ENVIRONMENTAL/INDUSTRIAL HYGIENE SURVEYS OF VINYL CHLORIDE MONOMER MANUFACTURING OPERATIONS AND OPERATIONS WHERE POLYVINYL CHLORIDE AND COPOLYMERS OF POLYVINYL CHLORIDE ARE PROCESSED

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Worker exposures to vinyl-chloride (75014) (VC) were surveyed at three VC manufacturing and seven polyvinyl-chloride (PVC) processing facilities (SIC-2821). Breathing zone and area air samples were taken in various areas within each facility, and were analyzed by flame ionization gas chromatography. VC concentrations in the three manufacturing companies ranged from 0.01 to 5.89, 0.01 to 84.77, and 0.02 to 21.8 parts per million (ppm), respectively. Personal exposures in excess of the 1.0ppm standard occurred for the laboratory technicians, operators and loaders at two manufacturing facilities, and for the loaders, operators, chromatography operators, and shift supervisors at the third facility. No detectable VC concentrations were found at six of the seven PVC facilities. At the seventh facility, VC concentrations ranged from 0.02 to 2.44ppm. The blender operators, driver-baggers, and banbury operators were exposed to excessive VC concentrations. The authors conclude that excessive VC exposure exists at several of the facilities surveyed. They recommend use of respirators and protective clothing, installation of devices to detect excessive VC concentrations in the work areas and use of positive air pressure in laboratories and eating and smoking rooms.

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SUMMARY

An in-depth survey of three vinyl chloride manufacturing and seven polyvinyl chloride processing plants was performed by the Bendix Launch Support Division Special Projects Group using the procedures set forth in the NIOSH Vinyl Chloride report, P&CAM #127[1] to determine the quantity of vinyl chloride existing in the breathing zone of each employee tested in the surveys. Area samples were also collected in a number of locations.

All of the samples were analyzed using a dual-column flame ionization gas chromatograph with chart-type recorder. Personal air sampling pumps set to operate at a flow rate of 50 milliliters per minute were used to collect all of the charcoal samples.

The companies selected for the in-depth surveys were chosen on the basis of a preliminary survey of six vinyl chloride manufacturing companies and 12 polyvinyl chloride processing companies. (See Table 1, Polyvinyl Chloride Processing Company Preliminary Survey List following.) In the preliminary survey, 10-second air samples were collected in a variety of work areas.

The information used in selecting the three vinyl chloride manufacturing plants for the in-depth surveys were:

- A general description of the vinyl chloride monomer processing operations.
- Eight-hour daily time-weighted average exposures (TWA's) of vinyl chloride for each different job type/job operation in the monomer processing area, including a specific job description for each of the job types.

[1]Organic Solvents in Air. National Institute for Occupational Safety and Health. P&CAM 127. May 1974. 11 p.

TABLE 1

POLYVINYL CHLORIDE PROCESSING COMPANY PRELIMINARY SURVEY LIST

Company	Bonding	Calendering	Compounding	Extruding	Fibers	Foams	Molding	Plastisols	Thermoforming
1.			X	X					
2.			X		X			X	
3. (Plant E)	X		X	X			X		
4.	X	X	X	X					
5.			X	X			X		
6. (Plant I)		X	X						X
7. (Plant J)	X	X	X	X	X	X		X	X
8. (Plant F)			X				X	X	
9.		X	X	X					
10. (Plant H)	X	X	X	X	X	X		X	X
11.					X			X	X
12. (Plant D)	X		X	X	X		X		
13. (Plant G)*			X	X		X	X		
Total	5	5	12	9	5	3	5	5	4

*This plant was selected for the in-depth survey after the preliminary survey was completed.

- General area (stationary) samples of vinyl chloride in areas of suspected high concentrations.
- Raw material and product lists and quantities thereof that relate to the past and present vinyl chloride levels.
- Ventilation design and ventilation measurements, including documentation of dates of ventilation changes and the extent of changes and how they relate to past and present vinyl chloride levels.
- Work practices that have been instituted to lower vinyl chloride levels.
- Photographs, sketches, etc. to document existing conditions.
- Documentation of past and present industrial hygiene practices, including utilization of protective clothing (i.e., type, frequency of change, laundering practices, etc.); protective devices (i.e., respirator-usage, frequency type, etc.); housekeeping practices; shower requirements; eating, smoking, and drinking practices in production areas, etc.

The information used in selecting the polyvinyl chloride plants for the in-depth surveys were:

- A survey of the following operations in at least three different plants: compounding, extruding, molding, calendering, thermoforming, bonding, foams, fibers, and plastisol processing.
- Information gained from preliminary site visits.
- Information gained from literature searches.
- Information gained from personal contacts.
- Representativeness of the operations to industry-wide processing.
- Operations having the greatest potential for worker exposures to vinyl chloride.

- Operations having the greatest gradient of worker exposures to vinyl chloride.
- Availability of historical inplant air measurements of vinyl chloride.
- The operations having the longest history of polymer processing.
- A general description of the processes in each plant.
- Eight-hour daily TWA's of vinyl chloride for each different job classification, including a description of each job classification.
- Area samples taken in areas of suspected high concentrations.
- A raw material and product list that relates to past and present vinyl chloride levels.
- Ventilation data.
- Changes made to the ventilation systems.
- Relation of changes to vinyl chloride levels.
- Work practices instituted to lower vinyl chloride levels.
- Photographs, sketches, etc. to document existing conditions.
- Documentation of past and present industrial hygiene practices, including utilization of protective clothing (i.e., type, frequency of change, laundering practices, etc.); protective devices (i.e., respirator-usage, frequency type, etc.); housekeeping practices; shower requirements; eating, smoking, and drinking practices in production areas, etc.

The results of the surveys indicate that vinyl chloride concentration levels found in Plant A range from <.01 to 5.89 parts per million (ppm). Job classifications in Plant A where vinyl chloride concentrations above the permissible 0.5 ppm action level and 1 ppm TWA were detected are: Laboratory Technicians (0.4 to 4.36 ppm), Operators (0.13 to 2.45 ppm), and Loaders (0.17 to 1.89 ppm). Area samples ranged from 0.56 to 5.89 ppm.

Laboratory personnel wore cartridge-type respirators during sample handling operations. Loaders wore air line breathing respirators during transfer and loading operations. No tank car loading operations were performed during the survey. All personnel are supplied with respiratory protection devices.

Vinyl chloride concentration levels in Plant B ranged from 0.01 to 84.77 ppm. Job classifications in Plant B where vinyl chloride concentrations above the permissible action level and TWA were detected are: Loaders (3.00 to 84.77 ppm), Operators (0.01 to 3.46 ppm), and Laboratory Technicians (.03 to 0.88 ppm). Area samples ranged from 0.09 to 1.22 ppm in the loading area to 0.05 to 0.38 ppm in the manufacturing areas. Laboratory personnel wore cartridge-type respirators during sample handling operations. Loaders wore air line breathing respirators during transfer and loading operations. No loading operations were performed during the survey. All personnel are supplied with respiratory protection devices.

Vinyl chloride concentration levels in Plant C ranged from 0.02 to 21.8 ppm. Job classifications in Plant C where vinyl chloride concentrations above the permissible action level and TWA were detected are: Loaders (0.06 to 21.8 ppm), Operators (0.08 to 18.2 ppm), Gas Chromatograph Operators (0.02 to 1.01 ppm), and Shift Supervisors (0.25 to 0.55 ppm). Area samples ranged from 0.59 to 7.06 ppm in the manufacturing areas. Laboratory personnel wore cartridge-type respirators during sample handling operations. Loaders wore air line breathing respirators during transfer and loading operations. Tank car loadings were performed during the survey. All personnel are supplied with respiratory protection devices. Hose line respirators were worn by the operators during the time they were exposed to the higher-than-permissible concentrations of vinyl chloride.

No vinyl chloride concentration levels above the permissible action level were detected in polyvinyl chloride processing plants D, E, F, G, H, and J. The only polyvinyl chloride processing plant where vinyl chloride levels were above the permissible action level and TWA was Plant I where levels ranging from 0.02 to 2.44 ppm were detected. Job classifications in Plant I where levels above the permissible action levels were detected are: Blender Operators (0.46 to 0.69 ppm), Banbury Operators (0.37 to 0.60 ppm), and a Driver-Bagger (0.02 to 0.76 ppm). Levels above the permissible TWA were detected on one day of the survey and ranged from 0.13 to 2.44 ppm.

Plant I is the only plant contacted during the survey that has an on-site polyvinyl chloride resin plant. It has two on-site resin plants which undoubtedly account for the high vinyl chloride concentration levels that appear in the survey analysis data. On the day that levels above the permissible TWA were detected, a rupture disc failed in one of the resin plant reactors. This allowed vinyl chloride fumes to vent to the atmosphere and the fumes were pulled into the adjacent processing plant via the ventilation system.

Respirator devices are available for personnel working in the polyvinyl chloride processing plants; however, due to the low levels of vinyl chloride normally found in these plants, they are seldom used. Dust-type respirators are worn during dusty compound preparation operations.

Eating in the vinyl chloride and polyvinyl chloride manufacturing plants is restricted to enclosed, air-conditioned rooms. Smoking is allowed in specified areas or in enclosed air-conditioned rooms.

The following conclusions were reached during the in-depth surveys performed at three vinyl chloride manufacturing plants and seven polyvinyl chloride processing plants.

- Despite sincere efforts on the part of all companies contacted to reduce the level of vinyl chloride to which their employees are exposed, vinyl chloride concentrations above the OSHA-prescribed 1-ppm TWA and 5-ppm, 15-minute ceiling still exist in some vinyl chloride manufacturing, storage, and loading areas.
- Loading personnel must wear respirators and protective clothing designed to handle the high concentrations of vinyl chloride that occur during vinyl chloride transfer and loading operations.
- Instruments that detect the presence of vinyl chloride in the work areas are necessary to prevent personnel from being unaware of exposure to vinyl chloride.
- All personnel working in vinyl chloride plants must be supplied with and trained in the use of respirator devices that are designed to handle the concentrations of vinyl chloride that can occur in the work area.
- Personnel handling vinyl chloride should wear gloves and disposable or washable outer garments in addition to a suitable respirator.
- All of the vinyl chloride manufacturing plants contacted for the vinyl chloride survey produced vinyl chloride in outdoor facilities. The enclosed control rooms, laboratories, and eating and smoking rooms should be maintained under positive pressure with the air free from chemical contaminants to prevent these areas from being contaminated by outside air.
- There have been many recent changes made in equipment seals and designs, improved ventilation, revised operating procedures, and improved industrial hygiene and safety practices. These changes

for improvement, plus the use of closed-loop sampling and loading systems have had and will continue to have considerable effect in reducing the concentration of vinyl chloride in vinyl chloride manufacturing plants. See Description of Vinyl Chloride Monomer Plants Surveyed (Plants A, B, and C).

- The reduction of entrained vinyl chloride in the polyvinyl chloride resins and compounds used by the polyvinyl chloride processing industry has reduced the exposure of the workers in this industry below the OSHA-prescribed action level of 0.5 ppm.

INTRODUCTION

Information that has been made available to the National Institute for Occupational Safety and Health (NIOSH) indicates that a serious health problem potentially exists in workers involved with the polymerization of vinyl chloride to polyvinyl chloride. Preliminary mortality information concerning vinyl chloride polymerization plants has revealed there is a definite excess of deaths due to angiosarcoma of the liver in workers that have been involved with this processing.

Deaths attributed to angiosarcomas of the liver for workers that have been exposed to vinyl chloride either in the manufacture of the monomer, the polymerization of the monomer into polyvinyl chloride, or the processing of the polymerized vinyl chloride into polyvinyl chloride products have been reported from Canada, Czechoslovakia, France, Italy, Norway, Rumania, Sweden, West Germany, and the United States. Based on the above, vinyl chloride has been shown to be an etiologic agent in the deaths of the above-mentioned workers.

Due to the large work force involved in the manufacture of vinyl chloride, polyvinyl chloride resins and compounds, and the conversion of the resins and/or compounds into finished goods, NIOSH immediately initiated an extensive epidemiological investigation (including environmental surveys) into operations and the workers involved in them where the exposure to vinyl chloride and polyvinyl chloride is known to exist.

The purpose of this contract was to document <u>past</u> and <u>present</u> worker exposures to vinyl chloride during (1) the monomer production and (2) the processing of polyvinyl chloride and polyvinyl chloride copolymers. In addition to documenting worker exposures to vinyl chloride, information on

work practices, environmental control procedures, and industrial hygiene practices was also documented. These data will be utilized to ascertain the extent of worker exposures to vinyl chloride and possibly other liver toxins so that the possible health effects impact in the industry can be determined, and appropriate priorities for corrective measures can be set.

GENERAL REMARKS

During the time period that the in-depth survey of the vinyl chloride manufacturing companies and the polyvinyl chloride processing companies was performed, the plastics industry, and large segments of other industries in the United States, were in an economic slump. In general, the companies surveyed were operating at 20 to 50 percent of their normal production rate. For this reason, the concentrations of vinyl chloride detected in the various locations sampled during the survey may well have been lower than normal. Also, a considerably lower number of employees were available to take part in the sampling program.

DESCRIPTION OF VINYL CHLORIDE MANUFACTURING PROCESSES

At the present time, vinyl chloride is manufactured in the United States using three basic processes: (1) acetylene-hydrogen chloride process, (2) oxyhydrochlorination process, and (3) ethylene dichloride pyrolysis process.

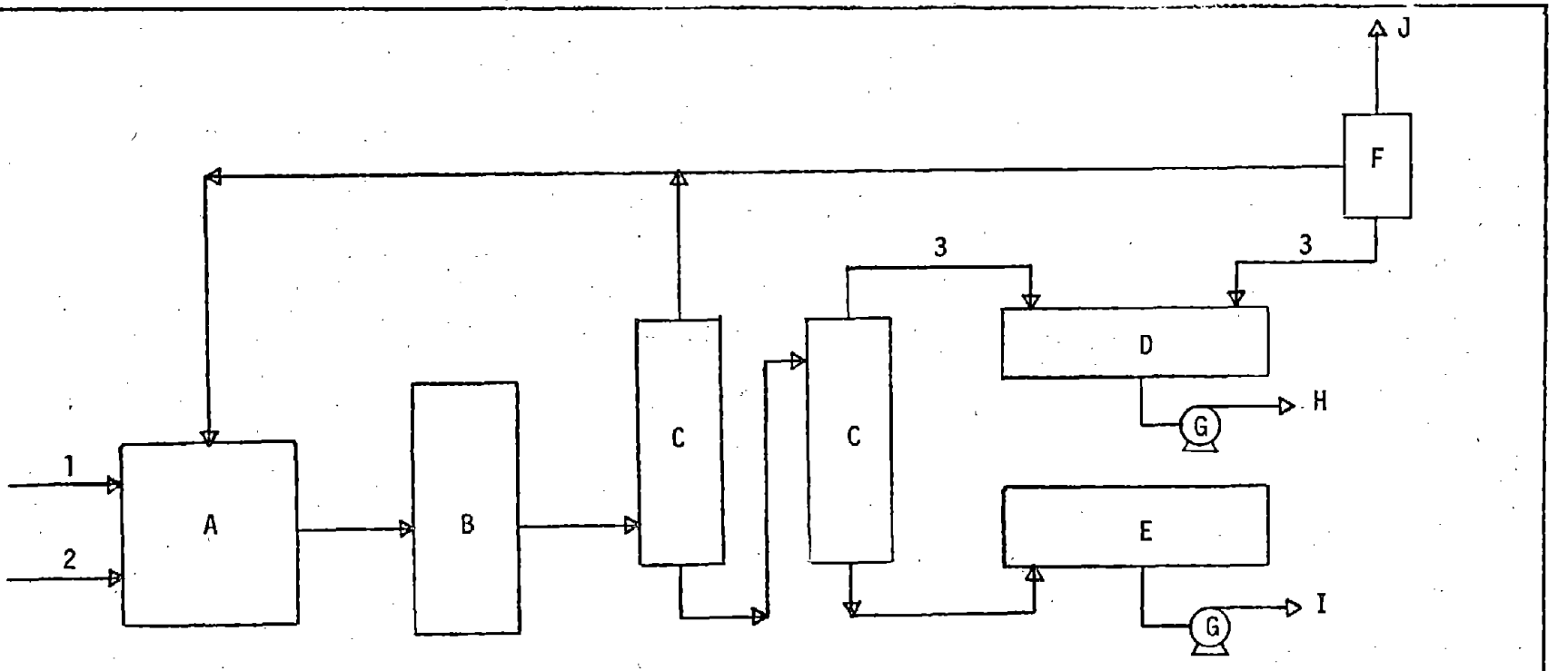
Acetylene-Hydrogen Chloride Process

$$C_2H_2 + HCl \longrightarrow CH_2CHCl$$

Dry acetylene and anhydrous hydrogen chloride are reacted in fixed-bed reactors containing mercuric-chloride-impregnated carbon catalyst. The reaction products are compressed, cooled, and passed to a refrigeration unit for separation of vinyl chloride by condensation. The condensed vinyl chloride is then passed to a two-column purification train. Low-boiling products are removed overhead in the first column and recycled to the fixed-bed reactor along with noncondensed vapors from the first column feed drum. A portion of the recycle is passed to a vent reactor where additional reaction occurs. The vent reactor products are returned to the distillation train; the inerts are vented to the atmosphere.

The partially purified vinyl chloride is passed to the second column where the high-boiling compounds are removed and passed to an incinerator for disposal. The purified vinyl chloride removed from the second column is first transferred to holding tanks where purity is checked, and then to storage spheres. Tank cars are loaded with vinyl chloride from the storage spheres for shipment to vinyl chloride polymerization plants.

A flow schematic of this process is shown in Figure 1.



Legend:
A - Reactor
B - Compressor & Cooler
C - Fractionation Train
D - Vinyl Chloride Storage Tank
E - Heavy Ends Storage Tank
F - Vent Reactor
G - Pumps
H - Tank Cars
I - Incinerator
J - Atmosphere
1 - Hydrogen Chloride
2 - Acetylene
3 - Vinyl Chloride

Figure 1. Acetylene-Hydrogen Chloride Process

Ethylene Dichloride Pyrolysis Process

$$C_2H_4 + Cl \longrightarrow ClCH_2CH_2Cl$$

$$ClCH_2CH_2Cl \longrightarrow CH_2CHCl + HCl$$

Wet ethylene dichloride produced by the direct chlorination of ethylene is passed through a drying column for removal of water, combined with recycle ethylene dichloride, and sent through a purification train for removal of heavy ends. The purified ethylene dichloride is vaporized in a vaporizer and fed into a cracking furnace. The reactants from the cracking furnace are cooled and partially condensed in a quench system. The condensate is fed to an ethylene dichloride recovery column where ethylene dichloride is removed from the bottom of the column, passed to a light ends column for removal of light ends, and recycled to the purification train. Overhead vapors from the ethylene dichloride recovery column are combined with quench system vapors, compressed, and fed to a hydrogen chloride recovery column. Pure hydrogen chloride is removed overhead, transferred to other on-site plants, and used in other processes. The bottoms from the hydrogen chloride recovery column is passed to a fractionating column where purified vinyl chloride is removed overhead and sent to storage spheres.

A flow schematic for this process is shown in Figure 2.

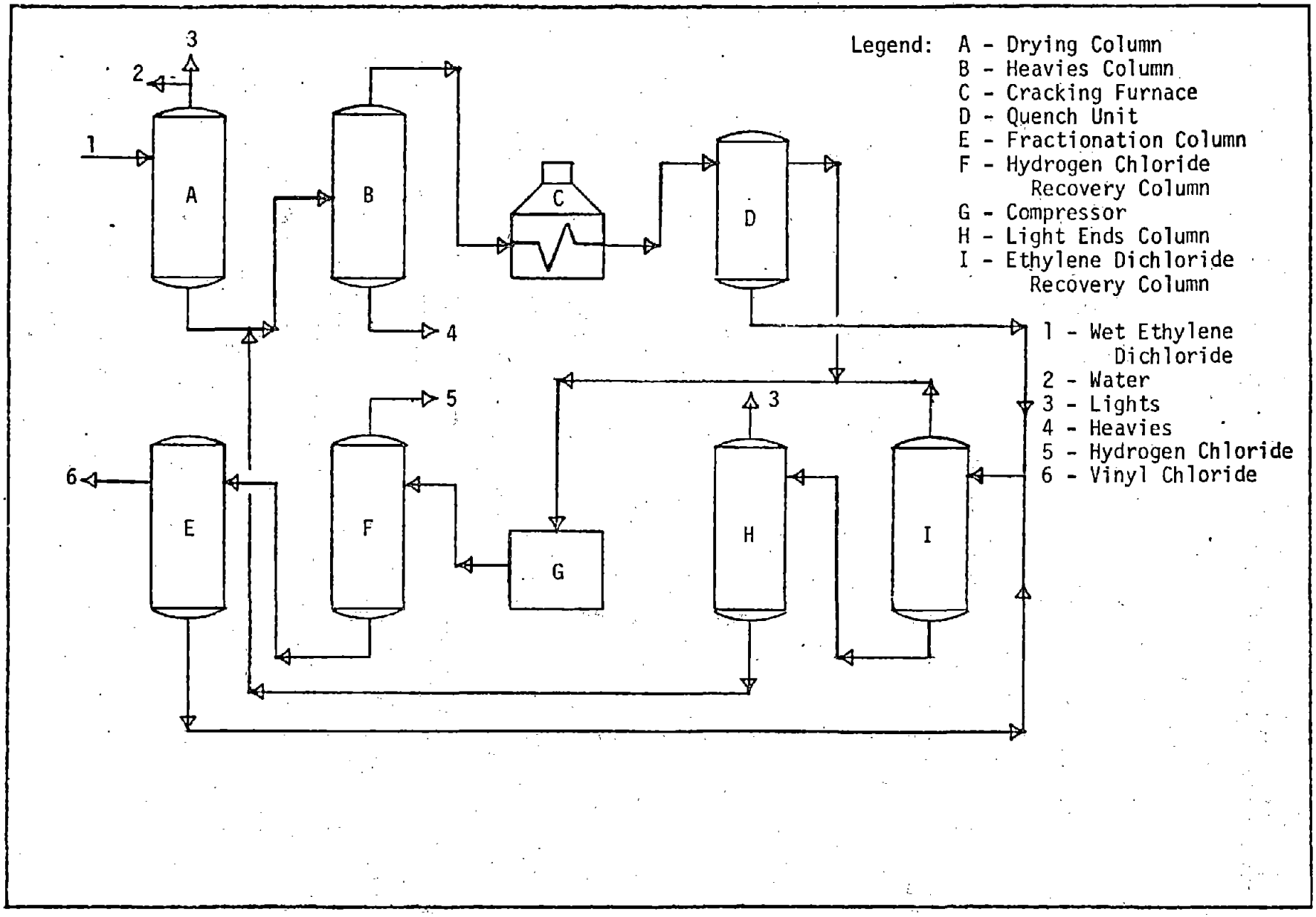


Figure 2. Ethylene Dichloride Pyrolysis Process

Oxyhydrochlorination Process

$$C_2H_4 + Cl_2 \longrightarrow ClCH_2CH_2Cl$$

$$ClCH_2CH_2Cl \longrightarrow CH_2CHCl + HCl$$

$$C_2H_4 + 2HCl + 1/2\ O_2 \longrightarrow ClCH_2CH_2Cl$$

Ethylene dichloride produced by reacting chlorine and ethylene is pyrolyzed to form vinyl chloride and hydrogen chloride. The hydrogen chloride is separated from the reaction products and reacted with ethylene and air (oxygen) to produce ethylene dichloride and water. The ethylene dichloride produced by this reaction is dried and pyrolyzed to form vinyl chloride and hydrogen chloride.

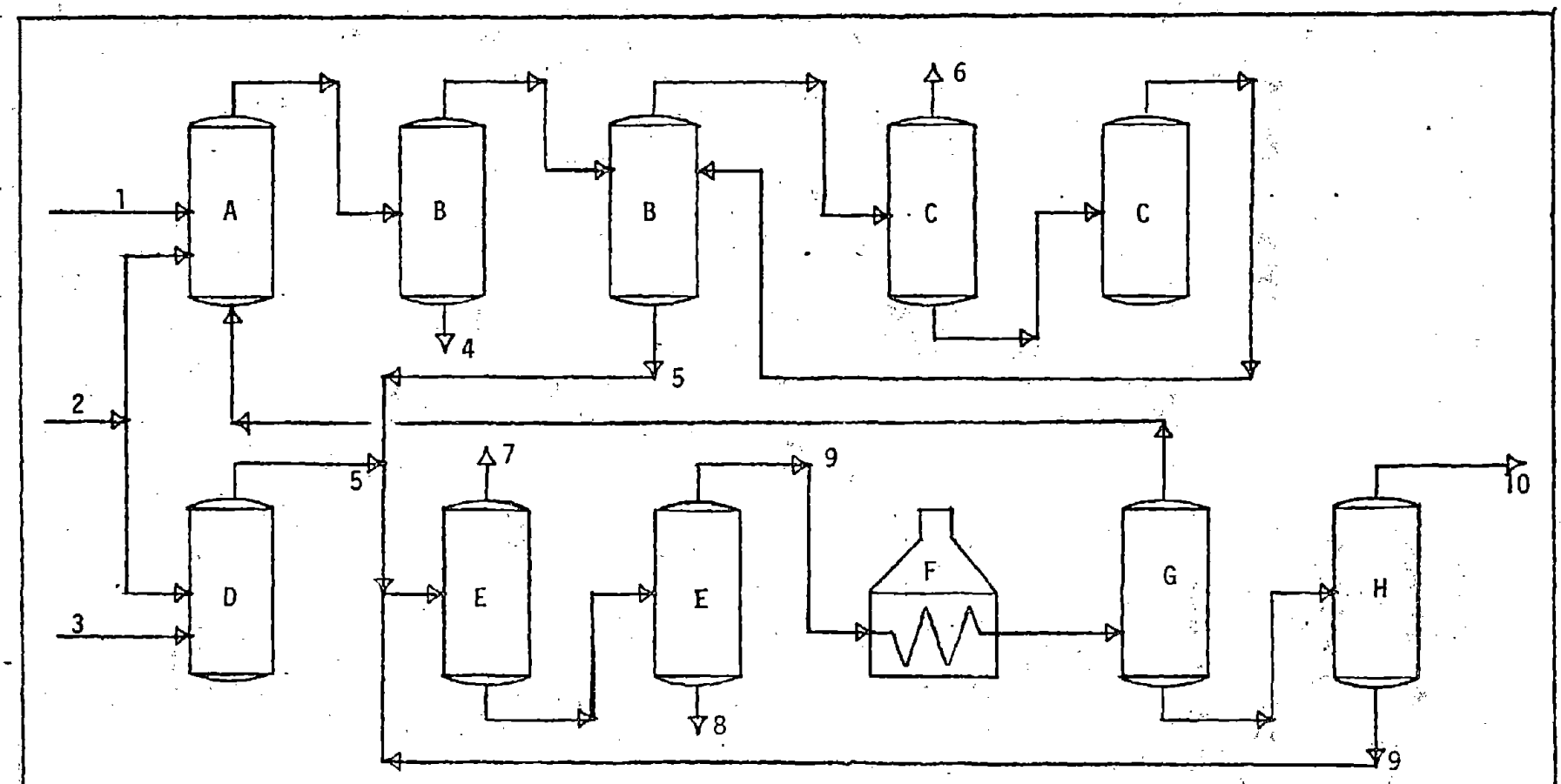
Ethylene and chlorine are reacted in a water-cooled direct chlorination reactor to produce crude ethylene dichloride. The crude ethylene dichloride is sent through an ethylene dichloride purification train where light ends are removed overhead in the first column and heavy ends from the bottom of the second column. Purified ethylene dichloride removed overhead from the second column is sent through an ethylene dichloride cracking furnace.

The reaction products from the cracking furnace are passed to a hydrogen chloride column where crude vinyl chloride is removed as bottoms and sent to a vinyl chloride purification column. Pure vinyl chloride is recovered from the top of the vinyl chloride column and transferred to a storage area where it is stored in large spheres. The bottoms from the vinyl chloride column are recycled to the ethylene dichloride purification train.

Pure hydrogen chloride coproduct from the top of the hydrogen chloride column is sent to the oxyhydrochlorination reactor where it is reacted with ethylene and air to produce ethylene dichloride and water. The reaction products are sent through an oxyhydrochlorination primary recovery unit where

the water is removed as bottoms and sent to waste. The overheads are passed to a second column where crude ethylene dichloride is removed as bottoms and cycled to the ethylene dichloride purification train. The overheads are passed to a secondary oxyhydrochlorination recovery unit. Vent gas is removed overhead in the first column, and the bottoms are sent to a second column. The overheads from the second column are recycled to the second column of the oxyhydrochlorination primary recovery unit. Pure vinyl chloride is transferred to tank cars for shipment to vinyl chloride polymerization plants.

A flow schematic for this process is shown in Figure 3.



Legend:

A - OHCL Reactor
B - OHCL Primary Recovery
C - OHCL Secondary Recovery
D - Direct Chlorination Reactor
E - EDC Purification
F - EDC Cracking Furnace
G - HCL Column
H - VCL Column

1 - Air
2 - Ethylene
3 - Chlorine
4 - Waste Water
5 - Crude EDC
6 - Vent Gas
7 - Lights
8 - Heavies
9 - Recycle EDC
10 - Vinyl Chloride

Figure 3. Oxyhydrochlorination Process

DESCRIPTION OF POLYVINYL CHLORIDE MANUFACTURING PROCESSES

Compounding

Compounding is the mixing of polyvinyl chloride resin with other materials, i.e., plasticizers, stabilizers, pigments, toners, fillers, lubricants, blowing agents, anti-oxidants, fungicides, santicizers, and modifiers to manufacture specific polyvinyl chloride products.

Compounding is generally accomplished in blenders, Banbury's, two-roll mills, and mixers. Combinations of the above equipment can be employed in a single compounding operation. Blenders are primarily used to make dry compounds. Mixers are normally used to make fluid-type compounds such as plastisols. Compounds containing solids are masticated using Banbury's, mixers, or two-roll mills.

Extrusion

Extrusion can be used to remove solids from plastic-type compounds, to deaerate and compact compound, and to generate sufficient pressure to force the material through an extrusion die. The extrusion can be in the form of a rope that is fed to a calender, or a long length of material having a uniform cross section. Examples of extruded items are hoses, pipes, rods, threads, pellets, and shapes of intricate cross section. Extrusions can be rigid or flexible.

Molding

Molding can be divided into a number of types, i.e., injection molding, blow molding, vacu-forming, and embossing. The equipment used for each type of molding is entirely different in design and operation.

Injection molding is accomplished by forcing a plastic or fluid-like compound into the cavity of a heated mold. The end product assumes the configuration of the mold cavity and can be solid, hollow, rigid, or flexible.

Blow molding begins with the injection of a predetermined amount of plastic compound into the cavity of a mold. Air is then injected into the center of the injection and expands the plastic compound until it reaches the wall of the cavity. Sufficient air pressure is used to make the injected compound assume the configuration of the mold. The mold is heated and sets the design of the molded item. Blow-molded products can be rigid, semi-rigid, or flexible. Examples are plastic containers, wheels for toys, and basketballs.

Vacu-forming is accomplished by laying a sheet of preheated film on top of a mold. The air between the film and the mold is removed by a vacuum pump, and the atmospheric pressure above the sheet forces the hot film against the mold. The cold mold sets the mold design in the film. Vacuum-formed items can be semi-rigid or flexible.

Embossing is the imprinting of a design into a sheet of plastic and is normally accomplished by feeding a plastic sheet through a set of rolls. One of the rolls contains the configuration that is to be imprinted into the plastic sheet. The other roll provides the pressure required to form the design in the plastic sheet. An example of embossing is the imprinting of a leather grain into plastic sheet stock.

Calendering

Calendering is generally accomplished using three- or four-roll calenders. The calender most often used in the plastics industry is the four-roll "F" form calender. This type of calender has a stack of three rolls in a vertical plane and two top rolls in a horizontal plane. In using this type of calender, a ribbon, cord, or belt of fluxed plastic is fed evenly across the "V" between the two top rolls of the calender to permit gravity feed of the stock to the calender. An adjustable gap between the calender rolls produces a continuous

sheet of plastic having uniform thickness and longitudinal physical properties across the width of the sheet. The calender rolls also impart a smooth finish to both sides of the sheet as it passes through the rolls. A smaller-diameter roll strips the sheet of plastic from the last calender roll and passes the sheet through a series of tensioning and cooling rolls. The cooled sheet is edge-trimmed and then fed to the windup rolls where the sheet is wound under uniform tension into rolls of desired diameter.

Thermoforming

Thermoforming is the forming of various shapes in thermoplastic sheets through the application of heat and pressure, and employs molds or forming blocks to shape the plastic. Seven basic types of thermoforming are recognized by the plastics industry. Each type uses various modifications of the molds, forming blocks, clamping devices, frames, and pressures to form the desired end product. The seven types are: straight vacuum forming, drape vacuum forming, male form forced above sheet, vacuum snap-back forming, plug and ring forming, air pressure forming, and matched metal mold forming. Thermoformed products are finding usage in the packaging, automotive, furniture, toy, and garment industries.

Bonding of Polyvinyl Chloride

Bonding is the joining of two or more pieces of polyvinyl chloride through the use of adhesives, or the application of heat with or without pressure. Thermoplastic sheets and films can be joined by heat sealing. Rigid thermoplastic materials such as laminate sheet, rod, and tubing can be joined by adhesives or by hot gas welding.

Polyvinyl chloride adhesives contain solvents such as tetrahydrofuran to produce tight, quick, and rapid assembly of components. Heat sealing can be

accomplished through the use of one or two metal items containing electrical heating elements, oven heat, or high-frequency or electronic heating. Hot gas welding employs a gas or electrically heated gun and polyvinyl chloride welding rod to join the materials. This type of weld is similar in appearance to metal welds.

Foams

Polyvinyl chloride foam formulations have a fluid or semifluid consistency and contain a blowing agent that produces a cellular structure in the finished item. In the case of sheet material, the formulation is spread onto paper or fabric and then passed through one or two ovens to expand and cure the sheeting. Normally, where paper is used as a backing material, the paper backing is stripped from the foamed sheet after leaving the first tunnel-type oven. The foamed sheet can then be joined to a second sheet to make a sandwich-type sheet stock that is sealed and final-cured in a second tunnel oven. Multi-layer sheet stock can be manufactured by joining a foam-coated fabric to a second vinyl sheet after the foam-coated fabric leaves the first tunnel oven. Sealing of the two layers and final curing of the foam composite takes place in the second tunnel oven.

Heated molds can be dipped into a plastisol formulation containing a blowing agent. A thick coating of the plastisol mixture adheres to and partially cures on the mold. The coated mold is withdrawn from the dip and is placed in an oven for the final cure and blowing operation.

Now, plastisol-type polyvinyl chloride compounds can be added to rubber-type compounds and a blowing agent to produce a compound that is processed on a Banbury and a two-roll mill. The milled stock can be further processed in a tube-type extruder. The extruded stock can be cut into desired shapes and expanded and cured in a series of two ovens, or the tubular stock can be expanded and cured in a tunnel-type oven.

Fibers

Polyvinyl chloride compounds can be extruded through a die containing a number of small round or rectangular openings to produce a round or rectangular cross-section thread. The thread is passed through a cold water bath, dried, and wound onto spools. Fibers or webs of fibers can be pressed into or layered onto a sheet of hot polyvinyl chloride in a calender to produce a sheet stock containing fibers or a web of fibers imbedded in the sheet. Polyvinyl chloride sheeting prepared in this manner has superior strength and resists tearing and stretching.

Plastisols

Plastisol formulations are of fluid or semifluid composition. Preheated molds are dipped into the mixture, causing a thick layer to coat and partially cure on the mold. The mold is then withdrawn and placed in an oven for final cure of the compound. After oven curing, the plastisol-coated mold is removed from the oven, and the formed item is stripped from the mold using air pressure. The mold is then dipped in or sprayed with a release agent and returned to the preheat oven. The operation can be performed by hand or by automated units.

Plastisol coatings can also be applied to a fabric in a uniform layer and then passed through an oven where the coated stock undergoes partial curing. The coated stock is final-cured in a hot platen press. The platens can be plain or configured, and any design on the platen will be reproduced in reverse on the surface of the finished stock.

DESCRIPTION OF VINYL CHLORIDE MONOMER PLANTS SURVEYED

Plant A

This facility manufactures vinyl chloride using the Acetylene-Hydrogen Chloride Process portrayed in Figure 4. The plant normally operates at 10 percent of capacity and when acetylene, manufactured at the plant, is available for the manufacture of vinyl chloride. Nearly all of the acetylene manufactured at this site is sold as product to nearby chemical plants. The vinyl chloride plant was in operation during the survey.

The vinyl chloride plant has been in operation for 12 years and employs 25 people. A total of 375 people are employed at the facility which manufactures acetylene, methanol, ammonia, and vinyl chloride as major products, and vinyl acetylene, diacetylene, methyl acetylene, dimethyl ether, and 2-chloropropene as byproducts. Liquid air and liquid nitrogen are also manufactured at the facility.

A vinyl chloride surveillance program was established at this company in April 1974. The manufacturing areas are monitored at various points using a Miran Infrared Scanner with chart readout, and a Century Organic Vapor Analyzer. Air samples are collected in mylar sampling bags on a regular basis. The air samples are analyzed for vinyl chloride concentration using gas chromatography.

The results of the company's sampling program show a hi-lo TWA concentration range of <.01 to 67 parts per million (ppm) of vinyl chloride.

Except for the control laboratory and control room, all operations are performed outdoors. The control laboratory and control room are air conditioned with one air change per minute.

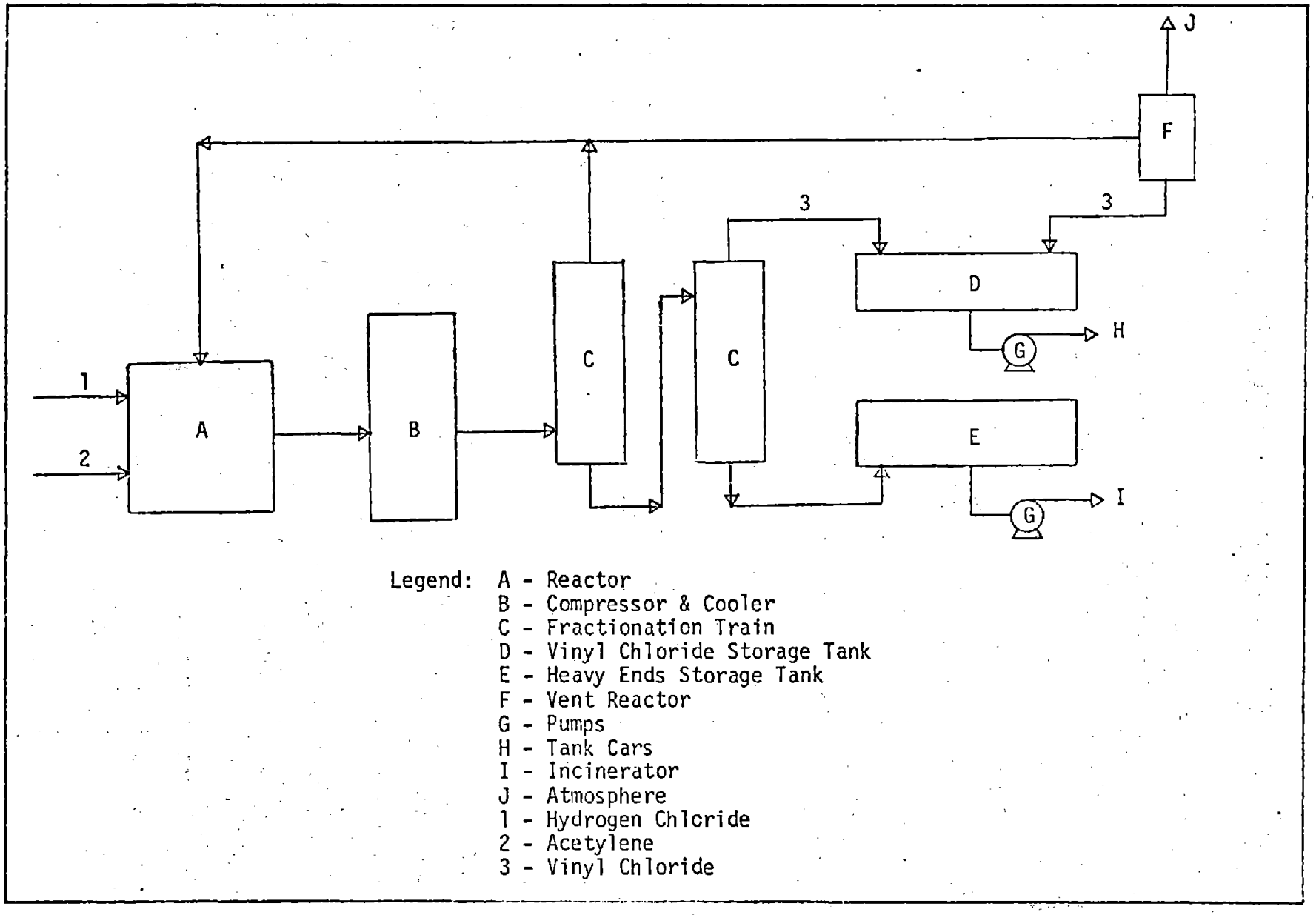


Figure 4. Flow Schematic, Plant A

The following changes have been made to their industrial hygiene program.

All employees are required to wear air-supplied respirators when vinyl chloride monomer is expected to be over 50 ppm.

Signs are posted whenever area monitoring indicates high vinyl chloride monomer is in the air.

Additional purging time is required on all vessels which handle vinyl chloride monomer prior to being opened.

High priority has been placed on work designed to eliminate vinyl chloride monomer leaks.

Gas masks and slicker suits are worn in accordance with current OSHA regulations.

Job descriptions for employees who potentially come into contact with vinyl chloride monomer are as follows:

Operators

Operators control the equipment vessels required to produce vinyl chloride monomer from acetylene and hydrogen chloride. The equipment operated includes reactors, heat exchangers, pumps, compressors, fractionating towers, and attendant instrumentation. They perform these duties in an open plant or an air-conditioned control room building on a 24-hour-day, 7-day-week manning schedule. They spend approximately 60 percent of their time in the processing area, and 40 percent of their time in the control room area. They oversee the equipment and specify when maintenance is required. They prepare the equipment for maintenance.

Shift Supervisors

Shift supervisors control the equipment and vessels required to produce vinyl chloride monomer from acetylene and hydrogen chloride. The equipment

operated includes reactors, heat exchangers, pumps, compressors, fractionating towers, and attendant instrumentation. They perform these duties outdoors or in an air-conditioned control room building on a 24-hour-day, 7-day-week manning schedule. They spend approximately 40 percent of their time in the processing area, and 60 percent of their time in the control room area. They oversee the equipment, and specify when maintenance is required. They prepare the equipment for maintenance, and issue work requests and the necessary permits.

Maintenance

Employees assigned to maintenance make necessary repairs to the equipment found in the vinyl chloride monomer plant. In addition, they do painting and insulating, and change catalyst. When working on equipment which has been in the vinyl chloride monomer service, they are required to obtain appropriate permits from the Shift Supervisor stating that the equipment is safe to work on.

Laboratory Technicians

Laboratory technicians obtain samples of gases and liquids in the vinyl chloride monomer unit. They perform gas chromatograph and reaction tests on these samples either in the unit or in the laboratory. When analyses are made on vinyl chloride monomer, the analyses are made under the hood.

Loaders

Loaders receive, prepare, load, and sample vinyl chloride monomer tank cars. When handling vinyl chloride monomer, they are required to wear a respirator.

Plant B

This facility produces vinyl chloride using the Ethylene Dichloride Pyrolysis Process. The vinyl chloride plant has been operating for 16 years and operates on a continuous basis. Vinyl chloride produced at the plant is sold as a product and is also used on site for the manufacture of polyvinyl chloride resin and 1,1,1-trichloroethane.

A total of 2,500 people are employed at the facility; however, only 100 people are involved in the manufacture of vinyl chloride. Other products produced at this facility are tetraethyl lead, tetramethyl lead, sodium, sodium hydroxide, methyl chloride, ethyl chloride, ethylene dichloride, trichloroethylene, and perchloroethylene.

The vinyl chloride plant and storage areas are located outside with the exception of the control room, which is air conditioned, and the quality control laboratory. The laboratory is equipped with a supply air blower and exhaust air system via the hoods. The laboratory air is changed every 1.4 minutes.

A flow diagram of the process that this company uses to manufacture vinyl chloride is portrayed in Figure 5.

A surveillance program for vinyl chloride was put into effect in April 1974. In this program, a Miran II Infrared Analyzer is used to monitor the plant air for vinyl chloride-in-air on a continuous basis, and portable Century Organic Vapor Analyzers are used for searching out emission sources or wherever "spot" monitoring is desired. The charcoal tube method is used to obtain 15-minute spot samples and 4-hour personnel samples on a regular basis. Gas chromatography is used to determine the concentration of vinyl chloride picked up in the charcoal tubes.

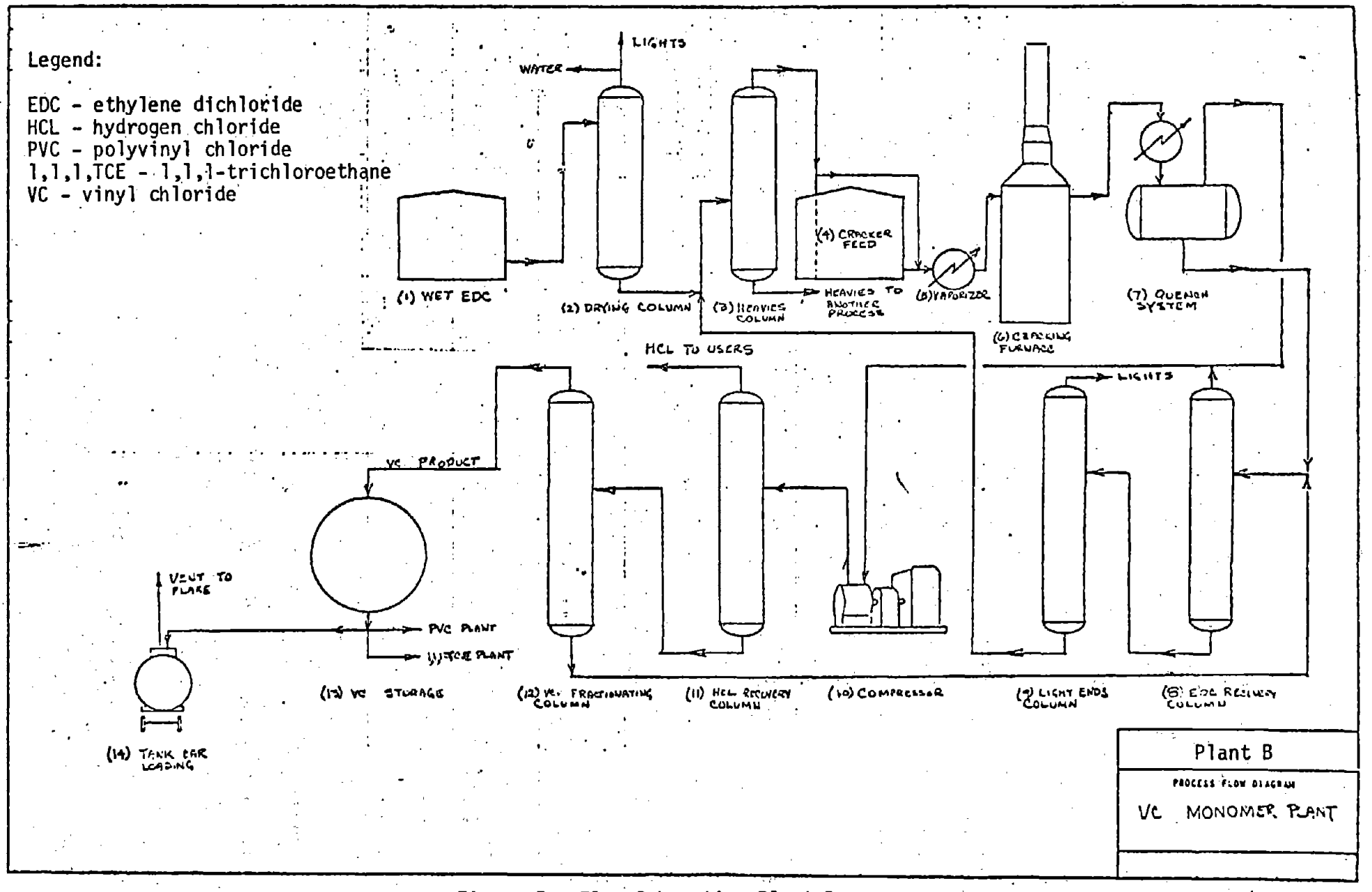


Figure 5. Flow Schematic, Plant B

The results of this company's sampling program show a hi-lo vinyl chloride concentration range of <.01 to 62 ppm.

The following work practice changes have been instituted to protect their employees.

During loading, vinyl chloride monomer tank car spew gauges were previously vented to atmosphere. The spew gauge vent system is now closed with a sensing device to detect liquid, indicating the car is loaded.

After loading, vinyl chloride monomer tank car load and equalizing lines were previously disconnected with residual vent (mostly vapor) allowed to escape to atmosphere. These lines are now purged with nitrogen (to flare) prior to disconnecting.

Vinyl chloride monomer liquid samples were previously taken and disposed of in such a manner that the potential for release of material to the atmosphere was quite high. Closed systems have been provided to permit purging of sample bombs and connections, obtaining of samples, and disposal of residual sample material without exposure of personnel.

The former practice of draining a gage glass to verify the liquid level has been discontinued.

Procedures for preparing equipment for opening have been revised, and extra precautions taken to minimize risk of vinyl chloride monomer release to atmosphere. Example: Vinyl chloride monomer liquid product scrubbers were previously prepared for recharging by displacing liquid (with nitrogen) and venting to flare. Purging to remove residual vapors was minimal at best. The revised procedure calls for thorough purging of the scrubber, utilizing heated inert gas and heating panels on the scrubber shell to ensure negligible release of vinyl chloride monomer to atmosphere when the scrubber is opened.

While respiratory equipment has always been available for use when needed, personal respirators are now issued to all individuals for use whenever the potential for exposure exists.

It is impossible to ascertain the effect of each work practice change separately, but the cumulative effect is favorable as indicated by the result of personnel and area monitoring.

Changes to their industrial hygiene practices are described below.

Prior to the establishment of the 50-ppm interim standard, vinyl chloride monomer was considered as one of a family of chlorinated hydrocarbons produced in the Hydrocarbon Area. There were no special hygiene practices in effect for vinyl chloride monomer. Respiratory equipment was available for use in the event of spills or in doing any job where exposure to excessive amounts of vinyl chloride monomer (other chlorocarbons, hydrogen chloride, chlorine) was likely to occur. The situation today, of course, is quite different. Area monitoring for vinyl chloride monomer-in-air is essentially continuous, using a Miran II Infrared Analyzer. Portable detectors, Century Organic Vapor Analyzers, are used for searching out emission sources or wherever "spot" monitoring is desired. Certain areas have been designated as requiring respiratory protection. All personnel have been issued respirators (and trained in their proper use) and have been instructed to wear them when doing any job, e.g., opening or closing valves, where the potential for exposure to vinyl chloride monomer exists. Supplied air respiratory facilities are being extended to all areas of the vinyl chloride monomer plant.

The Medical Department has instituted a program for routine personnel monitoring utilizing carbon tube adsorption units. A Medical Surveillance

Program for all personnel who may have been exposed to vinyl chloride monomer in the past has been instituted and will be continued as required by the regulations persuant thereto.

On-the-job eating, drinking, and smoking policies have not been revised as these activities are already restricted to designated areas.

This company does not use written job descriptions to outline the responsibilities of their plant personnel.

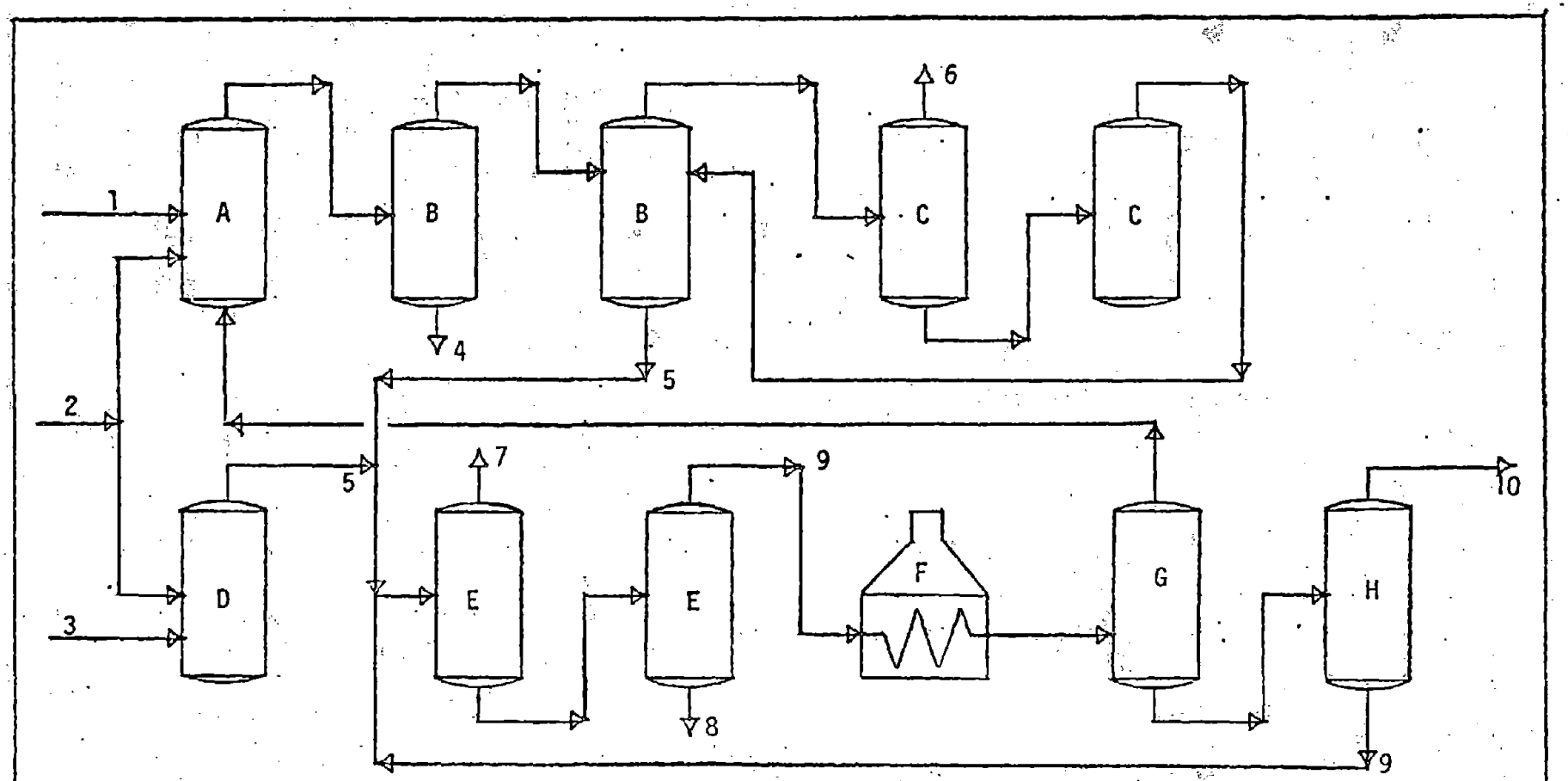
Plant C

The Oxyhydrochlorination Process is employed by this facility to manufacture vinyl chloride from ethylene and chlorine as illustrated in Figure 6. This company is a large producer of vinyl chloride, normally operates on a continuous basis, and has been producing vinyl chloride at this facility for 12 years. A total of 600 people are employed at this facility; however, only 242 employees are exposed to vinyl chloride. Products produced at this facility are ethylene, chlorine, ethylene dichloride, hydrochloric acid, vinyl chloride, trans-1,2-dichloroethylene, benzene, chloral, carbon tetrachloride, chloroform, trichloroethylene, ethyl chloride, and chloropropane. No vinyl chloride resin is produced at this site.

The manufacture of vinyl chloride is a closed-system operation, and all of the production equipment is located outdoors except for the instrument houses, control rooms, laboratory, and offices.

The offices, laboratory, control rooms, and instrument houses are kept under positive pressure. In addition, the equipment in the instrument houses is purged with nitrogen. No vinyl chloride is piped to the control rooms. All vinyl chloride in the laboratory is kept and handled in high-volume ventilation hoods.

All production employees have their own respiratory protection devices. Respiratory protection devices are kept in the control rooms for any maintenance personnel working in the area. All personnel have been trained in the use of the equipment and are required to wear respiratory protection equipment when working in areas or performing specific operations where the exposure to vinyl chloride is higher than, or could be higher than, the permissible OSHA limit. Disposable or washable coveralls are provided for hazardous operations, and gloves are required for personnel performing tasks which could



Legend:

A - OHCL Reactor
B - OHCL Primary Recovery
C - OHCL Secondary Recovery
D - Direct Chlorination Reactor
E - EDC Purification
F - EDC Cracking Furnace
G - HCL Column
H - VCL Column

1 - Air
2 - Ethylene
3 - Chlorine
4 - Waste Water
5 - Crude EDC
6 - Vent Gas
7 - Lights
8 - Heavies
9 - Recycle EDC
10 - Vinyl Chloride

Figure 6. Flow Schematic, Plant C

expose their hands to the chemicals. Shower facilities are provided, and safety showers are available in the vinyl chloride manufacturing areas for emergency use. Smoking and eating are confined to the cafeterias and the control rooms. Good housekeeping is maintained throughout the plant. Loading personnel are required to wear air pressure demand respirators when performing any operation where exposure to vinyl chloride is possible. Breathing air facilities are provided throughout the plant.

Each instrument house contains an infrared analyzer and gas chromatograph to detect concentrations of vinyl chloride and ethylene dichloride in the production areas. The instrument readout equipment is located in the control rooms and is checked out during each shift by the operator. In addition, portable Century Organic Vapor Analyzers are used to check areas where the exposure limits for organic vapors are higher than permissible.

A surveillance program for vinyl chloride was initiated in July 1973, using the charcoal tube method to determine the concentration of vinyl chloride that their personnel were exposed to, and the levels existing in the various work areas. In their surveillance program, 50 percent of all personnel exposed to vinyl chloride are monitored each week for approximately 10 minutes. The charcoal tube samples are analyzed using gas chromatography. In addition, all exposed personnel are given medical examinations meeting the requirements specified in OSHA regulation 29 CFR 1910.93q.

The following average time-weighted average (TWA) exposures to vinyl chloride have been determined using OSHA personnel monitoring techniques since August 1974.

Operator Job Classification	TWA Average
North and South Furnaces	0.3 ppm
North Purification	0.7 ppm
South Purification	0.6 ppm
North and South Spare	0.7 ppm
East Furnace and Purification	5.2 ppm
East Spare	1.7 ppm
East Synthesis	0.2 ppm
Vinyl Chloride Tank Farm	8.5 ppm
Laboratory Operator	0.6 ppm
Instrument Laboratory Operator	Insufficient Data
Maintenance	Insufficient Data

Samples were taken while performing activities which gave the greatest probability of exposure.

Numerous changes have been made to the facility to reduce or eliminate the possible exposure of personnel to vinyl chloride or other suspect agents. A number of these changes are described below.

Major equipment changes that have been made to reduce possible exposure to vinyl chloride monomer are:

A vinyl chloride monomer vapor collection and recovery system has been installed in the tank farm. Essentially, this consists of a compressor and condensing system. The recovered vinyl chloride monomer is transferred to off-specification storage.

A vinyl chloride monomer emergency collection and flare system has been installed for the process areas. In case of a vinyl chloride monomer release from a relief valve or vent, the vinyl chloride monomer is piped to a flare.

The caustic scrubbers have the greatest potential for exposing people to vinyl chloride monomer. A vinyl chloride monomer stripper system was installed to remove hydrogen chloride from vinyl chloride monomer and return the hydrogen chloride to the manufacturing unit without exposing people to organic vapors.

A system has been installed to supply respirators with breathing air from conveniently located stations throughout the plant.

A continuous monitoring system has been installed in the North ethylene dichloride unit. By means of a chromatograph, the atmosphere at ten different points in the unit is regularly analyzed for a number of chlorinated organics including vinyl chloride monomer and ethylene dichloride.

Additional valves have been put on vinyl chloride monomer tank car loading hoses to almost eliminate exposure due to venting the vinyl chloride monomer vented from the hoses at the end of the loading cycle.

The caustic scrubber blowdown has been piped to a blowdown knockout tank which eliminates exposure by venting the vinyl chloride monomer to flare.

The North and South hydrogen chloride columns have been re-trayed to extend periods between opening for cleaning.

Changes in operating and maintenance practices and procedures which have reduced possible exposure to vinyl chloride monomer are:

Shift monitoring of the plant areas by the operators for hydrocarbons and chlorinated hydrocarbons has been initiated. This is the single most important change as it gave impetus to the leak detection program and brought the operators and Maintenance full awareness of the vinyl chloride monomer levels in the plant.

Elimination of vinyl chloride monomer leaks and escapes was given the number one priority for maintenance and production.

Vessel atmospheres for employee entry have been improved. Longer and more effective "boil-outs" are now used and air movers are used to clear residual vapors from vessels requiring personnel entry. The Century Organic Vapor Analyzer (OVA) is also used to determine the level of residual organic vapor in the vessel. Since the OVA is sensitive to any organic vapor, the actual vinyl chloride level would be much lower than the OVA reading. The following guidelines are used for determining the degree of respiratory protection required for vessel entry:

Organic Vapor Level	Respiratory Protection Required
Above 50 ppm	Air-Fed Respirator
Between 25 and 50 ppm	Cartridge Mask
Below 25 ppm	No Protection

All vessels are being better prepared for entry and consequently they have shown levels no higher than the general atmosphere outside the vessel during personnel entry. It has not been necessary to use respiratory protection for personnel entry.

Respiratory protection procedures have been improved. A self-imposed policy of requiring cartridge masks for potential exposures to vinyl chloride in the range of 25 to 50 ppm has been instituted. Above 50 ppm, a continuous-flow air-line respirator or self-contained breathing apparatus is used. The plant's respiratory protection program conforms to Federal Register Code 1910.134.

The following general guidelines are being used to determine where, when, and what type of respiratory protection is required:

Any job which releases vinyl chloride to the atmosphere, and all work done on the domes of the tank cars will require air-line respirators.

Any task to be performed downwind or inside the sphere of contaminated

air of a known vinyl chloride leak will always require an air-line respirator.

Cartridge masks will be worn for only those equipment jobs where the vinyl chloride is less than 2 percent by volume of the stream or equipment contents, and where the wind movement is such that an employee can stay upwind and outside of the sphere of contamination by the released gas.

Casual observers or supervisors in the vicinity of any of the above operations will be required to wear the same respiratory protection as the person assigned to the job.

Air-line respirator usage in the vinyl chloride monomer tank farm has been made more convenient by providing a connection at each of the loading stations. Short hoses are easily moved from station to station.

The operators in the areas handling vinyl chloride use the OVA once each shift to monitor designated locations within their areas. Leaks are noted and corrected by the operator where possible. Otherwise the foreman is notified so Maintenance can immediately correct the leak.

The Safety Department is using the OVA to thoroughly monitor the production areas at least once a week. Readings are tabulated for each area, and if leaks are noted, they are referred to the area foreman for correction.

Most equipment containing vinyl chloride is being depressured to the flare stack, to other equipment, or to remote vents to prevent employee exposure.

The purge lines from the process analyzer instruments have been hooked to a common header which is exhausted in a remote area that prevents personnel exposure. Vinyl chloride monomer in the instrument houses has thus been eliminated. The operator area OVA readings taken each shift quickly detect leaks that have been developed. The process analyzer group then uses the OVA to pinpoint the leak for correction.

The laboratory "wet testing" hood has been updated to give higher volume ventilation and conform to the requirements for handling hazardous materials. Tests have shown no vapors are escaping from the hood.

Collected vinyl chloride monomer samples are no longer permitted to be stored in the process area control rooms. Outside storage is now required.

Employees performing tasks where it is possible to contact liquid vinyl chloride monomer are now being required to wear gloves impervious to vinyl chloride monomer.

In shutting down hydrogen chloride and vinyl chloride monomer columns, quench towers, etc., extra steps are taken to strip out the vinyl chloride monomer.

When the topping column is down, the overhead of the lights columns is collected by keeping the condensers very cold. In the past, this vapor was vented to the atmosphere.

These changes are examples of the greater effort that is made today to ensure that the people in this plant are not exposed to vinyl chloride monomer. These extra efforts by the Company, all of them costly in time or raw materials, have impressed plant personnel, salary and wage, how seriously plant management regards the vinyl chloride monomer problem. Their reaction has been most favorable to the plant's goals of very low exposure. Indeed, this attitude of cooperation and team spirit has been one of the major factors in the success to date.

Exposure reduction projects that are in process are:

- Vinyl chloride monomer process equipment drainage system.
- Vinyl chloride monomer tank car gauging system.
- Vinyl chloride monomer process enclosed sample system.
- Vinyl chloride monomer flare instrumentation.

- Re-traying of East hydrogen chloride column.
- Permanent air monitoring systems in all three cracking units.
- Corrosion-resistant vinyl chloride monomer stripper condenser.
- A method has been devised and tried which will eliminate employee potential exposure on much of the vinyl chloride monomer sampling. Hardware has been ordered to convert many sample points to closed sampling.
- A closed system for liquid blowdown from sodium hydroxide scrubbers is over 50 percent complete.
- A system is being worked out which will permit purging tank car loading lines to the flare before they are disconnected.
- A continuous analyzer for detecting water in vinyl chloride will eliminate the need for many samples now taken by operators.
- An additional large caustic scrubber to eliminate the need for small scrubbers is planned. This will permit all caustic scrubber operators to be handled in one area, and not only reduce the number of employees potentially exposed, but additionally will make controlling emissions much more feasible.
- A program to eliminate pump seal leakage is under way. A full investigation of ethylene dichloride-vinyl chloride pumps has been completed, and specific programs have been started which promise reduced pump seal failures.
- Quotations are being evaluated on providing a corrosion-resistant stripper condenser which will increase uptime and thus reduce exposure due to scrubber operation and stripper repair.
- A sampling method is being sought which will eliminate purging vinyl chloride into the atmosphere during tank car sampling

operations. One device has failed to be an improvement, but others will be tried.

- Reboiler venting system.
- Topping column revisions.
- Larger reboilers.
- Better level indicators and purges.
- Pump seal revisions.

This list is not all inclusive but is indicative of the planning and efforts going into further improvements.

The following job descriptions apply to the personnel that are directly involved in the manufacture of vinyl chloride in this plant.

Tank Farm Operator

Receive empty tank cars, prepare them for loading, load vinyl chloride monomer tank cars, set valves in tank farm to direct flow of vinyl chloride monomer to and from various spheres, set valves in tank farm to pump in and out of ethylene dichloride tanks, pump vinyl chloride monomer by pipeline.

East Furnace Operator

Crack ethylene dichloride to hydrogen chloride and vinyl chloride monomer, purify vinyl chloride monomer, and pump to the tank farm; send hydrogen chloride to the Oxyhydrochlorination reactor.

East Synthesis Operator

Receive hydrogen chloride from cracking and Catoxid and react the hydrogen chloride in the Oxyhydrochlorination reactor, run catalytic oxidation of byproducts to hydrogen chloride, recover ethylene dichloride from Oxyhydrochlorination reaction, pump crude ethylene dichloride to North Synthesis for purification.

East Spare Operator

Help East Synthesis and Furnace Operators.

North-South Furnace Operator

Crack ethylene dichloride to vinyl chloride monomer and hydrogen chloride, send products to North or South purification trains.

North Cracking Operator

Purify vinyl chloride monomer-hydrogen chloride stream from North furnaces, send hydrogen chloride to Oxyhydrochlorination reactor, send vinyl chloride monomer to tank farm, recycle recovered ethylene dichloride, send byproducts to storage.

North-South Spare Operator

Help other North and South operators.

Laboratory Operator

Perform routine testing for process control and product approval using classical methods - pH meters, titration, weighing, viscosimeters, etc.

Instrument Laboratory

Perform routine testing for process control and product approval using gas chromatographs and other analytical instruments.

Table 2 shows a list of job classifications for the vinyl chloride monomer processing personnel contacted during the survey, and the range of vinyl chloride in ppm that the personnel were exposed to during the survey.

TABLE 2

VINYL CHLORIDE CONCENTRATION RANGE
FOR PLANTS A, B, AND C

Areas or Job Classifications	A (ppm)	B (ppm)	C (ppm)	High-Low Range (ppm)
Loaders	.17-1.89	3.00-84.77	.06-21.8	.06-84.77
Operators (Plant)	.13-2.45	.01-3.46	.08-18.2	.01-18.2
Area (Plant)	.56-5.89	.05-.38	.59-7.06	.05-7.06
Lab Technicians	.04-4.36	.03-.88	.07-.11	.03-4.36
Area (Loading)	<.01-.01	.09-1.22		<.01-1.22
Chromatographers		.02-.12	.02-.27	.02-1.01
Shift Supervisors	.03-.21		.25-.55	.03-.55
Pipe Fitters		.01-.33	.16-.41	.01-.41
Instrument Men	.02-.25			.02-.25

Plant D

This facility processes polyvinyl chloride resins and compounds into numerous extruded, molded, and bonded items and yarn. The company has been fabricating polyvinyl chloride products for 25 years. The present facility was started up in August 1971.

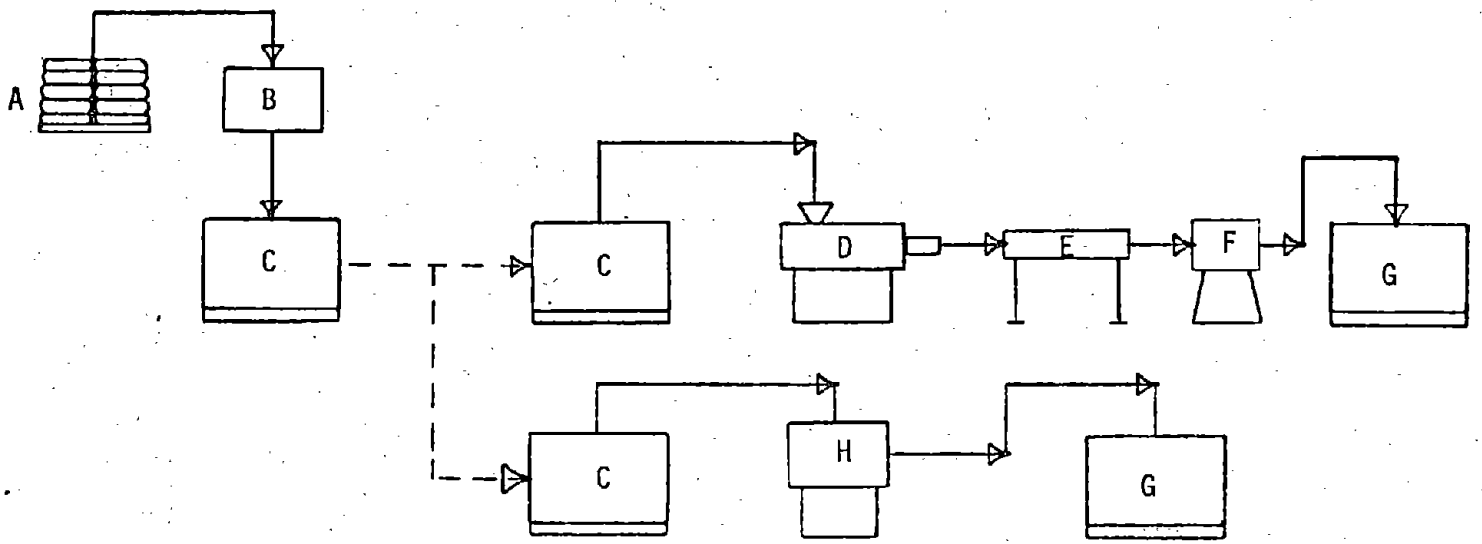
The company normally employs 150 people and operates 24 hours a day on a 5-day-week basis. All manufacturing operations are performed indoors in a modern, well-designed and -laid out plant. Approximately 50 people are involved in the manufacture of polyvinyl products. The manufacturing processes employed in the manufacture of polyvinyl products at this plant are: bonding, in the lamination of extruded polyvinyl chloride with plated mylar, or printed polyvinyl chloride film to make automotive or decorative trim; compounding, in the mixing of polyvinyl chloride resin with plasticizers, fillers, lubricants, stabilizer, pigments, and other materials to produce a dry-blend compound; extrusion, in the conversion of dry-blend or pelletized compounds into continuous plastic strips of a predetermined cross section; fibers, in the extrusion of pelletized compounds into spools of colored yarns used for the manufacture of woven products; and molding, by the injection of polyvinyl chloride compounds into a heated mold to produce items having a definite size, shape, and color. Compounding at this plant is accomplished in ribbon-type blenders, and conversion of the dry-blend or pelletized compounds into a plastic mass takes place in the extruders and injection molders. No basic changes have been made to their polyvinyl chloride fabrication operations.

Ventilation in the plant is provided by 16 roof-mounted exhaust fans with a total rating of 50,000 cubic feet per minute at 1/2-inch static pressure which provide an air change once every 30 to 35 minutes. The adjoining offices are air conditioned.

Overall housekeeping is very good and the equipment has been installed in a well-planned, uncrowded manner. An enclosed, air-conditioned cafeteria area has been provided for breaks and lunches. Smoking is restricted to special areas. Special clothing is not required.

The company does not have a vinyl chloride surveillance program; however, the plant has been surveyed for vinyl chloride concentrations by an insurance company. The company uses bulletin boards and meetings to keep their employees informed on health and safety programs.

Figure 7 shows a flow schematic of the processes used by Plant D to manufacture polyvinyl chloride products.



Legend:
A - Bagged Materials
B - Blender
C - Storage Container
D - Extruder
E - Cooling Bath
F - Cut-Off Machine
G - Shipping Container
H - Injection Molder

Plant D

Figure 7. Flow Schematic, Plant D

Plant E

This facility processes polyvinyl chloride resins into a wide variety of extruded and injection-molded products. The company has 21 years of experience in the manufacture of polyvinyl products.

The company normally employs 260 people and all of the employees are considered to be exposed to vinyl chloride. The plant operates on a 24-hour-per day, 5-day-per-week schedule, and all manufacturing operations are performed indoors.

The company uses the following processes in the manufacture of polyvinyl products: bonding, by hot-seal welding of flexible extruded profiles such as refrigerator seals; compounding, in the blending of polyvinyl chloride resin with plasticizers, fillers, stabilizers, pigments, and other additives in a semiautomated blender with a 45,000-pound-per-day capacity; extrusion, in the production of a wide range of profiles from powder-type compounds; and molding of dry polyvinyl chloride compounds into items such as automotive seals and cable enclosures by injection molding.

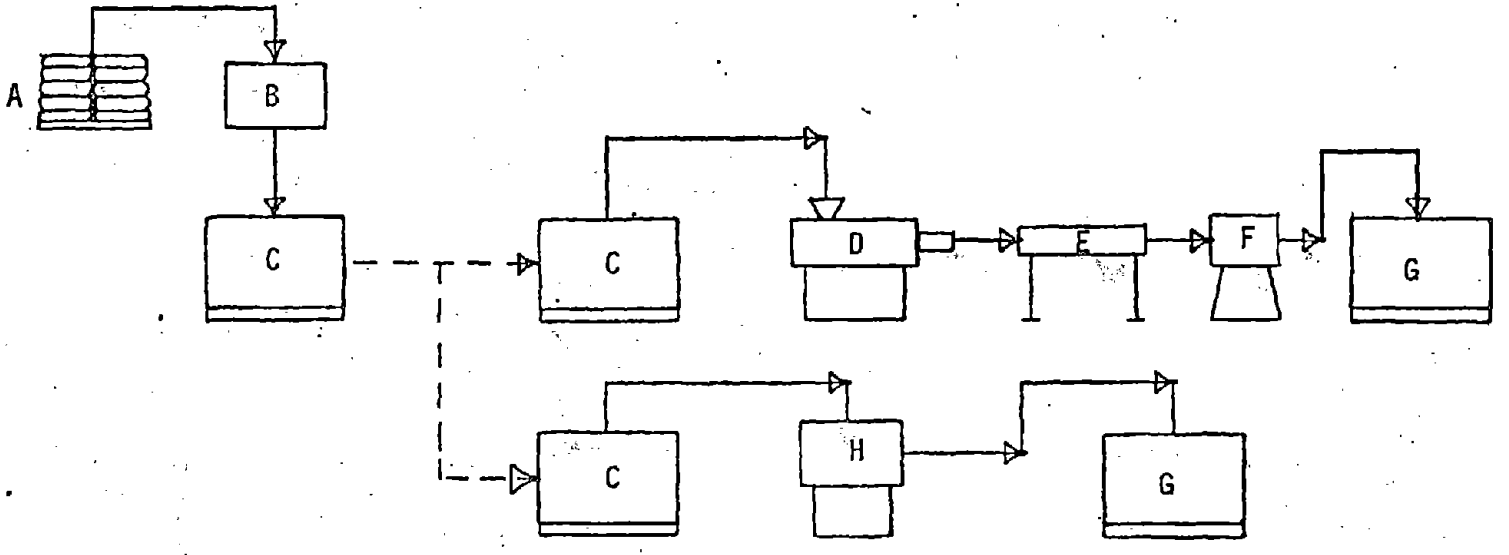
Ventilation throughout the plant is provided by air-circulating fans. Hoods vented to the atmosphere through a duct system have been installed on injection molding presses and the high-intensity compound mixer. Doors and windows are opened as required to assist the plant ventilation system.

The only significant change in the plant is the addition, in July 1974, of the new high-intensity compound mixer. The mixer is vented to the atmosphere through a duct system and should serve to reduce the escape of vinyl chloride to the plant air.

The company does not have a vinyl chloride sampling program and does not feel that it has concentrations of vinyl chloride above the permissible limit

in the plant. Other than the polyvinyl chloride resin, none of the other compounding ingredients used in the plant are recognized as liver toxins or cancer-producing chemicals. The company has an active safety and medical program.

Figure 8 shows a flow schematic of the processes used by Plant E to manufacture polyvinyl chloride products.



Legend:
A - Bagged Materials
B - Blender
C - Storage Container
D - Extruder
E - Cooling Bath
F - Cut-Off Machine
G - Shipping Container
H - Injection Molder

Plant E

Figure 8. Flow Schematic, Plant E

Plant F

This facility processes polyvinyl chloride resins into numerous dip-molded and dip-coated products using plastisol-type compounds. The company has been fabricating polyvinyl chloride products by the dip molding process for 25 years and normally employs 110 people. Due to the design of the plant, all of the employees are considered to be exposed to vinyl chloride. The plant normally operates on a one-shift-per-day basis, 5 days a week. The company added blow molding units 3 years ago. Blow-molded products are made from polyethylene compounds.

This company uses the following three processes to produce polyvinyl chloride products: (1) compounding, in the mixing of polyvinyl chloride resins with dicapryl phthalate, dioctyl adipate, and tallates as plasticizers; barium, cadmium, and zinc organic solutions as stabilizers; pigments; and fillers (other than the resins, none of the other compound materials are known liver toxins); (2) molding, by dipping a heated mold into a plastisol compound and curing the dipped mold in an oven; and (3) plastisols, in the compounding of plastisol mixtures.

The only change that has been made to their polyvinyl chloride manufacturing processes is the addition, 9 years ago, of an automated-conveyorized dip-molding line. All of the other dip-molding units are hand-operated, batch-type units.

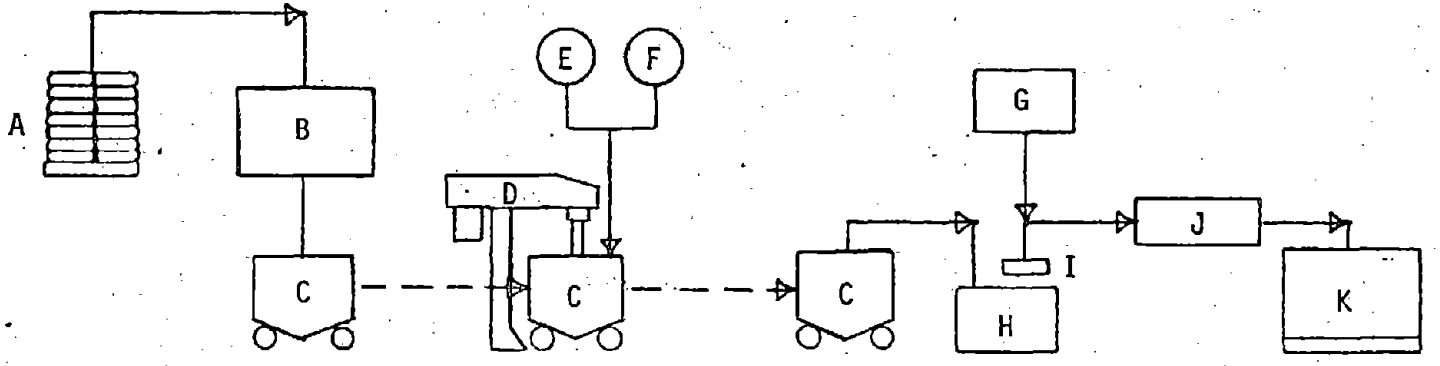
Plant ventilation is provided by roof-mounted fans. All of the ovens and blow-molding units are equipped with hoods which are ducted overhead to the atmosphere for removal of fumes. The adjacent offices are air conditioned.

The company has an active safety program and they perform area and personnel sampling using the carbon tube sampling method. The carbon tubes

are analyzed by one of the polyvinyl chloride resin suppliers. The results of the sampling analysis are posted on employee bulletin boards along with other safety and health bulletins. Sampling results show a hi-lo range of <.01 to 18.0 ppm.

An enclosed cafeteria is provided for smoking, drinking, and eating during breaks and the lunch period.

Figure 9 shows a flow schematic of the processes used by Plant F to manufacture polyvinyl chloride products.



Legend:
A - Bagged Materials
B - Blender
C - Mixing Tub
D - Mixer
E - Plasticizers
F - Pigments
G - Mold Heating Oven
H - Plastisol Dip Tank
I - Heated Mold
J - Curing Oven
K - Shipping Container

Plant F

Figure 9. Flow Schematic, Plant F

Plant G

This facility manufactures closed-cell expanded products from blends of polyvinyl chloride and rubber compounds. The manufacturing operations are performed in several indoor locations. The company has been making closed-cell expanded polyvinyl chloride/rubber products for 19 years, and no essential changes have been made to the original process.

The plant operates on a 24-hour-day, 5-day-per week schedule and performs a batch-type operation. The plant has 1,110 employees; however, only 160 of their employees are exposed to vinyl chloride in their manufacturing operations. The manufacturing processes performed by this company involving polyvinyl chloride resins and compounds are compounding, extrusion, foams, and molding.

The manufacture of the various closed-cell expanded product line produced by this company begins with the addition, to a Banbury mixer, of predetermined amounts of the materials required to make the desired compound. The Banbury-mixed compound is fed to a two-roll mill where further mixing takes place, and ends up as a sheet of compound on the mill roll. Sections of the sheet are cut off and placed on a portable rack. The milled slabs are fed into a tuber (tube-type extruder) where the extruded compound for the batch-type units is cut into sections. The sections are placed in a multi-leaf platen press where the section is heated under pressure to a definite shape, and partial expansion takes place. The shaped pieces are removed from the presses, loaded onto racks, and moved to a second oven. The loaded racks are placed in the oven where the partially blown sections are further expanded to approximately four times in size. The racks are removed from the oven, and the expanded slabs are unloaded and stacked onto skids for packaging and shipment.

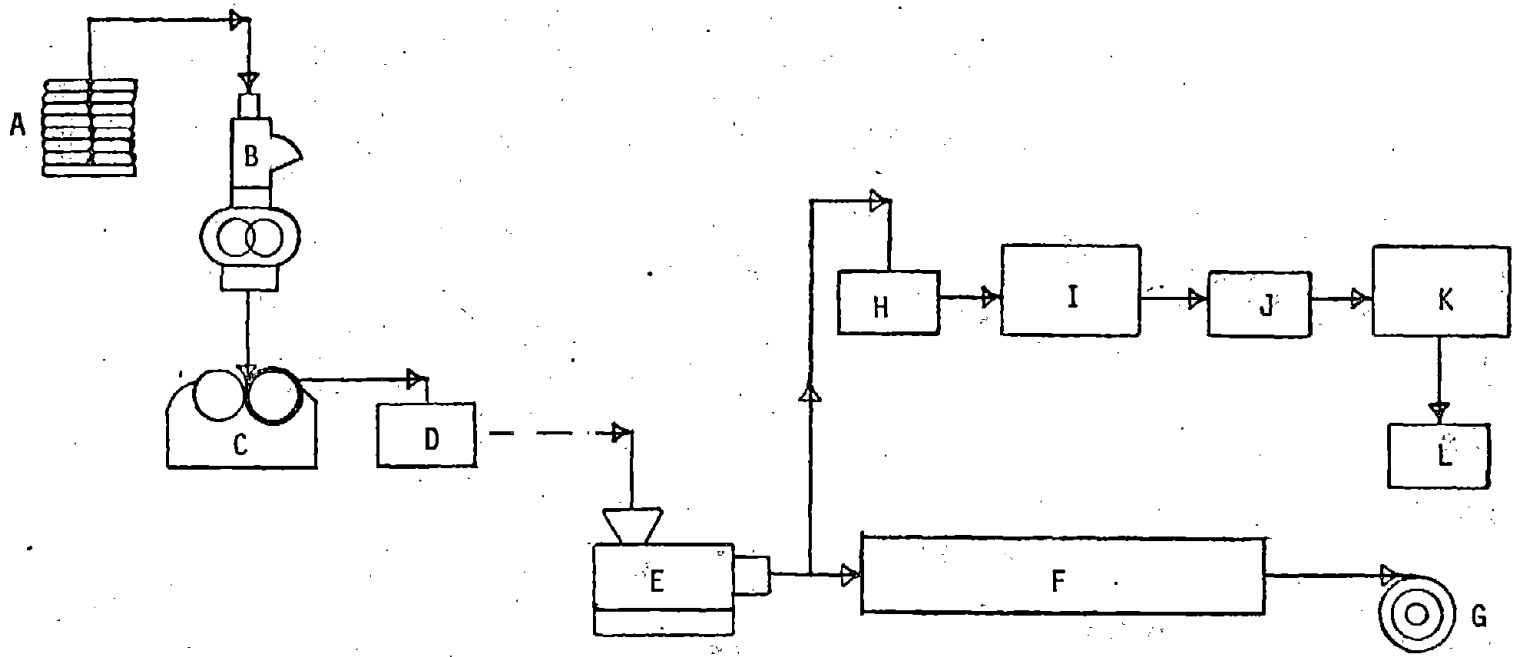
In another building, the milled slabs are fed into a continuous tuber located at the head of a long tunnel-type oven. The tubed stock is cured and fully expanded into a continuous sheet in the oven. The expanded sheet is cooled and passed to a cutter where it is cut into sections or rolled into rolls prior to packaging for shipment.

In other operations, the milled sheet can be extruded through heated dies to form continuous profiles of closed-cell expanded extrusions. This type of product would be primarily used for gasket, insulation, or cushioning materials.

The closed-cell expanded products can be coated with a plastisol compound and further cured to provide a clear or colored skin of desired thickness on the coated item.

The company has established a program for personnel sampling using the method called out in the NIOSH publication PCN No. 178, Vinyl Chloride in Air and Personal Gas Sampling Pumps. Initial samples collected in May 1974 indicated less than 1 ppm of vinyl chloride for 10 area samples. The charcoal tube samples were analyzed by an independent laboratory.

Figure 10 shows a flow schematic of the processes used by Plant G to manufacture polyvinyl chloride products.



Legend:
A - Bagged Materials
B - Banbury Mixer
C - Two-Roll Mill
D - Slab Rack
E - Tuber
F - Tunnel Oven
G - Product Rolls
H - Tube Rack
I - Hot Press
J - Oven Rack
K - Batch Oven
L - Shipping Container

Plant G

Figure 10. Flow Schematic, Plant G

Plant H

This facility manufactures plasticized polyvinyl chloride calendered film and sheeting, expanded vinyl sheeting, and printed vinyl film. The company has been making calendered products 35 years, and expanded (foam) type products 8 years.

The polyvinyl chloride plant normally employs 127 people and operates on a continuous basis 7 days a week. All production operations except the offloading of resins from truck-mounted sealed containers to storage bins located on the roof are performed indoors. No basic changes have been made to the manufacturing operations; however, a number of engineering improvements have been initiated to improve production and eliminate unsafe working conditions.

The company uses the following processes to produce the polyvinyl chloride products manufactured in this plant: bonding, in the lamination of two sheets of vinyl; calendering, in the conversion of a plastic mass of polyvinyl chloride compound into a film or sheet of controlled width and thickness; compounding, in the mixing of polyvinyl chloride resin with plasticizers, fillers, stabilizers, and other materials in ribbon-type blenders, and the conversion of the powdered blend into a plastic mass in Banbury mixers (color pigments and granulated trim are added to the charge in the Banbury mixers); extrusion, in the processing of the Banbury charge through a screen and extruder head to a "rope" that is fed to the calender; fibers, in the combining of a roll of fabric with a sheet of polyvinyl chloride plastisol; foams, in the expansion of a plastisol film in a blowing/curing oven; plastisols, in the compounding of plastisol mixtures; and thermoforming, in the embossing of designs into polyvinyl chloride film and sheeting.

Raw materials used in the production of polyvinyl chloride products are polyvinyl chloride resins, plasticizers, stabilizers (barium, cadmium, and zinc organic salts in solution form), fillers, pigments, and Celogen as a blowing agent. None of the above materials, other than the polyvinyl chloride resins, are known to be toxic to the liver.

The plant uses overhead fans ducted to roof-mounted fans and stacks for ventilation. Hoods are located above equipment that gives off fumes, and the hoods are ducted to roof-mounted fans and stacks. The blenders and dry-blend transport equipment are vented to the atmosphere through a dust collector.

The company has an active safety and sampling program and was willing to cooperate in the NIOSH survey. Thirty-minute briefings are given to all personnel, explaining the vinyl chloride monomer problem. Annual medical checkups are offered to all employees on a voluntary basis, plus a 6-month blood sampling and analysis program. Air sampling for personnel, and area sampling are employed to detect vinyl chloride, using the carbon-tube collection method. In addition, Miran II infrared analyzers plus Century organic vapor analyzers are used to check for vinyl chloride. The charcoal tubes are sent to their test center or a commercial laboratory for analysis. The analysis on the charcoal tubes can also be performed at this site. The sampling program was initiated in April 1974, and the only change that has been made is an increase in the sampling frequency. The results of their sampling program indicate a hi-lo vinyl chloride range of 0.2 to 1.1 ppm for their operating personnel.

Housekeeping throughout the plant is good and their safety department is doing everything possible to eliminate or reduce employee exposure to vinyl chloride below the permissible working levels. Employees performing

operations where exposures above the permissible limit are possible must wear protective clothing. Smoking, drinking, and eating are permitted in enclosed air-conditioned cafeteria areas or offices.

Figure 11 shows a flow schematic of the processes used by Plant H to manufacture polyvinyl chloride products.

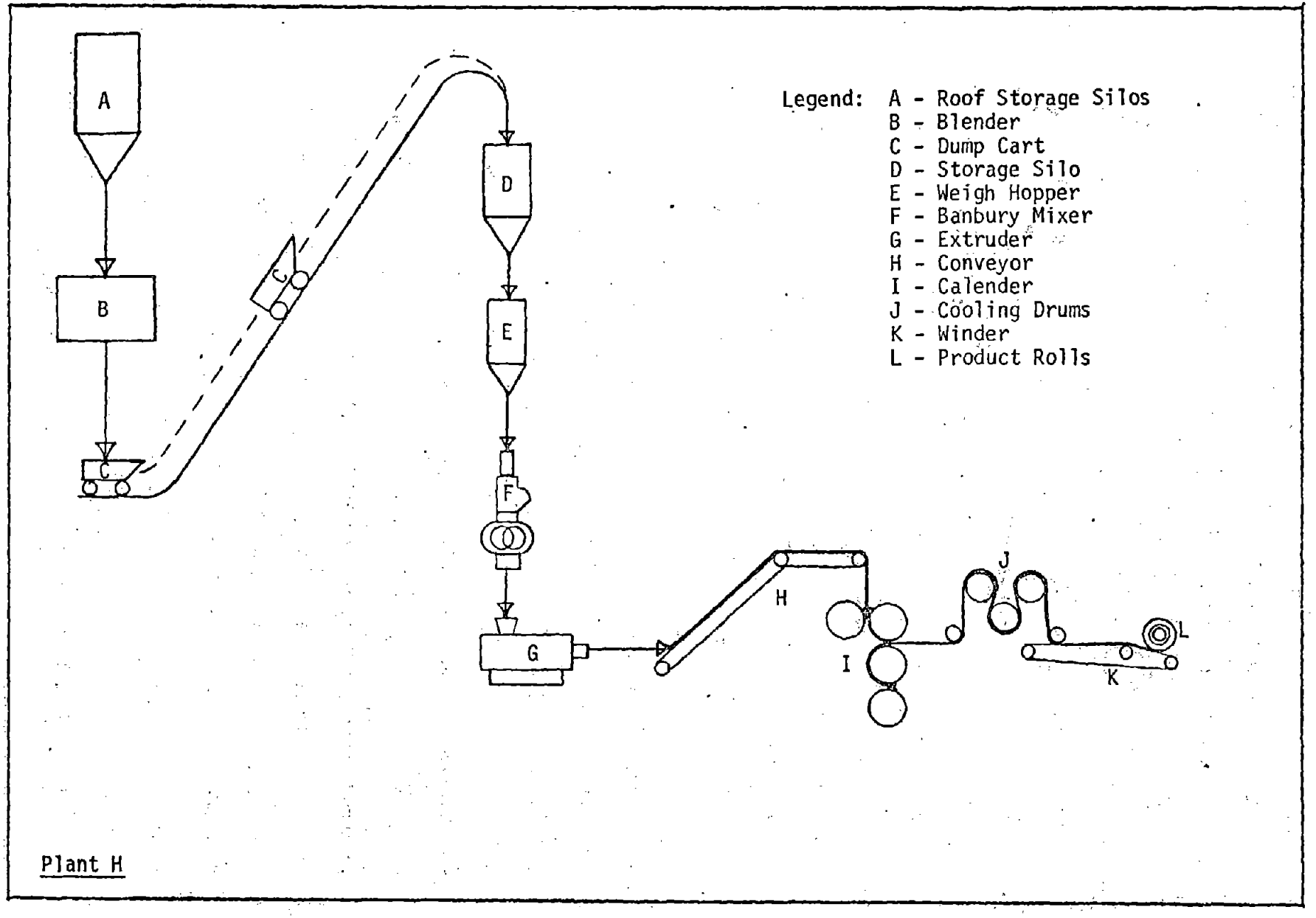


Figure 11. Flow Schematic, Plant H

Plant I

This facility processes polyvinyl chloride resins into pelletized polyvinyl chloride compounds, thermoformed products, vinyl film, and vinyl sheeting. The company has been performing calendering operations since 1946, thermoforming since 1958, and compounding since 1959.

The company employs 520 people; however, only 309 of the employees are considered to be exposed to vinyl chloride. The facility operates on a 24-hour-per-day schedule, 7 days a week depending on the work load. All of the production operations for the processing of polyvinyl chloride into finished products are performed indoors except for the offloading of resins to the roof-located storage hoppers, and the loading of compounded resins into bulk shipping devices.

The manufacturing operations performed in the conversion of polyvinyl chloride resins into salable products are compounding, calendering, and thermoforming. Compounding involves the mixing of polyvinyl chloride resins, plasticizers, stabilizers, fungicides, bacteriastats, lubricants, pigments, and fillers in continuous ribbon-type blenders. After the ingredients are blended, they are further processed into a plastic mass, sheet, or rope in Banbury mixers, two-roll mills, extruders, or a combination of the three units. Calendering converts a rope of plastic polyvinyl chloride compound into a continuous sheet or film of controlled width and thickness in a four-roll inverted "L" form calender. The plastic compound from the Banbury mixer in another product line is passed to an extruder-dicer unit to convert the dry-blend compound into a pelletized compound product. The pelletized compound is bagged and loaded onto skids for shipment as a salable product. Thermoformed products are produced by the vacu-forming process. In this operation, precut sheets of polyvinyl chloride sheet stock are fed to a vacu-forming

unit, where the sheet stock takes the form of the hot die, using negative pressure during the forming operation, and positive pressure to strip the formed item from the die. The formed items are stacked and loaded into boxes for shipment. The vacu-formed products are used as custom-formed plastic packaging for the protection and display of items such as candy and fruit.

Roof-type ventilators are used throughout the plant for ventilation. Dust-producing equipment and dust-laden atmospheres are ducted to baghouses and cyclone separators to remove airborne particulate prior to venting to the atmosphere.

The company has an active health, safety, and sampling program to protect its employees and prevent vinyl chloride excursion to the atmosphere. Safety and health information is transmitted to the employees by way of union-management meetings, and bulletin boards. Carbon tubes and Sipin pumps are used to collect area and personnel samples. The air samples are analyzed by gas chromatography in their in-plant laboratory. The company is also very active in the development of more-advanced methods of identifying vinyl chloride concentrations in the work area through the use of instant readout instrumentation. The only suspected liver toxins that are used in this plant are vinyl chloride, polyvinyl chloride resins, organic lead stabilizers, and tetrahydrofuran. The tetrahydrofuran is restricted to laboratory analysis usage. The results of their sampling program were not available.

The company is constantly revising its production procedures and equipment to take advantage of methods to increase production, lower operating costs, and increase the overall safety of its employees. The main changes that were made to the compounding operations are the changes in the mixing of compound ingredients in two-roll mills to Banbury mixers and then to ribbon-type blenders.

A cafeteria and designated smoking, drinking, and eating areas have been provided for the employees. Respirators were not worn in the blender areas.

Figure 12 shows a flow schematic of the processes used by Plant I to manufacture polyvinyl chloride products.

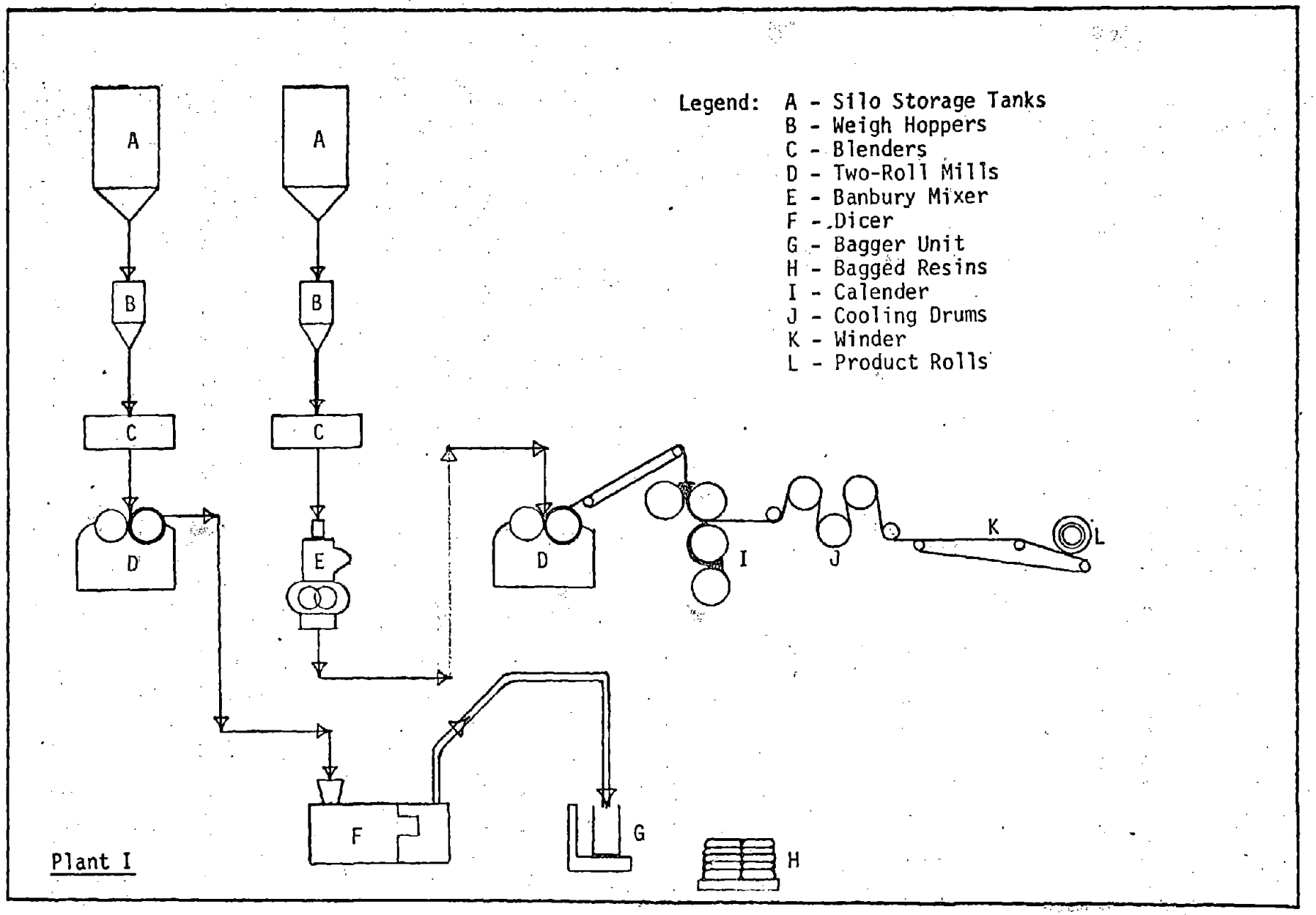


Figure 12. Flow Schematic, Plant I

Plant J

This facility converts polyvinyl chloride resins and other compounding ingredients into calendered film and vinyl-coated supported and unsupported fabrics that are sold to a number of industries.

The company has been in operation since 1947 for the manufacture of polyvinyl chloride products.

The plant normally operates on a 24-hour-per-day schedule, 5 to 6 days a week. All manufacturing operations are performed indoors except the off-loading of resin from bulk resin trucks to ground level storage silos. Resin from the silos is transferred by an airveyor system to a gravity supply hopper located on the roof of the plant.

The plant employs 325 people; however, only 50 workers are considered to be exposed to vinyl chloride in their manufacturing operations. The following processes are used by this company to make their polyvinyl chloride product lines: bonding, in the lamination of two sheets of vinyl; calendering, in the high-speed conversion of a rope of polyvinyl chloride compound into continuous film or sheet stock of controlled width and thickness; compounding, in the mixing of polyvinyl chloride resins with plasticizers, stabilizers, fillers, lubricants, and other additives in ribbon-type blenders, and the conversion of the powdered blend into a plastic mass in Banbury mixers (color pigments and granulated trim stock and scrap are added to the Banbury in the Banbury mixers); extrusion, in the processing of the Banbury charge through a screen and extruder head to form a rope of polyvinyl chloride compound that is fed to a calender; fibers, in the continuous combination of a sheet of fabric with a sheet of cast polyvinyl chloride film; foams, in the expansion of cast plastisol film in a blowing/curing oven; plastisols, in the compounding of plastisol mixtures used in the film casting line; and thermoforming, in the

embossing of designs into polyvinyl chloride film and sheeting. The embossing operation is performed on the calendering lines and the cast film line.

The plant uses roof-mounted ventilation fans, exhaust hoods, and ducts to supply fresh air and remove fumes and dust-laden atmospheres. The vented exhausts are passed through an electron precipitator to remove entrained solids prior to venting to the atmosphere. The solids collected in the precipitator are burned as a fuel. Recent changes that have been made to the ventilation system to reduce vinyl chloride concentrations within the plant are: a 30-horsepower, roof-mounted exhaust fan and duct system has been installed on each of the blenders to prevent the excursion of dry-blend compounds into the plant air; shrouded hoods have been installed on the mills to reduce area; and conveyors to the mills have been enclosed. A proposal is in the design stage to enclose the Banbury mixers with a duct system similar to the systems installed on the ribbon blenders.

The company has an active safety program and has recently initiated an area and personnel sampling program using the carbon tube method and personnel sampling pumps. The analysis of the carbon tubes is performed by an independent laboratory. The employees are kept up to date on safety and health problems by way of bulletin boards and safety meetings. All employees entering work areas where higher-than-permissible levels of vinyl chloride have been found or are possible must sign a form that lists the specific work area entered, and the time the area was entered and exited. Chemical cartridge-type respirators are worn by the employees when working in dusty areas or when higher-than-permissible levels of vinyl chloride are suspected.

A surveillance program for vinyl chloride was initiated in November 1974. The results of the survey to date indicate a hi-lo vinyl chloride concentra-

tion range of <.1 to 30.81 ppm based on area sampling over a period of 4 months.

Eating, drinking, and smoking are restricted to specified areas or enclosed office areas.

Figure 13 shows a flow schematic of the cast film production line for Plant J.

Figure 14 shows a flow schematic of the calendered film lines for Plant J.

During the field surveys in the polyvinyl chloride processing plants, it was found that all tasks were performed by several job classifications; therefore, the job classifications were grouped by similar tasks as shown on page 69.

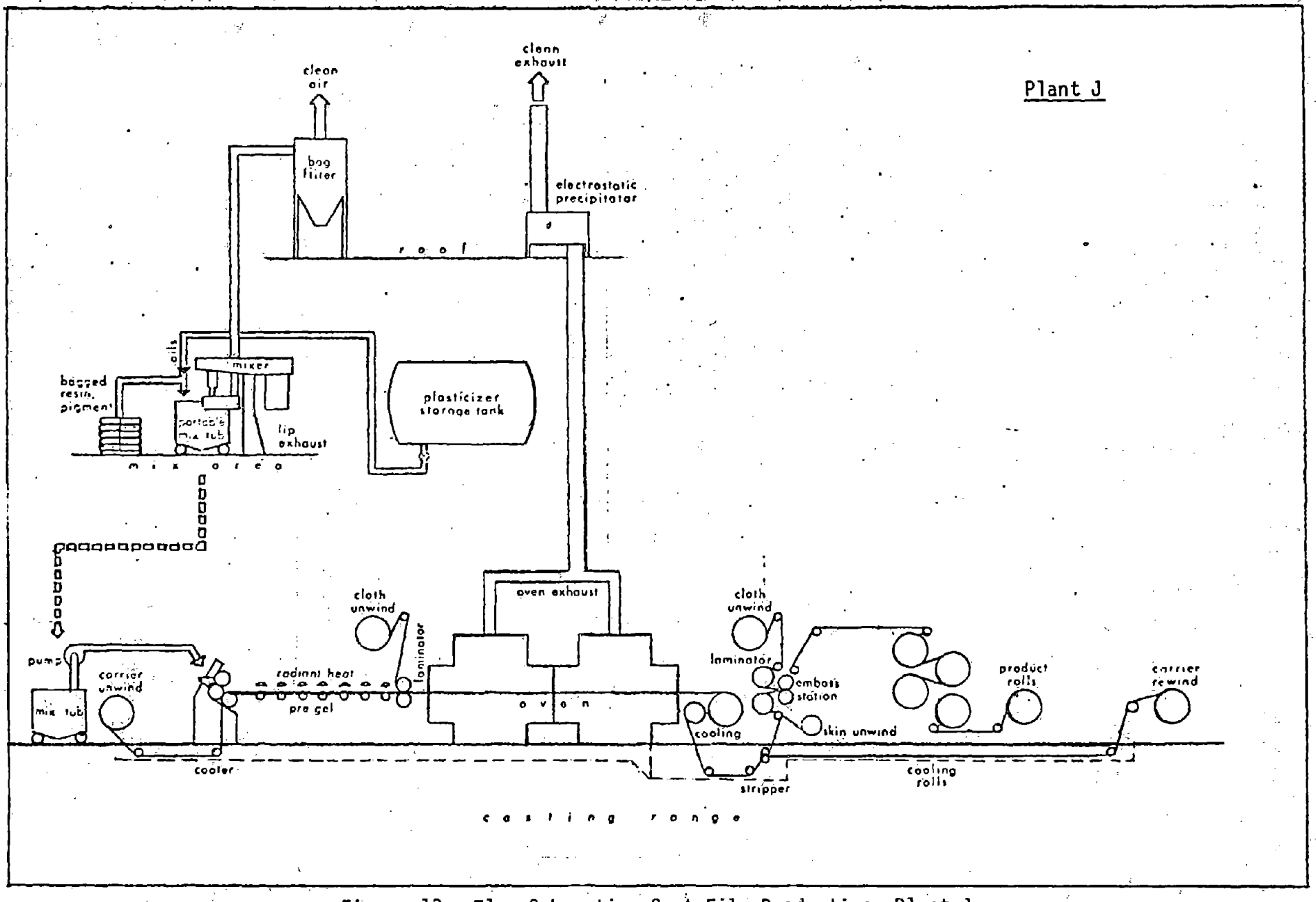


Figure 13. Flow Schematic, Cast Film Production, Plant J

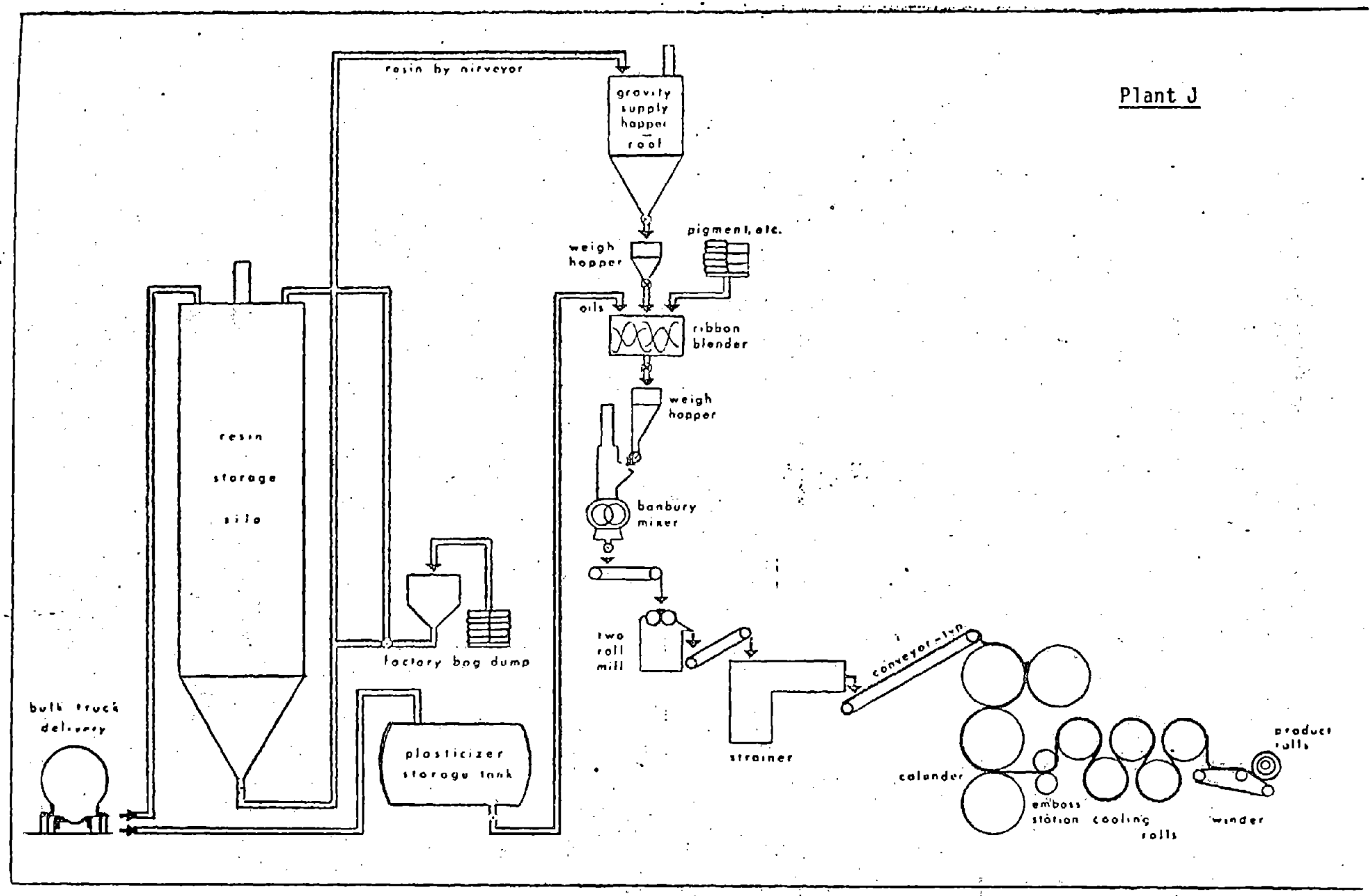


Figure 14. Flow Schematic, Calendered Film Production, Plant J

JOB DESCRIPTIONS FOR
POLYVINYL CHLORIDE PROCESSING PERSONNEL

Blenders - Blender Operators

Blender operators charge polyvinyl chloride resins and other compound materials such as plasticizers, stabilizers pigments, toners, fillers, lubricants, blowing agents, autix-oxidants, fungicides, santicizers, and modifiers into ribbon or high-intensity blenders and mix the above ingredients to prepare dry-blend compounds.

Banbury Mixers - Banbury Operators

Banbury Operators convert dry-blend compounds, or compounds made up from the individual ingredients required to prepare a compound, into a dough-like or plastic-like mass and then feed the plastic mass to an extruder or mill. They may also add scrap from the extruders or calenders to the Banbury charge for incorporation into the virgin compound.

Mill Men - Mill Operators - Feed Mill Operators

Mill operators convert dry-blend compounds, Banbury-mixed compounds, or compounds made up from the individual ingredients required to prepare a compound, into a plastic sheet. They may also add scrap from the extruders or calenders to the dry-blend or Banbury-mixed compounds in the milling operation. They may feed a strip of the plastic sheet from the mill to an extruder, tuber, or calender, or remove the stock from the mill as a roll or in sheet form and feed it to a tuber or extruder.

Extruders

Extruders convert blender-mixed, Banbury-mixed, or mill-mixed compounds into pugs, ribbon, or ropes which are fed to equipment such as a calender. They also maintain screens that are installed in the extruder ahead of the extrusion die to prevent trash or slugs of compound from entering the die.

Molders

Molders operate molding equipment such as blow molders, injection molders vacu-forming units, and embossing equipment to convert a plastic-type compound into molded items.

Compounders

Compounders mix polyvinyl chloride resins with the other ingredients required to prepare a compound in blenders, Banbury's, mills, or paddle-type mixers.

Mixers - Mixer Operators - Plastisol Blenders

Mixer operators mix polyvinyl chloride resin with the other ingredients required to prepare plastisol-type compounds in a stirred mixer equipped with an agitator.

Color Weighmen

Color weighmen weigh out the colors or pigments that are used to prepare colored compounds.

Tuber Operators

Tuber operators are responsible for the operation of tube-type extruders.

Tuber Feeders

Tuber feeders feed milled compounds in sheet or strip form to tube-type extruders.

Oilmen

Oilmen weigh out lubricants and other oil-like compounding additives, and add them to the compounds that are being prepared.

Foam Line Chief

The foam line chief is responsible for the operation of the foam-casting line.

Calender Chief

The calender chief is responsible for the overall operation of a calender line.

Assistant Operators

An assistant operator assists the calender chief or the foam line chief in the operation of a calender line. Film-casting line, or foam-casting line and relieves the chief during break and lunch periods.

Press Operators

Press operators operate the leaf-type platen presses that shape the polyvinyl chloride/rubber slabs and perform the initial blowing and curing operation.

Finishers

Finishers perform final operations on extruded products. These operations include cutting to length and shape, perforating, bonding of two or more lengths together for refrigerator gaskets, inspecting the finished item, and packing the finished item in boxes for shipment.

Dippers

Dippers remove the heated molds from the preheat oven and transfer them to the dipping unit, operate the plastisol dipping unit, remove the plastisol-coated mold from the dipping unit, and transfer the mold to the curing oven.

Line and Dip Operators

Line and dip operators remove the molds from the plastisol curing ovens; strip the cured plastisol products from the mold; dip the stripped mold in the mold release solution tank, or spray the mold with a release agent; transfer the mold to the preheat oven; inspect the molded product; and stack the molded products in boxes for shipment or additional operation. They also assist or relieve the dippers.

Set-up Men

Set-up men are responsible for changing polyvinyl chloride processing equipment to make a different product line and to correct problems with the equipment under operation in the manufacture of a product.

Maintenance Men or Mechanics

Maintenance personnel or mechanics are responsible for the repair of all the equipment used in the plant, to include: the equipment used to manufacture a product; instrumentation; lighting and other electric equipment; heating, air-conditioning, and ventilation systems; trucks; conveyor systems; and any other equipment requiring repair.

Truck Drivers

Truck drivers unload raw materials from trucks or railcars and transfer raw materials, compounds, semifinished products, and finished products between work stations and storage areas.

Tower Workers

Tower workers are responsible for the unloading of raw materials delivered to the plant in bulk containers to ground-level and roof-level raw material storage silos, the transfer of the raw materials from the storage silos into the weigh hoppers, and the dumping of the weigh hoppers into the blenders or Banbury mills.

Wind-up Men

Wind-up men operate the equipment that winds calender line, cast line, or foam line products onto paper shells; weigh packages; and unload the wound products onto skids for shipment.

Dicer Operators

Dicer operators operate the extruder, chiller, cut-off unit, and air-transfer equipment used in the manufacture of pelletized components.

Baggers

Baggers are personnel that weigh and fill paper bags with pelletized compound, label the bags, and load the filled bags onto shipping skids.

Driver-Baggers

Driver-baggers transfer the bagged pelletized compound skids from the bagging station to the warehouse area, supply skids for loading, and relieve the bagger during break periods.

Lab Men - Lab Personnel - Lab Technicians

Lab personnel and technicians work in the research and development laboratories, product control laboratories, and analysis laboratories.

Foremen

Foremen are responsible for the safety, health, and productivity of the employees working under their jurisdiction, the equipment in their area, and the quality and quantity of the product manufactured in their area.

Supervisors

Supervisors are normally responsible for all of the operations and personnel involved in their area of responsibility, and generally have two or more foremen working for them.

Project Engineers

Project engineers are generally responsible for designing the equipment required to manufacture a product, and for solving problems of manufacturing, equipment, and products.

Table 3 shows a grouping of job classifications for the polyvinyl chloride processing personnel contacted during the survey, and the range of vinyl chloride in ppm that the personnel were exposed to during the survey. The following job classification groupings serve to clarify the types of personnel within each classification.

Calender Personnel

- Assistant Operators
- Chief Operators
- Calender Operators
- Wind-up Man

Compounding Personnel

- Banbury Operators
- Blender Operators
- Color Weighman
- Compounders
- Feed Mill Operators
- Mill Operators
- Mixer Operators
- Plastisol Blenders
- Tower Workers

Extrusion Personnel

- Extruders
- Foremen
- Project Engineers
- Project Supervisors
- Tuber Feeders
- Tuber Operators

Dipping Personnel

- Dippers
- Foremen
- Line Girls
- Line and Dip Girls
- Set-up Men

Pelletizer Personnel

- Baggers
- Dicer Operators
- Driver-Baggers

Molding Personnel

- Molders
- Press Operators

Laboratory Personnel

- Laboratory Technicians

Maintenance Personnel

- Maintenance Men
- Mechanic

Miscellaneous Personnel

- Finishers
- Foam Line Chiefs
- Truck Drivers

TABLE 3

VINYL CHLORIDE CONCENTRATION RANGE
FOR PLANTS D, E, F, G, H, I, AND J IN PPM

Areas or Job Classifications	D	E	F	G	H	I	J	Low	Hi	Avr
Calender Personnel					<.01	.50-2.44	.02	<.01	2.44	.85
Pelletizer Personnel						.02-.76		.02	.76	.39
Compounding Personnel	<.01-.02	.01-.27		N.D.	<.01-.13	.24-.69	<.01-.02	<.01	.69	.16
Laboratory Personnel	<.01	.01-.06				.02-.68		<.01	.68	.03
Molding Personnel		<.01-.03		N.D.				<.01	.03	.02
Plastisol Dipping Personnel			<.01-.06					<.01	.06	.01
Extrusion Personnel	<.01-.02	<.01-.02		N.D.				<.01	.02	.01
Maintenance Personnel		<.01-.02			<.01			<.01	.02	.01
Miscellaneous Personnel	<.01-.02			N.D.	<.01			<.01	.02	.01
Area	<.01-.01	.37	N.D.	N.D.	<.01			<.01	.37	.13

SAMPLING PROCEDURE

All personnel samples were collected on Lot Number 101 organic vapor charcoal tubes supplied by the Anatole J. Sipin Company, using Model SP-1 Sipin pumps.

The pumps were set to operate as nearly as possible at a flow rate of 50 milliliters per minute, and to limit the volume of air sampled by each tube to 5 liters for Plants A, B, C, D, E, F, and G. The volume of the air sampled for each carbon tube used in Plants H, I, and J was increased to approximately 10 liters when the analysis of the carbon tube samples collected at the polyvinyl chloride product manufacturing Plants D, E, F, and G indicated that the vinyl chloride detected in the atmosphere in Plants D, E, F, and G was less than 0.02 ppm.

The personnel samples were collected from the breathing zone of the worker, with the carbon tube mounted in a lapel-type holder. The area samples were collected in a similar manner, with the tubes located in such a position as to represent the breathing zone of an employee working on the equipment.

All of the carbon tube samples collected during the vinyl chloride survey were analyzed using the procedures set forth in the NIOSH Vinyl Chloride report, P&CAM #127,[2] with the exceptions that Poropak type QS at 100° C, and 0.4 percent Carbowax 1500 on Carbopak A at 50° C were used as the chromatograph column materials.

This procedure requires the separation of the charcoal contained in the front (100-milligram) and back (50-milligram) sections of the charcoal tube,

[2] Ibid.

and the addition of each section of charcoal into 1 milliliter of carbon disulfide in a 2-milliliter glass septum vial. Each vial is then capped with a septum closure. The vials are then agitated to ensure that the gases absorbed by the charcoal are dissolved by the carbon disulfide.

A 5-microliter aliquot from each vial is injected into the inlet port of a gas chromatograph with chart readout. The height of the vinyl chloride peak is measured for each section and used in the following calculations to determine the amount of vinyl chloride absorbed by the charcoal in each charcoal tube in ppm.

The weight, in µg, corresponding to each peak area is read from the standard curve for vinyl chloride. No volume corrections are needed, because the standard curve is based on µg/1.0 mℓ CS_2 and the volume of sample injected is identical to the volume of the standards injected.

Corrections for the blank are made for each sample.

$$\mu g = \mu g_s - \mu g_b$$

where:

μg_s = µg found in front section of sample tube

μg_b = µg found in front section of blank tube

A similar procedure is followed for the backup sections.

These values are further corrected for the desorption efficiency at the level of vinyl chloride measured.

$$\text{Corrected } \mu g = \frac{\mu g}{\text{desorption efficiency}}$$

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

The concentration of the vinyl chloride in the air sampled is expressed in mg/m^3, which is numerically equal to µg/liter of air.

$$mg/m^3 = \mu g/\ell = \frac{\text{total } \mu g \text{ (Section 10.4)}}{V}$$

where:

V is the volume of air sampled

Another method of expressing concentration is ppm, defined as µℓ of vinyl chloride gas/liter of air.

$$ppm = \mu g/\ell \times \frac{24.45}{62.5} \times \frac{760}{P} \times \frac{T+273}{298}$$

where:

P = pressure (mm Hg) of air sampled

T = temperature (°C) of air sampled

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

62.5 = molecular weight (g/mole) of vinyl chloride

760 = standard pressure (mm Hg)

298 = standard temperature (°K)

SAMPLING RESULTS

A number of air velocity measurements were made in several of the polyvinyl chloride processing plants using an Alnor Velometer Jr. meter.

In open areas where the personnel were working, no air movement could be detected using the velometer, except where pedestal-type fans were employed to circulate the air. Measurements taken at the breathing zone level of an employee working beneath a ducted exhaust hood gave a zero reading; however, when a smoke tube was used, air movement into the hood was readily detected.

Velometer readings were made at the edge of hoods and on blender charging door screens with varying results depending on where the meter was positioned on any one hood or charging door. Based on the above observations,

the velometer readings were found to be meaningless and were not included as data in this report.

The results of the analysis of the organic vapor carbon sampling tubes collected during the vinyl chloride surveys performed at the vinyl chloride manufacturing Plants A, B, and C, and the polyvinyl chloride product manufacturing Plants D, E, F, G, H, I, and J are shown in the following Vinyl Chloride Concentration Data Sheets.

VINYL CHLORIDE CONCENTRATION DATA

PLANT A

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Lab Tech	A-9	12/3/74 1	156	92	5.046	4.36	1.27
			159	90	5.143	.27	
			162	90	5.282	.05	
			165	90	5.561	.32	
Loader	A-7	12/3/74 1	160	93	4.340	.10	1.07
			163	95	4.701	.74	
			166	90	4.129	1.62	
			167	88	4.217	1.89	
Operator	A-5	12/3/74 1	18	90	3.342	0.21	1.03
			23	108	4.235	2.45	
			39	90	3.529	0.13	
Operator	A-2	12/2/74 2	3	96	4.012	0.74	.72
			10	90	3.797	0.22	
			13	90	3.843	1.57	
			15	60	2.680	0.17	
Loader	A-3	12/2/74 2	148	85	3.781	0.17	.30
			150	90	4.038	0.32	
			152	85	4.303	0.35	
			154	58	2.912	0.41	
Instrument Man	A-6	12/3/74 1	19	97	3.363	0.25	.17
			22	88	3.216	0.09	
			21	92	3.363	0.02	
			37	90	3.329	0.32	
Lab Tech	A-8	12/3/74 1	155	90	4.319	.37	.16
			157	90	4.301	.07	
			161	93	4.487	.04	
			164	89	4.521	.15	
Shift Supervisor	A-1	12/2/74 2	2	93	5.138	0.04	.11
			6	92	4.758	0.08	
			9	90	4.598	0.20	
			12	90	4.667	0.13	
Shift Supervisor	A-4	12/3/74 1	20	100	4.618	0.03	.09
			41	90	3.922	0.04	
			43	92	3.852	0.21	

VINYL CHLORIDE CONCENTRATION DATA

PLANT A

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Area Samples							
Vinyl Chloride Plant		12/3/74 1	17	90	3.182	1.28	2.84
			24	118	5.036	5.89	
			40	103	4.448	2.03	
			42	90	3.916	1.33	
Vinyl Chloride Plant		12/2/74 2	4	93	3.765	0.56	1.96
			7	94	3.628	2.19	
			11	90	3.490	4.03	
			14	91	3.443	1.10	
Vinyl Chloride Plant		12/2/74 2	5	275	9.179	1.03	1.03
Loading Area		12/2/74 2	146	110	9.655	0.001	.01
			149	90	7.735	0.003	
			151	85	6.647	0.01	
			153	88	7.297	0.01	

VINYL CHLORIDE CONCENTRATION DATA

PLANT B

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Loader	B-15	12/12/74 3	71	90	4.541	84.77	26.46
			74	90	4.620	3.00	
			78	93	4.881	7.13	
			82	90	4.482	11.59	
Loader	B-1	12/11/74 1	58	60	2.610	10.80	17.30
			59	61	2.922	28.52	
			61	60	2.659	13.12	
			63	97	4.574	19.32	
			66	90	4.224	14.63	
Tower Operator	B-7	12/10/74 1	47	90	4.018	3.46	1.23
			44	90	3.830	.46	
			50	90	3.960	.81	
			53	90	4.301	.18	
Compressor House Operator	B-3	12/12/74 3	140	90	4.322	3.00	1.04
			138	90	4.520	.29	
			133	90	4.416	.73	
			98	90	4.464	.13	
Pipe Fitter	B-8	12/10/74 1	45	101	3.852	.33	0.17
			49	87	3.484	.26	
			52	102	4.251	.01	
			55	82	3.542	.08	
Lab Tech	B-11	12/11/74 1	25	83	3.667	.11	.40
			29	96	4.259	.55	
			34	86	4.162	.88	
			142	98	4.933	.06	
Cracker Operator	B-10	12/10/74 1	129	89	3.558	.07	0.07
			126	90	3.653	.07	
			124	88	3.253	.10	
			36	91	3.540	.04	
Furnace Operator	B-6	12/12/74 3	68	90	4.075	.10	.11
			72	90	4.022	.08	
			76	90	3.932	.11	
			80	90	3.812	.13	

VINYL CHLORIDE CONCENTRATION DATA

PLANT B

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Compressor Operator	B-9	12/10/74 1	130	90	4.080	.06	.11
			127	90	3.275	.14	
			123	90	2.591	.11	
			121	90	3.192	.13	
Tower Operator	B-14	12/12/74 3	69	90	3.826	.20	.09
			73	90	3.701	.06	
			77	90	3.851	.02	
			81	90	4.006	.09	
Control Room Operator	B-2	12/12/74 3	139	92	4.409	.10	.07
			136	88	3.374	.06	
			134	89	3.691	.06	
			100	91	3.523	.07	
Lab Tech	B-4	12/12/74 3	141	91	4.263	.16	.07
			137	90	3.868	.006	
			97	93	3.752	.09	
			101	86	3.539	.03	
Chromatographer	B-13	12/11/74 1	27	88	4.706	.06	.06
			31	90	4.199	.02	
			33	88	3.981	.12	
			143	93	3.983	.06	
Control Room Operator	B-6	12/10/74 1	131	90	4.267	.01	.04
			128	90	4.542	.06	
			125	88	4.573	.04	
			122	92	4.397	.05	
Area Samples							
Loading		12/11/74 1	57	60	2.357	1.22	.41
			60	67	2.661	.09	
			62	60	2.477	.20	
			64	90	3.881	.36	
			65	90	4.203	.31	
Outside Compressor House		12/10/74 1	48	90	3.165	.12	.16
			46	90	3.117	.12	
			51	91	3.302	.14	
			54	90	3.224	.25	

VINYL CHLORIDE CONCENTRATION DATA

PLANT B

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Area Samples (continued)							
Outside Compressor House		12/12/74 3	67	90	3.496	.17	.13
			70	90	3.225	.15	
			75	90	3.337	.12	
			79	90	3.210	.09	
Stock Room	B-12	12/11/74 1	26	88	4.706	.06	.13
			30	90	4.862	.006	
			35	90	4.799	.05	
			144	94	4.969	.38	
Cracker		12/11/74 1	56	360	14.223	.09	.09

VINYL CHLORIDE CONCENTRATION DATA

PLANT C

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Tank Farm Operator	C-21	12/19/74 2	247	90	4.513	17.6	11.03
			242	90	4.509	0.06	
			239	110	5.154	21.8	
			237	73	3.287	0.23	
Tank Farm Operator	C-22	12/19/74 2	246	91	3.850	6.19	8.22
			243	89	3.947	0.34	
			240	114	5.055	20.1	
			238	66	1.817	1.13	
VCl Operator East	C-10	12/17/74 1	169	91	4.968	18.2	5.06
			175	91	5.182	0.61	
			179	90	5.141	0.37	
			95	88	4.701	0.88	
Tank Farm Operator	C-23	12/19/74 2	245	91	3.974	1.74	4.96
			244	89	3.895	0.09	
			241	109	5.637	14.6	
			236	71	2.753	0.37	
VCl Operator East	C-6	12/16/74 2	182	93	4.925	6.24	2.20
			184	88	4.944	0.22	
			189	90	4.852	0.21	
			191	89	4.620	1.95	
Purification Operator North	C-1	12/16/74 2	194	91	4.672	3.35	.98
			199	90	4.569	0.20	
			203	90	4.358	0.25	
			88	90	4.725	0.10	
Tank Farm Operator	C-18	12/18/74 1	91	90	4.051	1.50	.95
			94	90	4.124	0.98	
			220	91	4.083	0.34	
			222	90	3.982	0.99	
Tank Farm Operator	C-17	12/18/74 1	93	90	3.939	0.67	.93
			219	90	3.903	2.31	
			221	91	4.144	0.35	
			223	90	3.759	0.38	
Synthesis Operator East	C-9	12/17/74 1	171	92	4.679	0.49	.42
			174	90	4.432	0.57	
			178	90	4.484	0.34	
			90	88	4.168	0.27	

VINYL CHLORIDE CONCENTRATION DATA

PLANT C

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Maintenance Coordinator	C-8	12/17/74 1	170	89	5.216	0.55	.40
			173	90	5.186	0.52	
			177	90	5.238	0.28	
			89	92	5.079	0.25	
Spare Operator	C-11	12/17/74 1	172	90	4.533	0.62	.37
			176	90	4.171	0.38	
			180	90	3.980	0.27	
			96	90	3.492	0.22	
Purification Operator South	C-4	12/16/74 2	195	91	4.687	0.46	.35
			198	90	4.561	0.19	
			202	90	4.338	0.66	
			85	90	4.355	0.09	
Spare Operator East	C-5	12/16/74 2	181	96	5.038	0.11	.32
			186	84	3.905	0.21	
			187	90	4.822	0.21	
			108	89	5.330	0.75	
Pipe Fitter North & South	C-16	12/17/74 1	103	90	4.179	0.41	.30
			112	90	4.299	0.32	
			117	91	4.241	0.16	
			206	92	4.172	0.32	
G. C. Operator	C-19	12/18/74 1	207	90	5.067	0.03	.28
			211	88	4.983	1.01	
			214	93	3.712	0.06	
			217	89	4.714	0.04	
Purification Operator South	C-13	12/17/74 1	104	90	4.675	0.51	.25
			109	90	4.613	0.15	
			114	90	4.717	0.11	
			119	90	4.698	0.24	
Spare North & South	C-2	12/16/74 2	192	88	4.552	0.40	.22
			196	90	4.497	0.20	
			200	90	4.835	0.17	
			86	91	4.621	0.13	
Synthesis Operator East	C-7	12/16/74 2	183	89	4.999	0.11	.21
			185	92	5.310	0.21	
			188	90	5.241	0.21	
			190	89	5.493	0.33	

VINYL CHLORIDE CONCENTRATION DATA

PLANT C

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Furnace Operator North & South	C-3	12/16/74 2	193	92	4.872	0.28	.20
			197	90	4.912	0.22	
			201	90	4.716	0.20	
			87	90	4.816	0.11	
Purification Operator North	C-14	12/17/74 1	105	90	4.755	0.13	.14
			110	90	4.786	0.09	
			115	90	4.679	0.12	
			120	90	4.827	0.22	
Spare Operator North & South	C-15	12/17/74 1	106	90	4.628	0.12	.14
			111	90	4.398	0.08	
			116	90	4.781	0.15	
			205	90	4.945	0.20	
Furnace Operator North & South	C-12	12/17/74 1	102	90	5.026	0.10	.13
			107	90	4.796	0.10	
			113	90	4.850	0.13	
			118	90	4.547	0.19	
G. C. Operator	C-24	12/19/74 2	224	90	4.883	0.19	.11
			227	87	4.615	0.10	
			230	90	4.758	0.08	
			233	93	4.893	0.06	
Instrument Lab Operator	C-20	12/18/74	208	85	5.133	0.02	.10
			210	90	5.230	0.27	
			213	92	5.319	0.07	
			216	93	5.290	0.04	
Wet-Lab Operator	C-25	12/19/74 2	225	92	5.278	0.09	.09
			229	88	4.069	0.11*	
			232	90	5.043	0.09	
			235	90	5.026	0.07	
Area Samples							
Plant Scrubbers		12/18/74 1	209	90	3.274	7.06	3.25
			212	90	3.260	1.60	
			215	90	3.315	1.61	
			218	90	3.451	2.73	

VINYL CHLORIDE CONCENTRATION DATA

PLANT C

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Area Samples (continued)							
VC Reflux Pumps North		12/19/74 2	226	98	4.821	0.59	2.49
			228	87	3.530	1.15	
			231	90	3.626	5.19	
			234	90	3.678	3.17	
North Plant		12/18/74 1	92	465	17.394	0.57	.57

*Front Only Est. Back Section.

VINYL CHLORIDE CONCENTRATION DATA

PLANT D

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Extruder	D-2	2/4/75 1	317	90	4.745	.01	.01
			322	90	4.790	<.01	
			327	120	6.164	<.01	
			332	65	3.334	<.01	
Blender	D-3	2/4/75 1	316	90	4.602	<.01	.01
			323	90	4.640	.01	
			328	121	6.210	<.01	
			333	60	3.149	.02	
Extrusion Foreman	D-6	2/5/75 1	338	90	4.786	.01	.01
			342	90	4.687	.02	
			346	108	5.647	.01	
			350	72	3.783	.01	
Extruder	D-1	2/3/75 1	303	120	5.419	<.01	<.01
			304	60	2.674	N.D.	
			308	90	4.003	N.D.	
			312	90	4.059	<.01	
Extruder	D-2	2/3/75 1	301	120	5.924	<.01	<.01
			305	60	2.909	<.01	
			309	90	4.412	<.01	
			313	91	4.445	<.01	
Extruder	D-1	2/4/75 1	318	90	3.989	<.01	<.01
			321	90	4.021	<.01	
			326	120	5.760	<.01	
			331	70	3.441	<.01	
Extrusion Foreman	D-6	2/6/75 1	352	90	4.442	<.01	<.01
			356	120	5.759	<.01	
			360	90	4.297	<.01	
			364	60	2.852	<.01	
Blender	D-3	2/3/75 1	302	120	5.023	<.01	<.01
			307	60	2.498	<.01	
			311	91	3.705	<.01	
			315	90	3.692	<.01	
Lab Man (Colorest)	D-7	2/6/75 1	354	88	4.730	<.01	<.01
			358	117	6.151	<.01	
			362	80	3.865	<.01	
			366	75	3.825	<.01	

VINYL CHLORIDE CONCENTRATION DATA

PLANT D

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Project Supervisor	D-5	2/5/75 1	337	92	4.713	N.D.	
			341	88	4.447	.01	<.01
			345	125	6.218	.01	
			349	55	2.742	.01	
Project Supervisor	D-5	2/6/75 1	353	90	4.264	<.01	
			357	120	5.517	<.01	<.01
			361	90	4.597	<.01	
			365	60	3.148	<.01	
Project Engineer	D-4	2/4/75 1	320	97	5.097	<.01	
			325	73	3.577	<.01	<.01
			330	100	4.834	<.01	
			334	90	4.597	.01	
Project Engineer	D-4	2/5/75 1	336	90	4.485	.01	
			340	90	4.506	.01	.01
			344	116	5.710	<.01	
			348	65	3.285	.01	
Area Samples							
Extrusion on Top of Extruder #6		2/5/75 1	339	90	4.882	.02	
			343	90	4.713	.01	.01
			347	100	6.078	.01	
			351	80	3.829	.01	
Top of Extruder #6		2/6/75 1	355	90	4.600	.01	
			359	120	6.247	.01	.01
			363	90	4.666	.01	
			367	60	3.159	<.01	
Blending Room		2/3/75 1	300	120	5.010	<.01	
			306	60	2.559	.01	<.01
			310	90	3.760	N.D.	
			314	90	3.909	N.D.	
Blending Room		2/4/75 1	319	90	3.940	<.01	
			324	91	4.217	N.D.	<.01
			329	120	5.690	<.01	
			335	60	3.169	<.01	

VINYL CHLORIDE CONCENTRATION DATA

PLANT E

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Mixer	E-8	2/11/75 1	397	90	4.474	.15	.16
			403	90	4.452	.11	
			409	90	4.550	.27	
			415	90	4.588	.11	
Compounder	E-5	2/10/75 1	376	90	4.118	.03	.03
			380	89	4.109	.06	
			387	91	4.517	.02	
			394	90	4.251	.01	
Lab Personnel	E-1	2/10/75 1	372	91	4.487	.05	.03
			379	89	4.706	.06	
			386	100	5.520	.01	
			393	81	4.405	.02	
Extruder	E-3	2/10/75 1	374	90	4.444	.02	.02
			382	90	4.474	.01	
			389	93	4.659	.01	
			368	87	4.484	.02	
Molder	E-4	2/10/75 1	375	90	4.577	.03	.02
			381	90	4.452	.02	
			388	90	4.346	.02	
			395	90	4.548	.01	
Lab Personnel	E-7	2/11/75 1	396	90	4.798	.04	.02
			402	90	4.901	.01	
			408	90	4.798	.02	
			414	90	4.904	.01	
Maintenance	E-6	2/10/75 1	377	90	4.351	.02	.01
			384	95	4.737	.01	
			391	99	4.408	.01	
			370	89	4.351	.01	
Extruder	E-10	2/11/75 1	399	90	4.355	.01	.01
			405	90	3.821	.01	
			411	91	4.548	<.01	
			417	89	4.435	<.01	
Finisher	E-2	2/10/75 1	373	90	4.569	.02	.01
			383	91	4.662	.01	
			390	92	4.624	.01	
			369	87	4.629	.01	

VINYL CHLORIDE CONCENTRATION DATA

PLANT E

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Molder	E-9	2/11/75 1	398	90	3.850	.01	<.01
			404	90	4.489	<.01	
			410	90	4.525	<.01	
			416	90	4.331	<.01	
Finisher	E-11	2/11/75 1	400	90	4.542	.01	<.01
			406	90	4.617	<.01	
			412	90	4.142	<.01	
			418	90	4.659	<.01	
Maintenance	E-12	2/11/75 1	401	90	4.697	.02	<.01
			407	90	4.715	<.01	
			413	90	4.635	<.01	
			419	90	4.686	<.01	
Area Samples							
Mixing Deck		2/10/75 1	378	90	4.387	.24	.37
			385	90	4.389	.43	
			392	92	4.401	.13	
			371	88	4.366	.68	

VINYL CHLORIDE CONCENTRATION DATA

PLANT F

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Dipper (Automatic)	F-2	2/12/75 1	432	95	5.168	.06	.02
			420	96	5.437	<.01	
			428	91	5.128	<.01	
			438	101	5.987	N.D.	
Line & Dip (Hand)	F-3	2/12/75 1	437	93	4.817	.06	.02
			422	87	4.300	.01	
			429	101	5.101	<.01	
			442	98	4.887	N.D.	
Line & Dip (Hand)	F-5	2/12/75 1	436	90	4.725	.04	.01
			424	89	4.735	.01	
			431	95	5.106	N.D.	
			440	98	5.241	N.D.	
Set-Up Man	F-6	2/12/75 1	435	89	4.844	.03	.01
			423	83	4.474	.01	
			430	102	5.331	<.01	
			443	101	5.217	N.D.	
Foreman	F-1	2/12/75 1	434	105	5.576	.02	.01
			421	87	5.163	.02	
			426	99	6.024	<.01	
			439	103	6.061	<.01	
Mixer	F-4	2/12/75 1	433	92	5.170	.02	<.01
			425	86	4.862	.01	
			427	103	5.485	<.01	
			441	101	5.230	N.D.	
Line Girl (Hand)	F-9	2/13/75 1	447	94	4.735	<.01	<.01
			463	87	4.292	N.D.	
			466	93	4.636	<.01	
			455	102	5.294	N.D.	
Mixer	F-4	2/13/75 1	445	98	5.356	<.01	<.01
			461	90	4.765	N.D.	
			467	91	5.192	N.D.	
			453	106	6.382	N.D.	
Dipper (Hand)	F-8	2/13/75 1	446	98	5.287	N.D.	N.D.
			462	88	4.957	N.D.	
			459	93	5.194	N.D.	
			454	103	5.903	N.D.	

VINYL CHLORIDE CONCENTRATION DATA

PLANT F

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Dipper (Hand)	F-10	2/13/75 1	448	94	4.916	N.D.	N.D.
			464	87	4.433	N.D.	
			450	93	4.589	N.D.	
			456	102	5.518	N.D.	
Lab Tech	F-7	2/13/75 1	444	93	4.830	N.D.	N.D.
			460	90	4.765	N.D.	
			458	99	5.184	N.D.	
			452	96	5.082	N.D.	
Area Samples							
Above & Left of Mixing Unit (Breathing Zone)		2/13/75 1	449	102	5.795	N.D.	N.D.
			465	87	4.884	N.D.	
			451	93	4.929	N.D.	
			457	101	5.507	N.D.	

VINYL CHLORIDE CONCENTRATION DATA

PLANT G

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Compounder	G-4	2/18/75 1	480	93	4.619	N.D.	
			483	95	4.643	N.D.	
			488	108	5.389	N.D.	
			492	91	4.207	N.D.	
Banbury Mixer	G-1	2/17/75 1	468	89	4.800	N.D.	
			471	90	4.991	N.D.	
			474	90	5.028	N.D.	
			477	101	5.488	N.D.	
Banbury Mixer	G-1	2/18/75 1	481	92	4.778	N.D.	
			484	95	4.688	N.D.	
			489	108	5.389	N.D.	
			493	86	4.457	N.D.	
Mill Operator	G-2	2/17/75 1	469	94	5.123	N.D.	
			472	83	4.669	N.D.	
			475	89	5.279	N.D.	
			478	99	5.637	N.D.	
Mill Operator	G-2	2/18/75 1	482	92	5.011	N.D.	
			485	94	4.968	N.D.	
			490	108	5.513	N.D.	
			494	87	4.447	N.D.	
Millman	G-7	2/19/75 1	497	94	5.298	N.D.	
			502	83	5.029	N.D.	
			507	88	5.314	N.D.	
			512	106	6.346	N.D.	
Tuber Feeder	G-8	2/19/75 1	498	93	4.931	N.D.	
			503	83	4.445	N.D.	
			508	88	4.837	N.D.	
			511	106	5.877	N.D.	
Tuber Operator	G-9	2/19/75 1	499	93	4.483	N.D.	
			505	82	3.937	N.D.	
			509	88	4.244	N.D.	
			514	106	5.247	N.D.	
Press Operator	G-3	2/17/75 1	470	82	4.038	N.D.	
			473	81	4.061	N.D.	
			476	90	4.465	N.D.	
			479	107	5.395	N.D.	

VINYL CHLORIDE CONCENTRATION DATA

PLANT G

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Press Operator	G-5	2/18/75 1	487	91	5.292	N.D.	
			486	93	4.911	N.D.	
			491	110	7.029	N.D.	
			495	85	5.373	N.D.	
Receiving Dock Truck Driver	G-6	2/19/75 1	496	99	4.840	N.D.	
			501	83	4.133	N.D.	
			506	87	4.295	N.D.	
			513	106	5.231	N.D.	
Area Samples							
Compounding		2/19/75 1	500	90	4.204	N.D.	
			504	90	4.063	N.D.	
			510	89	2.580	N.D.	
			515	132	6.178	N.D.	

VINYL CHLORIDE CONCENTRATION DATA

PLANT H

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Blender Operator	H-2	3/12/75	521	180	9.743	.13	.07
		1	523	180	9.506	<.01	
Blender Operator	H-1	3/13/75	531	180	10.714	<.01	<.01
		1	535	181	10.378	<.01	
Mixer Operator	H-5	3/12/75	525	187	9.090	<.01	<.01
		2	528	181	8.506	<.01	
Oil Man	H-4	3/12/75	524	183	9.032	<.01	<.01
		2	527	181	8.635	<.01	
Foam Line Chief	H-6	3/12/75	526	180	8.705	<.01	<.01
		2	529	180	9.054	<.01	
Calender Chief	H-3	3/12/75	520	180	10.317	<.01	<.01
		1	522	182	10.287	<.01	
Calender Chief	H-3	3/13/75	532	180	9.576	<.01	<.01
		1	536	181	9.634	N.D.	
Mechanic	H-7	3/13/75	530	184	8.888	<.01	<.01
		1	534	176	8.729	N.D.	
Blender Operator	H-1	3/11/75	516	192	10.726	N.D.	
		1	518	180	10.154	N.D.	
Blender Operator	H-2	3/11/75	517	182	9.488	N.D.	
		1	519	180	9.495	N.D.	
Area Samples							
L-1000 Blender		3/14/75	533	180	10.632	<.01	<.01
		1	538	180	11.456	<.01	
L-3000 Blender		3/14/75	537	180	8.771	<.01	<.01
		1	539	180	10.085	<.01	

VINYL CHLORIDE CONCENTRATION DATA

PLANT I

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
5-L Wind-up Man	I-10	3/18/75 1	555 561	180 221	8.797 11.164	1.68 1.92	1.81
5-L Wind-up Man	I-9	3/18/75 1	554 560	200 204	10.494 10.415	1.15 2.44	1.80
5-L Wind-up Man	I-8	3/18/75 1	553 559	182 227	9.169 11.483	1.05 1.36	1.22
5-L Assistant Operator	I-11	3/18/75 1	556 563	180 218	7.979 9.633	.50 1.56	1.07
Dicer II Blender Operator	I-4	3/17/75 1	543 546	183 120	8.390 5.320	.69 .54	.63
Dicer II Blender Operator	I-1	3/17/75 1	540 547	191 123	10.534 7.109	.68 .46	.59
5-L Blender Operator	I-3	3/17/75 1	542 548	186 118	10.907 7.373	.53 .58	.55
5-L Banbury Operator	I-2	3/17/75 1	541 549	192 119	10.518 5.847	.60 .37	.51
Dicer II Millman	I-5	3/17/75 1	544 551	186 109	9.590 5.100	.32 .48	.38
Dicer II Driver-Bagger	I-13	3/19/75 1	564 570	188 197	4.583 15.773	.76 .02	.38
5-L Millman	I-7	3/18/75 1	552 558	180 232	9.875 12.899	.39 .31	.35
Dicer II Operator	I-16	3/19/75 1	567 573	195 193	10.233 10.179	.57 .13	.35
R&D Lab Technician	I-18	3/19/75 1	569 574	184 207	10.616 11.779	.68 .02	.33
5-L Millman	I-6	3/17/75 1	545 550	180 99	8.411 4.880	.26 .24	.25
Dicer II Bagger	I-14	3/19/75 1	565 571	187 203	9.311 3.609	.48 .03	.24

VINYL CHLORIDE CONCENTRATION DATA

PLANT I

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
Dicer II Operator	I-12	3/18/75 1	557	199	11.270	.26	.20
			562	196	11.392	.13	
Dicer II Bagger	I-15	3/19/75 1	566	185	8.268	.38	.19
			572	203	9.635	.02	
Dicer II Blender Operator	I-17	3/19/75 1	568	186	10.620	.13	.14
			575	193	10.862	.14	

VINYL CHLORIDE CONCENTRATION DATA

PLANT J

Job Classification	Worker Code	Date & Shift	Sample Number	Time (min)	Volume (liters)	VCL (ppm)	TWA
"C" Calender Operator	J-6	4/9/75 1	581 587	180 180	8.224 8.786	.02 .02	.02
Plastisol Blender	J-9	4/10/75 1	590 596	185 175	11.699 11.423	.02 .02	.02
Plastisol Blender	J-10	4/10/75 1	591 597	184 176	10.086 9.822	.02 .02	.02
"C" Mill Operator	J-5	4/9/75 1	580 586	180 180	9.268 9.202	<.01 .01	.01
Tower Worker	J-1	4/9/75 1	576 582	180 191	9.196 11.339	<.01 <.01	<.01
"A" Blender Operator	J-2	4/9/75 1	577 584	180 180	7.374 8.142	<.01 <.01	<.01
"B" Blender Operator	J-11	4/10/75 1	592 598	186 174	8.808 8.347	<.01 <.01	<.01
"A" Banbury Operator	J-7	4/10/75 1	588 594	180 182	8.483 8.815	<.01 N.D.	<.01
"C" Banbury Operator	J-3	4/9/75 1	578 583	180 180	9.837 8.830	<.01 <.01	<.01
Color Weighman	J-4	4/9/75 1	574 585	180 180	9.428 10.032	<.01 <.01	<.01
"B" Feed Mill Operator	J-8	4/10/75 1	589 595	195 167	10.207 8.383	<.01 <.01	<.01
"B" Mix Mill Operator	J-12	4/10/75 1	593 599	196 164	10.099 8.834	.01 <.01	<.01

ANALYSIS OF DATA

General

Based on the Code of Federal Regulations, Title 29, Chapter XVII, Part 1910.93q, effective date 1 April 1975, an action level of 0.5 ppm averaged over an 8-hour day, a permissible exposure limit of 1 ppm averaged over an 8-hour day, and a ceiling of 5 ppm averaged over any period not exceeding 15 minutes is prescribed for employees exposed to vinyl chloride.

This survey has shown that exposures above the action level of 0.5 ppm, permissible exposure limit of 1 ppm (TWA), and ceiling of 5 ppm exist at times in the work areas of vinyl chloride manufacturing plants. Detection methods employed in this survey comply with the NIOSH Vinyl Chloride report, P&CAM #127.[3]

Data obtained from surveys conducted at three vinyl chloride manufacturing plants shows that employees classified as Loaders, Operators, and Laboratory Technicians perform in areas where concentrations of vinyl chloride above the TWA of 1 ppm and ceiling of 5 ppm were detected.

Plant A

The concentration ranges of vinyl chloride detected on the charcoal tubes exposed at Plant A are listed below.

Classification	Concentration Range (ppm)
Laboratory Technicians	0.04 to 4.36
Operators	0.13 to 2.45
Loaders	0.17 to 1.89
Instrument Men	0.02 to 0.25
Shift Supervisors	0.03 to 0.21
Area (plant)	0.56 to 5.89
Area (loading)	<0.01 to 0.01

[3] Ibid

During sample handling and operations, laboratory technicians wore cartridge-type respirators. Loaders are required to wear air line breathing respirators during all loading and transfer operations. All other personnel are required to wear cartridge-type respirators where vinyl chloride concentrations in the work area are above 25 ppm. No loading operations were conducted during the time that the survey was performed.

The 4.36 ppm concentration shown above for Laboratory Technicians was experienced by a laboratory technician who was out in the plant collecting vinyl chloride (liquid) samples from sampling ports during a 1-1/2-hour period, and who was exposed to vinyl chloride fumes.

The 2.45 ppm concentration shown for Operators resulted from the 108-minute period during which one operator was exposed to vinyl chloride while out in the plant performing routine inspection and control operations. Another operator, on a previous day, was exposed to 1.57 ppm of vinyl chloride while performing similar duties. Operators working in the control room were not exposed to concentrations of vinyl chloride above the action level during the same time periods.

During the three continuous 1-1/2-hour periods that the loader was exposed to concentrations of vinyl chloride above the action level, he was performing routine duties in the storage area, loading area, and pipe line transfer area. Another operator, on a previous day, was not exposed to concentrations of vinyl chloride above the action level during four continuous 1-1/2-hour periods while performing similar duties.

Stationary area samples taken near four individual vinyl chloride reactors indicated the presence of vinyl chloride concentrations of 0.56, 2.19, 4.03, and 1.10 ppm for four consecutive 1-1/2-hour periods on one

day, and 1.28, 5.89, 2.03, and 1.33 ppm for four consecutive 1-1/2-hour periods the next day.

Plant B

The concentration ranges of vinyl chloride detected on the charcoal tubes exposed at Plant B are listed below.

Classification	Concentration Range (ppm)
Loaders	3.00 to 84.77
Operators	0.01 to 3.46
Laboratory Technicians	0.03 to 0.88
Pipe Fitters	0.01 to 0.33
Chromatographers	0.02 to 0.12
Area (loading)	0.09 to 1.22
Area (plant)	0.05 to 0.38

During sample handling operations, laboratory technicians wore cartridge-type respirators. Loaders wore air line breathing respirators during transfer operations. All vinyl chloride plant personnel have been issued one or more types of respirators and are required to wear a respirator when the potential for exposure to vinyl chloride exists and when opening and closing valves.

No loading operations were conducted during the time that the survey was performed.

During four consecutive 1-1/2-hour periods, the third-shift loader was exposed to vinyl chloride concentrations of 84.77, 3.00, 7.13, and 11.59 ppm while performing transfer operations and other routine duties in the vinyl chloride storage and tank car loading area. The transfer line valves that were operated were located beneath the storage spheres.

On a previous day, during three separate 1-hour and two separate 1-1/2-hour consecutive time periods, a first-shift loader was exposed to vinyl chloride concentrations of 10.80, 28.52, 13.12, 19.32, and 14.63 ppm while

performing similar operations. Stationary samples taken beneath the tank car loader's shack gave readings of 1.22, 0.09, 0.20, 0.36, and 0.31 ppm for the same time periods. This indicates that vinyl chloride was leaking to the atmosphere during the operation of the transfer valves beneath the vinyl chloride storage spheres.

During the first 1-1/2-hour sample taken on a first-shift tower operator, a 3.46 ppm exposure level was detected, and a 3.0 ppm exposure level was detected for a third-shift compressor house operator for the first 1-1/2-hour sample. The remaining three 1-1/2-hour samples taken for both operators were below 1.0 ppm. In the sampling period during which the tower operator was exposed to 3.46 ppm of vinyl chloride, a sampling valve was noted to be leaking. The valve was replaced by personnel wearing hose line respirators and gloves. In the sampling period during which the compressor house operator was exposed to 3.0 ppm of vinyl chloride, two vinyl chloride samples were collected in sampling containers. During the sampling operation and when the operator was reading gauges in the rundown area, and operating shipment line valves, the operator was wearing a cartridge-type respirator.

A first-shift laboratory technician was exposed to 0.55 and 0.88 ppm of vinyl chloride during the second and third 1-1/2-hour sampling periods. During the second period, he received two vinyl chloride samples for testing. In the third period, he was testing the air at the hatch of a light ends recovery tank during the disposal of vinyl chloride. The technician was wearing a cartridge-type respirator during this operation.

Plant C

The concentration range of vinyl chloride detected on the charcoal tubes exposed at Plant C are listed following.

Classification	Concentration Range (ppm)
Loaders	0.06 to 21.8
Operators	0.08 to 18.2
Chromatographers	0.02 to 1.01
Shift Supervisors	0.25 to 0.55
Pipe Fitters	0.16 to 0.41
Laboratory Technicians	0.07 to 0.11
Area (plant)	0.59 to 7.06

During sample handling operations, laboratory technicians wore cartridge-type respirators and gloves. Loaders wore air line breathing respirators and gloves during tank car loading and transfer operations. All plant personnel have been issued respiratory protection devices and are required to wear them when working in areas or performing specific operations where the exposure to vinyl chloride is higher than, or could be higher than, the permissible OSHA limit. Disposable or washable coveralls and gloves are required for personnel performing tasks which could expose them to vinyl chloride.

During tank car loading operations, three loaders working as second-shift team were exposed to vinyl chloride. One loader was exposed to 17.6, 0.06, 21.8, and 0.23 ppm of vinyl chloride. The second loader was exposed to 6.19, 0.34, 20.1, and 1.13 ppm of vinyl chloride, and the third loader was exposed to 1.74, 0.09, 14.6, and 0.37 ppm of vinyl chloride in four consecutive 1-1/2-hour sampling periods. During the first sampling period, the loaders were hooking up a tank car for loading. During the second sampling period, they were in the loading house. Tank car sampling operations were performed in the third sampling period. Tank car filling operations were checked several times during the fourth sampling period. Air line respirators, gloves, and washable coveralls were worn during the above sampling and tank car filling operations. On the previous day, two first-shift loaders working as a team on tank car filling and sampling operations were exposed to 0.67, 2.31, 0.35, and 0.38 ppm of vinyl chloride for the first

loader and 1.50, 0.98, 0.34, and 0.99 ppm for the second loader. During the first sampling period, the tank car was sampled prior to filling. The tank car was hooked up for filling. Filling was started during the third sampling period and continued through the fourth sampling period. The loaders spent most of the third and fourth sampling periods in the loading house during the tank car filling operations. Air line respirators, washable coveralls, and gloves were worn when working near or on the tank car.

Two vinyl chloride operators in the East plant were exposed to higher-than-permissible levels of vinyl chloride on different days. A first-shift operator was exposed to 18.2, 0.61, 0.37, and 0.88 ppm, and a second-shift operator was exposed to 6.24, 0.22, 0.21, and 1.95 ppm of vinyl chloride during four consecutive 1-1/2-hour sampling periods. The first- and second-shift operators made a check of the scrubbers during the first and fourth sampling periods. Hose line respirators were worn by both operators during checkout of the scrubbers. Four 1-1/2-hour stationary area samples taken at the scrubbers read 7.06, 1.60, 1.61, and 2.73 ppm and are an apparent source of vinyl chloride fumes.

A second-shift purification operator in the North plant was exposed to 3.35, 0.20, 0.25, and 0.10 ppm of vinyl chloride during four consecutive 1-1/2-hour sampling periods. During the first sampling period, a rundown check of the valves, gauges, and equipment was performed. During the check-out, a cartridge-type respirator was worn. Four consecutive 1-1/2-hour stationary area samples taken at the vinyl chloride reflux pumps near the North plant purification train read 0.59, 1.15, 5.19, and 3.17 ppm.

A gas chromatograph operator was exposed to 0.03, 1.01, 0.06, and 0.04 ppm of vinyl chloride during four consecutive 1-1/2-hour sampling periods.

During the second sampling period, the operator was analyzing ethylene dichloride, ethyl chloride, and trichloroethane samples in the gas laboratory and was not handling any vinyl chloride. No respirator was worn during the analysis operations.

Plants D, E, F, G, H, I, and J

The concentration ranges of vinyl chloride detected on the charcoal tubes exposed in the polyvinyl chloride processing plants were below the OSHA-prescribed action level except for Plant I. The concentration ranges for the polyvinyl chloride plants surveyed are listed below.

Classification	Concentration Range (ppm)
Plant D	<.01 to .02
Plant E	<.01 to .37
Plant F	N.D. to .06
Plant G	N.D.
Plant H	<.01 to .13
Plant I	.02 to 2.44
Plant J	<.01 to .02

The potential for exposure to vinyl chloride is considerably higher at Plant I than for the other polyvinyl chloride processing plants surveyed. In addition to the polyvinyl chloride processing facilities, Plant I has two on-site polyvinyl chloride resin manufacturing plants. The potential for vinyl chloride in the atmosphere and work areas appears to be considerably higher for resin manufacturing plants than for the vinyl chloride manufacturing or polyvinyl chloride processing industries. During the second day of the survey at Plant I, a rupture disc failed in one of the polymerization reactors and vented vinyl chloride through a vent pipe in the roof of the polymerization plant. The polymerization plants are located on opposite sides of the 5L calender and diced compound plant where concentrations of

vinyl chloride above the 1 ppm TWA levels were detected on that day. Vinyl chloride levels ranging from 0.24 to 0.68 ppm were detected on samples collected the previous day, and 0.02 to 0.76 ppm on the day following the failure of the rupture disc. Housekeeping, equipment operation, compounding operations, and safety programs are good at this plant. The higher amounts of vinyl chloride detected in the processing plant were undoubtedly pulled into the processing plant from the adjacent resin plants via the ventilating system.

The elimination of entrained vinyl chloride in the polyvinyl chloride resin and compounds supplied to the polyvinyl chloride processing companies by the resin and compound manufacturing companies will eliminate the occurrence of vinyl chloride fumes above the OSHA-prescribed action level in the polyvinyl chloride plants that do not have nearby resin manufacturing facilities.

CONCLUSIONS

The following conclusions were reached during the in-depth surveys performed at three vinyl chloride manufacturing plants and seven polyvinyl chloride processing plants.

- Despite sincere efforts on the part of all companies contacted to reduce the level of vinyl chloride to which their employees are exposed, vinyl chloride concentrations above the OSHA-prescribed 1-ppm TWA and 5-ppm, 15-minute ceiling still exist in some vinyl chloride manufacturing, storage, and loading areas.
- Loading personnel must wear respirators and protective clothing designed to handle the high concentrations of vinyl chloride that occur during vinyl chloride transfer and loading operations.
- Instruments that detect the presence of vinyl chloride in the work areas are necessary to prevent personnel from being unaware of exposure to vinyl chloride.
- All personnel working in vinyl chloride plants must be supplied with and trained in the use of respirator devices that are designed to handle the concentrations of vinyl chloride that can occur in the work area.
- Personnel handling vinyl chloride should wear gloves and disposable or washable outer garments in addition to a suitable respirator.
- All of the vinyl chloride manufacturing plants contacted for the vinyl chloride survey produced vinyl chloride in outdoor facilities. The enclosed control rooms, laboratories, and eating and smoking rooms should be maintained under positive pressure with the air free from chemical contaminants to prevent these areas from being contaminated by outside air.

- There have been many recent changes made in equipment seals and designs, improved ventilation, revised operating procedures, and improved industrial hygiene and safety practices. These changes for improvement, plus the use of closed-loop sampling and loading systems have had and will continue to have considerable effect in reducing the concentration of vinyl chloride in vinyl chloride manufacturing plants. See Description of Vinyl Chloride Monomer Plants Surveyed (Plants A, B, and C).
- The reduction of entrained vinyl chloride in the polyvinyl chloride resins and compounds used by the polyvinyl chloride processing industry has reduced the exposure of the workers in this industry below the OSHA-prescribed action level of 0.5 ppm.