERSONAL SAMPLE RESULTS

Occupational Title	Date	Tube No.	Time On	Time Off	Vol., ℓ	Styrene conc., ppm	Butadiene A conc., ppm	Butadiene B conc., ppm
Lab Analyst	4/14	6 A&B	8:02	14:53	10.17	0.46	1.33	BLD
Lab Analyst	4/14	191 A&B	8:04	14:56	8.77	0.54	<0.52	---
Lab Analyst	4/14	122 A&B	7:55	14:52	9.74	0.96	0.46	---
Lab Technician	4/14	172 A&B	8:22	14:53	9.02	2.86	84.69	BLD
Lab Technician	4/14	155 A&B	7:56	14:54	10.36	0.91	2.18	BLD
Lab Technician	4/14	126 A&B	7:43	15:17	10.10	<0.23	<0.45	---
Lab Technician	4/14	124 A&B	7:47	15:16	10.97	<0.21	32.96	BLD
Lab Technician	4/14	113 A&B	8:11	11:53	5.26	<0.45	<0.86	---
Lab Technician	4/14	5 A&B	7:45	15:14	13.32	<0.18	0.34	---
Lab Technician	4/14	4 A&B	8:00	14:51	11.27	0.62	0.80	---
Lab Technician	4/14	1 A&B	8:24	14:52	13.14	2.14	144.55	BLD
Electrician	4/14	194 A&B	7:30	15:04	11.92	<0.20	<0.38	---
Electrician	4/14	125 A&B	7:38	15:01	1.12	<2.10	<4.04	---
Electrician	4/14	158 A&B	7:35	15:10	12.43	<0.19	<0.36	---
Electrician	4/14	182 A&B	7:32	15:11	11.02	<0.21	<0.41	---
Electrician	4/14	183 A&B	7:33	15:11	11.45	<0.20	<0.39	---
Carpenter	4/14	171 A&B	7:37	15:09	10.83	<0.22	<0.42	---
Carpenter	4/14	164 A&B	7:24	15:08	11.05	<0.21	<0.41	---
Carpenter	4/14	160 A&B	7:32	15:10	11.35	<0.21	<0.40	---
Carpenter	4/14	153 A&B	7:36	15:08	10.93	<0.21	30.60	---

BLD - Below Limit of Detection

---(dash line) - Tube was not analyzed

* Butadiene in B tube above one-third level found in A tube.

Table III - 4

ANALYSIS OF HIGH FLOW AREA SAMPLES (~200 cc/min)

Area	Sample No.	Extraneous Chemical Component Other Than Styrene and Butadiene
Drier #7	102	4-Vinylcyclohex-1-ene (Butadiene Dimer) (5)* Ethyl Benzene (4)* Methanes (20)*
Blend Tank #6	184	4-Vinylcyclohex-1-ene (10)* Ethyl Benzene (10)* 4-Isopropyl-1-Methylcyclohexane (Isomers of Methane) (20)*
Drier #5	97	4-Vinylcyclohex-1-ene (10)* Ethyl Benzene (10)* Methanes (25)*
Coag Tank #6	174	Similar to #97
Drier #6	98	Similar to #97
Control Lab	121	Toluene (130)*
Brine House	193	Toluene (110)*
Reactor 8A	181	Methanes (95)*
Tank Farm	99	Nothing Unusual
	51	Nothing, Pump Not Running

* Estimates on the concentrations for the components has been made based on normalizing the presence of styrene to 100 counts in each sample. Therefore, estimated amounts cannot be correlated from sample to sample.

Table III - 5

TOTAL PARTICULATE SAMPLE RESULTS
OMYA BSH - PLANT A

Job Title	Operation	Time On	Time Off	Filter No.	Flow Rate ℓpm	Date	Filter Loading, mg	Vol., Liters	Dust Conc. Mg/m^3
Helper Operator	6D Process	9:21	2:41	1954	1.55	7-14-76	0.305	496.0	0.62
Helper	Process	9:28	2:45	1951	1.7	7-14-76	1.363	538.9	2.53
I Bale Duster	Process	9:30	2:46	1881	1.65	7-14-76	0.587	521.4	1.13
C Baler Operator	Process	9:22	2:39	1992	1.6	7-14-76	0.365	507.2	0.72

Table III - 6

TOTAL PARTICULATE SAMPLE RESULTS
CARBON BLACK - PLANT B

Job Title	Operation	Time On	Time Off	Filter No.	Flow Rate ℓpm	Date	Filter Loading, mg	Vol., Liters	Dust Conc. Mg/m3
Operator	Carbon Black	9:45a	2:46p	2163	1.7	4-14-77	.129	511.7	.252
Maint. Mech.	Carbon Black	9:47a	2:48p	2196	2.0	4-14-77	.304	602.0	.505