



Foster D. Snell, Inc.

General Laboratories

Hanover Road

Florham Park, New Jersey 07932

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August 23, 1974

Mr. James Kallenborn
Acting Director of Planning, Evaluation and Research
OSHA
MNWA Building
Room 110
1726 M Street, N.W.
Washington, D. C. 20036

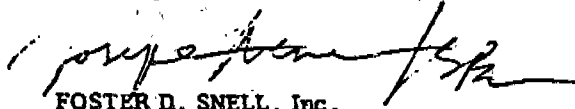
Re: Contract No. L/A 74-167

Dear Mr. Kallenborn:

The following is the preliminary report being submitted by August 23, 1974 for insertion into the Vinyl Chloride Hearing Transcripts. As agreed, the report presents the findings gathered by the study team during the seven weeks begun July 1, 1974. The conclusions developed and presented in this report are preliminary, and will be subjected to further analyses in the remaining period of the contract.

Please do not hesitate to call should you have any questions about this report.

Sincerely,


FOSTER D. SNELL, Inc.

Joseph Nemec, Jr., Ph.D.
Vice President

mjs

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BOOZ • ALLEN & HAMILTON Inc.

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DRAFT FINAL REPORT

ECONOMIC IMPACT STUDIES OF THE EFFECTS OF PROPOSED
OSHA STANDARDS FOR VINYL CHLORIDE

Contract No. ~~E/A~~ 74-167

Mr. James Kallenborn
Acting Director of Planning, Evaluation and Research
OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

U. S. DEPARTMENT OF LABOR

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September 13, 1974

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September 13, 1974

Mr. James Kallenborn
Acting Director of Planning, Evaluation and Research
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1726 M Street, N.W.
Washington, D.C. 20036

Re: Contract No. DA 74-167

Dear Mr. Kallenborn:

The following is the Draft Final Report being submitted for insertion into the Vinyl Chloride Hearing Transcripts. The Draft Final Report supersedes the Preliminary Report and includes refinement of the Preliminary Report as well as incorporation of limited new information.

This Draft Final Report presents Snell's evaluation of the technical feasibility and resulting costs of compliance with various target levels of Vinyl Chloride exposure. The work includes data on monitoring and personal protective equipment, and worker medical surveillance.

Mr. James Kallenborn
OSHA
September 13, 1974
Page Two

The report is organized into two sections:

- . Analysis of the findings and conclusions
- . Supporting Appendices

We would like to thank you for the cooperation provided by you and your associates in this study. Please do not hesitate to call should you have any questions about this report.

Sincerely,

FOSTER D. SNELL, Inc.

Joseph Nemec, Jr., Ph.D.
Vice President

mjs

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VI-1

PVC INDUSTRY CLAIMED ANNUAL COSTS TO ACHIEVE VCM TARGET LEVELS AND
SUSTAIN 1974 CAPACITY

VI-3

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INTRODUCTION

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I. INTRODUCTION

This chapter presents the background of the economic impact study of the proposed OSHA standards for vinyl chloride, the study scope and the organization of the report.

1. SNELL'S ASSIGNMENT WAS TO ASSESS THE ECONOMIC IMPACTS RESULTING FROM THE COST TO INDUSTRY FOR MEETING ALTERNATE STANDARDS FOR WORKER EXPOSURE TO VINYL CHLORIDE MONOMER (VCM) IN THE VCM AND POLYVINYL CHLORIDE (PVC) MANUFACTURING INDUSTRIES

On January 22, 1974 the Occupational Safety and Health Administration (OSHA) was informed by the National Institute for Occupational Safety and Health (NIOSH) that the B.F. Goodrich Chemical Company reported the deaths of several of its employees from a rare liver cancer (angiosarcoma) may have been occupationally related. As a result of this information, subsequent epidemiological studies and a fact-finding hearing, an Emergency Temporary Standard (ETS) was promulgated by OSHA on April 5, 1974 detailing preliminary regulations on worker exposure to VCM (50 ppm ceiling exposure limit).

As required by law, six months after the issuance of an ETS a permanent standard must be formulated and approved. Therefore, on May 10, 1974 OSHA published a proposed permanent standard which included "no-detectable limit".

To aid OSHA in carrying out its standard setting mandate Snell was assigned to prepare this report dealing with assessing the economic impacts of alternate standards for worker exposure to VCM in the VCM and PVC manufacturing industries. The alternate standards investigated are:

- . 50 ppm ceiling
- . 25 ppm ceiling
- . 25 ppm 8-hour time weighted average (TWA) with a 40 ppm ceiling
- . lower TWA(s) with a ceiling
- . "no-detectable" proposed permanent standard

The study is limited to U.S. production of VCM and PVC.

Exhibit I-1, on the following page, is a summary of the scope of the Snell study.

EXHIBIT I-1
U. S. Department of Labor/Occupational Safety
and Health Administration
THE SCOPE OF THE SNELL STUDY

Primary Emphasis

- Assess the economic impact of VCM regulation on VCM and PVC manufacturing only
- Concentrate on PVC manufacture (approximately 80% of level of effort)
- Investigate the following alternate standards
 - 50 ppm ceiling
 - 25 ppm ceiling
 - 25 ppm TWA⁽²⁾ with 40 ppm ceiling
 - lower TWA(s) with ceiling
 - 'no detectable' level
- Emphasize key regulatory considerations
 - engineering and work practices primarily
 - use of personal protective equipment
 - environmental and personal monitoring
 - assembling of exposure data
 - residual monomer levels in PVC

Secondary Requirements

- Include a study of VCM manufacture (approximately 20% of level of effort)
- Include secondary regulatory considerations⁽¹⁾
 - medical surveillance costs
 - record keeping costs
 - covered workers
 - regulated areas

Deliverables

• Deliver preliminary report on the 50 ppm, 25 ppm and 'no detectable' cases in 7 weeks starting on July 1, 1974 on 23 August 1974

• Present draft final report in 11 weeks (13 September 1974)

• Key deliverables are

- estimates of the time table required in each of these evaluations for effective implementation
 - .. in the near-term, 6 months to one year
 - .. in the longer-term, 2 years or more
- estimates of the costs of achieving the various levels of VCM controls evaluated
- assessment of economic impact on the basis of technical feasibility, timing and costs

(1) Other regulatory considerations include, for example, emergency situations and signs and labels, but were not included in the scope of Snell's work. All the regulatory considerations assigned for study are listed in the Exhibit. The work scope did not include study of PVC substitutes or evaluation of economic impacts outside the VCM and PVC sectors.

(2) TWA = Time weighted average

2. THE REPORT IS ORGANIZED INTO TWO PARTS

The report conclusions and recommendations are presented first supported by detailed appendices.

(1) The First Part Of The Report Represents The Findings Of Economic Impact Together With Recommendations

Part One includes the following outputs:

- . Chapter I - Introduction. This chapter summarizes the problem, the scope of the study and the organization of the study.
- . Chapter II - Methodology. This chapter presents the Snell study methodology.
- . Chapter III - Industry Structure. This chapter presents data on:
 - members of the VCM and PVC producing industries;
 - location of plants;
 - marketing and base-line economic data.
- . Chapter IV - The Technology of the Industry. This chapter describes the processes of VCM and PVC and includes:
 - process description and flow diagrams for each major process;
 - representative operating procedures.
- . Chapter V - Findings and Economic Analysis. This chapter details the major findings and economic analysis emphasizing technical feasibility, timing, and costs based on aggregating individual company data to the industry levels as a function of various VCM levels.

Chapter VI - Conclusions and Recommendations

(2) The Second Part Of The Report Presents Detailed Study Documentation (Appendices)

This part of the report is comprised of eight appendices and supports the material in Part One.

- . Appendix A - Detailed Process Description and Procedures
- . . Appendix B - Exposure Data For Polyvinyl Chloride (PVC) and Vinyl Chloride (VCM) Plants
- . Appendix C - Economic Details
- . Appendix D - Personal Protective Equipment and Hygiene
- . Appendix E - Monitoring Equipment
- . Appendix F - Medical Surveillance of Employees
- . Appendix G - Safety Awareness Programs
- . Appendix H - NIOSH Recommended Occupational Health Standard for the Manufacture of Synthetic Polymer from Vinyl Chloride.

* * * * *

This chapter presented the scope of the study and organization of this report. The following chapter details the methodology used by Snell to carry out the study.

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II. METHODOLOGY

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II. METHODOLOGY

The Final Report supersedes the Preliminary Report. The timing of the project was such that on August 23, 1974, seven weeks from the start of the study, the Preliminary Report was submitted to USDOL/ OSHA for inclusion into the Hearing Record for comments. The Preliminary Report featured:

- fact-finding, such as field visits and telephone interviews including recontacting of parties for data clarification;
- preliminary analysis of regulatory scenarios.

The Final Report represents refinement of the Preliminary Report as well as inclusion of limited additional information. The draft of the Final Report was timed for September 13, 1974 by the end of the eleventh week of the study.

The methodology used by Snell in fulfilling the work requirement was to perform the study in several major tasks described below. All exhibits are presented at the conclusion of the text of this chapter.

1. PLANT AND INDUSTRY VISITS WERE A PRINCIPAL MEANS OF INFORMATION GATHERING

- During the course of the investigation, Snell team members made 29 industry visits. The vinyl chloride and polyvinyl chloride industries consist of 30 producers and 53 plants. These visits involved either day long technical discussions in their engineering and production offices or detailed plant tours.
- Exhibit II-1 presents the plants, location and purposes of these trips. These trips were comprised of:

$$\frac{29}{53} = 54\%$$
$$\frac{24}{53} = 45\%$$

- 24 plant visits

- .. 16 polyvinyl chloride plants representing 41% of the polyvinyl chloride plants
- .. 8 vinyl chloride plants representing 53% of the vinyl chloride plants

- 8 visits to corporate engineering offices

out of 30 Co's $\frac{8}{30} = 26\%$

2. INDUSTRY RELATED ORGANIZATIONS, GOVERNMENTAL AGENCIES, EQUIPMENT MANUFACTURERS, AND SPECIALISTS WERE VISITED TO SUPPLEMENT INFORMATION OBTAINED FROM PLANT VISITS

In order to gain a broader view of the technical feasibility and necessary costs, personal visits were made to recognized experts in the areas covered by the study.

Exhibit II-1 details the organizations, governmental agencies, and equipment manufacturers visited and the types of information obtained. These visits included:

- 4 visits to government agencies
- 3 visits to industry organizations
- 4 visits to equipment manufacturers or technical specialists

3. A TELEPHONE SURVEY WAS CONDUCTED OF MANUFACTURERS OF MONITORING EQUIPMENT, RESPIRATORY DEVICES, PERSONAL PROTECTIVE EQUIPMENT AND PROCESS EQUIPMENT

The purpose of this task was to obtain detailed information covering costs, availability, and technology. Information was obtained both directly through the telephone survey and the brochures and catalogues sent to Snell as a result of the conversations.

Exhibit II-3 details the manufacturers interviewed during the telephone survey.
Calls were made to:

- 13 monitoring equipment manufacturers
- 7 manufacturers of respiratory equipment
- 6 producers of protective clothing
- 7 processing equipment manufacturers

4. THE SNELL INFORMATION CENTER STAFF CONDUCTED A LITERATURE SURVEY TO IDENTIFY AND OBTAIN BACKGROUND INFORMATION ON AREAS RELEVANT TO THIS STUDY

To obtain an overview of manufacturing processes, pollution problems, marketing, end-use products, and possible protective devices, etc., a survey of the following journals was performed:

- . Hydrocarbon Processing - 15 years
- . Modern Plastics - 5 years
- . Chemical Marketing Reporter - 3 years
- . Chemical and Engineering News - 3 years
- . Chemical Engineering - 5 years
- . European Chemical News - 3 years

Standard chemical reference texts such as the Encyclopedia of Polymer Science and Technology and the Kirk-Othmer Encyclopedia of Chemical Technology were also researched to obtain more general information.

Chemical Marketing Abstracts and Chemical Economics Handbook were used for basic industrial facts.

5. THE STUDY METHODOLOGY EMPHASIZED THE PARAMETERS DEFINED IN EXHIBIT I-1,
IN THE INTRODUCTION CHAPTER

The methodology described in the above points was employed to determine and define the scope of the following parameters:

- . Profiling of industry structure and processes
- . Definition of the number of workers potentially exposed to VCM considering
 - job description
 - unit operation
 - potential exposure to VCM levels
- . Determination of costs and means of controlling exposure levels through engineering controls and improved work practices with particular attention to:
 - "buttoning-up" of plants
 - ventilation
 - operation
 - maintenance
 - process improvements, such as reducing free monomer levels in the polymer
- . Investigation of further methods and costs of protection through the use of personal protective equipment beyond controlling exposure through engineering and work practices

Development of a technical and economic information base for personal and area monitoring and leak determination equipment

Isolation of information regarding:

- medical surveillance costs
- record keeping costs
- covered workers
- regulated areas

Detailed methodology is presented as footnotes to exhibits, textual reference or material in the appendices

6. AS DIRECTED BY OSHA THE STUDY DEALT PRIMARILY WITH PVC PRODUCTION

Approximately 80% of the level of effort was devoted to PVC production. Discussion emphasis in subsequent chapters reflects this.

PROCESSES
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7. WORK AFTER THE PRELIMINARY REPORT FOCUSED ON THE FURTHER ANALYSIS OF VCM LEVELS, AND THE RESULTANT COSTS, GENERAL DATA REFINEMENT AND FURTHER EVALUATION OF TECHNOLOGY

The principal work elements in the finalization of the Preliminary Report included:

- . Study of comments from OSHA, public review and Snell's internal review of the Preliminary Report resulting in clarifications and refinement of the data
- . Aggregation of individual plant exposure data from each company as well as from OSHA to develop industry profiles of average VCM levels
- . Development of order-of-magnitude estimates of the potential economic impacts of meeting the PVC industry exposure limits of a 10-15 ppm VCM ceiling with a 5-10 ppm TWA
- . Preparation of a case study in the PVC industry as an illustration of cost analysis approach
- . Internal review of the cost analysis resulting in data refinement
- . Incorporation of limited new information on technology such as stripping

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8. WHERE THERE WAS A QUESTION AS TO THE POSSIBLE PROPRIETARY NATURE OF INFORMATION, DATA SOURCES WERE CODED

The elements of each coded plant designation are as follows:

- Random number only for VCM plants
- Random leading number for PVC plant
- PVC Plant Capacity
 - S = Small, less than 100 million lbs.
 - M = Medium, 100 to 200 million lbs.
 - L = Large, over 200 million lbs.
 - PVC Plant Age
 - New = to 10 yrs.
 - Int. = 11 to 20 yrs.
 - Old = Over 20 yrs.
 - PVC Plant Siting
 - C = Cold climate
 - W = Warm climate

For example, the code for one of the PVC plants is as follows:

52 - S - Old - C

Exhibits featuring the code refer back to this page for meaning of the elements of the code

* * * * *

This chapter detailed study methodology. The chapter that follows presents the preliminary findings and conclusions.

EXHIBIT II-X1)
USDOL/OSHA
VINYL CHLORIDE/POLYVINYL CHLORIDE
PRODUCERS VISITED AND INTERVIEWED
BY PHONE BY SNELL STAFF FOR DATA
COLLECTION

Firm or Organization Visited

✓ Air Products, Inc.
Valley Forge, Pennsylvania

NO PLANT VISIT

✓ Allied Chemicals, Inc.
Corporate H.Q.
Morristown, New Jersey

NO PLANT VISIT

American Chemical Co.
Long Beach, California

Conoco

- Corporate H.Q. Saddlebrook, New Jersey
- Oklahoma City, Oklahoma

Diamond Shamrock

- Corporate H.Q. Cleveland, Ohio
- Delaware City, Delaware
- Deer Park, Texas

Dow Chemicals, USA

- Plaquemine, Louisiana
- Oyster Creek Division, Freeport, Texas
- Texas Division, Freeport, Texas

Ethyl Corporation

Eaton Rouge, Louisiana

✓ Firestone Tire & Rubber Co.
Akron, Ohio

General Tire & Rubber Co.
Ashtabula, Ohio

Purpose of Visit

Technical and engineering data collection on PVC

Technical and engineering data collection on VCM

Plant visit on VCM and PVC

Technical and engineering data collection
Plant visit on PVC

Technical and engineering data collection on PVC

Plant visit

Plant visit

Plant visit on VCM

Plant visit on VCM

Plant visit on VCM

Plant visit on VCM

Phone interview on PVC

Plant visit on PVC

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Firm or Organization Visited

Purpose of Visit

B.F. Goodrich Co.
• Corporate H.Q. Cleveland, Ohio
• Calvert City, Kentucky
• Long Beach, California
• Louisville, Kentucky
• Pedricktown, New Jersey

Goodyear Tire & Rubber Co.
Niagara Falls, New York

Great American Chemical Co.
Fitchburg, Massachusetts

Hooker Chemical Corp.
Florence, New Jersey

✓ Monsanto
Springfield, Massachusetts

✓ National Starch & Chemical Co.
Corporate H.Q. Plainfield, New Jersey

Olin-Thompson Plastics
Assonet, Massachusetts

Pantasote
Passaic, New Jersey

Robintech, Inc.
Painesville, Ohio

Shell Oil Co.
• Corporate H. Q. Houston, Texas
• Deer Park, Texas

Stauffer Chemicals
Delaware City, Del.

Tenneco
Burlington, New Jersey

Technical and engineering data collection
Plant visit on VCM
Plant visit on PVC
Plant visit on PVC
Plant visit on PVC

Plant visit on PVC

Plant visit on PVC

Plant visit on PVC

Phone interview on PVC

Technical and engineering data collection on PVC

Plant visit on PVC

Plant visit on PVC

Plant visit on PVC

Technical and engineering data collection on VCM
Plant visit on VCM

Plant visit on PVC

Plant visit on PVC

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EXHIBIT II-1(3)
USDOL/OSHA

Firm or Organization Visited

✓ Union Carbide, Inc.
So. Charleston, West Virginia

Uniroyal Chemical Co.
Akron, Ohio

Source: Snell

Purpose of Visit

Technical and engineering data collection on PVC

Plant visit on PVC

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EXHIBIT II-2
USDOL/OSHA
GOVERNMENT AGENCIES, INDUSTRY ORGANIZATIONS,
AND EQUIPMENT MANUFACTURERS VISITED BY SNELL
STAFF FOR DATA COLLECTION

I. Government Agencies

U. S. Department of Labor
Washington, D. C.

General data collection and attend hearings.

National Institute for Occupational Safety and Health
Cincinnati, Ohio

Discussion on medical, monitoring, and protective equipment

Environmental Protection Agency
Washington, D. C. and Research Triangle Park, N. C.

General data collection

U. S. Department of Commerce
Washington, D. C.

Industry marketing data collection

II. Industry Organizations

Manufacturing Chemists Association
New York, New York

Discussions on technical feasibility and marketing data

Organizational Resources Council, Inc.
Washington, D. C.

General discussion

Society of the Plastics Industry
New York, New York

Discussions on technical feasibility

III. Equipment Manufacturers, Medical Laboratories, Industrial Consultants, Etc.

The Pfaudler Co. - Div. Sybron Corp.
Rochester, New York

Discussions on polymerizers and other technical questions
(sole U. S. suppliers of glass lined equipment)

Diagnostic Sciences, Inc. - Ivan K. Smith
Morris Plains, New Jersey

Medical surveillance data collection

Tec-Air, Inc. - David Metal
East Northport, New York

Protective equipment data collection

Human Motivation Resources - Joel D. Schaffer
Morris Plains, New Jersey

Safety program data collection

Source: Snell

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EXHIBIT II-3 (1)
USDOL/OSHA

FIRMS CONTACTED DURING THE SNELL TELEPHONE
SURVEY OF EQUIPMENT MANUFACTURERS

I. Monitoring Equipment Manufacturers

AID
West Chester, Pennsylvania

Bacharach Instrument Co.
Pittsburgh, Pennsylvania

Beckmann Instrument
Fullerton, California

Bendix Corporation
Environmental Science Division
Baltimore, Maryland

Byron Instruments, Inc.
Raleigh, N. C.

Carle Instruments
Fullerton, California
Century Systems Corp.
Arkansas City, Kansas

Hewlett-Packard Co.
Avondale, Pennsylvania

Microchemical Specialties Co.
Berkeley, California

Perkin-Elmer
Norwalk, Connecticut

Anatole J. Sipin Co.
386 Park Avenue, S.
New York, New York

Varian Association
Palo Alto, California

Wilks Scientific
Norwalk, Connecticut

II. Respiratory Equipment Manufacturers

Bausch & Lomb
Rochester, New York

Mine Safety Appliances
Pittsburgh, Pennsylvania

Minnesota Mining & Manufacturing, Inc.
Minneapolis, Minnesota

Scott Aviation
South Haven, Michigan

Survive-Air
Santa Ana, California

Welsh Scientific, Inc.
Providence, Rhode Island

Willson Products
Pennsylvania

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III. Protective Clothing Manufacturers

Arrow Disposables, Inc.
Cincinnati, Ohio

E. I. Dupont de Nemours
Wilmington, Delaware

Durafab
Cleburne, Texas

Edmont-Wilson
Coshocton, Ohio

Mars, Inc.
Ashville, North Carolina

Uniroyal, Inc.
New York, New York

IV. Processing Equipment Manufacturers

Dresser Industries
(Compressors and Vacuum Pumps)
Connersville, Indiana

Durion Company, Inc.
(Valves and Pumps)
New York, New York

Fluid Handling System
(Viking Pumps)
Secaucus, New Jersey

GAF
(Cleaning Systems)
New York, New York

Nash Engineering Co.
(Compressors and Vacuum Pumps)
Norwalk, Connecticut

Process Pumps, Inc.
(Pumps)
Kenilworth, New Jersey

Stauffer Inc.
(Cleaning Systems)
Westport, Connecticut

Source: Snell

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III. INDUSTRY STRUCTURE

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III. INDUSTRY STRUCTURE

This chapter presents an overview of the structure of the U.S. vinyl chloride monomer (VCM) and polyvinyl chloride (PVC) industries. Key elements of production, prices and markets are delineated to provide a background and comparative criteria to judge the economic impact of proposed regulations on VCM and PVC manufacturing.

The chapter is divided into three sections:

- . Section IIIA - Vinyl Chloride Monomer Production
- . Section IIIB - Polyvinyl Chloride Production
- . Section IIIC - Key Polyvinyl Chloride Markets

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IIIA. VINYL CHLORIDE MONOMER

This section defines the structure of the vinyl chloride monomer (VCM) manufacturing industry.

1. NINE COMPANIES OPERATE 14 VCM PLANTS

- . Exhibit III-1, on the following page, presents a profile of the VCM producers in terms of plant locations, capacities and manufacturing process. Process related factors are discussed in Chapter IV.
- . Shell, Dow and Goodrich are the leading 1974-1975 producers, accounting for approximately 58% of nameplate capacity.
- . Approximately 5,225 million pounds VCM are estimated to be available annually for conversion into PVC in 1974-1975, assuming no major economic impact from OSHA regulations.
- . With the exception of the Goodrich plant in Calvert City, Kentucky, the U.S. VCM plants are located in warm climate areas -- Texas, Louisiana, Puerto Rico, and California. In general, the plants are open except for weather screening.
- . VCM plants are generally located in or near petroleum rich areas to minimize the cost of feedstock (ethylene) transfer.

EXHIBIT III-1

USDOL/OSHA

PROFILE OF VINYL CHLORIDE PRODUCERS

Major Producer/Location	1974-1975 Nameplate Capacity ^(1,3) (Million lbs.)	Process ^(2,3)
Allied, Geismar, La.	300	Oxychlorination
American Chemical, Watson, Calif.	170	Stauffer Oxychlorination
Conoco, Lake Charles, La.	625	Stauffer Oxychlorination
Dow, Freeport, Tex.	*180	Dow Oxychlorination
Dow, Oyster Creek, Tex.	1,400 { *700	Dow Oxychlorination
Dow, Plaquemine, La.	{ *450	Dow Direct Chlorination
Ethyl, Baton Rouge, La.	450 { *270	Direct Chlorination
Ethyl, Houston, Tex.	{ *150	Direct Chlorination
Goodrich, Calvert City, Ky.	1,000	Goodrich Oxychlorination
Monochem, Geismar, La.	350	Acetylene
PPG, Guayanilla, P. R.	900 { *500	Oxychlorination
PPG, Lake Charles, La.	{ *300	Oxychlorination
Shell, Deer Park, Tex.	1,500 { *600	Stauffer Oxychlorination
Shell, Norco, La.	{ *700	Stauffer Oxychlorination
Total	<u>6,695</u>	
Correcting for 90% operating level	670	
Subtotal	<u>6,025</u>	
5% lost in polymerization	300	
Subtotal	<u>5,725</u>	
Estimated 1974 exports	300	
Estimated 1974 imports	Negligible	
Subtotal	<u>5,425</u>	
Other uses of VCM	200	
Total available for PVC conversion	<u>5,225</u>	

*Order of magnitude values

Sources:

- (1) Company and industry totals based on Modern Plastics, May, 1974 and plant site estimates based on Chemical Marketing Reporter, 17 September, 1973, and industry interviews.
- (2) Industry interviews.
- (3) Snell assessment

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2. U.S. VCM PRODUCTION HAS INCREASED APPROXIMATELY 370% TO 6,000 MILLION POUNDS IN 1974 SINCE 1964, WHILE THE MID-1974 PRICE IS 7 TO 10 CENTS PER POUND OR ALMOST DOUBLE THE 1972 PRICE

- Exhibit III-2, on the following page, presents production, sales and price data for the years 1962 through 1978-1980 (estimated). Sales and unit cost information are also presented.
- Since 1964 production of VCM has increased from 1,615 million pounds to an estimated 6,025 million pounds in 1974, for an increase of 373%.
- For the years 1962 to 1972, production of VCM increased from 1,311 million pounds to 5,089 million pounds or 388%, while merchant sales increased from 516 million pounds to 3,343 million pounds or 647%. Merchant uses were 39% of production in 1962 and 66% of production in 1972. This indicates a decreased forward integration in the industry with growth.
- The doubling of price from 1972 to mid-1974 is attributed to the great escalation in feedstock costs due to the "energy crisis".

3. THE VCM MANUFACTURING INDUSTRY HAS APPROXIMATELY 940 PRODUCTION WORKERS

- Based on a Snell survey of VCM producers, representing approximately 65% of 1974-1975 nameplate capacity (see Exhibit III-1), estimates were developed of the number of production and related personnel in the industry.

EXHIBIT III-2

USDOL/OSHA

VINYL CHLORIDE MARKET TRENDS

<u>Year</u>	<u>Production⁽¹⁾</u> <u>(MM Lbs.)</u>	<u>Sales⁽¹⁾</u> <u>(MM Lbs.)</u>	<u>Unit Value</u> <u>(¢/Lb.)</u>
1962	1,311	516	7.5
1963	1,435	501	7.0
1964	1,615	597	6.4
1965	2,000	638	6.1
1966	2,500	836	5.9
1967	2,424	952	5.3
1968	2,969	1,463	4.6
1969	3,736	2,359	4.4
1970	4,040	2,720	3.9
1971	4,336	3,003	4.2
1972	5,089	3,343	4.0
1973	5,348	NA	5 ⁽²⁾
1974	6,025 ⁽³⁾	NA	7-10 ⁽²⁾
1978-- (Unimpacted by OSHA Standards)	6,800 ⁽⁴⁾	NA	NA

Sources:

- (1) "Synthetic Organic Chemicals", U. S. Tariff Commission, Annual Reports 1960-1973.
- (2) Posted price in tanks (works, freight equalized), Chemical Marketing Reporter, December 31, 1973 and June 24, 1974.
- (3) Estimate based on 1974 capacity 6,695 MM Lbs. in Exhibit III-1 at 90% utilization.
- (4) 7,500 MM Lbs. capacity at 90% utilization per Hydrocarbon Processing, May, 1974, p. 83.

NA=Not Available

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Exhibit III-3, on the following page, summarizes employment data for 1974

- production, maintenance and laboratory personnel have responsibilities with likelihood of VCM exposure; these represent 720 workers or 77% of manufacturing employment
- there are approximately 220 management and support personnel

* * * * *

This section defined the structure of the VCM industry. The section that follows similarly profiles PVC manufacture.

EXHIBIT III - 3

USDOL/OSHA

VINYL CHLORIDE PRODUCTION WORKERS - 1974

<u>Broad Job Classification</u>	<u>Approximate 1974 Number of Workers</u>	<u>Percent of Total</u>
Production ⁽¹⁾	410	44%
Maintenance ⁽¹⁾	250	27
Laboratory	60	6
Management and Support ⁽²⁾	<u>220</u>	<u>23</u>
Total VCM Workers Scaled From Snell Survey	<u>940</u>	<u>100%</u>

Notes:

(1) Includes line supervisors, such as foremen

(2) Includes plant managers, engineering staff, clerical, etc.

Source:

Snell survey of industry covering approximately 65% of 1974-1975 nameplate capacity

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IIIB. POLYVINYL CHLORIDE PRODUCTION

This section defines the structure of the polyvinyl chloride (PVC) manufacturing industry. The exhibits supporting this discussion appear sequentially after the text of this section.

1. 21 COMPANIES OPERATE 36 MAJOR PLANTS

A profile of PVC producers in terms of plant locations, nameplate capacities, and probable polymerizer (reactor) sizes is summarized in Exhibit III-4. Exhibits III-5 and III-6 provide interpretation of these data.

The total 1974 nameplate capacity of the industry is approximately 5.4 billion pounds per year, with over 1.9 billion pounds of new capacity scheduled over the next two years.

As shown in Exhibit III-5, no single company dominates PVC production.

- Goodrich, the largest single producer with five plants, produces approximately 20% of the nation's PVC.
- The next five largest producers, with a total of nine plants, each produce between 6% and 9% of total production. These producers are Firestone, Conoco, Union Carbide, Borden and Diamond Shamrock.
- Each of the next thirteen producers, with a total of twenty plants, shares from 1% to less than 5% of total production.
- The remaining two companies, with a total of two plants, each shares less than 1% of total PVC production.

PVC is produced in sixteen states, as shown in Exhibit III-6. Production is close to raw material supply (VCM) or near resin market centers.

- Over 50% of PVC resin capacity is concentrated in five states - Ohio, New Jersey, Texas, Massachusetts and California.
- Within these five states are located eighteen producing plants.
- Only ten plants are located in warm climates where open structures are possible; the remaining twenty-six plants are sited in states having moderate to cold temperatures.

26/36 = 72%

A majority of the operating plants are older than ten years, as estimated in Exhibit III-7.

- About 58% of the plants are older than ten years.
- Only 8% of operating plants are less than five years old, with the newest plant starting operation in 1971.
- Two new plants are scheduled to come on stream in late 1974, and several others are planned for later construction, seen from Exhibit III-4.

Historically, PVC production has been a batch operation and manufacturing was conducted in relatively small reactors to maintain product flexibility, quality, and most important, these reactors were not available in large capacities.

- As shown in Exhibit III-4, reactor sizes are almost equally divided between those plants using reactors less than 2,500 gal. capacity, and those between 2,500 gal. and less than 7,500 gal.
- Only nine plants use polymerizers equal to or larger than 7,500 gal.

According to recent technological developments, the trend is toward larger reactors in new plants. An industry-wide summary of PVC homopolymer production as a function of reactor size in 1972 vs. 1975 is summarized in Exhibit III-8.

- Approximately 85% of the homopolymer produced in 1972 was made in reactors with 7,500 gallons or smaller capacity.
- By 1975, it is expected that the smaller reactors will account for less than 60% of total production.
- Bulk polymerization capacity is expected to almost double.
- The use of small reactors is expected to continue in the long run, but only for production of specialty resins.

The four methods used for polymerizing PVC include suspension, emulsion, bulk, and solution polymerization, with suspension polymerization being used at a majority of plants as shown in Exhibit III-9.

- Suspension resin production is reported in 33 plants, accounting for 78% of 1973 output.
- Emulsion resin production is reported in 16 plants, accounting for 13% of 1973 output.
- Four plants produce bulk resins, while 2 plants produce solution resins, accounting for 9% of 1973 output.

2. THE PVC MANUFACTURING INDUSTRY HAS APPROXIMATELY 5,600 PLANT EMPLOYEES

Based on the survey of PVC producers by Snell, estimates were developed of the 1974 number of production and related personnel in the industry, as shown in Exhibit III-10.

- the approximately 3,600 workers identified with suspension processes represent 64% of industry employment, while emulsion process workers represent 27%; bulk and solution process workers represent 9%
- 55% of PVC plant employment is represented by production workers, while 24% by maintenance personnel; these approximately 3,900 workers have the highest likelihood of VCM exposure.

The Snell survey yielded an estimate of 5,575 plant employees. A confidential study by industry sources independent of Snell, presented in Exhibit B-1, identified 5,045 workers.

* * * * *

This section defined the structure of the PVC manufacturing sector. The section that follows defines key PVC markets.

EXHIBIT III - 4(1)

USDOL/OSHA

PROFILE OF POLYVINYL CHLORIDE PRODUCERS

Producer	Location	Approximate 1974 Nameplate Capacity (million lbs.)	Planned Million Lbs. Per Year	Additions Starting Date	Probable Polymerizer Size Range (gallons)		
					<2,500	2,500 - <7,500	>7,500
Air Products	Calvert City, Ky.	125	200-300	planned		x	
	Pensacola, Fla.	80				x	
American Chemical	Long Beach, Cal.	160			x	x	x
Atlantic Tubing			50	2nd qtr. 1974			
Borden	Illioopolis, Ill.	125	200	late 1974		x	
	Leominster, Mass.	190			x	x	
	Springfield, Mass.	70			x		
Certain-Teed	Lake Charles, La.		300	late 1974		n.a.	
Conoco	Aberdeen, Miss.	250	(	4th qtr.	x	x	x
	Oklahoma City, Okla.	215	(unspecified	1974			x
Diamond Shamrock	Deer Park, Tex.	250	200	late 1974		x	x
	Delaware City, Del.	100				x	x
Ethyl	Baton Rouge, La.	180	unspecified	under way		x	
Firestone	Pottstown, Pa.	190	{ unspecified	under way	x	x	
	Perryville, Md.	315				x	
General Tire & Rubber	Ashtabula, Ohio	125			x	x	

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EXHIBIT III - 4(2)

USDOL/OSHA

PROFILE OF POLYVINYL CHLORIDE PRODUCERS

Producer	Location	Approximate 1974 Nameplate Capacity (million lbs.)	Planned Million Lbs. Per Year	Additions Starting Date	Probable Polymerizer Size Range (gallons)		
					< 2,500	2,500 - < 7,500	> 7,500
Georgia-Pacific	Plaquemine, La.		220	4th qtr. 1974		n. a.	
B. F. Goodrich	Ayer Lake, Ohio	315			x	x	
	Henry, Ill.	235			x	x	
	Long Beach, Calif.	190			x	x	
	Louisville, Ky.	180			x	x	
	Pedricktown, N. J.	160			x	x	
Goodyear	Niagara Falls, N. Y.	100			x		x
	Plaquemine, La.	100	100	3rd qtr. 1974	x	x	
Great American Chemical	Fitchburg, Mass.	70			x		
Hooker Chemical	Burlington, N. J.	180	{ expansion held in abeyance				
	Hicksville, N. Y.	15			x		
Keysor-Century	Saugus, Cal.	35			x		
National Starch	Meredosia, Ill.	10 ⁽¹⁾			x		
Olin	Assonet, Mass.	150			x	x	
Pantasote	Passaic, N. J.	60			x		
	Point Pleasant, W. Va.	95 ⁽²⁾			x	x	

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EXHIBIT III - 4(3)

USDOL/OSHA

PROFILE OF POLYVINYL CHLORIDE PRODUCERS

Producer	Location	Approximate 1974 Nameplate Capacity (million lbs.)	Planned Million Lbs. Per Year	Additions Starting Date	Probable Polymerizer Size Range (gallons)		
					<2,500	2,500 - <7,500	>7,500
Robintech	Painesville, Ohio	250	220	4th qtr. 1974		x	
Stauffer	Delaware City, Del.	160	10	3rd qtr. 1975		x	x
			55	3rd qtr. 1976			
Tenneco	Burlington, N.J.	150				x	x
	Flemington, N.J.	85			x	x	
	Pasadena, Tex.		300	4th qtr. 1974		N. A.	
Union Carbide	S. Charleston, W. Va.	160				x	
	Texas City, Tex.	240				x	x
Uniroyal	Painesville, Ohio	120			x	x	
Total Nameplate Capacity		945	Planned or Anticipated New Capacity	1,900+	22	27	9

Notes: (1) Operates a pilot plant at Plainfield, N.J. with an estimated capacity of 0.2 million pounds
 (2) Jointly owned by Pantasote and General Tire & Rubber, and operated by Pantasote

Sources: Chemical Marketing Reporter, May 20, 1974; industry interviews; Modern Plastics, May 1974.

N. A. - not available

EXHIBIT III - 5

USDOL/OSHA

COMPANY CAPACITY AS PERCENT OF TOTAL
POLYVINYL CHLORIDE PRODUCTION CAPACITY

<u>Company</u>	<u>1974 Company Nameplate Capacity (million lbs.)</u>	<u>Share of Total Capacity at mid 1974 (percent)</u>	<u>Accumulated Percent</u>
B. F. Goodrich	1080	19.9%	19.9
Firestone	505	9.3	29.2
Conoco	465	8.6	37.8
Union Carbide	400	7.4	45.2
Borden	385	7.1	52.3
Diamond Shamrock	350	6.4	58.7
Robinsco	250	4.6	63.3
Tenneco	235	4.3	67.6
Air Products	205	3.8	71.4
Goodyear	200	3.7	75.1
Hooker	195	3.6	78.7
Ethyl	180	3.3	82.0
Stauffer	160	2.9	84.9
American Chemical	160	2.9	87.8
Pantasote	155	2.9	90.7
Olin	150	2.8	93.5
General Tire	125	2.3	95.8
Uniroyal	120	2.2	98.0
Great American	70	1.3	99.3
Keysor-Century	35	0.6	99.9
National Starch	10	0.2	100.1 ⁽¹⁾
Total	<u>5,435</u>	<u>100.1%⁽¹⁾</u>	

Note: (1) Does not add to 100% because of rounding errors,

Source: Exhibit III - 4 and Snell estimates

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EXHIBIT III - 6

USDOL/OSHA

GEOGRAPHIC DISTRIBUTION OF
POLYVINYL CHLORIDE PLANTS - 1971

State	Number of Plants	Production Capacity (million lbs.)	Share of Total Capacity (percent)	Accumulated Percent
✓ Ohio ⁽¹⁾	4	810 ✓	14.9 %	14.9 %
✓ New Jersey (1)	5	635	11.7	26.6
✓ Texas ⁽²⁾	2	490	9.0	35.6
✓ Massachusetts (1)	4	480	8.8	44.4
✓ California ⁽²⁾	3	385	7.1	51.5
✓ Illinois ⁽¹⁾	3	370	6.8	58.3
✓ Maryland ⁽¹⁾	1	315	5.8	64.1
✓ Kentucky ⁽¹⁾	2	305	5.6	69.7
✓ Louisiana ⁽²⁾	2	280	5.2	74.9
✓ Delaware ⁽¹⁾	2	260	4.8	79.7
✓ West Virginia ⁽¹⁾	2	255	4.7	84.4
✓ Mississippi ⁽²⁾	1	250	4.6	89.0
✓ Oklahoma ⁽²⁾	1	215	4.0	93.0
✓ Pennsylvania ⁽¹⁾	1	190	3.5	96.5
✓ New York ⁽¹⁾	2	115	2.1	98.6
✓ Florida ⁽²⁾	1	80	1.5	100.1 % ⁽³⁾
TOTAL	36	5,435	100.1 %⁽³⁾	
Notes: (1) Sited in moderate to cold climate				
	26	3,735	68.7	
(2) Sited in warm climate				
	10	1,700	31.4	
	<u>36</u>	<u>5,435</u>	<u>100.1 %⁽³⁾</u>	

Source: Exhibit III -4 and Snell estimates

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6 plant warm
weather plants
under 10 YRS

EXHIBIT III - 7(1)

USDOL/OSHA

U. S. POLYVINYL CHLORIDE PLANT AGE - 1974

Producer	Location	Plant Age As Approximately Indicated By Starting Date ⁽¹⁾ (years)					
		0 - 5	6 - 10	11 - 15	16 - 20	21 - 25	over 25
Air Products	Calvert City, Ky. Pensacola, Fla.			(x)	(x)		
American Chemical	Long Beach, Calif.			(x)			
Borden	Leominster, Mass. Illinois, Ill. Springfield, Mass.			(x) (x)		(x)	
Conoco	Aberdeen, Miss. Oklahoma City, Okla.	(x)	(x)				
Diamond Shamrock	Deer Park, Tex. Delaware City, Del.		(x)			(x)	
Ethyl	Baton Rouge, La.		(x)				
Firestone	Pottstown, Pa. Perryville, Md.		(x)			(x)	
General Tire	Ashtabula, Ohio				(x)		
Goodrich Chemical	Avon Lake, Ohio Henry, Ill. Long Beach, Calif. Louisville, Ky. Pedricktown, N. J.		(x)		(x)	(x)	(x)

EXHIBIT III - 7(2)

USDOL/OSHA

U.S. POLYVINYL CHLORIDE PLANT AGE - 1974

Producer	Location	Plant Age As Approximately Indicated By Startup Date ⁽¹⁾ (years)					
		0 - 5	6 - 10	11 - 15	16 - 20	21 - 25	over 26
Goodyear	Niagara Falls, N. Y. Plaquemine, La.	☒					☒
Great American	Fitchburg, Mass.				☒		
Hooker	Hicksville, N. Y. Burlington, N. J.		☒		☒		
Keysor-Century	Saugus, Calif.				☒		
National Starch	Meredosra, Ill.				☒		
Olin	Assonet, Mass.		☒				
Pantasote	Passaic, N. J. Point Pleasant, W. Va.		☒		☒		
Robintech	Painesville, Ohio		☒				
Stauffer	Delaware City, Del.		☒				
Tenneco	Flemington, N. J. Burlington, N. J.				☒	☒	

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EXHIBIT III - 7(3)

USDOL/OSHA

U. S. POLYVINYL CHLORIDE PLANT AGE - 1974

Producer	Location	Plant Age As Approximately Indicated by Startup Date ⁽¹⁾ (years)					
		0 - 5	6 - 10	11 - 15	16 - 20	21 - 25	over 26
Union Carbide	S. Charleston, W. Va. Texas City, Tex.		x x				
Uniroyal	Painesville, Ohio						x
Total		<u>3</u>	<u>12</u>	<u>6</u>	<u>8</u>	<u>4</u>	<u>3</u>

Notes:

- (1) Or when plant underwent drastic rebuilding
 (2) Joint plant with General Tire & Rubber and operated by Pantasote

Source:

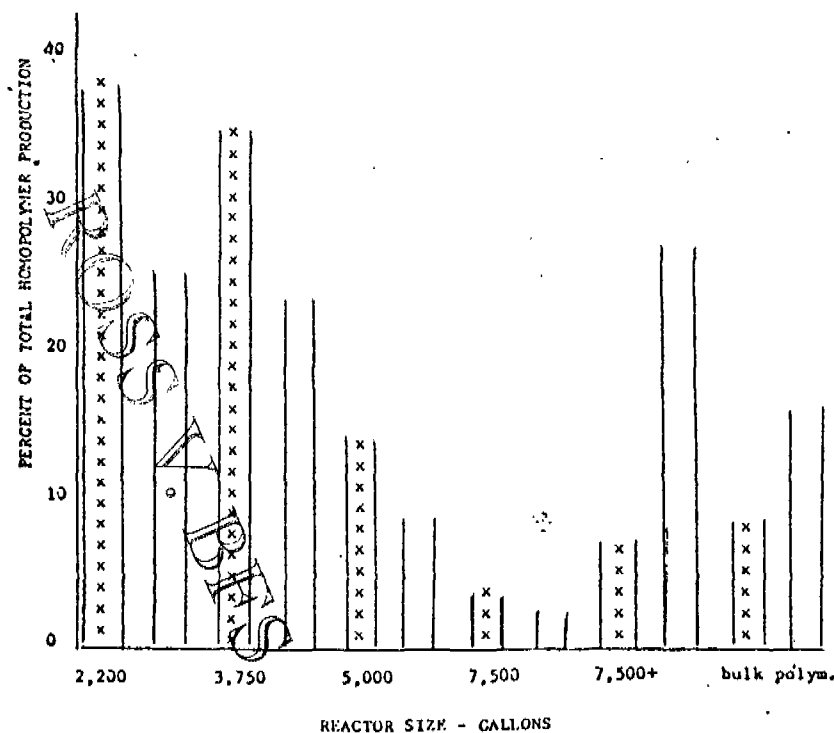
Snell industry interviews

4/12 WMM 2/6 7/8 1/4 0/3 WMM
 WMM WMM WMM

EXHIBIT III-8

USDOL/OSHA

PVC HOMOPOLYMER PRODUCTION IN VARIOUS
SIZE REACTORS - 1972 1975
[x] []



Note: Assumes no impact from OSHA requirements

Source: Disch, G.E., Plastics -- Raw Materials to End Markets and Coatings-- New Technology and Markets, American Chemical Society, Brooklyn, 1974, p.7.

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EXHIBIT III - 9(1)

USDOL/OSHA

POLYVINYL CHLORIDE PRODUCTION BY
RESIN TYPE

<u>Producer⁽¹⁾</u>	<u>Location⁽¹⁾</u>	<u>Product Line</u>			
		<u>Suspension Resin</u>	<u>Emulsion Resin</u>	<u>Bulk Resin</u>	<u>Solution Resin</u>
Air Products	Calvert City, Ky.	x			
	Pensacola, Fla.	x			
American Chemical	Long Beach, Calif.	x			
Atlantic Tubing		x			
Borden	Leominster, Mass.	x	x		
	Illioopolis, Ill.	x	x		
	Springfield, Mass.	x			
Conoco	Aberdeen, Miss.	x			
	Oklaoma City, Okla.	x			
Diamond Shamrock	Deer Park, Tex.	x	x		
	Delaware City, Del.	x	x		
Ethyl Corp.	Baton Rouge, La.	x	x		
Firestone	Pottstown, Pa.	x	x		
	Perryville, Md.	x			
General Tire	Ashtabula, Ohio	x			

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EXHIBIT III - 9(2)

USDOL/OSHA

POLYVINYL CHLORIDE PRODUCTION BY
RESIN TYPE

Producer ⁽¹⁾	Location ⁽¹⁾	Product Line			
		Suspension Resin	Emulsion Resin	Bulk Resin	Solution Resin
Goodrich Chemical	Ayer Lake, Ohio	x	x		
	Hemp, Ill.	x	x		
	Long Beach, Calif.	x			
	Louisville, Ky.	x	x		
	Pedricktown, N. J.	x	x	x	
Goodyear	Niagara Falls, N. Y.	x	x		
	Plaquemine, La.			x	
Great American	Fitchburg, Mass.	x			
Hooker	Burlington, N.Y.			x	
	Hicksville, N.Y.	x			
Keysor-Century	Saugus, Calif.	x			
National Starch	Meredosia, Ill.		x		
Olin	Assonet, Mass.	x			
Pantasote	Passaic, N.J.	x			
	Point Pleasant, W. Va.	x			

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EXHIBIT III - 9(3)

USDOL/OSHA

POLYVINYL CHLORIDE PRODUCTION BY
RESIN TYPE

<u>Producer (1)</u>	<u>Location (1)</u>	<u>Product Line</u>			
		<u>Suspension Resin</u>	<u>Emulsion Resin</u>	<u>Bulk Resin</u>	<u>Solution Resin</u>
Robintech	Painesville, Ohio	x			
Stauffer	Delaware City, Del.	x	x		
Tenneco	Burlington, N.J.	x	x		
	Flemington, N.J.	x			
Union Carbide	S. Charleston, W. Va.		x		x
	Texas City, Tex.	x		x	x
Uniroyal	Painesville, Ohio	x	x		
Total		<u>33</u>	<u>16</u>	<u>4</u>	<u>2</u>
1973 U. S. Production, million lbs.		3,558	593	274	137
Percent of Total Production		78%	13%	6%	3%

Note: (1) Jointly owned with General Tire, operated by Pantasote

Sources: Industry interviews and Snell assessment of product lines

Monthly Statistical Report, The Society of the Plastics Industry, Inc., April 6, 1973 and March 20, 1974 for production data

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EXHIBIT III - 10

USDOL/OSHA

POLYVINYL CHLORIDE PRODUCTION WORKERS - 1974

<u>Broad Job Classification</u>	<u>Workers By Process Type</u>					<u>Percent of Total</u>
	<u>Suspension</u>	<u>Emulsion</u>	<u>Bulk</u>	<u>Solution</u>	<u>Total</u>	
Production (1)	1,920	790	135	185	3,030	55%
Maintenance (1)	790	470	25	(	~ 1,350	24
Laboratory	260	100	{ 25	{ 125	~ 390	7
Management and Support (2)	610	140	{	{	~ 805	14
Total PVC Industry Workers Scaled From Snell Survey (3)	<u>3,580</u>	<u>1,500</u>	<u>185</u>	<u>310</u>	<u>5,575</u>	<u>100%</u>
Percent of Approximate 1974 Capacity Covered by Snell Survey °	79%	67%	100%	100%		

Notes:

- (1) Includes line supervisors, such as foremen
 (2) Includes plant managers, engineering staff, clerical, etc.
 (3) Personnel associated with compounding and fabrication in integrated facilities are not counted

Sources:

Snell survey of industry

IIIC. KEY POLYVINYL CHLORIDE MARKETS

This section presents data on polyvinyl chloride (PVC) output trends, prices, end-uses, and polymer characteristics regarding free monomer levels as shipped to fabricators. Supporting exhibits appear sequentially at the end of the text.

1. PVC PRODUCTION HAS INCREASED OVER 300 PERCENT FROM 1963 TO 1973, AND FROM 1972 TO MID-1974 PRICES HAVE APPROXIMATELY DOUBLED

Exhibit III-11 shows production, sales, and unit value trends since 1960.

- The increase in output from 1963 to 1973 was 318%.
- The leveling of output from 1972 to 1973 is attributed to a significant extent to feedstock and capacity shortages.
- In 1963, captive consumption represented only 13% of production, while in 1972 this was 10%.
- Unit value has steadily decreased until 1972.

Exhibit III-12 presents recent price data for the major resin types as well as price and supply/demand forecasts for the 1978-1980 period.

- Between 1972 and mid-1974 prices have approximately doubled due to the effects of the "energy crisis", for example, from \$0.10-\$0.11 per lb. in 1972 to \$0.21-\$0.23 per lb. in mid-1974 for homopolymer resins.
- By 1978-1980 price leveling is expected, assuming minimal impact from safety and environmental regulations.

- The average expected increase by 1978-1980 in PVC output compared to 1974 levels is of the order of 40%.
- In 1978-1980 VCM supply and PVC capacity is expected to be reasonably balanced if construction expectations materialize, although PVC capacity may be tight.

Exhibit III-13 summarizes the supply situation of PVC and VCM including imports and exports.

- Exports of PVC remained at approximately 160 million lbs. in 1972 and 1973, while VCM exports dropped 32% from 620 to 420 million lbs.
- Imports of PVC increased over 15 times from 1972 to 1973, from 4 to 65 million lbs., while VCM imports remained essentially negligible.
- Exports represent approximately 4% of U.S. PVC output and 8% of VCM output.

2. MAJOR MARKETS FOR PVC INCLUDE CONSTRUCTION, HOUSEHOLD PRODUCTS, CONSUMER GOODS AND ELECTRICAL USES

PVC products find use in almost every major sector of the economy as shown in Exhibit III-14.

- Pipe and conduit applications in building and construction are the single most important end-use, accounting for 24% of 1973 consumption.
- Flooring, wire and cable, and furniture account for another 25% of 1973 consumption.

- The more rapidly growing markets for PVC are construction products, packaging, pipe, and fittings.
- More mature segments include apparel, flooring, home furnishing, phonograph records, transportation equipment, and wire and cable coating.

Exhibit III-15 provides end-use forecasts of the PVC market through 1978-1980.

- During this period consumption is expected to range from 6,330 to 6,820 million lbs.
- Construction is expected to be the dominant segment at approximately 56% market share, a significant increase from approximately 43% in 1973.

3. PVC FABRICATION PROCESSES INCLUDE CALENDERING, COATING, EXTRUSION, MOLDING AND PASTE PROCESSES

Exhibit III-16 summarizes PVC consumption by major fabrication process as well as resin kind.

The table below shows the distribution of resin type in 1973 production.

Resin Kind & Use	1973	
	Thousand Lbs.	Percent of Total
Total Polyvinyl Chloride & Copolymers Production		
(Dry Resin Content)	4,561,500	100
Homopolymer Resins	3,432,677	75
Copolymer Resins	539,627	12
Dispersion Resins, Latexes, & Blending	589,196	13

Source: Exhibit III-16

The table below shows the distribution of fabrication type in 1973 end-use.

<u>Fabrication Type</u>	1973	
	<u>Thousand Lbs.</u>	<u>Percent of Total</u>
Calendering	913,166	19.0
Coating	483,583	10.5
Extrusion	2,207,992	50.1
Molding	511,032	11.1
Paste Process	155,577	3.4
All Other	224,391	4.9
Total U.S. Sales and Use	<u>4,585,796</u>	<u>99.9%</u>

Source: Exhibit III-16

Extrusion is the most important means of fabrication with 50% of the resin processed by this means. Approximately one-half the extrusion throughput is to manufacture rigid pipe and tubing (except fittings).

4. FREE MONOMER LEVELS IN PVC SHIPPED TO FABRICATORS VARY SIGNIFICANTLY AS A FUNCTION OF RESIN TYPE AND MAJOR END-USE.

Exhibit III-17 relates average order of magnitude free monomer levels in the principal types of PVC to major fabrication category.

The table below summarizes the quantity of resin in three categories of free monomer content.

<u>Possible Free Monomer Level (ppm)</u>	<u>Approximate 1973 U. S. Sales End-Use (Million Lbs.)</u>	<u>Percent of Total</u>
less than 100	805	18%
100 to 500	3,245	70
over 500	<u>540</u>	<u>12</u>
Total	<u>4,590</u>	<u>100%</u>

Source: Exhibit III-17

According to industry sources with improvements in stripping technology average monomer levels in pipe grade and general purpose resins of less than 100 ppm can be achieved. Thus, the total resin consumption averaging less than 100 ppm average free monomer levels can be 3,850 million pounds on a 1973 annual basis or approximately 84% of the total yearly consumption.

Stripping of copolymers and latex products to below 100 ppm free monomer levels is reported to require significant technological development.

Exhibit A-7 in Appendix A broadly discusses stripping technology

* * * *

This report chapter presented the industry structure of VCM and PVC production and end-uses. The chapter that follows briefly describes the technology of the industry.

EXHIBIT III - 11

USDOL/OSHA

POLYVINYL CHLORIDE AND COPOLYMER
RESINS, RESIN EQUIVALENT BASIS

<u>Year</u>	<u>Production</u> <u>1,000 lbs. dry basis</u>	<u>Sales</u> <u>1,000 lbs. dry basis</u>	<u>Value</u> <u>1,000 dollars</u>	<u>U.S. Value</u> <u>do. \$b.</u>
1960	935,508	900,431	208,550	1,000
1961	977,254	965,810	180,741	1,000
1962	1,214,510	1,150,807	202,001	1,000
1963	1,385,845	1,207,102	218,114	1,000
1964	1,620,891	1,373,740	240,056	1,000
1965	1,827,467	1,715,321	297,189	1,000
1966	2,163,531	1,816,457	301,743	1,000
1967	2,142,433	1,927,942	302,110	1,000
1968	2,630,394	2,329,541	326,566	1,000
1969	3,022,063	2,748,068	375,393	1,000
1970	3,115,204	2,847,001	383,506	1,000
1971	3,437,328	2,935,434	402,723	1,000
1972	4,322,000	3,865,000	503,048	1,000
1973 preliminary	4,423,434			

Source: "Synthetic Organic Chemicals", U.S. Tariff Commission, Annual Reports 1960-1973

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EXHIBIT III - 12

USDOL/OSHA

POLYVINYL CHLORIDE OUTPUT AND PRICE FORECASTS

<u>Resin</u>	<u>1970⁽¹⁾</u>	<u>1972⁽¹⁾</u>	<u>July 1974⁽²⁾</u>	<u>1978-1980⁽³⁾</u>
Homopolymer Resins, \$/lb.	0.10	0.10 - 0.11	0.21 - 0.23	0.22 - 0.25
Copolymer Resins, \$/lb.	0.12	0.13	0.23 - 0.25	0.24 - 0.27
Dispersion Resins, \$/lb.	0.19	0.19	0.31 - 0.35	0.32 - 0.35
Total PVC Production, ⁽³⁾ Million Lbs.			~ 4,700	6,300 - 6,500
PVC Capacity, ⁽³⁾ Million Lbs./Year			~ 5,000	6,120 - 6,200
VCM Capacity, ⁽³⁾ Million Lbs./Year			~ 6,200	~ 7,500

Note: 1978-1980 values do not include any impact of OSHA regulations, and price and output projections are judged by Shell to be on the low side.

Sources: (1) Disch, G. E., Plastics--Raw Materials to End Markets and Coatings--New Technology and Markets, American Chemical Society, Brooklyn, 1974, p. 7

(2) Chemical Marketing Reporter, July 22, 1974

(3) Hydrocarbon Processing, May 1974, p. 83

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EXHIBIT III - 13(1)

USDOL/OSHA

SUPPLY SITUATION OF POLYVINYL CHLORIDE
AND VINYL CHLORIDE
(Million pounds)

<u>Commodity</u>	<u>12 months, Jan. - Dec.</u>			<u>Recent Monthly Trends</u>						
	<u>1973</u>	<u>1972</u>	<u>73/72 (percent)</u>	<u>Oct.</u> <u>1973</u>	<u>Nov.</u>	<u>Dec.</u>	<u>Jan.</u> <u>1974</u>	<u>Feb.</u>	<u>March</u>	<u>April</u>
<u>Production Trends</u>										
PVC	4423	4289	+3	375	368	377	378	372	402	
VCM	5348	5175	+3	472	455	450	495	467	429 ⁽²⁾	
<u>Export Trends</u>										
PVC	162	158	+3	16	18	15	15	27	33	31
VCM	420	320	-32	28	30	41	36	24	45	52
<u>Import Trends</u>										
PVC	65	4	+1525	6	4	6	4	6	3	
VCM	2	neg.	-	neg.	-	1	0.3	-	neg.	
<u>Net Supply (1, 2)</u>										
PVC	4326	4135	+5	365	364	368	357	351	372	
VCM	4930	4555	+8	444	425	410	459	443	384	

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EXHIBIT III - 13(2)

USDOL/OSHA

SUPPLY SITUATION OF POLYVINYL CHLORIDE AND
VINYL CHLORIDE
(Million pounds)

	1973	Exports As Percent of Production		
		1972	Oct. - Jan, 1973 (cum.)	Jan. - Feb, 1974 (c . .)
PVC	3.7	3.6	4.4	3.6
VCM	7.9	12.0	7.2	6.2

Notes:

- (1) Long-term contracts about 65%
 (2) Net supply equals production plus imports less exports

Source:

Chemicals and Rubber Program, Office of Business Research and Analysis, U. S. Department of Commerce,
 April 16, 1974

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EXHIBIT III - 14(1)

USDOL/OSHA

POLYVINYL CHLORIDE MAJOR MARKET:
1970 - 1973 (million pounds)

<u>Market</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>
Apparel				
Baby Pants	23.0	19.8	24.2	26.4
Footwear	110.0	112.2	140.8	145.2
Outerwear	47.0	50.6	63.0	68.2
Building and Construction				
Extruded foam moldings	na	6.6	50.6	57.2
Flooring	325.0	288.2	470.8	404.2
Lighting	9.0	9.8	11.0	11.0
Panels and siding	60.0	53.4	70.4	85.8
Pipe and conduits	475.0	583.0	803.0	1155.0
Pipe fittings		74.8	85.8	96.8
Rainwater systems, soffits, fascias	na	28.6	30.8	35.2
Swimming pool liners	35.0	39.6	44.0	39.6
Weatherstripping	30.0	30.8	39.6	35.2
Windows, other profiles	45.0	50.6	55.0	57.2
Electrical				
Wire and cable	410.0	354.2	429.0	426.8
Home furnishings				
Appliances	24.0	23.6	35.2	44.0
Furniture	247.0	250.8	297.0	319.0
Garden hose	35.0	33.0	44.0	39.6
Housewares	80.0	81.4	103.4	112.2
Wall coverings and wood surfacing films	97.0	101.2	127.6	118.8

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INDUSTRIAL HYGIENE SURVEY OF VINYL CHLORIDE

LEVELS IN MONOMER PLANT No. 1

<u>JOB CLASSIFICATION</u>	<u>OPERATION</u>	<u>PEAK EXPOSURE</u>	
		<u>PPM VCM</u>	<u>MINUTES</u>
LOADING OPERATOR	DISCONNECTING TANK CAR*	20.4	5
		26.9	10
		35.9	16
		30.9	6
		161	8
		48.1	7
		26.2	8
		22.9	5
		8.0	9
		5.9	17
		26.8	13

JOB CLASSIFICATION

SR. ASST CHEM B

OPERATIONSAMPLING
PRODUCT TANKPEAK EXPOSURE

PPM VCM MINUTES

90.2	10
59.0	6
70.4	10.5
11.7	2.5
13.9	4
7.5	3
7.6	4
5.7	2
9.7	5
0.5	5
3.8	2

*FRESH AIR MASK WORN

EXHIBIT B-104 (1)
USDOL/OSHA
MONITORING RESULTS FOR 50

LEVELS IN MONITOR PLANT NO. 2

AREA MONITORING

SAMPLE PERIOD - 4/25/74 - 6/4/74

NO. OF SAMPLES - 499 EACH LOCATION

LOCATION

VCM CONCENTRATION, PPM

AVERAGE MAXIMUM

CONTROL ROOM

0.3

7.4

LABORATORY

0.4

9.1

LOADING RACK

0.4

11⁺(1)

PRODUCT TANKS

0.5

7.2

FURNACE AREA - 1

0.3

11⁺(1)

() NO. OF SAMPLES

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LEVELS IN MONOXY PLANT NO. 2

AREA MONITORING

SAMPLE PERIOD - 4/25/74 - 6/4/74

NO. OF SAMPLES - 499 EACH LOCATION

LOCATIONVCM CONCENTRATION, PPMAVERAGEMAXIMUM

FURNACE AREA - 2

0.5

11⁺(1)

FINISHING AREA - 1

0.3

11⁺(1)

FINISHING AREA - 2

0.7

7.5

FINISHING AREA - 3

0.5

11⁺(3)

FINISHING AREA - 4

0.6

11⁺(3)

() NO. OF SAMPLES

LEVELS IN MONOMER PLANT NO. 2

JOB CLASSIFICATION	TVA, PPM VINYL CHLORIDE	
	1973	1974
OPERATIONS SPECIALIST	1.5 (2)	1.3 (8)
SR. OP. TECHNICIAN		0.7 (4)
OP. TECHNICIAN	1.2 (2)	2.2 (8)
DAY OPERATIONS	1.2 (2)	0.6 (9)
LAB PERSONNEL	9.5 (3)	4.6 (8)
SHIFT SUPERVISORS	0.4 (2)	1.0 (6)
OFFICE PERSONNEL		0.6 (4)
BOILERMAKER		2.4 (5)
ELECTRICIAN	3.5	4.3 (5)

LEVELS IN MONOMER PLANT NO. 2		
JOB CLASSIFICATION	TWA ppm VINYL CHLORIDE	
	1973	1974
INSTRUMENT	1.9	1.0 (5)
LABORER	4.5	2.6 (5)
MILLWRIGHT	4.4	1.9 (4)
PIPEFITTER	4.5	4.7 (6)
LOADING OPERATOR	4.2	10.2 (5)
MARINE OPERATOR		1.3 (6)
TANK CAR CLEANER		3.7 (2)
OVERALL AVERAGE	2.2 (17)	2.7 (90)

Source: Snell summary of industry data

EXHIBIT B-105 (1)
 USDOL/OSHA
 MONITORING RESULTS FOR 38

LEVELS IN MONITOR PLANT NO. 3

JOB CLASSIFICATION	OPERATION	PEAK EXPOSURE	
		PPM VCM	MINUTES
LOADING TECHN	DISCONNECTING TANK CAR	13.3	10
LAB TECHN	SAMPLE ANALYSIS	24.6	10
REPAIR TECHN	OPENING EQUIPMENT	1.1	10
"FRESH AIR MASK WORN		1.0	10

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LEVELS IN MOYNER PLANT NO. 3

<u>JOB CLASSIFICATION</u>	<u>OPERATION</u>	<u>PEAK EXPOSURE</u>	
		<u>PPM VCM</u>	<u>MINUTES</u>
DISTN. TECHN	EQUIPMENT SURVEILLANCE	.6	10
		2.3	10
		.3	10
		.6	10
REACTOR TECHN - 1	EQUIPMENT SURVEILLANCE	.3	10
		.3	10

LEVELS IN FOMEX PLANT NO. 3

JOB CLASSIFICATIONTWA, PPM VINYL CHLORIDE197319741ST QTR2ND QTR

REACTOR TECHN - 1

1.0

< 0.1 (3)

6.4

REACTOR TECHN - 2

N.D.*

0.1 (2)

0.5 (2)

REACTOR TECHN - 3

0.1

0.4

0.1

DISTN. TECHN

< 0.1

0.8 (2)

3.4 (4)

CONTROL CTR TECHN

—

0.4

() NO. OF SAMPLES

*N.D. = NONE DETECTED

LEVELS IN MONOMER PLANT NO. 3			
JOB CLASSIFICATION	TWA, PPM VINYL CHLORIDE		
	1973	1974	
		1ST QTR	2ND QTR
LAB TECHN	10.4	6.1 (2)	7.4 (3)
LOADING TECHN	2.1	12.3 (5)	6.3
REPAIR TECHN	0.1	<0.1	0.4 (7)
SUPERVISION	N.D.*	---	0.3
SERVICES TECHN	---	---	0.9
OVERALL AVERAGE	1.7 (8)	1.2 (17)	1.2 (21)
() NO. OF SAMPLES			
*N.D. = NONE DETECTED			

Source: Snell summary of industry data

EXHIBIT B-106(1)
 USDOL/OSHA
 MONITORING RESULTS FOR 2

<u>Area — Unit Operation</u>	<u>Current VC, ppm</u>	<u>How Measured</u>	<u>*Historical VC, ppm</u>	<u>*How Measured</u>
Polymerization	2.8 - 15	Personal Sampler, Carbon Tube		
Quality Control Lab	1.6			
Warehouse	0.9			
Silo	2.3			

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VINYL CHLORIDE EXPOSURE DATA SUMMARYPERSONNEL MONITORING RESULTS

<u>PVC Area</u>	<u>Dates 1974</u>	<u>No. Samples</u>	<u>Average Exposure (ppm)</u>	<u>Range ppm</u>	<u>Remarks</u>
Emulsion Autoclave Charge Operator	3/14-3/15	2	2.8	1.5-4.0	Within temporary standard
Suspension Autoclave Charge Operator	3/14-5/3	15	3.7	0.1-7.8	Within temporary standard
Autoclave Cleaner	3/15-5/2	7	5.2	0.3-13	No entry. Within temporary standard
Autoclave Cleaner	3/14-5/3	15	75	5.5-162	Vessel entry with mask. 6 samples above standard but exposure less because of protection.
First Floorman	4/16-5/3	14	15	1.6-44	Within temporary standard
Ribbon Blender Operator	4/16-5/3	14	4.1	0.6-13	Within temporary standard
FCM Mill Operator	4/16-5/3	14	3.7	0.2-12	Within temporary standard
Q.C. Lab Technician	4/16-5/3	14	1.6	0.1-5.6	Within temporary standard
Hopper Car Load Operator	4/16-5/3	11	2.3	0.3-4.4	Within temporary standard
Bagging Machine Operator	4/29	1	0.9	-	Within temporary standard

NOTE:

- * Previous analyses performed are not now regarded as being reliable. Based on observations following 50 ppm regulation, one location (autoclaves) was above 50 ppm and two other locations (centrifuge shed and water collection drains in polymerization building) may range above 50 ppm for brief periods. Fresh air masks are now used before entering an autoclave and the centrifuge shed. Measurement means for specific jobs was carbon tube pump system attached to operators. Area and unit operation surveillance analyses were by Miran I and II infrared instruments and a portable Century OVA flame ionization hydrocarbon analyzer.

Source: Snell summary of industry data

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EXHIBIT B-107

USDOL/OSHA

VINYL CHLORIDE TWA AS A FUNCTION OF JOB CLASSIFICATION
FOR VINYL CHLORIDE PRODUCING PLANTS

<u>Job Classification</u>	<u>Plant 34</u>	<u>Plant 50</u>	<u>Plant 38</u>	<u>Average</u>
Supervisors	3	1	0.3	1
Reactor Technicians	NA	2	2	2
Distillation Technicians	NA	NA	3	NA
Control Room Technicians	1	1	0	3
Loading Operators	12	10	6	9
Maintenance	2	3	0.4	2
Chemists	13	NA	NA	NA
Lab Technicians	1	5	7	4
Office Personnel	NA	0.6	NA	NA
Tank Car Cleaners	NA		NA	NA

Sources: Exhibits B-103, B-104, and B-105 and Snell assessment of industry provided data.

NA = Not Available

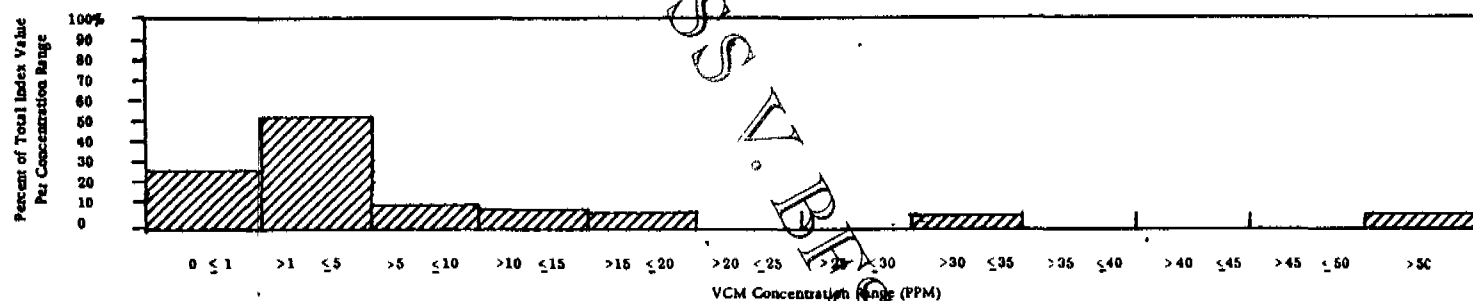
EXHIBIT B-108

USDOL/OSHA

SUMMARY OF OSHA VINYL CHLORIDE MONOMER MONITORING DATA
VINYL CHLORIDE MONOMER PLANTS

Plant	Number of VCM Concentration Measurements ⁽¹⁾ Giving Values in Concentration Ranges (PPM)												Total Points for Plant
	0-≤1	>1-≤5	5-≤10	>10-≤15	>15-≤20	>20-≤25	>25-≤30	>30-≤35	>35-≤40	>40-≤45	>45-≤50	>50	
2 ⁽²⁾ Index ⁽³⁾	3 3.75	7 8.75	2 2.50	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	12 15
9 ⁽²⁾ Index ⁽³⁾	3 7.50	2 5.00	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 2.50	6 15
14 ⁽²⁾ Index ⁽³⁾	0 0	6 10.00	0 0	1 1.67	1 1.67	0 0	0 0	1 1.67	0 0	0 0	0 0	0 0	9 15
Total No. of Points	6	15	2	1	1	0	0	1	0	0	0	1	27
Total Index Value	11	24	0	2	2	0	0	2	0	0	0	3	47
% of Total Index Value for Concentration Range	23%	51%	0%	4%	4%	0	0	4%	0	0	0	7%	100%

Average VCM Concentration for Reported 27 Samples = 8 PPM



Notes: (1) Data based on approximately 10 min. nippin type samples with 1 liter ambient air collection over charcoal tubes analyzed by the NIOSH method.

(2) Plant codes are those developed by OSHA.

(3) Index (1) developed from the formula: Number of points in range/total number of points reported = 1/15.

Sources: OSHA data submitted to Snell; Snell assessment of data.

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APPENDIX C

ECONOMIC DETAILS

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APPENDIX C

ECONOMIC DETAILS

This appendix presents economic details supporting the findings and conclusions of Chapters IV and V.

- . Exhibit C-1 presents typical delivery times for key equipment items.
- . Exhibit C-2 presents Snell's overview of the time requirements in implementing engineered controls for VCM exposure in PVC plants.
- . Exhibit C-3 is a case study for a PVC plant representative of the industry
- . Exhibit C-4 provides the statistical analysis of the economic data for the 50 ppm ceiling case for PVC.
- . Exhibit C-5 presents the distribution of reported plant additions of engineering controls estimated for selected VCM levels in PVC plants.

EXHIBIT C.- 1(1)

USDOL/OSHA

TYPICAL EQUIPMENT DELIVERY TIMES
FOR MID-1974 ORDERS

Item	Months from Order to Shipment Delivery Time	
Pumps ⁽¹⁾	Centrifugals	Carbon Steel (C. S.) Stainless Steel (S. S.) Hastelloy
		4 6
	Canned	C. S. to 15 hp 15 to 50 hp
		14 - 16 12 14 - 18
	Nash Vacuum	1,000 ACFM 23" Vac. C. S. 1,000 ACFM 28" Vac. S. S.
		8 18
Valves ⁽¹⁾	Viking (positive displacement)	All sizes
	All Types	C. S. and S. S.
		Other (plastic lined)
		5 - 6 4 - 6 6 - 8
Compressors ⁽²⁾	Low hp reciprocating	to 10 hp
	Medium sizes reciprocating	10 to 100 hp
	Standard sizes centrifugal	10 to 100 hp
	Large sizes centrifugal	over 100 hp
	Medium sizes screw type	
		2 - 3 4 - 8 4 - 8 10 - 12 4 - 5
Reactor Vessels	Glass lined	5,000 to 18,000 gal.
	Stainless	Same sizes
		16 - 24 Somewhat less than glass lined

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EXHIBIT C - 1(2)

Tanks	Field erected	over 10,000 gal.	16 - 20
Spare Parts	Pump shafts, impellers, casing		10 - 12
	Valve parts		3 - 4
	Agitators for reactors		3 - 4
	Gaskets		1 - 2
	Filter cartridges		1 - 2
	Heat exchanger tubes	C. S. S. S.	9 - 10 much longer than C. S.
	For control instruments		2 - 3

Notes:

- (1) 1 to 5 items of standard construction can be obtained straight off the shelf in many instances
 (2) Based on delivery schedules reported to be subject to substantial upward revisions

Sources:

Interviews with selected major suppliers and Snell estimates

EXHIBIT C-2(1)

USDOL/OSHA
SNELL'S OVERVIEW OF TIME REQUIREMENTS
IN IMPLEMENTING ENGINEERED CONTROLS
OF VCM EXPOSURE IN PVC PLANTS

1. THE NATURE OF THE ENGINEERING SOLUTION IS A MAJOR FACTOR IN THE DETERMINATION OF THE IMPLEMENTATION TIME

From Snell's evaluation of the various measures reported by the industry several broad categories of engineering control measures to reduce area VCM concentrations and to forestall excursion have emerged.

- . Ventilation, including spot ventilation of critical pieces of equipment
- . Modification of the loading/unloading equipment
- . Modifications to the reactors including automatic cleaning
- . Improvement of the stripping equipment

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Others, such as:

- piping modifications
- pump and compressor replacement
- provision for adequate, contained venting of critical pieces of equipment, sections of piping, etc.

(1) Ventilation Of Enclosed Areas And Spot Ventilation Of Critical Equipment Has Already Been Substantially Implemented To Meet The Emergency Temporary Standard

While indicating that substantial additions are still required to meet more stringent standards, most of the respondents have installed some form of improved ventilation. In the Northern climates substantial additions to heating equipment will be required to maintain adequate temperatures in the enclosed areas.

The considerable ductwork and additional heating, necessary to implement the 10 fold increase in ventilation required in many plants, may require up to 6 months of design work, with another 8 months for procurement and 3 months for installation. Thus significant venting improvements have a time delay of about 18 months.

Comparatively minor work on spot ventilation can usually be accomplished in about 1/2 to 3 months. Necessity for spot welding and such may require a shutdown of at least part of the plant, which, for production reasons, may add a further delay to the implementation.

(2) Changes To The Loading And Unloading Facilities Are Required, Some Of Them May Require Substantial Amounts Of Time

- The replacement of the present system of gauging the tank cars with more sophisticated equipment may be a major cost element to VCM producers who own and operate fleets of tank cars. A delay of 1 year to 2 years may be expected due to the large number of units involved.
- Immediately required changes to loading and unloading facilities pertains to venting of the connect-disconnect line between tank car (or barge) and product storage. This can be accomplished by venting through a vacuum pump, and/or nitrogen flush and implementation is a matter of weeks.

(3) Leaks Around The Reactor May Be The Most Difficult To Control

- The problems of the leaks around the reactors have been fully discussed in Appendix A, and in particular Exhibit A-3.
 - time needed in replacing or reconditioning the reactors is estimated at 18 to 24 months
 - time needed in installing solvent washing system is estimated at 30 months and 24 months for water wash system

(4) Improvement Of Stripping Would Reduce The Amount Of Free Monomer Downstream Of The Reactor, But Implementation May Be Subject To Long Delays

- PVC manufacturers recognize the advantages of improved stripping and some steps have already been implemented in many plants.
- The problem in the implementation of improved stripping systems is that some manufacturers are awaiting the completion of engineering development work before installing any interim improvement.
- A very important element in stripping improvement is the introduction of sparging steam into the stripper. Some plants will have to add steam generating capacity to achieve this, and thus implementation will be dependent on design, procurement and installation of additional steam generating equipment. In this case a delay of up to 3 years can be anticipated.

(5) Implementation Of Other Engineering Control Methods Is More Directly Related To Delays In Equipment Delivery

Typical of such Engineering Control methods would be, for instance:

- Replacement of reciprocating by rotary compressors (estimated delay 18 months).
- Replacement of seal pump by seal-less (canned) pumps (estimated delay 12 months).

- . Repiping (substitute welded for flanged).
- . Replacement of flexible (or even open channel) transfer lines with permanently connected piping.
- . Replacement of open strainers with more sophisticated (possibly self-cleaning) equipment.

2. THE NOVEL TECHNOLOGIES WHICH MAY BE REQUIRED TO ACHIEVE EXTREMELY LOW LEVELS ARE SEVERAL YEARS AWAY

Due to the extremely proprietary nature of any new development, it is not possible to indicate engineering details of new technologies involved. Continuous polymerization has a good potential, but commercialization has not been achieved to date.

The main areas of new technologies are:

- . Radical changes in production methods.
- . Generalization of the bulk (or mass) process subsequent to equipment improvements.
- . Improvement of stripping.

(1) Radical Changes In Production Methods May Be Under Development

- . Continuous polymerization in totally enclosed, remotely controlled trains would obviously contribute to bringing the PVC plant to very low background levels. Appropriate equipment type, with a view to the minimization of leakage, could be incorporated into the design at nominal incremental cost.

The table below summarizes a potential timetable for the implementation of such technology.

Hypothetical Continuous Polymerization Implementation

<u>Step</u>	<u>Completion Date</u>
Develop	January 1976
Demonstrate	January 1977
Design	January 1978
Procure and Install	January 1980

A variant may be utilization of part of present equipment. This may lead to a somewhat earlier implementation.

Since such technology is a matter of economics and engineering risk, the added burden of severe limitations on VCM emission may actually help to spur its development by making it more economically attractive. It is to be noted that one respondent indicated the existence of such a technology but described it as "highly uneconomical".

EXHIBIT C-2 (7)

USDOL/OSHA

(2) The Bulk (Mass) Process May Potentially Be More Amenable To Low Area Levels Of VCM

- Inherently the bulk process, which has no spent water stream, nor dryer gas to be disposed of, should be more environmentally acceptable. At present too few plants exist in the United States to permit an evaluation of the specific economic impact of engineering controls measures without disclosing proprietary data.
- The values reported by the one respondent using the Bulk Process both for the implementation time and for the costs per pound of capacity are among the highest in the industry.

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EXHIBIT C-3
USDOL/OSHA
PVC PLANT CASE STUDY

A CASE STUDY OF A REPRESENTATIVE PVC PLANT DETAILS THE ESTIMATED PROGRESSIVE
PLANT ADDITIONS TO REACH A VCM TARGET LEVEL OF 25 PPM CEILING WITH 10 PPM TWA

- Exhibit C-3A details the equipment which the case study plant is installing to meet a 50 ppm VCM ceiling.
- Supplier delays in shipment have delayed installation of ventilation fans and the sequential monitoring system; however, installation of all equipment to reach the 50 ppm VCM ceiling is estimated by the company to be approximately 90% complete.
- Exhibit C-3B details the equipment requirements which the case study plant estimates for a 25 ppm VCM ceiling target level. Engineering, purchase and installation is estimated to require three years.
- Exhibit C-3C details the equipment requirements which the case study plant estimates for a 25 ppm VCM ceiling with a 10 ppm TWA target level. Development, engineering, purchase and installation is estimated to require up to four years.
- Page C-3A (4) presents a sample calculation for productivity loss. In the industry aggregates, productivity loss was calculated based on the plant sample for each VCM target level.

EXHIBIT C-3A (1)

USDOL/OSHA

CASE STUDY, COMPANY ESTIMATED COSTS TO ACHIEVE A
50 PPM VCM CEILING IN A PVC PLANT AND SUSTAIN 1974 CAPACITY

<u>Item</u>	<u>Description</u>	<u>Capital Costs (¢/lb.)</u>	<u>Annual Costs (¢/lb.)</u>
I. Engineering Controls			
VCM Unloading	No additions at 50 ppm VCM ceiling		
Ventilation	Building Ventilation	0.0370	0.0033
	Raise Vent Stacks	0.0014	0.0003
	Ventilate Strainer	0.0028	-
	Supplement Polymerizer Exhaust System	0.0014	0.0007
Reactor Cleaning	Proprietary Equipment	0.0016	0.0007
Stripping	No additions at 50 ppm VCM ceiling		
Other Engineering	Replace Resin Air Conveyor Ducting	0.0004	-
	New Pump Seals	0.0004	-
	Housekeeping	0.0250	-
Subtotal, Engineering Controls		0.0700	0.0050
Amortization of Capital (12% - 10 Years)			0.0124
Total Annual Engineering Controls Costs			0.0174

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EXHIBIT C-3A (2)

<u>Item</u>	<u>Description</u>	<u>Capital Costs</u> (¢/lb.)	<u>Annual Costs</u> (¢/lb.)
II. Personal Protective Equipment			
Showers and Eating Facilities	(Reallocated to 25 ppm VCM ceiling)		
Breathing	Install Breathing Air Lines	0.0014	-
	Respirators and Filters All Employees	0.0216	0.0079
	Cartridge Respirators	0.0018	0.0659
	Airfed Respirators	0.0014	0.0026
Clothing	Daily Coveralls for Employees	-	0.0528
	Impervious Suits	-	0.0079
Other	Employee Training		0.0082
Subtotal, Personal Protective Equipment		<u>0.0262</u>	<u>0.1453</u>
Amortization of Capital (12% - 5 years)			<u>0.0073</u>
Total Annual Personal Protective Equipment Costs			<u>0.1526</u>

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EXHIBIT C-3A (3)

<u>Item</u>	<u>Description</u>	<u>Capital Costs</u> <u>(¢/lb.)</u>	<u>Annual Costs</u> <u>(¢/lb.)</u>
III. Monitoring			
Personal Monitoring	Pumps, Cartridges and Contract Analysis	0.0014	0.0177
Area and Leak Monitoring	(3) Organic Vapor Analyzers Sequential System	0.0082 0.0412	0.0528 0.0007
Medical Testing	Testing Program and Follow-Up	-	0.0385
Recordkeeping	Personnel Records	-	0.0029
Subtotal, Monitoring Costs		<u>0.0508</u>	<u>0.1126</u>
Amortization of Capital (12% - 5 years)			<u>0.0141</u>
Total Annual Monitoring Costs			<u>0.1267</u>
Subtotal, Engineering, Protective and Monitoring Costs		<u>0.1470</u>	<u>0.2966</u>
(1) Productivity Loss		<u>0.84</u>	<u>0.46</u>
Total Costs		<u>0.987¢</u>	<u>0.7566¢</u>

(1) Productivity Loss

	Capital Costs (¢/lb.)	Annual Capital Costs (¢/lb. /yr.)	O&M Costs (¢/lb. /yr.)	Annual Capital And O&M Costs (¢/lb. /yr.)
Production Loss = $\frac{\text{No. of Lbs. Lost}}{\text{1974 Capacity}} = 0.075$ (Lbs. - unimpacted by OSHA standard)				
Industry Costs Per Lb. of Plant Output	11.11¢	1.97¢	3.90¢	5.87¢
(Capital Costs From Exhibit IV-13, Manufacturing Cost From Exhibit IV-13, i. e. Cost of Manufacture Less VCM Costs And Capital Charges)				
Additional Estimated Costs for Engineering Controls in Case Study Plant at 1974 Capacity	<u>0.07</u>	<u>0.01</u>	<u>0.00</u>	<u>0.01</u>
Subtotal, Estimated Plant Cost Per Lb. Output (Capital Amortized @ 12% - 10 Years)	<u>11.18</u>	<u>1.98</u>	<u>3.90</u>	<u>5.88</u>
Additional Personal And Monitoring Costs in Case Study Plant at 1974 Capacity (Capital Amortized at 12% - 5 Years)	<u>0.08</u>	<u>0.02</u>	<u>0.26</u>	<u>0.28</u>
Subtotal	<u>11.26</u>	<u>2.00</u>	<u>4.16</u>	<u>6.16</u>
Total Additional Costs Per 1974 Production Lb. To Sustain 1974 Production (Capital or Annual Cost x Production Loss)	<u>0.84¢</u>			<u>0.46¢</u>

Source: Company Interview and Snell estimates.

EXHIBIT C-3B (1)

USDOL/OSHA

CASE STUDY
 COMPANY ESTIMATED COSTS TO
 ACHIEVE A 25 PPM VCM CEILING
 IN A PVC PLANT AND SUSTAIN
 1974 CAPACITY

<u>Item</u>	<u>Description</u>	<u>Capital Costs</u> <u>(¢/lb.)</u>	<u>Annual Costs</u> <u>(¢/lb.)</u>
I. Engineering Controls			
VCM Unloading	No additions at 25 ppm VCM ceiling		
Ventilation	Building ventilation	0.2923	0.0264
	Latex blend tank exhaust	0.0007	0.0002
	Exhaust hoods for tanks and charge pumps	0.0071	0.0003
	Vent hoods for recovery pumps	0.0028	-
	Vent hoods for polymerizers	0.0082	0.0010
	Ventilation for suspension blend tanks	0.0083	0.0010
Reactor Cleaning	Proprietary equipment	0.0550	0.0165
	Modify reactor manhead gaskets to permit multiple reactor opening for cleaning without leakage	0.0313	-
Stripping	No additions at 25 ppm VCM ceiling	-	-

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EXHIBIT C-3B (2)

<u>Item</u>	<u>Description</u>	<u>Capital Costs</u> (¢/lb.)	<u>Annual Costs</u> (¢/lb.)
Other Engineering	Proprietary equipment to reduce polymerizer entry	0.0033	0.0016
	Maintenance equipment for pump and line cleaning to reduce employee exposure to VCM (Temporary workplace hoods, exhaust systems, etc.)	0.0495	0.0132
	Strainer bleed-off system to VCM recovery	0.0220	-
	Reactor cleaning water collection system	0.0220	0.0007
	Replace existing reactor relief system with valves	0.0769	0.0132
	Subtotal, Incremental Engineering Controls Costs, 25 ppm VCM Ceiling	0.5794	0.0741
	Engineering Costs To Meet 50 ppm VCM Ceiling	0.0700	0.0050
	Subtotal, Engineering Controls, 25 ppm VCM Ceiling	0.6494	0.0791
	Amortization of Capital (12% - 10 years)		0.1149
	Total Annual Engineering Controls Costs, 25 ppm VCM Ceiling		0.1940

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EXHIBIT C-3B (3)

<u>Item</u>	<u>Description</u>	<u>Capital Costs (¢/lb.)</u>	<u>Annual Costs (¢/lb.)</u>
II. Personal Protective Equipment			
Showers and Eating Facilities	Showers and eating facilities	0.1544	0.0609
Breathing	No additions for 25 ppm VCM ceiling		
Clothing	No additions for 25 ppm VCM ceiling		
Other	Training and records	-	0.0066
Subtotal, Incremental Personal Protective Equipment, 25 ppm VCM Ceiling		<u>0.1544</u>	<u>0.0675</u>
Personal Protective Equipment Costs To Meet 50 ppm VCM ceiling		<u>0.0262</u>	<u>0.1453</u>
Subtotal, Personal Protective Equipment Costs, 25 ppm VCM Ceiling		<u>0.1806</u>	<u>0.2128</u>
Amortization of Capital (Showers and Eating @ 12% - 10 Years, Remaining Items @ 12% - 5 years)			<u>0.0343</u>
Total Annual Personal Protective Equipment Costs, 25 ppm VCM Ceiling .			<u><u>0.2471</u></u>

EXHIBIT C-3B (4)

<u>Item</u>	<u>Description</u>	<u>Capital Costs (¢/lb.)</u>	<u>Annual Costs (¢/lb.)</u>
III. Monitoring			
Personnel	Gas Chromatograph (Split 50 - 50 with area monitoring)	0.0029	0.0033
Area and Leak Monitoring	Gas Chromatograph (Split with personnel monitoring)	0.0029	0.0033
Area and Leak Monitoring	Computerize sequential monitoring system for trend analysis	0.0269	0.0020
Medical Testing	No additions for 25 ppm VCM ceiling	-	-
Recordkeeping	Included under personal equipment, other	-	-
Subtotal, Incremental Monitoring Costs, 25 ppm VCM Ceiling		<u>0.0327</u>	<u>0.0086</u>
Monitoring Costs To Meet 50 ppm VCM Ceiling		<u>0.0508</u>	<u>0.1126</u>
Subtotal, Monitoring Costs, 25 ppm VCM Ceiling		<u>0.0835</u>	<u>0.1212</u>
Amortization of Capital (12% - 5 years)			<u>0.0231</u>
Total Annual Monitoring Costs, 25 ppm VCM Ceiling			<u>0.1443</u>
Subtotal, Engineering, Protective and Monitoring Costs		<u>0.91</u>	<u>0.41</u>
Productivity Loss (@12.5%)		<u>1.50</u>	<u>0.81</u>
Total Costs		<u>2.41¢</u>	<u>1.22¢</u>

Source: Company Interview and Snell estimates.

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EXHIBIT C-3C (1)

USDOL/OSHA

CASH STUDY .
 COMPANY ESTIMATED COSTS TO
 ACHIEVE A 25 PPM VCM CEILING
 WITH 10 PPM TWA IN A PVC PLANT
 AND SUSTAIN 1974 CAPACITY

<u>Item</u>	<u>Description</u>	<u>Capital Costs</u> <u>(¢/lb.)</u>	<u>Annual Costs</u> <u>(¢/lb.)</u>
I. Engineering Controls			
VCM Unloading	No additions for 25 ppm VCM ceiling with 10 ppm TWA	-	-
Ventilation	No additions for 25 ppm VCM ceiling with 10 ppm TWA	-	-
Reactor Cleaning	Clean vessel technology (Includes cleaning techniques and potential reformulation of reactor charge) *	0.2747	0.0275
Stripping	Improved processes to remove VCM from product (Proprietary) *	5.6044	0.0879
Other	Improve reactor emergency relief system (manifold additional valves to VCM recovery)	0.1099	0.0055
	Repair VCM leaks	-	0.0165

* Development work is incomplete as of June 1974, company estimates = 4 years to completion.

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EXHIBIT C-3C (2)

	Capital Costs (¢/lb.)	Annual Costs (¢/lb.)
Subtotal, Incremental Engineering Controls, 25 ppm VCM Ceiling With 10 ppm TWA	<u>5.9890</u>	<u>0.1374</u>
Engineering Costs To Meet a 25 ppm VCM Ceiling	<u>0.6493</u>	<u>0.0791</u>
Subtotal, Engineering Costs, 25 ppm VCM Ceiling With 10 ppm TWA	<u>6.6383</u>	<u>0.2165</u>
Amortization of Capital (12% - 10 years)		<u>1.1750</u>
Total Annual Engineering Controls Costs, 25 ppm VCM Ceiling With 10 ppm TWA		<u>1.3915</u>

EXHIBIT C-3C (3)

<u>Item</u>	<u>Description</u>	<u>Capital Costs (¢/lb.)</u>	<u>Annual Costs (¢/lb.)</u>
II. Personal Protective Equipment			
Showers and Eating Facilities	No additions for a 25 ppm VCM ceiling with 10 ppm TWA	-	-
Breathing		-	-
Clothing		-	-
Other		-	-
Subtotal, Incremental Personal Protective Equipment, 25 ppm VCM Ceiling With 10 ppm TWA		-	-
Personal Protective Equipment Costs To Meet a 25 ppm VCM Ceiling		0.1806	0.2128
Subtotal, Personal Protective Equipment Costs, 25 ppm VCM Ceiling With 10 ppm TWA		<u>0.1806</u>	<u>0.2128</u>
Amortization of Capital (Showers and Eating Facilities @ 12% - 10 years, Remaining Items @ 12% - 5 years)			<u>0.0343</u>
Total Annual Personal Protective Equipment Costs, 25 ppm VCM Ceiling With 10 ppm TWA			<u>0.2471</u>

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EXHIBIT C-3C (4)

<u>Item</u>	<u>Description</u>	<u>Capital Costs</u> <u>(¢/lb.)</u>	<u>Annual Costs</u> <u>(¢/lb.)</u>
III. Monitoring			
Personal	No additions for 25 ppm VCM ceiling and 10 ppm TWA	-	-
Area and Leak	Monitor VCM leaks (Additional Personnel)	-	0.0082
Medical Testing	No additions for 25 ppm VCM ceiling and 10 ppm TWA	-	-
Recordkeeping	No additions for 25 ppm VCM ceiling and 10 ppm TWA	-	-
Subtotal, Incremental Monitoring Costs, 25 ppm VCM Ceiling With 10 ppm TWA		-	0.0082
Monitoring Costs To Meet a 25 ppm VCM Ceiling		<u>0.0835</u>	<u>0.1212</u>
Subtotal, Monitoring Costs, 25 ppm VCM With 10 ppm TWA		0.0835	0.1294
Amortization of Capital (12% ÷ 5 years)			<u>0.0231</u>
Total Annual Monitoring Costs, 25 ppm VCM Ceiling with 10 ppm TWA			<u>0.1525</u>
Subtotal, Engineering, Protective and Monitoring Costs		<u>6.90</u>	<u>0.56</u>
Productivity Loss (@17.5%)		<u>3.15</u>	<u>1.34</u>
Total Costs		<u>10.05¢</u>	<u>1.90¢</u>

Source: Company Interview and Snell estimates.

EXHIBIT C-4 (1)
USDOL/OSHA
STATISTICAL ANALYSIS OF THE ECONOMIC DATA
FOR THE 50 PPM CEILING CASE FOR PVC

Snell performed a statistical analysis of the data submitted by the industry and audited by Snell, on the basis explained below.

A unit cost per pound of plant capacity was developed by dividing the total annual costs of compliance by the nameplate capacity for each reporting plant.

Annual cost elements for VCM controls developed by Snell from audit of industry reports as detailed in the case study of Exhibit C-3, the explanatory text of Chapter V, and as summarized below:

Annual engineering costs including:

- capital costs at a recovery factor of 12% over 10 years
- operation and maintenance cost of the additional equipment
- other costs as reported by the individual plants.

Annual cost of protective equipment including:

- capital cost of additional shower and eating facilities over 10 years at 12% capital recovery
- capital cost of personal protective equipment such as respirators and ancillary equipment amortized over 5 years at 12%
- costs of short lived items (garments) on a yearly basis
- operations and maintenance costs of the equipment including the costs of breathing air.

Annual cost of monitoring equipment including:

- capital cost amortized over 5 years at 12%
- operation and maintenance costs of the equipment
- medical and record keeping costs.

The summation of these cost elements gave, for each plant in the sample, a total annual cost incurred or committed to meet the Emergency Temporary Standard. This total annual cost divided by the nameplate capacity of the plant gives the unit cost per pound of capacity for controlling VCM exposure on an annual basis.

Examination of the data led to the a priori exclusion of three samples from the population. Two are data pertaining to the two Firestone plants and the third sample corresponds to a very small manufacturing plant which has to bear the burden of very high costs on a minimal production (about 1/20 of plant average).

With these exclusions, the characteristics of the population are:

Mean unit cost	0.221¢/lb.
Standard Deviation	0.152

The excluded data were examined to validate statistically their exclusion. The differences from the mean were respectively: 2.29¢/lb., 2.076¢/lb., and 0.659¢/lb., 15 Standard Deviation, 13.6 Standard Deviation, and 4.0 Standard Deviation. The highest sample included was only 2.7 Standard Deviations away from the mean. The exclusion of these three samples was statistically justified, particularly given the comparative large size of the sample population examined. In such cases usually an "ascribable cause" for the exclusion is found. As indicated above, in one case the size of the plant was responsible.

EXHIBIT C-4 (3)
USDOL/OSHA

The two other excluded samples represent Firestone data for both plant locations. Snell reviewed the Firestone data with particular care and the audit results are shown in the table below with comparison with the industry averages for ready reference. It can be seen that in all items except monitoring equipment Firestone data are out of proportion with those reported by the rest of the industry.

Item		Firestone		Industry Average
		Pottstown	Perryville	(Other 23 Respondents)
Engineering	Capital	\$4,324,000	\$1,867,000	\$275,000
Engineering	Annual	4,271,000	2,347,000	152,000
Personal Protective Equipment	Capital	487,000	89,000	26,000
Personal Protective Equipment	Annual	135,000	37,000	38,000
Monitoring Equipment	Annual	365,000	185,000	121,000

Part of the cost differences which are apparent from the table can be ascribed to inclusion to Firestone of equipment items that the rest of the respondents did not feel necessary to include at the 50 ppm level.

Of particular interest is the inclusion at Pottstown plant of a flare system with a capital cost of 2.5 million dollars and an annual engineering cost (as defined previously) of 2.2 million dollars. This equipment, in Snell's opinion, is not necessary to meet the OSHA requirements and, while it represents an environmental protection device, its inclusion as an answer to a 50 ppm ceiling requirement is not justified. The same can be said for a modification to a waste water treatment system at Perryville at a capital cost of \$200,000.

Source: Snell analysis

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EXHIBIT C-5 (1)

USDOL/OSHA

DISTRIBUTION OF REPORTED PLANT ADDITIONS OF ENGINEERING CONTROLS
ESTIMATED FOR SELECTED VCM LEVELS IN POLYVINYLCHLORIDE PLANTS

Engineering Item VCM Standard	Number of Plants Not Reporting Detailed Cost Estimates (1)	Number of Plants Reporting Detailed Cost Estimates			Number of Plants Endangered (2)	Approximate Cumulative Capital Cost Per Plant Reporting an Expenditure (\$1,000)	Comments
		Number of Plants Reporting an Initial Expenditure	Number of Plants Reporting an Increased Expenditure	Number of Plants Reporting No Expenditure			
VCM Unloading (3)							
• 50 ppm ceiling	2	2	0	17	0	50	• Modifications to transport equipment may be completed by VCM supplier.
• 25-40 ppm ceiling with 15-25 ppm TWA	0	0	0	12	2	50	
• 15-25 ppm ceiling with 10-15 ppm TWA	7	0	1	0	7	60	
Ventilation (4)							
• 50 ppm ceiling	4	10	0	2	0	100	• Ventilation is used at all levels.
• 25-40 ppm ceiling with 15-25 ppm TWA	0	1	11	1	2	400	• Substantial costs are estimated to reach all target levels.
• 15-25 ppm ceiling with 10-15 ppm TWA	7	1	1	0	7	600	• Most plants have engineered ventilation at the 50 ppm level.
Reactor Cleaning (5)							
• 50 ppm ceiling	4	5	0	14	0	100	• 5 of 19 plants install reactor cleaning equipment for the 50 ppm level.
• 25-40 ppm ceiling with 15-25 ppm TWA	0	0	2	4	2	400	• Most plants have reactor cleaning for the 25-40 ppm ceiling with 15-25 ppm TWA target level.
• 15-25 ppm ceiling with 10-15 ppm TWA	7	0	1	0	7	• (6)	
Slugging (7)							
• 50 ppm ceiling	4	5	0	13	0	300	• Three plants report expenditures > \$380,000 at the 50 ppm ceiling level probably for new systems.
• 25-40 ppm ceiling with 15-25 ppm TWA	0	7	3	2	2	500	• 7 plants report expenditures of < \$70,000 to reach a 25-40 ppm ceiling with 15-25 ppm TWA target level. These expenditures represent improvements to existing equipment. Three plants estimate expenditures > \$750,000 probably for new systems.
• 15-25 ppm ceiling with 10-15 ppm TWA (8)	7	2	0	1	7	4,000	• At the 15-25 ppm ceiling with 10-15 ppm TWA, 7 plants report expenditures > \$1 million for R&D and new systems.
Other (9)							
• 50 ppm ceiling	4	13	0	0	0	100	• Extensive modifications to physical plant are estimated for all levels.
• 25-40 ppm ceiling with 15-25 ppm TWA	0	0	7	5	2	600	• At 15-25 ppm VCM ceiling with 10-15 ppm TWA expenditures of > \$400,000 are estimated for such items as emergency reactor pressure relief systems (no VCM recovery) and computerized control systems.
• 15-25 ppm ceiling with 10-15 ppm TWA	7	3	0	1	7	1,200	
Total (10)							
• 50 ppm ceiling						650	
• 25-40 ppm ceiling with 15-25 ppm TWA						2,000	
• 15-25 ppm ceiling with 10-15 ppm TWA						5,750	

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Notes

- (1) Plants in this category did not release detailed cost estimates which could be separated into the five engineering items. Instead a total cost for engineering controls was provided; the total costs per plant for these plants are:

VCM Target Level

Approximate Cost
Per Plant
(Dollars in Thousands)

50 ppm ceiling	\$ 200
25 ppm ceiling	900
15-25 ppm ceiling	
10-15 ppm TWA	\$,000

- (2) Endangered - Management will seriously consider plant shutdown; cost estimates not provided.
- (3) Ventilation - Fans, ducting, etc.
- (4) VCM unloading - Additions to unloading racks, modifications to VCM piping, unloading pumps and compressors.
- (5) Reactor cleaning - High and low pressure water systems and solvent cleaning systems.
- (6) Only one plant reported a \$500,000 additional expenditure.
- (7) Stripping - VCM stripping tanks, pumps, piping, compressors and condensers.
- (8) At the 50 ppm and 25 ppm ceiling levels stripping expenditures generally address improvements to present systems to meet in-plant requirements. The much larger expenditures at the 15-25 ppm ceiling and 10-15 ppm TWA levels reflect an effort to also improve the residual free monomer levels in the product.
- (9) Other - Non-specific pumps, compressors, piping, seals, etc.
- (10) Costs rounded to one significant figure.

Source: Industry interviews and Snell estimates.

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APPENDIX D

PERSONAL PROTECTIVE EQUIPMENT AND HYGIENE

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APPENDIX D

PERSONAL PROTECTIVE EQUIPMENT AND HYGIENE

This appendix presents the elements of personal protective equipment and hygiene as related to their purpose, costs, and availabilities. The appendix summarizes the relevant portions of the testimony at the public hearings and details which types of equipment have been purchased by the industry. All exhibits follow the text of the appendix sequentially.

1. REVIEW OF THE REGULATORY REQUIREMENTS PRESENTED BY THE OSHA VINYL CHLORIDE TEMPORARY AND PROPOSED PERMANENT EXPOSURE STANDARDS IN RELATION TO PERSONAL PROTECTIVE EQUIPMENT AND HYGIENE ARE SUMMARIZED BELOW

This section summarizes the requirements of employers in the vinyl chloride monomer (VCM) and polyvinyl chloride (PVC) producing industries concerning breathing equipment, protective clothing and personal hygiene as they relate to both the temporary and proposed permanent exposure standards.

(1) The Emergency Temporary Standard (ETS) For Exposure To VCM⁽¹⁾

The ETS applies to any area or operation in which VCM is:

- manufactured
- reacted
- handled
- processed
- released
- repacked
- stored

(1) 29 CFR 1910, Occupational Safety and Health Standards Emergency Temporary Standard for Exposure to VCM

Wherever any monitoring sample reveals VCM at a concentration in excess of 50 ppm, or whenever any accident, such as rupture of equipment or spillage, indicates the likelihood of a greater than usual release of VCM into the ambient air

- all employees exposed to such concentrations should be withdrawn to a safe area
- the employees should not be permitted to re-enter the work area unless they wear either
 - .. type C continuous flow or pressure demand air-supplied respirators
 - .. self-contained breathing apparatus

Work which may reasonably be expected to release VCM in concentrations in excess of 50 ppm, such as the

- repair
- maintenance
- cleaning

of a reactor or other equipment containing VCM, should be accomplished only by employees wearing type C continuous flow or pressure demand air-supplied respirators or self-contained breathing apparatus.

(2) The Proposed Permanent Standard (PPS) For Exposure To VCM⁽¹⁾

The PPS states that engineering controls are favored methods of compliance because they tend to avoid contamination of the ambient air in the workplace. However, until these controls are instituted it requires the use of respirators of the continuous flow or pressure demand types only. The PPS requires

(1) 29 CFR 1910 Occupational Safety and Health Standards, Proposed Standard.

- a respiratory protection program in accord with CFR §1910.134 should be established and implemented where respirators are required to be used by the PPS
- respirators should be used only in cases of emergency and where engineering controls or change in work practices have not as yet been instituted
- respirators or combinations of respirators for protection from VCM should be selected from among the following types:
 - .. positive pressure full facepiece self-contained breathing apparatus
 - .. pressure demand full facepiece self-contained breathing apparatus operating in the pressure demand mode
 - .. combination type C pressure demand full facepiece respirator operating in the pressure demand mode and a pressure demand self-contained breathing apparatus operating in the pressure demand mode
 - .. combination type C continuous flow respirator and a pressure demand self-contained breathing apparatus operating in the pressure demand mode

Employee entering regulated areas should be provided with full-body protective clothing, footwear or shoe cover, at no cost to the employee. The employee should be required to wear this clothing. Where PVC powder contains detectable levels of VCM in handling, employee should also be

- provided and required to wear head covering
- required to remove all protective clothing at each exit from the regulated area

- required to shower after the last exit of the day
- clean protective clothing should be provided whenever contaminated or soiled, but not less frequently than weekly
- contaminated clothing should be decontaminated before re-use by removal for laundering or disposal

Where employees are required by the PPS to wear protective clothing and equipment, change rooms should be provided in accordance with §1910.141 (e).

Where employees are required by this section to shower, shower facilities should be provided in accordance with §1910.141 (d) (3).

The PPS prohibits in regulated areas

- the storage or consumption of food or beverages
- the storage or use of smoking or non-food chewing products
- the storage or application of cosmetics

2. A SUMMARY WAS DEVELOPED OF THE STATEMENTS OF INDUSTRY AND GOVERNMENT REPRESENTATIVES PRESENTING COMPARISONS OF PROTECTIVE EQUIPMENT TYPES AT THE OSHA HEARINGS ON THE PPS

This section presents summaries of selected statements of witnesses at the OSHA public hearings who gave test results on detailed comparisons of respiratory protective devices and protective clothing. These are presented in five exhibits.

Exhibit D-1 presents the statement of Karl Oelfke, Dow Chemical Company comparing the types of respiratory devices.

Exhibit D-2 details the presentation of Dr. Joseph F. Tomashefski of the Cleveland Clinic also comparing various types of respiratory equipment.

4. A SUMMARY WAS PREPARED OF SNELL INTERVIEWS WITH VCM AND PVC PRODUCERS TO DETERMINE THE COST OF RESPIRATORY EQUIPMENT AND PROTECTIVE CLOTHING UNDER THE ETS AND THE PROJECTED EXPENDITURES FOR VCM LEVELS BELOW THE ETS

In this section of Appendix D the results of Snell's interviews with the VCM and PVC producing industry in relation to present and projected costs of respiratory equipment and protective clothing are presented. The exhibits detail:

- . Purchased equipment and clothing types
- . Capital costs
- . Operating and maintenance costs (O&M)
- . Procurement lead times
- . Relevant industry comments regarding topics such as human factors

The information is arranged in the following manner:

- . Exhibit D-10 summarizes the costs to the industry for protective equipment under the ETS.
- . Exhibit D-11 presents case studies of cost profiles for respiratory equipment as a function of VCM levels and projected covered workers, including expected wearing time.

- Exhibit D-3 is another contribution of Dr. Tomashefski. This exhibit is an in-depth discussion of human factors relating to the use of respirators.
- Exhibit D-4 is a summary of the statement of Dr. Marcus Key, NIOSH, Cincinnati discussing breakthrough times of VCM in air purifying respiratory equipment.
- Exhibit D-5 is a general composite statement of several individuals relating to the human factors involved in wearing protective clothing.

3. BASED ON A SURVEY, SNELL COMPILED RESPIRATORY DEVICES AND PROTECTIVE CLOTHING TYPES INCLUDING DESCRIPTIONS, COMPARISONS, THEIR COST AND AVAILABILITY

This portion of the appendix gives detailed description and comparison of the various types of respiratory devices and protective clothing. Also included are their costs and availability to the industries studied by type and manufacturer. As in the previous section, an exhibit format is used for the presentation of the information.

- Exhibit D-6 is a general presentation detailing the procedure for the selection of the proper type of respiratory protective devices as a function of use.
- Exhibit D-7 is an in-depth of matrix presentation listing respiratory devices and detailing by type important topics including:
 - function
 - advantage
 - disadvantage
 - comparisons with other types
 - Bureau of Mines approval
- Exhibit D-8 presents the costs and availability of typical respiratory devices by type and manufacturer.
- Exhibit D-9 is a comparison to Exhibit D-8 as it describes typical protective clothing types and their cost and availability by manufacturers.

EXHIBIT D - 1

USDOL/OSHA

STATEMENT OF KARL OELFKE
COMPARING TYPES OF RESPIRATORY DEVICES
AT OSHA HEARINGS

Respiratory Device	Advantages	Disadvantages	Breakthrough Time
Nose-mouth cartridge or canister respirator (N-M)	• Easy to don • Small size • Lightweight • Easy to wear and carry	• Interferes with certain types of eye protection such as goggles • Can't fit all faces	100 cc canister has breakthrough time of 15 min. at 1 ppm VCM and flow rate of 300 L/min.
Full face canister type respirator (FF) w/face mounted canister	• Has larger canister than N-M type last longer • Eye protection is an integral part of mask	• Wearing of hard hat becomes difficult • Can't fit all faces	Acme canister of 300 cc size had breakthrough time to 1 ppm of 23 min. at 1000 ppm VCM.
Full face canister type w/chest mounted canister	• Longer breakthrough time than above	• Bulkiness • Can't fit all faces • Poor mobility for worker due to air hose	1 ppm breakthrough after 167 min. Same conditions as above.
Continuous flow air supplied hood (Acid Hood)	• Good head spill protection	• Bulkiness • Vision restriction • Lack of head movement • Poor mobility for worker	(NA)
Continuous flow air supplied hood (Acid Hood)	• Good protection	• Vision restriction • Poor mobility for worker due to air hose	(NA)
Continuous flow air supplied full mask	• Best of air supplied breathing apparatus	• Wearing of hard hat becomes difficult • Poor mobility for worker due to air hose	(NA)
Self-contained breathing apparatus	• Mobility	• Air supply is normally limited to 15-20 minutes in the pressure demand mode	(NA)
Portable breathing air cylinders	• Mobility • Long respiratory protection. Two hours at a demand of 53 L/min.		(NA)

Source: Karl Oelfke, Production Manager for Vinyl Chloride, Texas Div., Dow Chemical Co., Statement presented to USDOL/OSHA Hearings on Vinyl Chloride; Occupational Exposure Standard, June 25, 1974 and Snell assessment.

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EXHIBIT D-8

USDOL/OSHA

STATEMENT OF DR. JOSEPH F. TOMASHEFSKI COMPARING TYPES OF RESPIRATORY EQUIPMENT
AT OSHA HEARINGS

Respiratory Device	Purpose	Method of Operation	Advantages	Disadvantages	(Other) Comments
1. Air Purifying Type	Used to remove contaminants from an atmosphere that contains an adequate concentration of O_2 (>16% by volume).	Work by either filtration, adsorption, or a chemical reaction to remove contaminants.	Canister masks have attached to them a canister containing an adsorbent. Such masks are of value in protection against: • Organic vapors • Acids • Ammonia • Carbon dioxide They are very effective and they can provide effective and reliable protection.	Respiration intended to filter particulates offers no protection against gases or vapors. Air purifying respirators produce high resistance to breathing. Adequate fit to the face contour because of differences in size and shape and anthropological characteristics is often a problem. Many times masks must be molded to individuals--as a result leakage commonly occurs. The resistance to both inspiration and expiration causes most workers to discard filter type masks precisely if they can't see the dust, yet this time, non-visible dust may be most harmful. Chemical cartridge type masks are usually of the half mask variety, the chemical adsorbents (charcoal, soda lime, or silica gel) have very limited application and are of value when used against vapors and gases of low toxicity.	To prevent clogging of the canister and to decrease the resistance to breathing it is permissible to use the filter within such units where protection against particulates is not required.
2. Air-Supplied	Usually employed for specific tasks or for hazardous environments.	This type has a hose connected to an uncontaminated air source. They may be equipped w/o blower or they may have an inline attachment for continuous or demand flow.	They may be used with full face masks, hoods, or with full body suits. Many air-supplied respirators employ a slight positive pressure in order to prevent inward leaks. They are good for hazardous environments not immediately dangerous to life.	When blowers are employed with such respirators, it is necessary to have an individual attending the blower or a stand-by. Such respirators produce an increased resistance to breathing. They frequently have a long hose attached, which, in itself, may be a nuisance or a safety hazard. There are limitations on the maximum length of hose that can be used: • Use w/o blower: < 50 ft. • Use w/blower: 160 ft. to 200 ft.	One must be sure that compressed air supplied is free of CO and CO ₂ .
3. Self-Contained	Provide complete respiratory protection for any concentration of toxic gas or oxygen deficiency.	Pressure-demand type. The slight negative pressure initiated by the individual at the beginning of inspiration forces the valve so that the gas will flow as it is needed as an appropriate amount.	They can be used with an air source or an oxygen source.	The self-contained apparatus is heavy, bulky and requires highly trained individuals for use.	It is necessary when one employs self-contained respirators to have warning devices indicating that the person's supply is getting low.

Source: Joseph F. Tomashefski, M.D., Head of Pulmonary Disease Department of The Cleveland Clinic, statement presented to USDOL/OSHA hearings on vinyl chloride; Occupational Exposure Standard, June 26, 1974 and final comments.

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EXHIBIT D-3 (1)

USDOL/OSHA

STATEMENT OF DR. JOSEPH F. TOMASHEFSKI
DISCUSSING HUMAN FACTORS IN RESPIRATOR USE AT
THE OSHA HEARINGS - PROPOSED PERMANENT STANDARD

GENERAL PROBLEMS ASSOCIATED WITH RESPIRATOR USE

Problem Areas

Problems

1. Safety in Terms of Fit and Improper Sealing of Mask

- If a leak occurs at the mask, especially an inward leak, the toxic materials may be inhaled and a false security will be provided.
- There is a marked variability in the contour of faces-- therefore it is very important that any mask fit comfortably, otherwise an individual using it over a long period of time may find a mask to be intolerable.

2. Perspiration

- When effort is expended and work is performed requiring increased oxygen demand, perspiration is not adequately evaporated--it remains within the mask and produces an unpleasant effect.
- Toxic substance may become trapped between the skin and the mask causing local irritation.
- Allergic reactions have been known to occur.

3. Psychological

- Many people find the confinement and sense of isolation distressing.
- Others are uneasy about the need to work in an environment that requires the use of such equipment.

4. Respirator and Mask Dead Space

- It is very important that the individual not rebreathe exhaled air, and that the dead space in the mask be kept to <150 cc or that the mask be adequately ventilated to flush out the dead space. Otherwise there would be rebreathing of exhaled CO₂ and a deficiency in inspired O₂.

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GENERAL PROBLEMS ASSOCIATED WITH RESPIRATOR USE (Cont'd.)

Problem Areas	Problems
5. Design Problems Associated With the Eyepiece on Full-Face Masks	• They should not distort the vision. • They do decrease the field of vision. • If an individual wears glasses, the glasses can become fogged or the eyepiece itself may become fogged. • The individual with bifocal vision may have difficulty in performing his task. • It may be necessary to construct the eyepieces by means of special grinding with built-in lenses • Anti-fogging compounds may have to be employed or a nose clip worn to prevent fogging of the eyepiece. • All of these can decrease efficiency and be uncomfortable and unpleasant for the individual.
6. Speech Transmission	• Upon movement of the jaws, the mask may become distorted and leaks occur. • It may be necessary to equip the masks with special diaphragms, microphones, amplifiers, and radios to provide ability for communication.
7. People With Respiratory Diseases	• People who have bronchitis, emphysema or chronic asthma should not be employed in work using respirators. • This limitation knocks out a large segment of the working population (approx. 32% of all males and females over the age of 35).
8. Personnel Training in the Use of Respirators	• Personnel must be trained in respirator use, workings and care.

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GENERAL PROBLEMS ASSOCIATED WITH RESPIRATOR USE (Cont'd.)

Problem Areas	Problems
9. Maintenance of Respirators	• Masks must be inspected monthly. • They have to be cleaned and examined after each use. The washing should be done with soap and water or with detergent and allowed to be air or force dried. • Occasionally it may be necessary to sterilize the mask, because it may become a source for bacterial contamination and disease transmission. • Cleaning and repair stations have to be set up where masks or respirators are being used.
10. Storage	• Storage is another factor that must be considered. Proper facilities must be provided to keep the respirators and their component parts in good condition.

Source: Joseph F. Tomashefski, Head of Pulmonary Disease Department, The Cleveland Clinic, Statement presented to USDOL/OSHA Hearings on Vinyl Chloride; Occupational Exposure Hazard, June 25, 1974 and Snell assessment.

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EXHIBIT D-4

USDOL/OSHA

SUMMARY OF THE STATEMENT OF
DR. MARCUS M. KEY AT OSHA HEARINGS - AIR
PURIFYING EQUIPMENT TO VINYL CHLORIDE MONOMER
BREAKTHROUGH TIMES.

<u>Respiratory Device</u>	<u>Test Conditions</u>	<u>Breakthrough</u>	<u>Comments</u>
Organic Vapor Cartridges	• VCM concentration: 50 ppm • 50% R. H. • Flow rate consistent with a moderately heavy work rate	• 10% breakthrough in 40 to 75 minutes • Service life decreases as R. H. increases	Because the odor threshold of VCM is considerably higher than the breakthrough concentration, it is the position of NIOSH that the only suitable respiratory protective devices for VCM are supplied respirators or positive mask self-contained breathing apparatuses.
Canister Gas Masks	• VCM concentration: 100 ppm • 50% R. H. • Flow rate consistent with a moderately heavy work rate	• 10% breakthrough in 200-350 minutes • Service life decreases as R. H. increases	
Gas Mask Facepieces	• VCM concentration: 100 ppm • 50% R. H. • Flow rate consistent with a moderately heavy work rate	• 1% leakage	

Source: Marcus M. Key, M.D., Director, NIOSH Center for Disease Control, Statement presented to USDOL/OSHA Hearings on Vinyl Chloride; Occupational Exposure Standard, June 25, 1974 and Snell assessment.

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USDOL/OSHA

STATEMENT OF INDUSTRY REPRESENTATIVES ON HUMAN FACTORS RELATING
TO PROTECTIVE CLOTHING AT THE OSHA HEARINGS

Industry Representative	Clothing Type	Advantages	Disadvantages	Physiological Considerations	Human Factors	Comments
K. H. Oelrich ⁽¹⁾	Full impervious pressurized suit	Protective against vinyl chloride	Places worker in situation of unacceptable heat stress	A worker, while wearing such a suit in a test after 3 minutes sitting at 85° F ambient temperature, had a skin temperature of 100.2° F. After five additional minutes of slow walking the skin temperature was 101.80° F and the body temperature which had been 98.4° F at the beginning of the test, rose to 102.6° F.	Suit tends to be a safety hazard because of its bulkiness and limited visibility. Breathing is difficult. Communication with others is almost impossible.	The use of this type suit should be limited to emergency situations.
F. F. May ⁽²⁾	Full body impervious air supplied suit	Prevents vinyl chloride gas from contacting body	Prevents body heat and moisture from passing to the atmosphere. Garment would guarantee long-term exposure to VCM if, by chance, some of the gas entered the garment.	The heat and discomfort produced will produce fatigue reducing employee alertness. Perspiration generated by the suits will cause severe discomfort.	Reduction of employee efficiency due to cumulative effects of fatigue, unsure footing. Reactor cleaners, required by their job to be sure footed, will be greatly impaired by bulk of suit. Employee efficiency will drop as much as 75% when such suits are worn.	Premium wages will be required to induce employees to wear them. Recognizing the fact that the suit represents a safety hazard, if a Secretary of Labor did not require their use in the same long term standards. Because reactor cleaners are identified as a group of maximum risk they should be supplied with "protective" rather than impervious clothing and gloves in order to protect them from this contact.
	Impervious gloves	Prevents vinyl chloride from contacting hands	Gloves will diminish employee's dexterity		Operation will find it difficult to operate controls and keep records, and maintenance men, particularly instrument and electrical repairmen, will not be able to perform their jobs safely and properly.	

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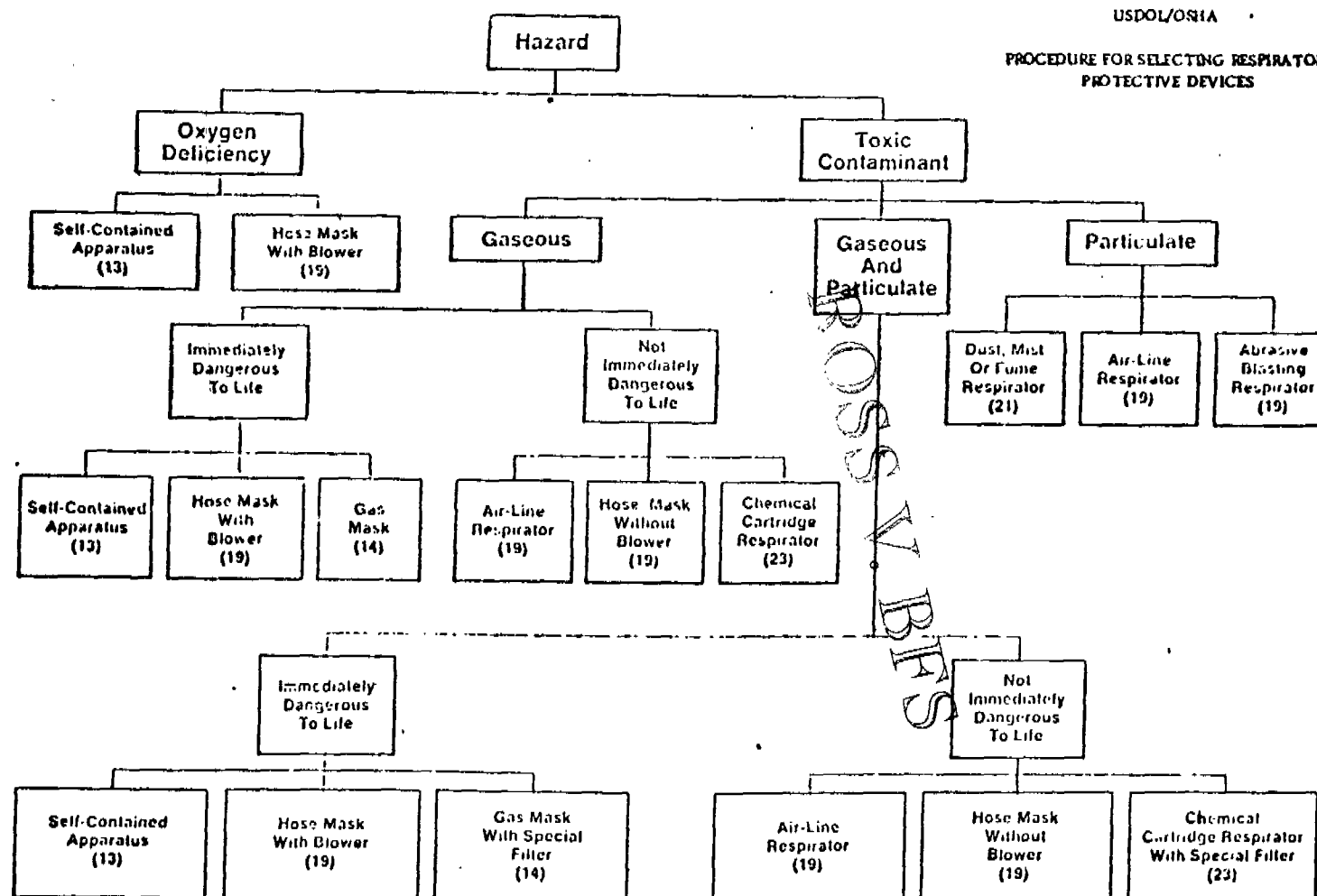
EXHIBIT D-3 (2)

Industry Representative	Clothing Type	Advantages	Disadvantages	Physiological Considerations	Human Factors	Comments
H. H. Fawcett/30	Air supplied suits	Designed for exactly the kind of situation as reactor cleaning			People could work for long periods of time wearing air supplied suits if the air were directed throughout the suit. Equipment can be used if people are educated to use it and know the advantages and necessity for using it	People don't want this type of equipment because it is trouble and costs money

- Sources: (1) Written submission by K. M. Oelke, Production Manager at the Texas Division of Dow, Chemical U.S.A. presented at the USDOL/OSHA hearing on the proposed permanent standard for occupational exposure to vinyl chloride, June 28, 1974.
- (2) Statement of F. F. Hoj, plant manager, Firestone Plastics Company, Ferryville, Maryland presented at USDOL/OSHA hearing on the proposed permanent standard for occupational exposure to vinyl chloride, July 14, 1974.
- (3) Statement of H. H. Fawcett, Chairman of the Committee on Chemical Safety of the American Chemical Society at the USDOL/OSHA hearings on the proposed permanent standard for occupational exposure to vinyl chloride, July 9, 1974.
- (4) Small statement.

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PROCEDURE FOR SELECTING RESPIRATORY
PROTECTIVE DEVICES

Note: Numbers in parentheses refer to Bureau of Mines Schedules and Revisions thereof.

Source: After Bureau of Mines information circular 7792

EXHIBIT D-7 (3)

USDOL/OSHA

COMPARISON OF RESPIRATORY PROTECTION DEVICES

Respiratory Device	Application	Method of Operation	Limitations	Useful Life	Business Approval	Comments
1. Air Purifying Devices	Air Purifying Devices remove contaminants from the atmosphere.	Various chemicals remove specific gases and vapors and non-chemical filters remove particulate matter.	Can be used only in atmospheres containing sufficient oxygen to sustain life (at least 19% by volume at sea level) and within specified concentration limitations of the specific device.	The useful life of an air purifying device is dependent upon the concentration of the contaminants, the breathing volume of the wearer, and the capacity of the air purifying medium.		
(A) Mechanical Filter Respirators	Mechanical Filter Respirators provide respiratory protection against particulate matter such as non-volatile dusts, fumes, or metal fumes. Selection of the appropriate respirator is based on the type, toxicity, and particle size of the particulate matter.	They consist essentially of a soft resilient facepiece of either half-mask or full-face design, to which is directly attached one of several types of mechanical filters made up of some fibrous material which removes the harmful particles by physical trapping as air is inhaled through the material. Gaseous matter such as air itself will pass through the filter, but solid or liquid particles are trapped in much the same manner as rocks and pebbles are separated from sand in a screening process. The filter must be highly efficient however to stop the small harmful particles.	Mechanical filter respirators do not provide against gases, vapors or oxygen deficiency.		Schedule 21	Other than the difference between a half mask facepiece and a full facepiece, which is used when the particulate exposure is harmful or irritating to the eyes as well as the respiratory tract, the filter is the most essential distinction among classes of respirators. The most desirable compromise must be worked out for each class with respect to breathing area (size), resistance to breathing, efficiency in filtering particulates of specific size ranges and time required to clog the filter.
(B) Chemical Cartridge Respirators	Chemical Cartridge Respirators afford protection against light concentrations (0.5% to 1%) by volume, depending upon the contaminant) of certain acid gases, alkaline gases, organic vapors, and anesthetic vapors by utilizing various chemical filters to purify the inhaled air.	They differ from mechanical filter respirators only in that they use small cartridges containing chemicals to remove harmful gases and vapors.	Chemical Cartridge Respirators are non-emergency respiratory protective devices and should never be used in immediately dangerous atmospheres, except for escape purposes. However, to clarify this general statement, it will be well to list four other major negative rules which apply to Chemical Cartridge Respirators. 1. Do not use Chemical Cartridge Respirators for protection against gaseous material which is extremely toxic in very small concentrations (carcinogens such as VCM). 2. Chemical Cartridge Respirators should not be used for exposures to harmful gaseous matter which cannot clearly be detected by odor (such as VCM) in concentrations < 250 ppm.		Schedule 22	Most purpose type chemical cartridge respirators offer protection against airborne exposures to light concentrations of gases and vapors or may be used for relief against irritant vapors. The multipurpose design pattern is commonly carried by the worker in during all working hours or stored conveniently near the work area for immediate availability. Combination mechanical filter chemical filter respirators utilize dust, mist, or fume filters with a chemical cartridge for dual or multiple exposure. Respirators with independently replaceable mechanical filters are preferred for this type because the dust filter normally plugs before the chemical cartridge is exhausted. One combination mechanical-chemical filter respirator employs a back mounted filter element and is especially well suited for spray painting and welding operations, where the air contaminant is concentrated in front of the worker.

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Regulatory Device	Applications	Method of Operation	Limitations	Useful Life	Failure Approval	Comments
(B) Gas Masks	Gas masks have been used effectively for many years for respiratory protection against certain gases, vapors and particulate matter which otherwise might be harmful to life or health. They provide simplicity of operation, compactness, ease of maintenance and economy.	Use large canisters mounted on wearers' torso, same principle of operation as in the cartridge systems. Some canisters located on chin. Canisters differ from cartridges in that they are much larger than the latter.	Chemical Cartridge Respirators should not be used against any gas which is lethal in concentrations which are highly irritating to the eyes. Obviously, Chemical Cartridge Respirators cannot be used for protection against gaseous material which is not effectively stopped by chemical filter utilized, or against low concentrations of toxic gases. Because gas masks are air purifying devices designed solely to remove specific contaminants from the air, it is essential that their use be restricted to atmospheres which contain sufficient oxygen to support life (at least 10% by volume at sea level) and which contain generally no more than 2% concentrations of toxic gases and vapors by volume.	The service life of an air purifying canister type gas mask depends on the following factors: - The design, including the quality and amount of chemical fill, packing uniformity and density. - Varying exposure conditions, including concentration of contaminant in the air, breathing rate of the wearer, temperature and humidity. Generally, higher concentrations, breathing rates and humidity conditions adversely affect service life. Since the exposure conditions are subject to wide variation, it is most difficult to estimate the service life of a gas mask canister. However, for guidance purposes, actual man tests performed under Bureau of Mines Schedule 14F stipulate the following minimum service requirements at an average breathing rate of 25 liters per minute in concentrations of 2% for most gases and vapors of 0.5% ammonia: - Industrial Size - Canister 30 minutes - Type N₁ Canister - Acid Gases 15 minutes - Organic Vapors 25 minutes - Ammonia 15 minutes - Carbon Monoxide 30 minutes Super Size Canister, because of their greater volume of chemical fill, will last approximately twice as long as the equivalent Industrial Size Canister. This Style Canister, because of their small size, should be used in concentrations not in excess of 0.5%.	Schedule 14	<u>Canister Replacement</u> It is generally recommended that gas mask canisters used for emergency purposes should be replaced after each use. Specific instructions for canister replacement and/or return to fresh air are: - If canisters with window indicators show the specified color changes. - If any leakage is detected by smell, taste, eyes, nose or throat irritation. - If high breathing resistance develops. - If the canister shelf life is exceeded. <u>Warning Signs</u> Specific warning signs which require immediate return to fresh air are: - Uncomfortable heat in the isolated eye. (A properly operating canister will become warm in exposure to certain gases or vapors, but a canister which becomes extremely hot indicates that concentrations above the canister limit have been encountered.) - If normal, dissipation of signs of distress develops.

IDENTITY D-1 (a)

Respiratory Device	Application	Method of Operation	Limitations	Useful Life	Approval	Comments
B. Supplied Air Devices	Provide air from outside source for long periods of use.	Deliver breathing air through a supply hose connected to the wearer's facepiece.	Shall be used only in atmospheres not immediately harmful to life. Air source must be located in clean air and monitored frequently.	As long as air is supplied and wearer is comfortable.	Schedule 19	
(1) Air-Line Respirators		The air-line respirator is connected to a suitable compressed air source by a hose of small inner diameter and air is delivered to the user continuously or intermittently in sufficient volume to meet the wearer's breathing requirements.	Air-Line Respirators shall be used only in atmospheres not immediately harmful to life or from which the wearer can escape without the use of the respirator. This limitation is necessary because the air-line respirator is entirely dependent upon an air supply which is not gained by the wearer of the respirator. If the air supply fails, the wearer is without respiratory protection and might not escape from the immediately hazardous atmosphere. Another limitation of air-line respirators is that the air supply hose limits the wearer to a fixed distance from the air supply source.			Accessory equipment such as pressure regulation, pressure relief valves and air filters may be necessary to ensure that the air is at the proper pressure and quality for breathing.
			The Bureau of Mines approves air-line respirators under Schedule 19 which has the following significant requirements. The maximum hose length for which approval is granted is 250 feet, and the maximum permissible inlet pressure is 125 psig. Approval is sought for specific hose lengths and inlet pressures. With the longest hose lengths for which approval is sought assembled to the respirator, and the lowest inlet pressure introduced to the air supply hose, constant flow units must deliver at least four cubic feet per minute (CFM) measured at the face-piece. The calculation resistance at 85 liters per minute shall not exceed one (1) inch of water-column height.			Air-line respirators are furnished in many types, but there are three basic classes. There are constant flow, demand flow and pressure-demand flow, with the respirators equipped with full masks or full facepieces. If eye protection is required, a full face-piece must be used.
			When helmets or hoods are used, the same requirements must be met except that the flow rate must be at least six (6) cubic feet per minute. For both types of assemblies with the highest inlet pressure and shortest hose length, the maximum flow shall not exceed 85 liters (3.0 cubic feet per minute).			The air supply is the responsibility of the user, and the air-line respirator is approved for use only when it supplies respirable air at the correct pressure and flow. The compressed air shall meet the most recent requirements of 49 CFR 191.16 (a) and (b) for Type 1, Class B gas service air. This currently means that the carbon monoxide level not exceed 20 parts per million (ppm), the carbon dioxide content not exceed 1000 ppm, and oil and steam hydrocarbons not exceed 5 mg per cubic meter.
Constant flow type	Constant flow units are normally used where there is an ample air supply such as provided by an air compressor.					With internally lubricated piston-type compressors, overheating may produce carbon monoxide making testing for carbon monoxide in the condition of a constant monitoring analyzer is desired.
	Constant-flow Air-Line Respirators with facepieces alone are used where respiratory protection only is needed. A hood can be added to the facepiece for protection against wind or dust blast and frequently a helmet is used for this application with a hood or cape fitted to it. Such units are used also for fixed gas testing.					Some air compressors are manufactured specifically to provide respirable air. They use compression and liquids such as water or glycerine for delivering the air.

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Respiratory Device	Application	Method of Operation	Limitations	Useful Life	Subliminal Approval	Comments
• Demand type	Demand type are generally used where only compressed air cylinders are available.	Demand type air-line respirators with half masks or full facemasks deliver air flow only during inhalation with exhalation to the atmosphere.	A suitable pressure regulator is required to ensure that the air is at the proper pressure for breathing. The same requirements for approval apply to the demand type as to the constant flow units, except the minimum flow rate maximum resistance of two (2) inches of water column height measured at the facepiece shall be at least four (4) cubic feet per minute and not more than fifteen (15) cubic feet per minute with all hose lengths within the rated pressure range for which approved. The exhalation resistance at 85 liters per minute shall not exceed one (1) inch of water.			
• Pressure demand type	For those conditions where the possible inward leakage caused by the negative pressure during inhalation always present in demand systems is unacceptable and there can't be the relatively high air consumption of the constant flow units.	It provides a positive pressure during both inhalation and exhalation.	It must meet the same requirements for demand systems except that the static pressure in the facepiece shall not exceed 1.5 inches of water, the exhalation resistance shall exceed the minimum of 4 cubic feet per minute in the facepiece by more than 2.0 inches of water and that there be at least 4 cubic feet per minute flow during inhalation before a negative pressure is developed in the facepiece.			
(2) Flow masks						
• With blower	Flow masks with blowers may be approved by Division for respiratory protection in any atmosphere regardless of the degree of contamination or oxygen deficiency, providing clean, breathable air can be reached within the distance of the permissible hose length.	Blower forces air into mask.	Flow masks with blowers can be used with up to 200 ft. of hose. The blower should always be used with this type of equipment. Only hand driven blowers are currently approved.			The entire flow mask assembly, including facepiece, harness, air hose, and blower, is usually packaged in a portable tank. The blower should never run as a standby or guard, ready to end the workman in case of mishap.
• Without blower	Flow masks without blowers are used when uncontaminated air can be reached within a distance of 75 feet.	Worker forces air into mask through his own breathing.	The air hose must have a large inside diameter, approximately one inch, or, in case of blower failure, the worker can breathe through the hose while escaping from the contaminated area, and it must be highly resistant to petroleum vapors as well as be able to withstand crushing weight. That accounts for the heavy wire reinforced construction of flow-mask hoses. Can only be used up to a distance of 75 feet. Those units, however, carry only limited approval and cannot be used in atmospheres immediately harmful to life. Bureau of Mines Approval.			

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IDENT D-1 (A)

Respiratory Device	Application	Method of Operation	Limitations	Useful Life	Battines Approval	Comments
0. Self-Contained Breathing Apparatus	Self-contained breathing apparatus provide complete respiratory protection in toxic gases and where there is oxygen deficiency. The wearer is independent of the surrounding atmosphere because he is breathing with a system admitting no outside air. The oxygen or air supply of the apparatus itself takes care of respiratory requirements.	Self-contained breathing apparatus are divided into three basic types--oxygen cylinder rebreathing, demand, and self-generating.	Major problem or limitation is bulkiness of apparatus.	Dependent on size of air cylinder and, in the case of the rebreathing types, on the CO ₂ removal container.	Schedule 13	
(a) Oxygen Cylinder Rebreathing and Self-Generating Types		The oxygen cylinder rebreathing type in use today is the "lung protecting" type which automatically compensates for the varying breathing demand of the user. It consists of a relatively small cylinder of compressed oxygen, reducing and regulating valves, a breathing facepiece or mouthpiece plus non-return valve and a chemical container to remove carbon dioxide from the exhaled breath. The self-generating type uses the principle of rebreathing; but it has no mechanical operating components. Both types function in the same manner and will be discussed together. The high pressure oxygen from the cylinder is reduced in pressure to a breathing level by means of a reducing and regulating valve. In some units there is a constant flow plus a lung-controlled valve which adds any required additional flow. Other apparatus have only an admission valve which delivers the oxygen from the breathing bag to the wearer's face. Exhaled breath passes down another tube into the container holding the carbon dioxide removing chemical and then through a cooler. Finally, the purified exhalation flows into the breathing bag where it mixes with the incoming oxygen from the cylinder. The rebreathing principle permits the most efficient utilization of the oxygen supply. The exhaled breath contains both oxygen and carbon dioxide as the human body extracts only a small part of the oxygen inhaled.	The oxygen cylinder must be refilled and the carbon dioxide-removing chemical replaced after each use. As is true of all respiratory protective equipment, training in proper use and maintenance is essential for the most efficient operation. The one hour service life for the self-generating type apparatus is based on test procedures of Bureau of Mines Approval Schedule 13 and in use a longer or shorter protection period may result based on the user and his level of exertion.	The types of cylinder rebreathing units now manufactured are approved by the Bureau of Mines for two, three or four hour duration. The self-generating type apparatus is approved by the Bureau for one hour.	Schedule 13	The self-generating breathing apparatus differs from conventional cylinder rebreathing apparatus in that it utilizes a chemical canister which re-oxygenates and removes the exhaled carbon dioxide exhalation with breathing requirements. It utilizes high pressure cylinders, regulating valves and other mechanical components. The canister, which contains potassium superoxide, releases oxygen when contacted by the moisture carbon dioxide in the exhaled breath, and neutralizes the carbon dioxide and moisture. Rebreathing is important as it aids in preventing team fatigue. In use, the self-generating unit operates as an independent breathing apparatus except that the wearer, as the canister, makes his own oxygen instead of drawing from a compressed gas cylinder. The constant features of this type are its simplicity of construction and use, and lesser need for maintenance when paired with high pressure apparatus. There are several methods for refilling or recharging high pressure air or oxygen cylinders. Common are sometimes used, but the simplest and most versatile method is to cascade from large supply small apparatus cylinders.

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Regulatory Device	Application	Method of Operation	Limitations	Useful Life	Bureau Approval	Comments
		As the user exhales into the container, the carbon dioxide is removed by the chemical and the oxygen which is left is re-used. This method of operation applies to all oxygen cylinder rebreathing type apparatus as well as to the self-generating type.				
(b) Demand Type	Demand-type apparatus are available in different models for specific applications. Of particular application to some industries is a short duration unit known as an "escape mask." It is normally worn by a worker at times when he is in an area where a potentially toxic atmosphere, above the capacity of a gas mask exists. Areas in which high pressure gases are piped fall into this category. Another type of short duration unit is put on at the time escape is necessary. A work mask type of apparatus is used for planned maintenance work. The apparatus is actually a two-fold unit. - A self-contained apparatus with which the wearer can move freely about by using a small cylinder to enter or leave the toxic atmosphere--either routinely or in the failure of the main breathing supply. - There is a provision for connecting a hose to the demand regulator so that the wearer can breathe during the work period from a large cylinder which has a pressure reducing valve attached to provide low pressure for the connecting hose. Manifold assemblies can be provided to permit more than one worker to work from a common breathing source. It is imperative that the small emergency cylinder be used with this type of apparatus; otherwise, a failure of the supply from the large cylinder would expose the wearer to the toxic atmosphere.	All consist of a high pressure cylinder, a demand regulator connected either directly or by high-pressure tube to the cylinder, a facepiece and tube assembly with an exhalation valve or valves. As a method of securing the complete apparatus on the body. In use, the wearer turns on the cylinder valve after putting on the facepiece. Inhalation of breathing pressure through the demand regulator to the facepiece and then exhalation through a valve in the facepiece to the surrounding atmosphere.	All demand apparatus are relatively inefficient when compared with the rebreathing type, because the exhaled oxygen is released to the atmosphere instead of being re-used. Work mask types are limited by the connecting hose which limits the free movement of the wearer to the length of the hose. It is not an emergency type unit as, for use, it requires setting up some auxiliary equipment. The duration of the demand type apparatus depends on such factors as: - The degree of physical activity of the user; - The degree to which the user's breathing is increased by excitement, fear or other emotional factors; - The degree of training or experience which the user has with this or similar equipment; whether or not the cylinder is fully charged at the start of the work period; - The possible presence in the compressed air of carbon dioxide concentrations greater than the .04% normally found in atmospheric air; - The atmospheric pressure - The condition of the apparatus Under the current Schedule 13E, all demand type apparatus must initially be conducted at -27°F, although low temperature components such as nose-cups to reduce fogging may be added if needed.	Typical demand type apparatus such as the MSA "Air Cub" are certified by Bureau for 15 minutes. Others such as the MSA "Air Mask" are certified for 30 minutes under schedule 13 for entry into and escape from inoperable atmospheres. These service life ratings are based on tests by the Bureau of Mines on men performing moderate to heavy work in each of the different types of work tests or breathing machine tests at a rate of 40 liters per minute. The user should not expect to obtain the exact rated service life on each use. The work being performed may be more or less strenuous.	The term, demand regulator, means that the air flow is on inhalation demand, automatically regulating itself to the demand level in composition for variation in breathing needs. Demand apparatus depend upon wearing a pressure source to learn as the breathing supply has dropped to a point where the user must return to fresh air. A self-actuating warning device is required for Bureau of Mines Approval. The warning device can be either audible or use forehead breathing resistance to alert the wearer to return to fresh air.	

Source: Basic Elements of Respiratory Protection, Mine Safety Appliances and Small Telephone Survey of Respiratory Equipment Industry.

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EXHIBIT D-8(1)

USDOL/OSHA

COSTS AND AVAILABILITY OF TYPICAL RESPIRATORY DEVICES

Respiratory Device/Manufacturer	Catalog Number	Description	Lot Size	Cost Per Unit (1974 Dollars)	Availability (Weeks To Receive After Order)
1. Air Purifying Devices					
(1) Mechanical filter respirators					
• Bausch and Lomb (B&L)	R 10	Provides protection against dusts (single cartridge).	Up to 50 units	\$ 7.35	Stock item
	R 20	Same as above but with dual cartridge.		8.90	Stock item
	5-15-10	Replacement filters.	Pack of 50	0.28	Stock item
• Mine safety apparatus (MSA)	96000	Dustfree ?? provides protection from dusts and mists having a TLV of not less than 2.4 million particles/cu. ft.	24-71	7.25	Stock item
	96106	Filters	Pack of 50	0.13	Stock item
	79983	Dustfree provides protection against finely divided aerosols up to 0.3 microns diameter (99.98% effective).	72-143	8.35	Stock item
	79984	Type "H" cartridge.	144 and up	2.55	Stock item
	8201-R	Duo-seal dual cartridge high efficiency dust filter (0.3 micron particles).	50-99	9.00	Stock item
• Scott	8004-R	Replacement cartridge.			
	8101-R	Same as above respirator but single cartridge.	50-99	8.99	Stock item
	502-R	Replacement cartridge.	50-99	2.80	Stock item
• Welsh	7680	Protex dual cartridge respirator for dusts with TLV more toxic than 0.1 mg/m ³ full face mask.	1	45.75	
	7600-8	Replacement cartridge.	4	1.34	
	7406	Protex single cartridge half face mask.	72-143	5.50	
	7500-6B	Static wool filter replacement.	72-143 packages of 100 ea.	0.13	
(2) Chemical cartridge respirators					
	R 21	Provides protection against low concentrations of organic vapors.	50-99	10.70	
• B&L	5-15-21	Organic vapor cartridge replacement for R 21.	50-99 boxes of 6	1.51	Stock item
• MSA	85556	MSA chemical cartridge respirator for protection against organic vapors (0.1%).	72-143	9.70	Stock item
	44135	Replacement cartridge for 85556.	100-149	1.45	Stock item
	76853	MSA same as 85556 but with single cartridge for organic vapor.	72-143	9.30	Stock item
	76883	Replacement cartridge for 76853.	100-149	2.65	Stock item

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EXHIBIT D-8 (2)

Respiratory Device/Manufacturer	Components		Lot Size	Cost Per Unit (1974 Dollars)	Availability (Weeks To Receive After Order)						
	Catalog Number	Description									
• Scott	8201-OV	Duo-seal respirator for organic vapors. Dual cartridge	50-99	\$ 9.00	Stock item						
	82004-OV	Replacement cartridge for 8201-OV	100-499 pr.	2.50	Stock item						
	8101-OV	Same as 8201-OV but with single cartridge	100-499	8.30	Stock item						
	502-OV	Replacement cartridge for 8101-OV	100-499	2.30	Stock item						
• Welsh	7601	Full-face respirator for organic vapors. Dual cartridge	1	45.85							
	7600-1	Replacement cartridge for 7601	72-143 packs with 6 pieces/pack	1.28							
(2) Gas masks											
• MSA	457081	MSA industrial size for up to 2% by volume organic vapors and toxic dusts with full face mask and body mounted canister.	6-11	78.05	Stock item						
	77705	Replacement canister for 457081	12-71	7.45	Stock item						
	457112	MSA chin type mask for up to 0.5% by volume organic vapors	6-11	53.90	Stock item						
	88339	Replacement canister for 457112	100 and up	5.85	Stock item						
• Scott	679-1	Chest style gas mask for up to 2% by volume organic vapor protection with full facepiece	18 and up	75.43	3 weeks						
	184-OV	Replacement canister for 679-1 (1000cc)	12-71	6.50	Stock items						
	661-1	Chin style gas mask for organic vapor protection (full face)	18 and up	42.16	Stock item						
	282-OV-L	600cc replacement canister for 656-1	50-99	5.10	Stock item						
2. Supplied Air Devices											
(1) Air line respiration											
• Constant flow											
• MSA	457162	Ultra-Vue facepiece and low pressure control valve (10-15 psig with 50 foot hose)	1	82.30	Stock item						
	457161	Same as 457162 box with hyper-flow control valve (40-100 psig with up to 250 feet of air-hose)	1	82.30	Stock item						
• Scott	4622-10	Zephyrair-complete full vision mask with belt mounted filter body and manual control valve. Adjust air pressures as follows with 3/8" ID hose	18 and up	80.94	2 weeks						
<table><tr><td>Hose Length</td><td>Pressure at Hose Inlet</td></tr><tr><td>15' to 50'</td><td>8 to 17 psi</td></tr><tr><td>50' to 250'</td><td>17 to 30 psi</td></tr></table>						Hose Length	Pressure at Hose Inlet	15' to 50'	8 to 17 psi	50' to 250'	17 to 30 psi
Hose Length	Pressure at Hose Inlet										
15' to 50'	8 to 17 psi										
50' to 250'	17 to 30 psi										

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EXHIBIT D-8 (2)

Respiratory Device/Manufacturer	Components		Lot Size	Cost Per Unit (1974 Dollars)	Availability (Weeks To Receive After Order)
	Catalog Number	Description			
• Demand types	7600A	Low pressure (10-25 psi) full facepiece.	1	\$ 57.85	
• MSA	457157	Mask-mounted demand air-line respirator w/ultra-vue facepiece; 30-125 psi/15-250 ft. hose lengths.	1	95.90	Stock item
	457165	Belt-mounted demand flow air-line respirator w/ultra-vue facepiece 30-125 psi/15-250 ft. hose lengths.	1	95.90	Stock item
• Scott	4637-1	Demand type respirator w/full vision mask 60-125 psi/15-25 ft. of hose length.	18 and up	75.43	3 weeks
• Hose masks/MSA	457140	One man combination hose mask, with hand operated blower (centrifugal) and 50 ft. of hose.	1	668.00	60-90 days
	457142	Same as 457140 but is a two man unit.	1	972.00	60-90 days
• Accessories for air-line systems					
• Compression systems/MSA	32057	"Clear air" blower that washes, cools, and humidifies air for 12 masks (Nash Co. compressor)	1	2,586.00	16-18 weeks
	81857	Air-line filter for removal of dusts, mists, fumes as a final.	1	44.55	Stock item
	46727	Replacement chemical cartridge for 81857 filter (2 required).	1-71	2.40	Stock item
	79030	Particulate element replacement for 81857 filter.	1	4.80	Stock item
	66716	MSA pressure regulator reduces plant compressor air pressure to the rated value for the equipment.	1	34.90	Stock item
	66709	Pressure relief valve-16 psig.	1	9.80	Stock item
	68265	Pressure relief valve-25 psig.	1	14.65	Stock item
• Pressure regulators/MSA	68858	Required accessory when air-line respirators are operating from a high pressure cylinder 0-4000 psi hi-pressure gauge 0-200 psi low-pressure gauge.	1	94.35	Stock item
• Air-lines and manifolds/MSA	455020	Air hose - 15 ft. long	1	16.65	Stock item
	455021	Air hose - 25 ft. long	1	23.95	Stock item
	455022	Air hose - 50 ft. long	1	43.20	Stock item
	93931	Manifold-4 man (snap-tite)	1	59.20	30 days

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EXHIBIT D-6 (4)

Respiratory Device/Manufacturer	Components		Lot Size	Cost Per Unit (1974 Dollars)	Availability (Weeks To Receive After Order)
	Catalog Number	Description			
3. Self Contained Respirator					
(1) Pressure demand-full-facepiece self-contained breathing apparatus 1, 2 MSA	95049	With single-lens clear-vue facepiece and audible alarm	1	\$515.00	Two weeks
(2) Combination pressure demand full facepiece respirator and pressure-demand self-contained breathing apparatus 1, 2 MSA	96386	Complete in carrying case	1	\$99.00	Two weeks
(3) Positive pressure full facepiece self-contained breathing apparatus 1, 2		Would be very wasteful of compressed air			Not available
(4) Combination continuous flow respirator and a pressure demand self-contained breathing apparatus 1, 2		Would be very wasteful of compressed air			Not available
(5) Demand work mask w/quick-connect/disconnect assembly which can be attached to primary air supply MSA	457159	MSA unit complete with ultra-vue facepiece assembly, speaking diaphragm, demand regulator, harness, and 12 cu. ft. capacity air cylinder in carrying case	1	496.00	2 weeks
4. Cylinder Recharger Systems					
MSA	Cascading System for Cylinder Recharging				
	68850	Air coupler tee	1	17.50	Stock item
	69851	Air pigtail	1	22.95	Stock item
	68346	Air outlet connection, complete with gauge	1	34.90	Stock item
	77203	High pressure airfilling hose, 5 ft. long.	1	24.30	Stock item

Notes: (1) Permitted types under the temporary 50 ppm standard.
 (2) Permitted types under the proposed permanent no detectable standard.
 (3) Stock items are delivered in not more than one week.

Sources: Bausch & Lomb Safety Products Division Catalog, 1974.
 Mine Safety Appliances Respiratory Protection Catalog, 1974.
 Scott/Airco Products Respiratory Protection Equipment and Accessories Catalog, 1974.
 Welsh Catalog TCR, 1974.
 Results of Snell survey of the respiratory equipment manufacturers.

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EXHIBIT D-9 (1)

US DOL/OSHA

COST AND AVAILABILITY OF PROTECTIVE CLOTHING

Protective Clothing/Manufacturer	Catalog No.	Components Description	Lot Size	1974 Cost Per Unit (Dollars)	Availability
I. Disposable Clothing					
1. Coveralls, Hood and Shoe Coverings, Gloves					
. Datasab					
	-	Coverall made of Dupont Tyvek (R) with elastic wrist and ankle for tight fit.	-	\$ 2.28	Stock item
	790205	Shoe covering of Dupont Tyvek (R) Hightop with drawstring for tight fit.	100	0.51	Stock item
	520205	Hood made of Dupont Tyvek (R) with drawstring for tight fit around face.	300	0.40	Stock item
. Arrow Disposables					
	-	Coverall made of Dupont Tyvek (R) with elastic wrist and ankle for tight fit.	-	2.00	In development 2 - 3 months before available in quantity
. Mam Inc.					
	-	Coverall made of Dupont Tyvek (R) with elastic wrist and ankle for tight fit.	-	2.00	Stock item
. Flomer Rubber					
	V-6	Disposable liquid proof gloves.	144	0.21	30 weeks
2. One-Piece Pressurized Suits					
. MSA					
	91783	Airfed positive internal pressure suit made of vinyl. Complete with attached hood with clear vinyl face-piece. Room for respiratory protective equipment. Designed for one use only.	1	47.00	Stock item
II. Permanent Clothing					
1. Full Impervious Pressurized Suits					
. American Optical					
	6111	Vapor chemical suit pressurized with self-contained breathing equipment.	1	298.45	6-8 weeks
. MSA					
	75098	Chempruf (R) suit complete with case, hood and air supply system. Used with manifold and airline suit develops positive internal pressure.	1	393.45	15-17 weeks
	33496	Ruthenized Protection Suit can be worn with MSA air mask not supplied with unit.	1	178.12	6-8 weeks

Note: Stock items are delivered in one week or less.

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EXHIBIT D-9 (2)

Protective Clothing/Manufacturer	Catalog No.	Components Description	Lot Size	1974 Cost Per Unit (Dollars)	Availability
2. Acid Resistant Suit					
• MSA	37108	Sun Ray ^(R) suit, vinyl coated nylon made to be decontaminated after each use. Jacket has safety cuffs and is fastened with bolt and socket fasteners. Pants have bib front and no fly.	1	\$ 47.60	2-3 weeks
	31834	Rubber utility suit jacket has stand-up collar with storm fly front. Pants have bib front with no fly. All seams pressure welded.	12	21.50	Stock item
• Uniroyal	M2U-A27	Neoprene coated on nylon jacket with attached hood with drawstring for tight face fit. Closed with storm fly front.	1	11.66	Not less than 2 months
	MRO-957	Neoprene coated on nylon bib type pants with map fly.	1	9.46	Not less than 2 months
• American Optical	9011	Acid resistant coveralls made of neoprene coated on nylon.	1	25.00	6-8 weeks
	503-1	Acid resistant jacket made of heavy duty vinyl with storm fly front.	1	25.80	6-8 weeks
	512	Acid resistant bib type pants made of heavy duty vinyl.	1	22.90	6-8 weeks
	524	Hood made of heavy duty vinyl with clear vinyl facepiece covering shoulders and upper chest.	1	48.70	6-8 weeks
3. Cloth Work Clothes					
• MSA	39134	Coveralls made of synthetic fiber fabric Dynel ^(R) made to cover or replace the worker's street clothes.	72	18.60	2-4 weeks

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Protective Clothing/Manufacturer	Components		Lot Size	1974 Cost Per Unit (Dollars)	Availability
	Catalog No.	Description			
4. Gloves					
• MSA	36688	Heavy duty acid resistant rubber designed with curved fingers and using high quality latex for pliability and chemical resistance over a wide temperature range.	12	\$ 4.02	2-3 weeks
	37643	Flexible, completely coated with vinyl 12" gauntlet type.	72	1.71	Stock item
• Pioneer Rubber	N-31	Lightweight designed for liquid tight protection. Glove is not particularly durable.	12	0.91	6-8 weeks
5. Boots					
• Uniroyal	M8801	Knee length acid resistant rubber with steel safety toe.	12	16.90	Stock item
	M8990	Knee length medium weight acid resistant rubber with safety toe.	12	15.55	Stock item
	M8951	Knee length imported acid resistant rubber with safety toe.	12	12.70	Stock item

Sources: Dunlap 1974 sales brochure, Mine Safety Appliances 1974 catalogue, Uniroyal 1974 catalogue, Pioneer Rubber 1974 Catalogue and Snell Survey of Protective Clothing Manufacturers.

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EXHIBIT D-10 (1)

USDOL/OSHA

SUMMARY OF SNELL INTERVIEWS WITH
VINYL CHLORIDE/POLYVINYL CHLORIDE MANUFACTURERS
RELATING TO PROTECTIVE EQUIPMENT PURCHASED

<u>VC or PVC Producer (1)</u>	<u>Class of Protective Equipment</u>	<u>Number of Workers Requiring Protective Equipment</u>	<u>Cost of Equipment (1974 Dollars)</u>	<u>Operating and Maintenance Costs (1974 Dollars)</u>	<u>Comments</u>
11M-Int. -C and 175-Int. -W	Respirators, half face air supplied	16-20 16-20	\$200,000 200,000	\$ 25,000 25,000	Several tripping accidents have been attributed to respirators as some of the workers are reluctant to wear them. Minute-by- minute supervision required to ensure use.
27	Respirators	47	16,000	N.A.	
20 and 21M-Int. -W	Respirators, half face air supplied	N.A.	N.A.	N.A.	6 weeks procurement lead time.
40L-New-W	1. Respirators, airline	88	60,000	5,000	
	2. Protective clothing				
	Disposable coveralls		30	300	
	Rubber gloves		30	300	
15	Respirators	20	4,750	6,300	
19L-New-W	Respirators, airline		14,000	6,500	MSA type.
	Respirators, airline				One incident of face and scalp rash from use of air mask.
41L-Old-W		16	13,000	5,000	
64M-New-C		16	8,000	6,000	
34	Respirators, pressure demand or continuous flow	6.5	10,000	6,000	
38	Same	3	4,000	2,500	

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<u>VC or PVC Producer</u>	<u>Class of Protective Equipment</u>	<u>Number of Workers Requiring Protective Equipment</u>	<u>Cost of Equipment (1974 Dollars)</u>	<u>Operating and Maintenance Costs (1974 Dollars)</u>	<u>Comments</u>
10M-New-W	Respirators, half face mask	26	\$ 25,000	\$ 5,000	Workers complain of dry throat and impaired movement.
M-Int. -C	Respirator	8			
	Protective clothing	N.A.			
	Coveralls		40,000	12,000	
	Shoe covers				
	Head covers				
	Gloves				
6L-Old-C	1. Respirator				
	Airline masks		23,500	N.A.	
	Self-contained respirators	112	7,025	N.A.	Scott type
	Cartridge respirators		2,312	72,000	
	2. Protective clothing				
	Waterproof suits	N.A.	Disposable clothing		
	Head covers, dust shields, gloves	N.A.	listed as operating cost	2,400	
				1,500	
13	Respirator				
	Airline	81	67,000		
	Cartridge		15,000	18,000	MSA type.
8L-New-C	1. Respirators	50	5,000	3,000	Welsh and Scott type.
	2. Protective clothing				
14M-Int. -W	1. Respirators, self-contained	2	4,500	N.A.	There have been complaints by workers on wearing respirators.
	cartridge	40	N.A.	N.A.	Scott type.
	2. Protective clothing			36,000	
	coveralls				
	Disposable suits	N.A.		4,800	

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<u>VC or PVC Producer</u>	<u>Class of Protective Equipment</u>	<u>Number of Workers Requiring Protective Equipment</u>	<u>Cost of Equipment (1974 Dollars)</u>	<u>Operating and Maintenance Costs (1974 Dollars)</u>	<u>Comments</u>
49M-Old-C	1. Respirators, air supplied	N.A.	\$ 2,500	\$ 4,800	People with heart or lung problems have been advised not to wear respirators - have been reassigned to areas not requiring their use.
	Canridge	N.A.	3,300	120,000	
	Protective clothing	N.A.	1,250	N.A.	
	Hard hats	N.A.		72,000	
	Coveralls	N.A.		14,400	
	Waterproof suits	N.A.			
44M-New-C	1. Respirators	37	21,188	30,800	One worker with history of asthma became ill while wearing air-line mask.
	2. Protective Clothing			56,000	
22M-Old-C	Respirators, continuous flow airline	25	20,000	12,000	
95-Int.-C	Respirator	N.A.	500	N.A.	Scott type. Individual cases of workers refusing to wear respirators.
30M-New-C	Respirators, full face mask type C continuous flow	76	45,000	3,000	2 - 5 weeks procurement lead time.
35S-Int.-C	Protective clothing	N.A.	5,000	26,000	
31M-New-C	Respirators	N.A.	25,000	N.A.	1 - 2 months procurement lead time. Problems in fitting masks on personnel with beards and mustaches.
42S-Int.-C and 39S-New-C	Respirators	N.A.	15,000	N.A.	Increased absenteeism and refusal of overtime has been attributable to use of respiratory equipment.
28L-New-C	Respirators, bottle supplied air masks	20	10,300	20,000	One complaint of ear problems caused by respirator use.
	Self-contained		1,700	N.A.	

<u>VC or PVC Producer</u>	<u>Class of Protective Equipment</u>	<u>Number of Workers Requiring Protective Equipment</u>	<u>Cost of Equipment (1974 Dollars)</u>	<u>Operating and Maintenance Costs (1974 Dollars)</u>	<u>Comments</u>
36M-Int.-C	Protective Clothing Rain suits	N.A.	\$ 13,000	N.A.	
46M-Old-C	Respiration	200-300	41,000	\$ 18,000	3 months procurement lead time. Workers have complaints of nasal and throat dehydration.

Note: (1) For meaning of producer code, see page II-6.

Source: Results of Snell interview with the VCM/PVC manufacturing industry.

NA = Not applicable.

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EXHIBIT D-11 (1)

USDOL/OSHA

SAMPLE COSTS VS. NUMBER OF COVERED WORKERS NEEDING RESPIRATORY EQUIPMENT
AS A FUNCTION OF VINYL CHLORIDE MONOMER LEVELS BY PRODUCER

VCM/PVC Producer (1)	VCM Level (2) (PPM)	No. of Employees Wearing Respirators	Job Classification	Wearing Time (% of 8 Hr. Day)	Incremental Capital Costs (Dollar)	Operations and Maintenance Costs (1974 Dollar)	Comments
2A	50	2	Tank car unloading	50%	\$11,050	\$1,000	Total for 50 ppm level.
		2	Maintenance	25			
		2	Ship loading	100			
		2	Operating (samples, etc.)	0			
Total		8	AS ABOVE				
	25	8	Operating	50	\$11,000	\$1,200	With no engineering improvements
		13	Maintenance	75			
		7	Laboratory	66			
		10	Ship loading	100			
Total		40					
	10	7	Operating	50			With engineering improvements.
		9	Maintenance	25			
		-	Laboratory	-			
		6	Ship loading	100			
Total		22					
	1	34	Operating	100	NA	NA	
		40	Maintenance	100			
		35	Supervising and support	100			
		10	Ship loading	100			
		121					
100-Mw-47	50	4	Normal operation	10	14,000	8,500	
		12	Vessel cleaning	10			
		8	Routine maintenance	10			
		21	Non-routine maintenance	10			
Total		45					
	25	11	Normal operation	20	No increase		
		12	Vessel cleaning	20			
		8	Routine maintenance	27			
		24	Non-routine maintenance	27			
Total		55					
	"NO DETECTABLE"		NOT FEASIBLE				

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VCM/PVC Product	VCM Level (PPM)	No. of Employees Wearing Respirators	Job Classification	Wearing Time (% of 8 Hr. Day)	Incremental Capital Costs (Dollars)	Operations and Maintenance Costs (1974 Dollars)	Comments
40L-40W-40	50	20 4 4 8 20 4 4 8 12 4 <u>82</u>	Reactor cleaning Large reactor operation Large reactor lead operation Small reactor lead operation Small reactor operation Reactor department shift supervisor Dryer lead Dryer operation Dryer utilities Dryer shift supervisor	25% 8 3 12 30 3 3 3 3 3	\$40,000	\$5,000	
Total	55	80 4 4 8 20 4 4 8 12 4 <u>121</u>	Reactor cleaning Large reactor operation Large reactor lead operation Small reactor lead operation Small reactor operation Reactor shift supervisor Dryer lead Dryer operation Dryer utilities Dryer shift supervisor	30 15 5 20 40 8 3 3 15 8	No Increase	NA	
30	30	12 8 6 <u>26</u>	Sampling Loading Maintenance	<1 10 7	10,000	5,000	
Total	35	12 8 6 <u>26</u>	Sampling Loading Maintenance	1 10 10	No Increase for 50 ppm Level	7,000	
Total	10	12 8 6 60 <u>86</u>	Sampling Loading Maintenance Other	1 100 25 1	NA	NA	
Total	1	100 100	All jobs	100	350,000	NA	

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VCM/PVC Product	VCM Level (PPM)	No. of Employees Wearing Respirators	Job Classification	Wearing Time (% of 8 Hr. Day)	Incremental Capital Cost (Dollars)	Operations and Maintenance Costs (1974 Dollars)	Comments
20	20	8	Leader	10%			
		4	Maintenance	8	\$ 4,000	\$2,500	
Total		12					
	25	8	Leader	10	No Increase	No Increase	
Total		4	Maintenance	8			
	10	8	Leader	63	NA	NA	
		4	Maintenance	100			
Total		100	Other	7			
		112					
	1	272	All	100	NA	NA	
		272					
BL-Har-C	20	20	Poly building personnel	1	2,000	<50,000	
	25	10	Poly building personnel				
Total		10	Maintenance, technical	3	10,000	NA	
	10 TWA and 25 (Colling)	10	Same as above	25			
Total		10					
	1		NOT FEASIBLE				
1000-400, -W	20	9	Charging polys	10	7,000	NA	
		9	Recovery polys	15			
		12	Helper	21			
		1	Bulk loading resins	15			
		4	Bagging resins	8			
		2	Maintenance, pipelitting	1			
		2	Maintenance, mechanics	1			
		1	Maintenance, electronics	8			
		1	Maintenance, instruments	1			
Total		1	Painting, lagging	3			
	25	42					
	10		Same as above but more use of air mask		No Increase		
			NOT FEASIBLE				

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VCM/PVC Product	VCM Level (ppm)	No. of Employees Wearing Respirators	Job Classification	Wearing Time (% of 8 Hr. Day)	Incremental Capital Costs (Dollars)	Operations and Maintenance Costs (1974 Dollars)	Comments
484-016-C	50 (Ceiling)	4	Latex charge operator	5	\$2,500	\$4,000	Helpers use both air-fed respirators and cartridge type respirators. The air-fed respirators are used for opening and cleaning polymerization and the cartridge respirators are used on other jobs where the concentration might be above 25 ppm but below 50 ppm.
		4	Plastic latex operator	5			
		4	Latex recovery operator	1			
		4	Latex helper	20			
		20	Charge operator	5			
		20	Recovery operator	<1			
		24	IRRC operators	15			
		4	Utility operators	25			
		20	Helpers	20			
		12	Dryer operators	<1			
		10	Baggers	<1			
		4	Transfer operators	<1			
		150	Maintenance mechanics	10			
			Tank farm operators	25			
		10	Foremen	10			
		5	Day supervisors	<1			
		5	Engineers	<1			
		2	General foremen	<1			
		1	Department manager	<1			
Total		333					
	25 (Ceiling)	4	Latex charge operator	10	NA	NA	With a 25 ppm ceiling the use of cartridge respirators would be eliminated. The use of air-fed respirators would be increased and economy masks would be used. Increasingly, because of their longer life and better mobility.
		4	Plastic latex operator	10			
		4	Latex recovery operator	5			
		4	Latex helper	25			
		20	Charge operator	10			
		20	Recovery operator	5			
		24	IRRC operators	20			
		4	Utility operators	25			
		20	Helpers	20			
		12	Dryer operators	5			
		10	Baggers	<1			
		4	Transfer operators	<1			
		150	Maintenance mechanics	20			
			Tank farm operators	25			
		10	Foremen	10			
		5	Day supervisors	5			
		5	Engineers	5			
		2	General foremen	5			
		1	Department manager	<1			
Total		333					

EXHIBIT D-11 (S)

VCM/PVC Producer	VCM Level (FTM)	No. of Employees Wearing Respirators	Job Classification	Wearing Time (% of 8 Hr. Day)	Incremental Capital Costs (Dollars)	Operations and Maintenance Costs (1974 Dollars)	Comments
404-OM-C (none)	22 (CalMag) 20 TWA	4 4 4 4 20 20 24 4 20 12 10 4 10 4 150 10 2 6 2 1	Latex charge operator Plastic latex operator Latex recovery operator Latex helper Charge operator Recovery operator HMC operator Utility operator Helper Dryer operator Bagger Transfer operator Maintenance mechanics Tank farm operator Foreman Day supervisor Engineer General foreman Department manager	15 15 10 25 20 10 24 40 25 12 6 6 40 20 6 6 6 6 41	NA	NA	For this level the wearing of respirators would be increased as indicated.
Total		333					
	1		NOT FEASIBLE				
22	22	21	Sampling Draining equipment Opening equipment Repairs	6	\$82,200	\$19,000	
	22	21	Above, plus taking readings on going into unit while any leaks exist on VCM equipment.	12	No Increase	NA	
	19 (CalMag) 2 TWA	21	Same as above	20	No Increase	NA	
	1		NOT FEASIBLE				

Note: (1) Ceiling levels unless otherwise stated.
(2) For meaning of producer codes see page B-6.

Source: Dollar amounts are the results of interviews with VC/PVC producers.

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APPENDIX E

MONITORING EQUIPMENT

APPENDIX E

MONITORING EQUIPMENT

This appendix details the elements of monitoring equipment currently available to industry for the detection of vinyl chloride monomer (VCM) including their costs and availability. The appendix also reviews relevant material from the public hearings and lists the monitoring equipment purchased by VCM and polyvinyl chloride (PVC) producers. All exhibits appear sequentially at the end of the appendix.

1. A REVIEW OF THE TEMPORARY AND PROPOSED REGULATORY REQUIREMENTS FOR THE MONITORING OF VCM AND PVC PLANTS FOLLOWS

This section summarizes the monitoring required under the Emergency Temporary Standard for exposure to VCM (50 ppm) and the monitoring required under the proposed permanent standard (no-detectable limit).

(1) 50 ppm Emergency Temporary Standard (ETS) ⁽¹⁾

The ETS required that as soon as possible but not later than April 22, 1974, every employer of an employee working in an area or operation in which VCM is

- manufactured
- reacted
- handled
- processed
- released
- repacked
- stored

should begin monitoring the ambient air of the area to determine whether it contains VCM in concentrations in excess of 50 ppm.

(1) 29 CFR 1910, Occupational Safety and Health Standards, Emergency Temporary Standard for Exposure to VCM

• The monitoring should be of the nature that a sufficient number of employees be monitored so that a representative sample of exposure to the gas may be determined.

- monitoring should be accomplished not less frequently than weekly until all results from three consecutive weeks are at a level below 50 ppm
- after achievement of the 50 ppm level, the monitoring should be conducted not less frequently than monthly as long as the concentration of VCM does not exceed 50 ppm
- if a monitoring sample reveals VCM in concentrations in excess of 50 ppm, weekly monitoring should be resumed until all monitoring results for three consecutive weeks are at or below 50 ppm

• Monitoring should be accomplished through personnel monitoring by collecting samples by suitable device worn by the employee.

- the samples should be analyzed by gas chromatography or by any other method which is of equivalent sensitivity
- the analytical procedure shall be sensitive to 5 ppm of VCM in air with an accuracy of $\pm 20\%$ for a ten minute air sample

• Employees working in an area of operation whose ambient air is monitored, or their representative, should be given a reasonable opportunity to observe the personal monitoring described by the emergency temporary standard.

• Periodic tests should be conducted for equipment leaks and for emission of VCM which may result from work practices.

(2) Proposed Permanent "No-Detectable" VCM Level Standard (PPS) (1)

A program of monitoring would be required to establish whether there are detectable levels in regulated areas and to permit determination of employee exposures on an individual basis. A regulated area is where

- VCM is

- .. manufactured
- .. reacted
- .. released
- .. repackaged
- .. stored
- .. used

- PVC capable of releasing detectable levels of VCM is

- .. manufactured
- .. reacted
- .. released
- .. repackaged
- .. stored
- .. used

Provision is also made for an employee to observe monitoring by them or their designated representative. The monitoring will assume that any exposure may be determined for each authorized employee with a confidence level of 95%. An authorized employee is one

- whose duties require him to be in the regulated area and who has been specifically assigned by the employer

(1) 29 CFR 1910, Occupational Safety and Health Standards, Proposed Standard

any employee who enters such an area as designated representative of employee to exercise an opportunity to observe monitoring and measuring of VCM

The PPS requires that monitoring be accomplished by a sampling and analytical method capable of detecting vinyl chloride at concentrations of 1 ppm with an accuracy of 1 ppm $\pm$ 50%.

The PPS is, in part, based on the NIOSH recommended Standard for VCM Exposure as transmitted to OSHA on March 11, 1974. The NIOSH recommendations are presented in their entirety in Appendix H.

2. SNELL PERFORMED AN INDEPENDENT SURVEY OF AVAILABLE MONITORING EQUIPMENT AND DETERMINED AVAILABILITY AND COSTS

- Exhibit E-1 and E-2 present a summary of highlights of the testimony dealing with monitoring systems.
- Exhibit E-3 presents the proposed NIOSH procedures for VCM monitoring.
- Exhibit E-4 presents a summary of the Snell survey of VCM monitoring devices currently available; the survey sample included 9 manufacturers.
- Exhibit E-5 presents a summary of the availability and costs of VCM monitoring devices.
- Exhibit E-6 presents the results of the Snell interviews of VCM and PVC manufacturers relating to current monitoring procedures and equipment.
- Exhibit E-7 presents the VCM and PVC industry costs of purchasing monitoring equipment in compliance with the 50 ppm standard.

EXHIBIT E-1

USDOL/OSHA

STATEMENT OF R. H. STEHL COMPARING METHODS OF
VINYL CHLORIDE MONOMER ANALYSIS

Type of Equipment	Operating Parameters	Advantages	Disadvantages
Gas Chromatographs (GC)	Flame ionization	Reproducible at constant operating parameters; selective in identification; .1 - 1 ppm sensitivity.	Cannot be used where explosion hazards exist; 5 - 15 min. /analysis.
Infrared	Gas-cell type	Little interference; each compound has characteristic bands; 2 minutes to make energy absorption measurement; 2 - 5 ppm sensitivity.	Water vapor interferes and reduces sensitivity.
Combustion-Conductivity	Conversion by pyrolysis to HC_1 and CO_2	30 secs for analysis; can be computerized.	Interference from other compounds (Freon).
Total Flame Ionization Detectors (FID)	Combustion, but not decomposition	2 minutes/sample analysis.	Non-specific.
GC - Mass Spectrometry	Magnetic field.	1 ppm sensitivity; no interference.	Not applicable to area monitoring; reference method only; requires trained analyst.
Personal Monitoring Equipment	Adsorption - onto media (air pump, sample tube)	NA	Non-continuous

Source: Testimony of Dr. R. H. Stehl, Dow Chemical Co., Midland, Mich., comparing methods of VCM analysis as presented at DOL/OSHA hearings, June 25, 1974 and Snell assessment.

NA = Not available.

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EXHIBIT E-2

USDOL/OSHA

STATEMENT OF R. L. DANIEL DETAILING METHODS OF
MONITORING AND ANALYSIS OF VINYL CHLORIDE MONOMER

Type of Equipment	Operating Parameters	Advantages	Disadvantages
Continuous Monitoring Equipment	Flammable gas detection	NA	Only alarms at 4000 ppm level.
Sequential Monitoring	GC, 12 point 15 minute cycle (Monomer plant #1)	NA	NA
Sequential Monitoring	GC, 10 point 6 minute cycle (Monomer plant #2)	NA	NA
Sequential Monitoring	GC, 10 point 6 minute cycle (Monomer plant #3)	NA	NA
Sequential Monitoring	Non-specific analyzer combustion-conductivity type, 18 point, 1/2 minute cycle, alarms at 25 ppm (Copolymer plant)	NA	NA
Personnel Monitors	Exposure type	NA	Can only be analyzed after the fact; does not provide on the spot data; does not give min./max. concentration in employee's work area.

Source: Testimony of R. L. Daniel, Dow Chemical Co., Freeport, Texas concerning methods of monitoring and analysis of
VCM used at Freeport, Texas as related at DOL/OSHA, June 25, 1974 and Snell assessment.

NA = Not available.

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EXHIBIT E-3 (1)

USDOL/OSHA

RECOMMENDED NIOSH PROCEDURE FOR PERSONAL
MONITORING OF EMPLOYEES FOR VINYL CHLORIDE
MONOMER EXPOSURE

1. SUBSTANCE:

Vinyl Chloride Gas

2. SCOPE OF METHOD:

Vinyl chloride is a gas boiling at - 13.4 degrees C and having a vapor pressure of 2660 mm of mercury at 25 degrees C. The lower limit of detection for the method is approximately 1 ppm.

3. SAMPLING EQUIPMENT:

- (a) Personal sampling pump
- (b) 250 cc glass gas collecting tubes with teflon stopcocks.

4. SAMPLE SIZE:

250 CC

5. SAMPLING PROCEDURE:

Glass Gas Collecting Tubes

- (a) The gas collecting tube is connected at one end to the personal sampling pump. Both stopcocks are opened and air pulled through at approximately one liter per minute.
- (b) A sampling period of 15 minutes would allow collection of a representative sampling of the worker environment.
- (c) Stopcocks shall be closed tightly, closing the stopcock nearest the pump first.

6. ANALYSIS:

The gas collecting tube sample is analyzed directly by gas chromatography.

7. SHIPPING INSTRUCTIONS:

The gas collecting tube should be wrapped with cushioning material, placed in the shipping case and shipped via Air Mail to the OSHA laboratory, Salt Lake City.

Source: NIOSH Recommended Occupational Health Standard for the Manufacture of Synthetic Polymer from Vinyl Chloride, March 11, 1974.

EXHIBIT E-4 (1)

USDOL/OSHA

COMPARISON OF TYPICAL MONITORING DEVICES PRESENTLY
AVAILABLE FOR VINYL CHLORIDE MONOMER DETECTION

Monitoring Device	Example of Available Equipment (Manufacturer/Model)	Description	Method of Operation	Sensitivity	Calibration Procedure	Level of Training Required for Operator	Necessary Support Equipment or Supplies	Comments
1. Personal Monitoring								
(1) Colorimetric	Time Safety Appliances/ Model 68413	Halogenated hydrocarbon detector, detecting unit consists of two parts - a reactive tube and a glass detector tube, which are joined together for testing sample. The reactive tube holds two frangible glass ampules containing chemicals which are mixed immediately before use and serve to oxidize the halogenated hydrocarbon releasing free Cl_2 or Br_2 . The correct detector tube is selected for the gas of interest.	The sample is drawn through the detector unit by an aspirator bulb assembly. The released halogen reacts with the chemicals in the tube to form a length of stain indication which is correlated with the number of aspirations to give the concentration of the halogenated hydrocarbon.	~ 0-360 ppm	Tubes are calibrated for use at atmospheric pressure between temperatures of 50° and 90°F and relative humidities of 0 and 80%. Tubes should be warmed for use at lower temperatures.	Technician or operating foreman.	None	Simple in operation, needs no maintenance.
	Beckman/Model 3617330	Beckman/Gauche Fraction Gas Detection System. System combines two proven effective components for the precise sampling and detection of toxic gases and vapors. • Accurate, convenient direct reading detection tubes. • A piston-type volumetric pump.	Break off the tip of a fresh tube. Insert into pump and pull handle which automatically locks at 50 or 100cc sample. The absorbing media will immediately react to the gas or vapor being analyzed, and a constant color stain is produced which will vary in length according to the concentration being measured.	0.025-95 in 2.5 strokes	No calibration needed but tubes should be refrigerated below 40°F.	Technician or operating foreman.	None	Simple in operation, needs no maintenance.
(2) Charcoal Tube/ Pump System (Assessments)	Assess 1, Syntex Co., Model SP-2 & 3	Dimensions of Syntex personal sampler pump: • Depth 1-1/4" • Width 2-1/2" • Length 5-1/8" • Weight 12 oz. It is carried in breast pocket of worker's shirt or coat or in a pouch clipped to the worker's belt. Pump is used to draw a continuously measured volume of air through a charcoal tube from a worker's breathing zone for the duration of a working shift. More than eight hours of continuous operation can be provided before recharging of the battery.	The equipment utilizes a glass tube packed w/activated charcoal through which an air sample containing a vapor such as VCM is pumped. The vapor is quantitatively adsorbed by the activated carbon. The VCM collected on the tube is quantitatively with carbon disulfide, and an aliquot of the resulting mixture is introduced into a gas chromatograph. An alternate to sorbent tubes is the use of plastic bags to collect samples.	Can detect VCM down to 0.1 ppm	Pump may be calibrated simply by checking the cc per stroke factor. This is done by drawing air through a charcoal tube preceded by a soap bubble flowmeter. Total cc's sampled = factor No. of strokes required (K) The factor has been initially determined by calibration, and it is shown on the pump case.	Technician or foreman to collect tubes and check pump. Chemist for calibration and operation of gas chromatograph.	Soap bubble flowmeter, WFLD.	Pump system was developed for OSHA and is used by USDOL for OSHA inspections.

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Monitoring Device	Example of Available Equipment (Manufacturer/Model #)	Description	Method of Operation	Sensitivity	Calibration Procedure	Level of Training Required for Operator	Necessary Support Equipment or Supplies	Comments
B. Area Monitoring								
(1) Gas Chromatographic Systems (Automatic, sequential analysis)	Berthom Instruments Company/Model 6700	Process Gas Chromatograph Unit is designed for field location in hazardous areas and may be separated from the programmer by distance up to 1,000 ft.	Air is drawn into sampling pipe by pump and is filtered. Sample is drawn into G.C. and analyzed for VCM by a flame ionization detector. Results are displayed on bargraph or on a numerical basis via a minicomputer. Sample analysis time is 120 minutes. A particular area can be monitored every 20 minutes.	0.1 ppm	System is calibrated using gas mixtures whose VCM concentrations are known. These mixtures are commercially available or can be "made up" in plant laboratory with care.	Graduate chemist for system operation. Technician for maintenance	Calibration gases N ₂ gas for flow	
	Newton-Packard/Model 3814A	Modified research grade H ₂ gas chromatograph with automatic operation.	Same as above. This system may be used to monitor up to 16 different streams in one plant by adding a 16 port stream selection valve and pump.	0.1 ppm	Same as above. Baseline response can be performed with the minicomputer accessory.	Same as above.	Same as above.	
	Beck	Similar to the above instrumentation						
(2) Gas Chromatographic Systems (Manual)	Various, including: • Beckman • DuPont • Hewlett-Packard • Pye-Diner • Varian/Aerograph	Use of research type gas chromatograph coupled with manually collected samples.	Air sample is manually collected by technician in: • Evacuated tubes • Tedlar bags • Activated charcoal tubes The samples are brought to the laboratory and injected into G.C.	0.1 ppm	Same as above.	Graduate chemist for system operation. Technician for maintenance and sample taking.	Calibration gases • H ₂ • N ₂ • Compressed air Sample collection such as: • Glass tubes • Tedlar bags • Activated charcoal tubes	Although this type of system is definitely less of a capital investment than the automated sequential analysis, it still would require high operating costs as the technician time in obtaining samples. Also many fewer area samples could be analyzed per day as in the practical dimension of manual operation.

RIGHT 1-4 (2)

Monitoring Device	Example of Available Equipment (Manufacturer/Model #)	Description	Method of Operation	Sensitivity	Calibration Procedure	Level of Training Required by Operator	Necessary Support Equipment or Supplies	Comments
(3) Total Hydrocarbon Analyzer	Beckman	Automated multi-point analyzer. Is capable of monitoring up to 10 sample streams.	- Method of operation is similar to that of the gas chromatographic automated systems. - Major difference is that there is no column for the separation of the component gases in the sample stream. Device, therefore, reports the concentration of total hydrocarbons, rather than just VCM. - Detector is usually of the flame ionization variety for concentration ranges around 1 ppm.	0.1 ppm	Similar procedure as for Gas Chromatographic apparatus	Unattended operation, however, needs plant instrumentation man for maintenance	- Calibration gases - Operating gases - H₂ - O₂ - Compressed air	If VCM concentration is very low compared to background hydrocarbon level, changes in VCM level will not be detected
(4) Infrared Spectrophotometric Analyzer	Parkinson/Clarke/Model 267	Manually operated system involving the Model 267 IR equipped with a 20 meter gas cell	- Similar to the method for gas chromatography - Sample collected in - Charcoal tubes - Evacuated tubes - Teflon bags - Sample is brought to laboratory and worked up - Introduction of sample into I.R. spectrometer	~1 ppm	Calibration is performed as in gas chromatography using test gases with known concentrations	- Graduate chemist for operation and result analysis - Technician for maintenance and sample collection	- Calibration gases - Sample collection - Charcoal tubes - Evacuated tubes - Teflon bags	Model is 10x less sensitive than 10-100% C and gives only more expensive 8 on a comparable sized gas chromatograph.
Automatic systems	Wills Scientific/Model 11 Ambient Air Monitor	System utilizes the electronic and detection system described below under Leak Detection System with a Gas Analyzer. This ambient air monitor is capable of analyzing air at twelve remotely located points specifically for VCM on a sequential basis at one minute per point. The distance from the area monitored can be up to 200 feet. Alarm system can be included in the system for excursions above the allowed maximum.	Sampling: Air is drawn from 12 to a manifold controlled by solenoid valves. Samples are continuously pumped from the manifold to the gas cell. A multi-point recorder/computer sequentially opens the solenoid valves allowing the air sample to flow into the analyzer cell. It then records an identified point on the strip chart.	0-100 ppm	Calibration gases	Technician	Calibration gases	

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EXHIBIT E-4 (4)

Monitoring Device	Example of Available Equipment (Manufacturer/Model #)	Description	Method of Operation	Sensitivity	Calibration Procedure	Level of Training Required for Operator	Necessary Support Equipment or Supplies	Comments	
2. Leak Detectors (Portable Instruments)	(1) Gas Chromatograph	Camary Systems, Inc./OVA-99	Light weight 10 lbs. box & 1/2 lbs. probe and meter. Portable instrument, flame ionization GC analyzer, specific for VOC's only. Runs eight hours on one battery charge. Has 18 columns.	Flame ionization column works on the principle of cold absorption--there is no heater.	1 ppm	Same as for stationary G.C.	Technician	Calibration gases operating gases	New model data device purchased by over 50 companies and OSHA and OSHA
	Analytical Instrument Development, Inc.	Completely self contained portable gas chromatograph with flame ionization detector. Weighs 40 lbs. - Can also be used as a total hydrocarbon analyzer - Has interchangeable FID-EC-TL detectors	Manual GC/FID operation as described above	<1 ppm	Same as for stationary G.C.	Technician	Same as above	Uses 5 ft. x 1/4" columns packed w/10% charcoal	
	(2) Catalytic Combustion Principle	Beckman Instruments Co./TLV Portable Analyzer	- Portable instrument - Cigar box size 9" x 3 1/4" x 6.625" - Weight - 5 lb. - When nickel cadmium batteries are used instrument will drive recorder up to 8 hours. - Instrument is not specific to VOC's. - Audible alarm is over-ride if the reading exceeds an adjustable level.	Model QLV operates on the heat of combustion principle, a particular physical characteristic of all combustible gases and vapors.	2 ppm based on hexane	Instrument is calibrated with hexane in air mixtures	Operator or technician	Hexane in air mixtures. - Dust filters - Nickel battery - Battery charger	According to manufacturer, maintenance is minimal and is limited to periodic calibration checks and replacement of the dust filter.

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Measuring Device	Example of Available Equipment (Name, Model, or Model #)	Description	Method of Operation	Sensitivity	Calibration Procedure	Level of Training Required for Operator	Necessary Support Equipment or Supplies	Comments
(2) Infrared	Miran II Infrared Gas Analyzer	This instrument can be readily sensitized and calibrated for the particular gas analysis required. The Miran II is equipped with a variable-path-length gas cell, adjustable by a single control knob over a range of 0.15 to 20.25 meters. Output of the unit is linear in absorbance units. Assuming a linear Beer's Law relationship a reading directly in percentage of gas concentration can be obtained. Weight - 35 lbs. Dimensions: 8.5 x 12 in. x 6 in. Time constant: 1 and 6 seconds	Two wavelengths are measured and an output in the ratio of the two energies is provided. This allows one measurement to be taken on an analytical absorption band and the other of a nearly non-absorbing wavelength to provide a reference signal. The two energy measurements are electronically subtracted after they have passed through the same analyzer and log converter. Single beam, dual wavelength photometer	0-100 ppm	Use of calibration gases	Operator or technician	Inventor for a battery operating. Calibration gases.	Can be used on 12 volt battery power with any inverter necessary. Manufacturer provides for easy maintenance.
	Miran I Infrared Analyzer	Instrument designed for portability Weight - 18.5 lbs. Dimensions: 6.5 x 6.5 x 10.5 in. 6 x 8" sample platform	Similar in operation to Miran II but can be used to analyze any gas that absorbs in the IR	0-100 ppm	Same as above	Same as above	Same as above	Same as above

Source: Analytical Instrument Development, Inc. Catalog, 1973;
Beckman Instruments Co. J-W Model IRV Catalog, 1974;
Beckman Bulletin 1155B, Beckman Instruments, Inc.;
Bentley/Chance Catalog, 1974;
Century Systems, Inc. CUA-91 Catalog;
Hewlett Packard Bulletin 11510, 1971;
Alpha Safety Apparatus, Inc. Model 2142 Catalog, 1974;
Parker-Timer-Law Chromatographic and Infrared Equipment Catalog, 1973;
Vetco Scientific, Miran I & II Catalog, 1974;
and a survey of gas detection equipment manufacturers.

EXHIBIT E-5 (1)

USDOL/OSHA

AVAILABILITY AND COSTS OF TYPICAL MONITORING DEVICES
FOR VINYL CHLORIDE MONOMER DETECTION

Monitoring Device	Manufacturer (Instrument Name)	Components		Unit Purchase Cost (1974 Dollars)	Procurement Lead Time (From Time Messenger Receives Order)
		Catalog Number	Catalog Description/Lot Size		
1. Personal Monitoring					
(1) Colorimetric	Bendix/Gastec (Precision Gas Detector)	24175-34	Pump kit/6 or more	\$72.00	Stock item
		131	Detector tubes (10/box, 6 or more boxes)	.96	Stock item
		24175-38	Spare parts kit/1	8.95	Stock item
	Mine Safety Appliances (Halogenated Hydrocarbon Detector)	85842	Halogenated hydrocarbon detector (Group A)/1	\$76.25	Stock item
		85833	Tubes for 85841/package of 12	1.38	Stock item
(2) Charcoal Tube/Pump System (Automated)	Anatole J. Sipin (Sipin Personal Sampler Pump)	SP-1 or SP-2	Personal air sampler kit/1	300.00	8-10 Weeks
		-	Charcoal tubes/packages of 12	.53	2 Weeks
2. Area Monitoring					
(1) Automated, Sequential Gas Chromatographic Systems	Beckman (Process Gas Chromatograph- FID)	Model 6700	Process gas chromatograph including Leeds & Northrup Strip Chart Recorder Ten point sampling system	6,000.00	3-6 Months
			Application engineering department final system check-out	3,770.00	
				650.00	
	Byron Instruments, Inc. (FID G.C.)	Model 320	VCM monitor 0-10 ppm, fully automated, 10 points, 2 min per point, w/bar graph or strip chart recorder	65.00	2 Months
	Hewlett-Packard (FID Automatic Gas Chromatograph w/ Minicomputer)	Model 5830	Reporting gas chromatograph w/16 point sequential sampling system (complete)- system also includes built-in digital processor, keyboard control center and printer/plotter	10,875.00	6 Weeks
(2) Manual Gas Chromatographs For Area Monitoring, Charcoal Tube Analyses, and Residual VCM Determinations	Perkin-Elmer (Industrial Atmospheric Analyzer)	Model 3920	Model 3920 GC with FID, linear temperature programmer, complete automatic data handling as an option		
	Varian/Aerograph	144010-00	Single column (18") FID, w/linear programmer, Gas Chromatograph Columns/1	3,075.00	2-3 Months
		00-9145-01	Recorder, single pen	~ 50.00	Stock item
		9270	Disc R integrator	1,140.00	2 Months
		9610	Disc R automatic printer	795.00	2 Months
			485.00	2 Months	

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EXHIBIT E-5 (2)

Monitoring Device	Manufacturer (Instrument Name)	Components		Unit Purchase Cost (1974 Dollars)	Procurement Lead Time (From Time Messenger Receives Order)
		Catalog Number	Catalog Description/Lot Size		
(3) Total Hydrocarbon Analyzer	Bendix/TIA Multipoint System	-	- Cost includes 10 point sampling stream system - FID based	\$6,600.00	3-4 Months
(4) Infrared Spectrophotometer (Automated)	Wilks Scientific/ Miran II Ambient Air Monitor	206-2120	Miran II I-R System complete including: 20M variable path cell - Calibration curves for specific analysis - L&N Speedimax II Multi-Point Recorder - Six sample inlet ports controlled by nylon solenoid valve. - Sample pump capable of pulling samples @ 200 feet through 1/2" I.D. tubing - Internal plumbing - System housing - Particulate filter for each line	11,250.00	3 Months
		212-2120	Same as above but for 12 sampling points	12,500.00	3 Months
(5) Infrared Spectrophotometers (Manual) for Area Monitoring and Residual VCM Determinations	Beckman/Accu Lab. 6	1896 OCU	Acculab GIR Spectrophotometer complete with recorder	6,130.00	3-4 Months
		580248	20M multipath cell (sample cell)	2,310.00	
		580249	20M multipath cell (reference cell)	2,310.00	
	Perkin-Elmer 267	Model 267	Infrared spectrometer	8,860.00	3 Months
			Single twenty meter cell	2,590.00	
			Closed loop circulation system	275.00	
			Reference beam alternator	40.00	
3. Leak Detecting					
(1) Gas Chromatographic	Analytical Instrument Development Inc. / Portable G.C.	Model 511	Port. G.C. equipped w/hydrogen flame ionization detector	3,300.00	2 Months
		210-6001	Recorder-Esterline Anglia 2 multivolt fixed range completely portable and contains its own rechargeable batteries Six chart spec	610.00	
	Century Systems Corp. / Organic Vapor Analyzer	OVA-2N	FID w/strip chart, reindex/meter	3,500.00	5-6 Weeks

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EXHIBIT E-5 (3)

Monitoring Device	Manufacturer (Instrument Name)	Catalog Number	Components	Unit Purchase Cost (1974 Dollars)	Procurement Lead Time (From Time Messenger Receives Order)
			Catalog Description/Lot Size		
(2) Catalytic Combustion Principle	Bacharach Instrument Co. / TLV Sniffer	23-7350	TLV portable sniffer, battery powered, linear scale readout	\$ 678.00	30-45 Days
(3) Infrared Spectrophotometric	Wilks Scientific/Miran I	5652	Miran Portable Gas Analyzer w/linear absorber readout, spectral range 2.5 to 14.5 micron, variable path gas cell	4,825.00	
	Wilks Scientific/Miran II	201-2120	Miran II w/20 M variable gas cell Specific for VCM	4,900.00	3 months

Sources: Analytical Instrument & Development, Inc. Catalog, 1974;
 Bacharach Instrument Co. J-W Model TLV Catalog, 1974;
 Beckman Bulletin 4175D, Beckman Instruments, Inc.;
 Bendix/Gastec Catalog, 1974;
 Century Systems, Inc. CUA-93 Catalog;
 Hewlett Packard Bulletin 5830, 1974;
 Mine Safety Apparatus, Inc. Model 85842 Catalog 1974;
 Perkin-Elmer Gas Chromatographic and Infrared Equipment Catalog, 1974;
 Wilks Scientific, Miran I & II Catalogs, 1974;
 Varian Associates, Varian Amerograph Catalog, 1974;
 Snell Survey of Gas Detection Equipment Manufacturers.

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EXHIBIT E-4 (1)

USDOL/OSHA

SUMMARY OF SNELL INTERVIEW RESULTS WITH VINYL CHLORIDE AND
POLYVINYL CHLORIDE PRODUCERS RELATING TO PURCHASES OF VINYL CHLORIDE
MONITORING EQUIPMENT⁽¹⁾ PERSONAL AND LEAK DETECTION DEVICES

VCM/PVC Producer ⁽¹⁾	Type of Monitoring Equipment	Name of Equipment Manufacturer	Total Installed Unit Costs (1974 Dollars)	Operating and Maintenance Costs (1974 Dollars)	Timing		Comments
					Procurement	Start-Up	
JIM-Inst-C and JIM-Inst-W	1. Personal monitoring Carbon tube	N.A.	\$ 20,000	\$ 80,000		Short times for delivery.	Costs are for the 2 plants. Assumed to include costs of laboratory gas chromatograph and chemist(s).
	2. Leak detection • Organic vapor analyzer ²	Century	10,000	5,000	N.A.	Short times for delivery.	Assumed to be costs for 3 OVAs and part-time operator.
	• Gas chromatograph	N.A.	10,000	5,000	N.A.	Short times for delivery.	Assumed to be costs for 2 portable units and part-time operators.
ST	1. Leak detection • Organic vapor analyzer	Century	2,000	4,500	N.A.	N.A.	Snell estimates OVA costs at \$3,000 per unit.
JIM-Inst-W	1. Leak detection • Organic vapor analyzer	Century	2,000	N.A.	N.A.	N.A.	
GAL-New-W	1. Personal • Pumps and impingers	Bentix (C116)	1,350	15,000 (see comments)	3/74	4/74	O&M is total cost for all following categories: 3 units 4 units
		Sipin	1,400	See comment for O&M	5/74 9/74	9/74	
	G.C. for analysis of charcoal samples (I ID)	Hewlett Packard (Model 5750)	6,000	See comment for O&M	N.A.	4/1/74	Used also to determine VCM residual levels.
JIM-New-W	2. Leak detection • Organic vapor analyzer	Century OVA	17,000	See comment for O&M	2-5/74	Complete	1 unit
	1. Personal monitoring • Gas bags	Calibrated Instruments Inc.	3,300	15,000	2-3 weeks		9 units
	2. Leak detection	Century OVA	2,800	1,200	5 weeks		

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EXHIBIT E-6 (3)

VCM/PVC Product	Type of Monitoring Equipment	Name of Equipment Manufacturer	Total Installed Unit Costs (1974 Dollars)	Operating and Maintenance Costs (1974 Dollars)	Timing		Comments
					Procurement	Start-Up	
41L-OM-W 21M-New-C	1. Personal monitoring • Charcoal adsorption w/ G.C. analysis	N.A.	40,000	100,000	50% complete	1/74	Assumed to include cost of G.C.'s and chemists.
38	1. Personal sampling • 1 FID chromatograph for analysis of personal sampling	N.A.	15,000	N.A.	8/72	-	
34	2. Additional analytical • Personal monitoring	N.A. N.A.	15,000 10,000	10,000 20,000	2/74 N.A.	3/74 12 months after go-ahead	
2M-Im.-C	1. Personal monitoring • G.C. (FID) for analysis of charcoal tubes • Personal samples	Perkin-Elmer TPO-C	10,500	Not yet known	N.A.	N.A.	
	2. Leak detection • Organic vapor analyzer	Century	9,000	10,000	N.A.	N.A.	3 units
4L-OM-C	1. Personal monitoring carbon tube pumps G.C. analysis of samples and VCM residuals Monitoring G.C. Minicomputer to compute and store all monitoring data	Beckman Microtrak II N.A. N.A.	850 13,000 13,000 26,000	20,800 20,000 20,000 2,000	N.A. N.A.	N.A. 2 months 3 months 1 month 1 month	Needed to comply with a 25 ppm standard.

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EXHIBIT E-4 (3)

VCM/PVC Producer	Type of Monitoring Equipment	Name of Equipment Manufacturer	Total Installed Unit Costs (1974 Dollars)	Operating and Maintenance Costs (1974 Dollars)	Timing		Comments
					Procurement	Set-Up	
BL-New-C	1. Personal monitoring equipment	N. A.	\$ 1,200	\$ 24,000	4 months	1 month	Costs suggest addition of analytical staff.
	2. Leak detection • Organic vapor analyzer	Century	6,500	3,000	Complete		2 units
14-M-Int.-W	1. Personal monitoring	N. A.	2,500	12,000			Costs suggest addition of analytical staff.
49M-Old-C	1. Personal monitoring	Bendix	2,500	32,200	In operation		Costs suggest addition of analytical staff.
	2. Leak detection • Organic vapor analyzer	N. A.	15,000	84,000	In place		
12M-OM-C	1. Personal monitoring • Gas chromatograph for charcoal tube analyzer	Hewlett Packard	9,000	Not yet known	In place		
	2. Leak detection • Organic vapor analyzer	Century	12,000	60,000	In place		4 units
96-Int.-C	1. Leak detector • Organic vapor analyzer	Century	10,000	N. A.	N. A.	N. A.	
30M-New-C	1. Personal monitoring • Dosimeters	Bendix	8,000	1,000	12 weeks	1 week	
		Sipin	3,300	1,000	8 weeks	-	
	• G.C. for carbon tube analysis	Varian Aerograph	6,000	1,000	12 weeks	1 week	
	2. Leak detection • Organic vapor analyzer	Century	6,400	500	8 weeks	-	
	• Combustion principle	J&W	1,450	250	8 weeks	-	

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EXHIBIT E-6 (4)

VCM/PVC Producer	Type of Monitoring Equipment	Name of Equipment Manufacturer	Total Installed Unit Costs (1974 Dollars)	Operating and Maintenance Costs (1974 Dollars)	Timing		Comments
					Procurement	Set-Up	
31M-New-C	Monitoring equipment	N.A.	\$ 65,000	\$ 20,000		6 months from order	
	1. Personal monitoring						
	• Charcoal tube type	N.A.	2,100	4-5,000	Complete		For seven instruments.
	• G.C. for analysis of tubes	Varian aerograph	500	20-25,000	Complete		\$500 is for rebuilding of G.C. Costs suggest addition of analytical staff.
	2. Leak detection						
	• Organic vapor analyzer	Century	12,000	20,000	Complete		Three instruments.
28L-New-C	1. Personal monitoring						
	• Personal sampler	N.A.	250 each	N.A.	N.A.	N.A.	
	2. Leak detection						
	• Organic vapor analyzer	Century	2,500	N.A.	N.A.	N.A.	
	• Portable G.C.	AID	7,500	N.A.	N.A.	N.A.	
30M-New-C and 28L-New-W	1. Personal monitoring						
	• Lab chromatograph for analysis of:	N.A.	10,200	25,000	In place		
	• Bags						
	• Carbon tubes						
40M-Old-C	2. Leak detection						
	• Infrared unit	Misco	8,200	80,000	N.A.	N.A.	
	• Organic vapor analyzer	Century	24,000	70,000	3 units in place 2 units August 1974 4 weeks delivery		4 units Costs suggest addition of analytical staff.

Notes: (1) For meaning of product code, see page E-6.

Source: Results of field interviews with the VCM/PVC manufacturing industry.

NA = Not Available.

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EXHIBIT E-7(1)

USDOL/OSHA

SUMMARY OF SNELL INTERVIEW RESULTS WITH VINYL CHLORIDE AND POLYVINYL
CHLORIDE PRODUCERS RELATING TO PURCHASES OF VINYL CHLORIDE MONITORING
EQUIPMENT: AREA MONITORING DEVICES⁽¹⁾

VCM/PVC Producer ⁽²⁾	Area Monitoring Device		Name of Equipment Manufacturer	Total Cost Including Installation (Dollars)	Operating and Maintenance Costs (Dollars)	Timing		Comments
	Description	No. of Points				Procurement	Start-Up	
11M-Int. -C and 17S-Int. -W	NA	30	NA	\$200,000	\$ 45,000		6 mos. from order	Costs are for 2 plants, 30 pts. per plant
40'-New-W	Fixed point continuous system.	NA	Honeywell 1000	98,000	1,200	8/74	9/74	
19L-New-W	Fixed point continuous system.	20	Honeywell 1000	45,000	2,000		8-10 wks.	
41L-Old-W 34M-New-C	Continuous analyzer	NA	NA	500,000	100,000	18 mos.	4/76	Costs are for 2 plants
38	FID chromatograph with sampling systems and computer interface equipment. Sampling point located throughout operations and loading area.	24	Amscor	60,000	NA	7/74	Pending	2 units
34	Same as above.	80	Amscor	200,000	20,000	18 mos. for project start-up		6 units
5-Old-C	Automation total hydrocarbon analyzer.	24	Bendix	40,000	27,300	NA	NA	4 units
81-New-C	Same as above.	NA	Bendix	10,500	6,000	Complete		
14M-Int. -W.	Same as above.	6	Bendix	6,000	6,000	Complete		
49M-Old-C	Same as above.	NA	Bendix	10,450	12,000	6 mos.		
	Mind-Computer for Bendix		NA	49,000	3,600	5 mos.		
22M-Old-C	Sequential chromatographic system without computer.	18	Bendix	60,000	NA	NA	NA	NA

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EXHIBIT E-7(2)

VCM/PVC Producer	Area Monitoring Device		Name of Equipment Manufacturer	Total Cost Including Installation (Dollars)	Operating and Maintenance Costs (Dollars)	Timing		Comments
	Description	No. of Points				Procurement	Start-Up	
8S-Int.-C	FID gas chromatograph.	NA	Perkin-Elmer	\$ 18,000	NA	NA	NA	
30M-New-C	Fixed point system.	80	NA	200,000	\$ 30,000	26 wks.	8 wks.	
42S-Int.-C	FID gas chromatograph.	NA	Hewlett-Packard	NA	NA	NA	NA	
28L-New-C	FID system.	NA	NA	70-80,000	30-40,000	NA	NA	
26M-New-C and 29L-New-W	Automatic chromatograph with data system.	20	Custom made	30,000	NA	NA	NA	
46M-Old-C	Sequential monitoring chromatograph	NA	Bendix	137,000	10,000	6 mos. total		2 instruments

Notes: (1) Equipment installed in compliance with the temporary standard or in anticipation of a permanent standard.
(2) For meaning of producer codes see page II-G.

Source: Results of Snell interview with the VCM/PVC Manufacturing Industry.

NA = Not available.

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APPENDIX F

MEDICAL SURVEILLANCE OF EMPLOYEES

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APPENDIX F

MEDICAL SURVEILLANCE OF EMPLOYEES

This appendix details the elements of routine medical surveillance and their attendant costs. All exhibits appear sequentially at the end of the appendix.

1. A REVIEW FOLLOWS OF THE TEMPORARY AND PROPOSED REQUIREMENTS FOR THE MEDICAL SURVEILLANCE OF EMPLOYEES IN VINYL CHLORIDE (VCM) AND POLYVINYL CHLORIDE (PVC) PLANTS

This section summarizes the medical surveillance required under the emergency temporary standard for exposure to VCM (50 ppm) and the medical surveillance required under the proposed permanent standard (no detectable limit).

(1) 50 ppm Emergency Temporary Standard (ETS) ⁽¹⁾

The ETS does not recommend or require any medical surveillance of employees in VCM and PVC plants. It is concerned only with the fixing of exposure levels to 50 ppm value (127.0 ms/cm).

(2) Proposed Permanent "No-detectable" VCM Standard (PPS) ⁽²⁾

Comprehensive requirements for employee medical examination are proposed, including necessary tests. Some additional guidance is included for the convenience of physicians. The proposed requirements have been recommended to OSHA by NIOSH (see below) as reasonable and appropriate to detect liver dysfunction which may be indicative of, or predisposing to, the development of liver angiosarcomas.

(1) 29 CFR 1910, Occupational Safety and Health Standards, Emergency Temporary Standard for Exposure to VCM.

(2) 29 CFR 1910, Occupational Safety and Health Standards, Proposed Standard.

Records of medical examination are to be kept with provision for access by appropriate OSHA and NIOSH officials. Specific requirements are made to furnish a copy of a medical record to an employee's physician on the employee request. In the event of an "emergency", that is, an unforeseen circumstance or set of circumstances resulting in the release of VCM into areas occupied by employees, a special medical surveillance by a physician shall be instituted within 24 hours for employees present in the affected area at the time of the emergency.

(3) NIOSH Recommendations For Medical Surveillance Referred To By The Proposed Permanent Standard

The following recommendations are directed primarily at medical screening to detect liver disease and/or hepatic tumor. They should be considered in the context of routine health screening for any general employee health problem, including non-hepatic health condition potentially related to VCM exposure. Routine health screening should include at the time of initial employment:

- the recording of past medical history
- the performance of
 - a general physical examination
 - certain basic laboratory procedures including:
 - .. complete blood count
 - .. urinalysis
 - .. chest x-ray

Provisions should also be made for routine periodic health follow-up examinations.

- (1) NIOSH, Recommended Occupational Health Standard For the Manufacture of Synthetic Polymer From VCM, March 11, 1974.

Employees covered by the following specific recommendations shall encompass all persons engaged in VCM production and polymerization including personnel peripherally involved such as in clerical and management assignments. The recommendations shall be applied both as a pre-employment requirement and as a part of periodic health follow-up. Screening priority should be given to current employees with prolonged and close potential exposure to VCM, whether in present or past work settings.

The recommended examination protocol is:

- At the time of initial employment, or upon institution of screening, a physical examination shall be performed with specific attention to detecting enlargement of liver or spleen by abdominal palpation.
- At the time of initial employment, or upon institution of screening and annually thereafter, a medical history check-list shall be completed by the employee. This list shall include questions concerning:
 - alcohol intake
 - past history of hepatitis
 - past exposure to potential hepatotoxic agents including drugs and chemicals
 - past history of blood transfusion
 - past history of hospitalization

The completed medical check-list shall be reviewed by a physician and should be acted upon as medically indicated for each individual employee.

At the time of initial employment, or upon institution of screening, a serum specimen shall be obtained for screening with respect to the following five bio-chemical determinations of liver function:

- total bilirubin
- alkaline phosphatase
- serum glutamine oxalacetic transaminase (SGOT)
- serum glutamine pyruvic transaminase (SGPT)
- gamma glutamyl transpeptidase (GGTP)

Additional tests that optionally may be considered for use in screening include

- lactic dehydrogenase (LDH)
- serum protein determinations
- serum protein electrophoresis
- platelet count

Laboratory analyses shall be performed in laboratories accredited by the College of American Pathologists, licensed in accordance with the provision of the Clinical Laboratories Improvement Act of 1967.

If results of laboratory screening are normal, screening shall be repeated on an annual basis. If the person being screened has been employed directly in vinyl chloride monomer production or polymerization for 10 years or longer, screening shall be repeated every six (6) months.

If one or more liver function tests are abnormal, serum testing shall be repeated as soon as possible, preferably within two (2) to four (4) weeks. If no abnormalities are present upon rescreening, testing should be repeated in three (3) months.

If abnormalities persist on rescreening, the employee shall be removed from contact with VCM operations and an individualized workup shall be instituted. Suggested as initial steps in medical workup are

- a complete physical examination
- various special procedures such as
 - .. hepatitis B antigen determination
 - .. liver scanning

If liver function abnormalities are determined to be unrelated to liver disease (e.g. elevated alkaline phosphatase in a young, physically active man or elevated bilirubin in Gilbert's syndrome) or to be transient (e.g. due to recent hepatitis or recent alcohol intake), the employee may be permitted to return to VCM related employment, subject to individual medical evaluation.

In view of the preliminary results of animal toxicology studies, it is recommended that no woman who is pregnant or who expects to become pregnant should be employed directly in VCM operations.

2. SNELL ASSESSMENT OF THE COST OF MEDICAL SURVEILLANCE UNDER THE PROPOSED PERMANENT STANDARD (1)

This section details the cost of medical surveillance needed by the VCM and PVC industries to comply with the requirements of the Proposed Permanent Standard (PPS). Costs are essentially based on the physical examinations and laboratory tests recommended to OSHA by NIOSH. (2)

- . Exhibit F-1 presents a screening flow sheet for the physical examination and laboratory tests which may be performed. It details the screening steps which are given by the PPS.
- . Exhibit F-2 presents the time required for an average worker to spend on obtaining the needed physical examination and laboratory tests by a physician under contract to the VCM and PVC manufacture.
- . Exhibit F-3 details the types of laboratory tests which may be required as well as their normal values. It is from these tests that a portion of the total cost is based.
- . Exhibit F-4 summarizes the itemized costs for the various elements of the medical surveillance program from Snell estimates based on the detailed study. The Snell estimate is \$160 per worker.
- . Exhibit F-5 shows the costs which were reported by the VCM and PVC industry for their medical surveillance program. Their costs average out to \$143 per worker based on sixteen reporting firms.

(1) 29 CFR, 1910, Occupational Safety and Health Standards, Proposed Standard For Exposure to VCM

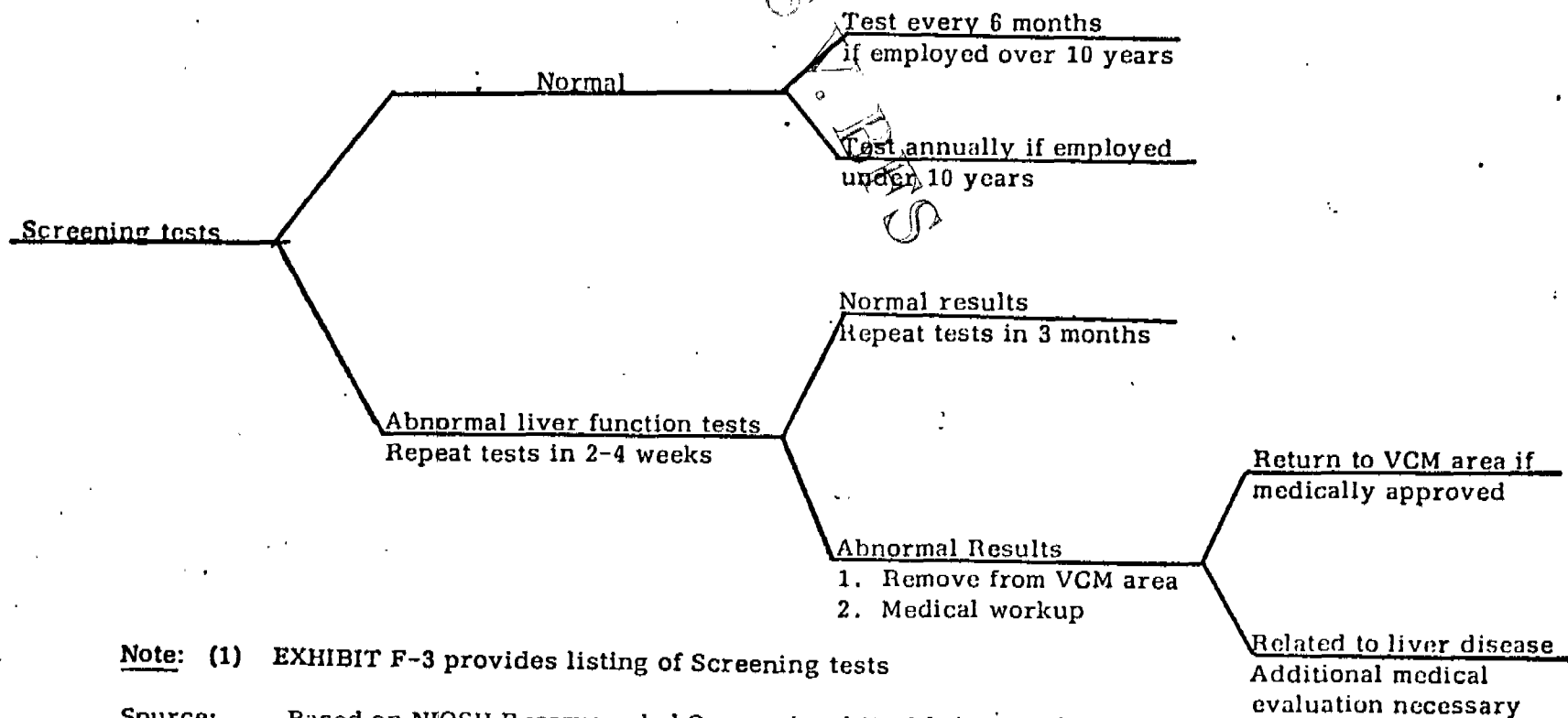
(2) NIOSH Recommended Occupational Health Standard For the Manufacture of Synthetic Polymer From VCM, March 11, 1974

3. REVIEW WAS COMPLETED OF THE INFORMATION BY NORMAN B. JAVITT, M.D., PH.D. HEAD,
DIVISION OF GASTROENTEROLOGY, DEPARTMENT OF MEDICINE, NEW YORK HOSPITAL-CORNELL
MEDICAL CENTER

According to Dr. Javitt in his letter to Snell, shown in Exhibit F-6, he reviewed the appendix and in his judgment, "the proposed protocol adequately reflects both the recommendations of the appropriate governmental agencies, and considering the constraints of time and expense, is carefully constructed to obtain a sensitive estimate of the existence of liver dysfunction as well as other ancillary data on health status."

Dr. Javitt in his letter also suggests modifications or clarifications to the NIOSH recommended protocol as is seen in the Exhibit.

EXHIBIT F-1
USDOL/OSHA
SCREENING FLOW SHEET
BASED ON NIOSH RECOM-
MENDATIONS TO OSHA FOR
THE PROPOSED PERMANENT
STANDARD



Note: (1) EXHIBIT F-3 provides listing of Screening tests

Source: Based on NIOSH Recommended Occupational Health Standard for the Manufacture of Synthetic Polymer from Vinyl Chloride, March 11, 1974

EXHIBIT F-2
 USDOL/OSHA
 TIME REQUIRED FOR TRAVEL,
 PHYSICAL EXAMINATION AND
 LABORATORY TESTS OUTSIDE
 OF PLANT

Worker Completes
 Medical History
 Checklist While
 Waiting

30 minutes

Blood Samples
 Taken

5 minutes

Urine Sample
 Provided

5 minutes

Chest X-ray
 Taken

10 minutes

EKG Taken

10 minutes

Physical
 Examination

30 minutes

Total Time Required

Examination and laboratory tests
 Travel to and from examination facility
 Maximum time required

1.5 hours
2.5 hours
4 hours

Source: Snell estimates

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EXHIBIT F-3 (1)
USDOL/OSHA
NORMAL VALUES IN
LABORATORY TESTS

<u>Laboratory Test</u>	<u>Purpose</u>	<u>Normal Values</u>
<u>Blood Chemistry</u>		
Cholesterol (1)	Cholesterol metabolism	150 to 300 mg/100 ml
Calcium (1)	Calcium metabolism	9 to 11.5 mg/100 ml
Inorganic Phosphorus (1)	Phosphorus absorption	2.5 to 4.5 mg/100 ml
Total Bilirubin (1,2)	Liver function	0.2 to 1.0 mg/100 ml
Total Protein (1)	Liver function	6.0 to 8.0 gm/100 ml
Albumin (1)	Kidney and liver function	3.5 to 5.0 gm/100 ml
Uric Acid (1)	Purine metabolism	2.5 to 7.5 mg/100 ml
BUN (1)	Kidney function	10 to 20 mg/100 ml
Glucose (1)	Carbohydrate metabolism	65 to 100 mg/100 ml
LDH (1,2)	Organ damage	67 to 122 technicon units
Alkaline Phosphatase (1,2)	Liver function	4 to 17 KA units
SGOT (1,2)	Organ damage	15 to 45 units
Creatinine (3)	Kidney function	0.9 to 1.7 mg/100 ml
GGTP (2)	Liver function	6 - 28 mμ/ml
SGPT (1,2)	Organ (part. liver) damage	15 to 56 units
NPN (3)	Kidney function	25 to 38 mg/100 ml

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EXHIBIT F-3 (2)
USDOL/OSHA
NORMAL VALUES IN
LABORATORY TESTS

<u>Laboratory Test</u>	<u>Purpose</u>	<u>Normal Values</u>
<u>Hematology</u>		
RBC (2)	Standard screening for all diseases	4.6 to 6.2 x 10 ⁶
WBC (2)	"	4.8 to 10.8 x 10 ³
Hgb (2)	"	15 to 18 gm
Hct (2)	"	42 - 52%
<u>Differential (2)</u>		
Polys	"	60 - 70%
Stabs	"	0 - 1%
Eosinophils	"	1 - 3%
Basophils	"	0.25 - 0.5%
Lymphocytes	"	25 - 33%
Atypical Lymphocytes	"	0 - 1%
Monocytes	"	2 - 6%
Platelets	"	2 - 4 x 10 ⁵
MCV	"	80 - 94 μ^3
MCH	"	273 $\mu\mu\text{g}$
MCHC	"	32 - 36%

EXHIBIT F-3 (3)

<u>Laboratory Test</u>	<u>Purpose</u>	<u>Normal Values</u>
<u>Urinalysis</u> ⁽²⁾		
Color	Standard screening for all diseases	Pale straw to amber
Appearance	"	Clear to slight hazy
Specific Gravity	"	1.905 to 1.002
pH	"	5.5 - 7
Albumin	"	Negative
Glucose	"	Negative
Acetone	"	Negative
Bile	"	Negative
Urobilinogen	"	Up to 2.1 Ehrlich units

- Notes:
- (1) Included in automated SMA12 analysis
 - (2) recommended for determination within first screening or initial examination by NIOSH to OSHA specifically for liver function.
 - (3) Included to obtain a total laboratory profile of the worker
 - (4) Recommend as a special test by NIOSH to OSHA.

Sources: Ivan K. Smith, Diagnostic Services, Inc., 520 Speedwell Ave., Morris Plains, NJ 07950;
 NIOSH, Recommended Occupational Health Standard for the Manufacture of Synthetic
 Polymer From Vinyl Chloride, March 11, 1974;
 Snell assessment of the NIOSH recommendations to OSHA

EXHIBIT F-4 (1)
 USDOL/OSHA
 APPROXIMATE COSTS OF PHYSICAL
 EXAMINATIONS AND LABORATORY
 TESTS COMPLETED OUTSIDE PLANT
 BASED ON A MANUFACTURING
 FACILITY WITH 500 COVERED WORKERS

38%

<u>Element</u>	<u>Cost (Dollars)</u>
Full-time clerical person for typing, filing, coordinating visits to labs and physicians, etc. (\$9,000 x 1.25 in fringe)	\$ 11,225
Records, stationary, postage, etc	7,500
Overhead (1)	5,000
500 examinations by physician (general practioner) @ \$20 per examination	10,000
500 reviews of physical and laboratory examination results by physician @ \$15/review	7,500
500 chest x-rays @ \$20 per worker	10,000
500 laboratory test series @ \$24 per series (2)	12,000
500 EKG's @ \$25 per worker	12,500
125 repeat laboratory test series (25% of workers) @ \$24 per series (2)	3,000
125 repeat medical reviews by physicians @ \$15 per review	1,875
25 special laboratory tests @ 5% of the workers @ \$25 per worker (3)	625
25 reviews by physician at special laboratory tests @ \$15 per worker	375
Total expenditures per annum for 500 covered workers	\$ <u>81,500</u>
Approximate cost of medical screening per worker	160

EXHIBIT F-4 (2)
USDOL/OSHA

- Notes:
- (1) overhead includes electricity, telephone, heating, space allocations for clerical activities, etc.
 - (2) initial laboratory screening tests include SMA12, SGPT, GGTP, CBC with platelets and urinalysis
 - (3) special laboratory tests may include: serum hepatitis B determination, serum protein electrophoresis.

Sources: Ivan K. Smith, Diagnostic Sciences, Inc., Morris Plains, NJ 07950; Snell assessment

EXHIBIT F-5 (1)
 USDOL/OSHA
 RESULTS OF SNELL INTERVIEWS TO
 DETERMINE THE COSTS OF MEDICAL
 SURVEILLANCE COST PER WORKER
 PER YEAR

<u>Number of Workers</u>	<u>Total Cost (Dollars)</u>	<u>Cost per Worker per Year (Dollars)</u>
97	16,000	165
173	34,000	200
(NA)	(NA)	(NA)
57	3,000	52
222	(NA)	(NA)
1,137	(NA)	200
50	(NA)	(NA)
325	(NA)	150 - 200
128	12,000	94
420	12,900	40
(NA)	(NA)	(NA)
81	10,000	125
150	22,000	146
3,204	224,280	70
68	(NA)	200
74	(NA)	200
135	(NA)	(NA)

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EXHIBIT F-5 (2)
USDOL/OSHA

<u>Number of Workers</u>	<u>Total Cost (Dollars)</u>	<u>Cost per Worker per Year (Dollars)</u>
338	45,000	133
200	(NA)	(NA)
693	110,600	160
111	(NA)	(NA)
150	20,000	133
700	(NA)	200

Average annual cost per employee

\$ 143⁽¹⁾

= 1.0615 \$/hr

Notes:

(1) Cost for examinations assumes tests are based on NIOSH recommendations.

Sources:

Snell review and assessment of interviews with VCM and PVC manufacturers.

NA = not available

EXHIBIT F - 6(1)

USDOL/CSHA

LETTER OF DR. NORMAN B. JAVITT
TO SNELL REVIEWING THE
DATA IN APPENDIX F

525 EAST 68th STREET, NEW YORK, N.Y. 10021
THE NEW YORK HOSPITAL-CORNELL MEDICAL CENTER

DEPARTMENT OF MEDICINE
DIVISION OF GASTROENTEROLOGY

August 16, 1974

TO: John W. Keating, Ph. D.
Director, Biological Sciences
Poster D. Snell, Inc.

FROM: Norman B. Javitt, M.D., Ph. D.
Professor of Medicine and
Head, Division of Gastroenterology
New York Hospital-Cornell Medical Center

SUBJECT: Review of Appendix F (first draft) Technical Feasibility
and Economic Impact Study

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EXHIBIT F - 6(2)

USDOL/OSHA

I have reviewed the above appendix with special emphasis on Exhibits F-2 through F-5 and have the following comments:

1. In my judgement the proposed protocol adequately reflects both the recommendations of the appropriate governmental agencies, and considering the constraints of time and expense, is carefully constructed to obtain a sensitive estimate of the existence of liver dysfunction as well as other ancillary data on health status.

2. I would suggest consideration of the following modifications:

A. Routine tests:

1) Hepatitis B antigenemia (by RIA). A positive test should be an automatic exclusion from working with vinyl chloride because of the possibility of the person being a high risk for developing toxicity. Final judgement would require complete medical evaluation. Expense for this test is probably minimal since now, by state law, every unit of blood obtained for the purpose of transfusion must be tested for the presence of Hepatitis B antigen.

B. Special tests in the event of abnormal screening tests:

In the event of persistent abnormal test of liver function, the following further studies should be done:

- *1. Alpha₁ Fetoprotein (correlates with hepatoma)
- *2. Alpha₁ Anti-trypsin deficiency (at special risk to develop chronic lung and/or liver disease).

EXHIBIT F - 6(3)

USDOL/OSHA

- *3. 2-hour post-prandial serum bile acid. (The most specific sensitive test for hepatobiliary disease - not as yet activated-cost per test on contract basis, \$20 test).
- * Probably can be cost-accounted through Bio-Science Laboratories and other similar laboratories.

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APPENDIX G

SAFETY AWARENESS PROGRAMS

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APPENDIX G

SAFETY AWARENESS PROGRAMS

An important element of the Proposed Permanent Standard For Worker Exposure To Vinyl Chloride is the requirement for a safety awareness program for employees of vinyl chloride monomer (VCM) and polyvinyl chloride (PVC) plants⁽¹⁾. The purpose of the program is to indoctrinate and educate them as to the problems associated with working with VCM. The appendix contains two exhibits which follow the text:

- .. Exhibit G-1 presents a general discussion of a sample safety awareness program.
- . Exhibit G-2 provides a cost estimate for the sample program for a VCM or PVC plant with 110 employees.

(1) 29CFR 1910 Occupational Safety and Health Standards, Proposal Standard.

EXHIBIT G-1 (1)
USDOL/OSHA
SAMPLE SAFETY AWARENESS
PROGRAM (1)

Upon the institution of any new program, process or installation, people must be trained for new skills or taught to adapt and accept new conditions. To adapt and accept new conditions is not a difficult transition if the individual is motivated and encouraged.

Of the prime motivators to man, none is more paramount than survival itself. An effective in-plant training program concerning the critical nature of vinyl chloride should capitalize on the prime motivator.

Using multi-media presentations geared to the subject, an employee is able to witness and internalize the importance and significance of proper safety procedures and the use of the safety equipment provided for his or her own benefit.

A shock effect presentation instills initial fear and doubt. The images remain vivid and the fear and doubt

diminish in due course. As a learning process, none leaves as lasting a memory of the subject matter as a "shock presentation". With "shock" being the prime motivator, a three phase multi-media presentation will effectively begin training and lay the foundation for continuous training and re-enforcement.

Presentation One is the preconditioning that teaches the individual data that can be recalled as a rational thought when a "shock presentation" is used. It is a subliminal presentation unrelated to the daily routine of the worker. It takes the worker from his job into the jobs of others who have adapted and accepted external conditions that are critical with ease and facility. The viewer does not relate to the total presentation, yet many common factors become apparent. The need of the space suit, the helmet for the Appollo astronauts, the life support system on a submarine, proper ventilation of exhausts at a toll booth, a mask on a pilot, a pressurized cabin all show common need for life support and present the fact on visions of idolic professions.

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The first presentation impresses upon the viewer that the need for life support is present in many areas and that these are important supports for important positions.

Presentation Two displays the shock and actual conditions that arrive from exposure to the substance. The critical nature and danger are vividly displayed.

Presentation Three is a custom presentation featuring the safety measures instituted by a given facility for the protection of the employees.

Each presentation plays an integral part in the total educational presentation. Independent of one another, each can be used for re-enforcement on a yearly basis. The training program can be viewed in large and small groups.

By installing a theme of name for the safety program displayed in Presentation Three, an award program that seeks to re-enforce and recognize performance can be phased in upon completion of the initial training. Motivation is achieved through recognition.

A program of awards that can be presented to the

achiever in full view of all and continuously displayed in the plant not only recognizes but motivates future performance as well. Those who have achieved strive to continue, those who have not are motivated to become an achiever. Peer group pressures serve as a motivator when a department seeks an award. Individual needs for social acceptance and self-esteem motivates a man.

Giving praise and recognition to an employee for a task well done seems so fundamental that it appears a bit pretentious to label the act a management technique. But at a time when business is battling a cost squeeze, high rates of employee absenteeism and turnover, and low productivity, sometimes the first step towards finding a solution is to get back to the basics.

Positive action demands recognition and praise. A long term goal can be established and achieved through training and a basic recognition program.

With the program, constant attention must be paid

1 "Where Skinner's Theories Work", Business Week
(December 2, 1972).

to features in in-house organs, bulletin boards, posters and all media established by a company for communication with its employees.

All areas of communication should be examined as a Texas chemical company did when it decided to send a "season's greetings" card to the employees stating "Merry Christmas and Happy New Year, here's wishing you another safe year."

Programs must be sequenced and developed prior to implementation from training to practice. Listed are the items to consider as a model containing the ingredients for a viable safety program.

- Initial high-impact training seminar for all employees
- Award for completion of seminar uniform patch with project name
- Poster program with continuous safety reminders
- Supervisor's guide to motivation and continuing re-enforcement
- Section or line awards for annual performance based upon down time, etc.

- Continuation of annual award of patch with color sequence
- In-house organ promotion of safety awards and people at work
- Annual scrolls for achievers
- Monthly red and green safety plaques for foreman's area
- Annual recognition gift.

The above discussion presented an analysis of the rationale behind safety awareness programs and a sample of such a program. For an in-depth discussion of the concept of management awareness of OSHA rules, knowledge of testing, and evaluations procedures see source (2) below.

Source: (1) Joel D. Schaffer, Human Motivation Resources, Inc.
P. O. Box 225
Morris Plains, New Jersey 07950 and Snell analysis.

(2) Stephen F. Nagy and Herbert Terry, Management Awareness of OSHA,
presented at: OSHA and the Plastics Industry, National Conference, New York, April, 1973.

EXHIBIT G-2

USDOL/OSHA

COST ESTIMATE FOR A SAMPLE SAFETY AWARE-
NESS PROGRAM AS OUTLINED UNDER THE PROPOSED
PERMANENT STANDARD FOR WORKER EXPOSURE TO

VINYL CHLORIDE

Individual, First Year

Training	\$25
Awards	5
Misc.	<u>11</u>
Total	<u>\$31</u>

Supervisors and Foremen

Training	\$40
Awards	15
Misc.	<u>10</u>
Total	<u>\$65</u>

First Year Start-Up Costs:
100 Employees, 10 Supervisors

Employees	\$3,100
Supervisors	650
Misc.	<u>500</u>
Total	<u>\$4,250</u>

Cost Per Employee	\$ <u>40</u>
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Annual Budget Second Year--Continuing

Awards	\$500
Misc.	<u>200</u>
Total	<u>\$300</u>

Cost Per Employee	\$ <u>7.50</u>
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Source: Joel D. Schaffer, Human Motivation Resources, Inc.

P.O. Box 225, Morris Plains, New Jersey 07950 and Snell analysis.

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APPENDIX H

NIOSH RECOMMENDED OCCUPATIONAL HEALTH STANDARD FOR THE MANUFACTURE OF SYNTHETIC
POLYMER FROM VINYL CHLORIDE

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APPENDIX H

NIOSH RECOMMENDED OCCUPATIONAL HEALTH STANDARD FOR THE MANUFACTURE OF SYNTHETIC POLYMER FROM VINYL CHLORIDE

1. SCOPE AND APPLICATION

This standard regulates the manufacture of synthetic polymer from vinyl chloride (chloroethene, Chemical Abstracts Registry No. 75014), in order to protect the health and safety of workers.

Vinyl chloride also known as vinyl chloride monomer (VCM), chloroethylene and chloroethene, is a colorless sweet smelling gas at ordinary temperature and pressure and has a boiling and melting point at one atmosphere of -13.8°C , and -153.71°C , respectively. Its chemical formula is CH_2CHCl and it has a molecular weight of 62.50. Although non-corrosive at normal atmospheric temperatures, in contact with water and at elevated temperatures it accelerates the corrosion of iron and steel. Of considerable concern is the fact that vinyl chloride is easily ignited and has a lower and upper explosive limit of 3.6% and 26.4%, respectively.

2. DEFINITIONS

For the purpose of this standard:

- a. "Assistant Secretary" means the Assistant Secretary for Occupational Safety and Health, U. S. Department of Labor or any person directed by him.
- b. "Director" means the Director, National Institute for Occupational Safety and Health, or any person directed by him or the Secretary of Health, Education, and Welfare to act for the Director.

c. "Authorized employee" means an employee whose duties require him to be in the regulated area and who has been specifically assigned by the employer.

d. "Detectable levels" means the determination that airborne concentrations of vinyl chloride are in excess of the limit of sensitivity of the sampling and analytical method recommended by the Director.

e. "Clean change room" means a room where employees put on clean clothing; clean change room shall be contiguous to and have an entry from a shower room, when the shower room facilities are otherwise required in this standard.

f. "Closed container" is any container which is used to prevent the physical contact of employees with material containing vinyl chloride monomer.

g. "Closed system" means an operation involving vinyl chloride where containment prevents the release of vinyl chloride into regulated areas, nonregulated areas, or the external environment.

h. "Contaminated" refers to detectable levels of vinyl chloride monomer.

i. "Decontamination" means the inactivation of vinyl chloride to less than detectable levels or its safe disposal.

j. "Disposal" means the safe removal of vinyl chloride from the work environment.

k. "Emergency" means an unforeseen circumstance or set of circumstances, such as a ruptured transfer line, resulting in the release of

vinyl chloride sufficient to produce acute symptoms among workers exposed or having contact with the vinyl chloride.

l. "External environment" means any environment external to regulated and nonregulated areas.

m. "Regulated area" means an area where entry to and exit from a vinyl chloride workplace is restricted and controlled.

n. "Nonregulated area" means any area under the control of the employer where entry and exit is neither restricted nor controlled.

o. "Protective clothing" means clothing designed to protect an employee against contact with or exposure to vinyl chloride.

p. "Waste resin" means any resin or other vinyl chloride reaction product which has been removed from vessels during clean-up operations, or which has been collected as a result of in-plant housekeeping operations.

3. REQUIREMENTS FOR REGULATED AREAS

A regulated area shall be established where synthetic resins containing vinyl chloride are manufactured. These regulated areas shall include but are not limited to vinyl chloride loading or unloading operations, storage, and transfer facilities; synthetic resin polymerization processes and operations; and resin handling, compounding, packaging and storage areas. Access shall be restricted to authorized employees only. All such regulated areas shall be controlled in accordance with the following requirements.

a. Routine Operations

(i) Initial concentration of vinyl chloride in all regulated areas shall be determined by performing air measurements at strategic sampling points under normal operating conditions. These initial sampling points must be selected by a professional industrial hygienist and will serve as monitoring locations for future environmental measurements. The sampling pattern shall be adequate to represent the environment of the controlled area.

(ii) Where detectable levels of vinyl chloride are measured, a Control Plan to reduce such levels shall be developed and implemented. The Plan shall consist not only of establishing goals for reducing vinyl chloride levels by designing and introducing engineering and process controls, but shall also identify plans for developing additional (healthful) work practices. Target dates shall be established for all goals and the Plan must be updated at least on an annual basis. Copies of the Control Plan shall be posted in all regulated areas and be provided to all authorized employees.

(iii) There shall be periodic tests for process or equipment leaks and for emission of vinyl chloride which may result from work practices. The frequency of these tests shall be such as to insure the integrity of equipment, adherence to proper work practices, and to determine achievement of the goals of the Control Plan. Tests shall be performed at each sampling point at least daily or more frequently if concentrations of vinyl chloride are in excess of those established in the Plan. When such levels are exceeded, additional samples to identify sources of contamination shall be taken. Results of all such tests shall be made

available to authorized employees in such a manner as to evaluate achievement of goals contained in the Control Plan.

(iv) Until exposures to vinyl chloride are reduced below detectable levels, employees entering any regulated area shall be provided with and required to wear and use a full-face, supplied air respirator, of the continuous flow or pressure demand type in accordance with §1910.134.

(v) In operations involving loading or unloading vinyl chloride monomer from tank cars, trucks, barges, or other conveyance equipment, each transfer line and each vapor-equalizing line shall be equipped with vent connections permitting, at the completion of the transfer, pressure to be vented and the hose purged with an inert gas in such a manner to preclude any employee exposure. Specific and detailed transfer procedures shall be developed and provided to involved employees in written form.

(vi) Employees shall be provided with and required to wear, clean, full-body protective clothing (smocks, coveralls, or long-sleeved shirt and pants), and gloves prior to entering the regulated area.

(vii) Prior to each exit from a regulated area, employees shall be required to remove and leave protective clothing and equipment at the point of exit and at the last exit of the day, to place used clothing and equipment in impervious containers at the point of exit for purposes of decontamination or disposal. The contents of such impervious containers shall be identified as required under paragraph e(2)(i) of this standard.

b. Reactor and Vessel Entry

(i) A reactor and vessel entry procedure shall be developed and provided to involved employees in written form. Employees shall be familiarized with the procedure and shall be trained and rehearsed in the techniques provided for in the procedure. Emphasis shall not only be placed on concern for potential exposure to vinyl chloride but shall also include appropriate precautions for entry into confined spaces.

(ii) Techniques shall be developed and applied to minimize to the maximal practicable extent employee exposure to vinyl chloride when opening any closed vessel. Examples of effective methods are the application of heat or suction to the vessel prior to opening, or use of sufficient exhaust ventilation around the vessel. Where operations such as cleaning or maintenance conducted inside an open vessel could result in the liberation of vinyl chloride, suitable procedures such as exhaust ventilation shall be developed and implemented to insure that vinyl chloride is not released into the general work environment.

(iii) Exhaust air shall not be discharged to regulated areas, nonregulated areas, or the external environment unless decontaminated.

(iv) All piping to and from the vessel shall be blanked or otherwise isolated prior to entry.

(v) Employees entering the reactor or vessel shall be provided with and required to wear and use a full-face, supplied air respirator, of the continuous flow or pressure demand type in accordance with §1910.134.

(vi) Employees entering the reactor or vessel where levels of vinyl chloride are monitored and are found to not exceed ambient levels external to the vessel shall be provided with and required to wear clean, full body protective clothing (coveralls or long-sleeved shirt and pants), gloves, footwear or foot coverings, and head covering. Where vessel levels are in excess of ambient levels, employees shall instead be provided with and required to wear impervious clothing to prevent skin contact of vinyl chloride or other materials containing vinyl chloride.

(vii) After each exit from the reactor or vessel, employees shall be required to remove and leave protective clothing and equipment at a designated point in the regulated area, and at the end of each work shift to place used clothing and equipment in impervious but vented containers for the purpose of decontamination or disposal. The contents of such impervious containers shall be identified as required under paragraph e(2)(i) of this standard.

(viii) Employees engaged in reactor cleaning or other operations involving vessel entry shall shower at the end of the work shift.

c. Maintenance and Decontamination Activities

(i) Emphasis shall be placed upon immediate clean up of spills, periodic inspection, prompt repair of equipment and leaks, and proper handling, storage and disposal or decontamination of materials to prevent airborne contamination and accidental skin contact with vinyl chloride. Because vinyl chloride is a gas

at normal temperatures, waste materials, equipment, and other sources of the monomer in closed containers, shall not be placed in areas of excessive temperature or sunlight since build-up of internal pressure may result in rupture of the container, fire or explosion.

(ii) Waste resins or other materials contaminated with vinyl chloride shall be placed in closed containers identified as required under paragraphs e(2)(i) or (ii) of this standard.

(iii) Appropriate procedures shall be developed and implemented for the decontamination and/or disposal of all such waste material.

(iv) In clean-up of leaks or spills, maintenance or repair operations on contaminated systems or equipment, or any operation involving work where direct contact with vinyl chloride monomer could result, each authorized employee involved in such operations shall be provided with and required to wear clean, impervious garments, including gloves, boots and continuous air supplied hoods in accordance with §1910.134, be decontaminated before removing the protective garments and hood; and be required to shower upon removing the protective garments and hood.

d. General Regulated Area Requirements

1. Employee identification.

A daily roster of employees entering regulated areas shall be established and maintained. The rosters or a summary of the roster shall be retained for a minimum period of 20 years by the employer or successors thereto. The rosters and/or summaries shall be pro-

vided upon request to authorized representatives of the Assistant Secretary and the Director. In the event that the employer ceases business without a successor, rosters shall be forwarded by registered mail to the Director.

2. Emergencies.

In an emergency, immediate measures including but not limited to the requirements of subdivisions (i), (ii), (iii), (iv), and (v) of this subparagraph shall be implemented.

(i) The potentially affected area shall be evacuated as soon as the existence of the emergency has been determined.

(ii) Hazardous conditions created by the emergency shall be eliminated and the potentially affected area shall be decontaminated prior to the resumption of normal operations.

(iii) Special medical surveillance by a physician shall be instituted within 24 hours for employees present in the potentially affected area at the time of the emergency. A report of the medical surveillance and any treatment shall be included in the incident report, in accordance with paragraph (g)(3) of this standard.

(iv) Where an employee has a known contact with liquid vinyl chloride such employee shall be required to shower as soon as possible unless contraindicated by physical injuries.

(v) An incident report on the emergency shall be reported as provided in paragraph (g)(3) of this standard.

3. Hygiene facilities and practices.

(i) Storage or consumption of food, storage or use of containers of beverages, storage or application of cosmetics, smoking, storage of

smoking materials, tobacco products or other products for chewing, or the chewing of such products, are prohibited in regulated areas.

(ii) Where employees wear protective clothing and equipment clean change rooms shall be provided, in accordance with §1910.141(e)(3).

(iii) Where employees are required by this standard to wash, washing facilities shall be provided in accordance with §1910.141(d)(1) and (2)(ii) through (vii).

(iv) Where employees are required by this standard to shower, shower facilities shall be provided in accordance with §1910.141(d)(3).

4. Contamination control.

(i) Regulated areas, except for outdoor systems, shall be maintained under negative pressure with respect to nonregulated areas. Local exhaust ventilation may be used to satisfy this requirement. Clean tempered makeup air shall replace air removed. Exhaust air shall not be discharged to regulated areas, nonregulated areas, or the external environment unless decontaminated.

(ii) Any equipment, material, or other item taken into or removed from a regulated area shall be done so in a manner that does not cause contamination in nonregulated areas or the external environment.

(iii) Decontamination procedures shall be established and implemented to remove vinyl chloride from the surfaces of materials, equipment and the decontamination facility.

e. Signs, Information, and Training

1. Signs.

(i) Entrances to regulated areas shall be posted with signs bearing the legend:

CANCER-SUSPECT AGENT AREA
AUTHORIZED PERSONNEL ONLY

(ii) Entrances to regulated areas containing operations covered in paragraph 3(c) of this standard shall be posted with signs bearing the legend:

CANCER-SUSPECT AGENT IN THIS AREA.
IMPERVIOUS SUIT INCLUDING GLOVES,
BOOTS, AND AIR-SUPPLIED HOOD REQUIRED
AT ALL TIMES. AUTHORIZED PERSONNEL
ONLY.

2. Container contents identification.

(i) Containers of waste or other materials contaminated with vinyl chloride shall be labelled as follows:

VINYL CHLORIDE CONTAMINATED
MATERIAL
CANCER SUSPECT AGENT
DISPOSE OF OR DECONTAMINATE USING
APPROVED PROCEDURES

(ii) Containers of synthetic polymers made from vinyl chloride shall be labelled as follows:

SYNTHETIC VINYL CHLORIDE POLYMER
VINYL CHLORIDE IS A CANCER SUSPECT
AGENT

POLYMER CONTAINS ____% BY WEIGHT
UNREACTED
VINYL CHLORIDE

*(To be analytically determined by manufacturer and appropriate value entered on labels.)

(iii) Containers of vinyl chloride shall be labelled as follows:

VINYL CHLORIDE

DANGER! EXTREMELY FLAMMABLE LIQUID
AND GAS UNDER PRESSURE

CANCER SUSPECT AGENT

HARMFUL IF INHALED

MAY POLYMERIZE VIOLENTLY
UNDER FIRE CONDITIONS OR
LOSS OR REMOVAL OF
INHIBITOR

Keep away from heat, sparks, and open flame.

Keep container closed.

Use with adequate ventilation.

Avoid breathing vapor.

Avoid contact with skin.

Keep cylinder out of sun and away from heat.

Container should be grounded when being
emptied.

Never drop cylinder.

FIRST AID: If inhaled, remove to fresh air. If
not breathing give artificial respiration, preferably
mouth-to-mouth. If breathing is difficult,
give oxygen. Call a physician.

In case of:

Fire — Use water spray, dry chemical, or
CO₂.

Spill or Leak — For small spills, evacuate
area and permit to evaporate. For large
spills or leaks, evacuate area. Dike or
flush to ground and let evaporate. Do not
flush to sewer because of explosion

hazard.

3. *Training and indoctrination.*

(i) Each employee, prior to being authorized to enter a regulated area, shall receive a training and indoctrination program including, but not necessarily limited to:

(a) The nature of the carcinogenic hazards of vinyl chloride monomer, including local and systemic toxicity;

(b) The specific nature of the operation involving vinyl chloride monomer which could result in exposure;

(c) The purpose for and application of the medical surveillance program;

(d) The purpose for and application of decontamination practices and purposes;

(e) The purpose for and significance of emergency practices and procedures;

(f) The employee's specific role under normal operating or emergency conditions;

(g) Specific information to aid the employee in recognition and evaluation of conditions and situations which may result in the release of vinyl chloride monomer;

(h) The purpose for and application of specific first aid procedures and practices;

(i) A review of this standard at the employee's first training and indoctrination program and annually thereafter.

(ii) Specific emergency procedures shall be prescribed, and posted, and employees shall be familiarized with their terms, and rehearsed in their application.

(iii) All materials relating to the program shall be provided upon request to authorized representatives of the Assistant Secretary and the Director.

f. *Environmental Monitoring and Record-keeping*

(i) Environmental concentrations of vinyl of methods for sampling and analysis recommended by the Director or by methods of at least equal sensitivity.

(ii) Employees or their representatives shall be provided with the opportunity to observe chloride shall be determined through the use environmental monitoring activities and shall have access to the results.

(iii) Complete and accurate records of all environmental measurements shall be maintained for at least 20 years by the employer or successors thereto and shall be provided upon request to authorized representatives of the Assistant Secretary or the Director.

g. *Reports*

1. *Operations.*

Within 60 days the following information shall be reported in writing to the appropriate Occupational Safety and Health Administration (OSHA) Area Director. Any change in such information shall be similarly reported within 15 calendar days of such change.

(i) A brief description and in-plant location of the area(s) regulated and the address of each regulated area.

(ii) The number of employees in each regulated area, during normal operations, including maintenance activity.

(iii) A copy of the Control Plan is developed under paragraph 3(a)(ii).

2. *Environmental Measurements.*

On a semi-annual basis the results of measurements taken at strategic sampling points,

presented in such a manner as to identify achievement of goals established in the Control Plan, shall be reported in writing to the appropriate OSHA Area Director.

3. Incidents.

Incidents which result in the release of vinyl chloride monomer into any area where employees may be potentially exposed shall be reported in accordance with this subparagraph.

(i) A report of the occurrence of the incident and the facts obtainable at that time including a report on any medical treatment of affected employees shall be made within 24 hours to the appropriate OSHA Area Director.

(ii) A written report shall be filed with the appropriate OSHA Area Director within 15 calendar days thereafter and shall include:

(a) A specification of the amount of material released, the amount of time involved, and an explanation of the procedure used in determining this figure;

(b) A description of the area involved, and the extent of known and possible employee exposure and area contamination;

(c) A report of any medical treatment of affected employees, and any medical surveillance program implemented; and

(d) An analysis of the circumstances of the incident, and measures taken or to be taken, with specific completion dates, to avoid further similar releases.

h. Medical Surveillance

The following recommendations are directed primarily at medical screening to detect liver disease and/or hepatic tumor. They should be considered in the context of routine health

screening for any general employee health problems, including non-hepatic health conditions potentially related to vinyl chloride monomer exposure. Routine health screening should include at time of initial employment the recording of past medical history and the performance both of a general physical examination and certain basic laboratory procedures (e.g., complete blood count, urinalysis, chest X-ray); provisions should also be made for routine periodic health followup examinations.

Employees covered by the following specific recommendations shall encompass all persons engaged in vinyl chloride monomer production and polymerization, including personnel peripherally involved such as in clerical and management assignments. The recommendations shall be applied both as a pre-employment requirement and as part of periodic health followup. Screening priority should be given to current employees with prolonged and close potential exposure to vinyl chloride monomer, whether in present or past work settings.

(i) At time of initial employment, or upon institution of screening, a physical examination shall be performed with specific attention to detecting enlargement of liver or spleen by abdominal palpation.

(ii) At time of initial employment, or upon institution of screening and annually thereafter, a medical history check-list shall be completed by the employee. This list shall include questions concerning:

- (a) alcohol intake;
- (b) past history of hepatitis;
- (c) past exposure to potential hepa-

toxic agents, including drugs and chemicals;
(d) past history of blood transfusions;
and

(e) past history of hospitalizations.

Completed medical check-list shall be reviewed by a physician and should be acted upon as medically indicated for each individual employee.

(iii) At time of initial employment, or upon institution of screening, a serum specimen shall be obtained for screening with respect to the following five bio-chemical determinations of liver function:

- (a) total bilirubin;
- (b) alkaline phosphatase;
- (c) serum glutamic oxalacetic transaminase (SGOT);
- (d) serum glutamic pyruvic transaminase (SGPT); and
- (e) gamma glutamyl transpeptidase (GGTP).

Additional tests that may optionally be considered for use in screening include lactic dehydrogenase (LDH), serum protein determinations, serum protein electrophoresis, and platelet count. Laboratory analysis shall be performed in laboratories accredited by the College of American Pathologists or licensed in accordance with the provisions of the Clinical Laboratories Improvement Act of 1967.

(iv) If results of laboratory screening are normal, screening shall be repeated on an annual basis. If the person being screened has been employed directly in vinyl chloride monomer production or polymerization for 10 years or longer, screening shall be repeated every six (6) months.

(v) If one or more liver function tests are abnormal, serum testing shall be repeated as soon as possible, preferably within two (2) to four (4) weeks. If no abnormalities are present upon rescreening, testing should be repeated in three (3) months.

(vi) If abnormalities persist on rescreening, the employee shall be removed from contact with vinyl chloride monomer operations and an individualized medical workup shall be instituted. Suggested as initial steps in medical workup are a complete physical examination and various special procedures such as hepatitis B antigen determination and liver scanning.

If liver function abnormalities are determined to be unrelated to liver disease (e.g., elevated alkaline phosphates in a young, physically active man or elevated bilirubin in Gilbert's syndrome) or to be transient (e.g., due to recent hepatitis or recent alcohol intake), the employee may be permitted to return to vinyl chloride-related employment, subject to individual medical evaluation.

(vii) In view of the preliminary results of animal toxicology studies, it is recommended that no woman who is pregnant or who expects to become pregnant should be employed directly in vinyl chloride monomer operations.

RECOMMENDED OSHA SAMPLING DATA SHEET

1. Substance:
Vinyl Chloride Gas
2. Scope of Method:
Vinyl chloride is a gas boiling at -13.4 degree C and having a vapor pressure of 2660 mm of mercury at 25 degree C. The lower limit of detection for the method is approximately 1 ppm.

3. Sampling Equipment:
 - a) Personal sampling pump
 - b) 250 cc glass gas collecting tubes with teflon stopcocks
4. Sample Size:
250 CC
5. Sampling Procedure:
Glass Gas Collecting Tubes
 - a) The gas collecting tube is connected at one end to the personal sampling pump. Both stopcocks are opened and air pulled through at approximately one liter per minute.
 - b) A sampling period of 15 minutes would allow collection of a representative sampling of the worker environment.
 - c) Stopcocks shall be closed tightly, closing the stopcock nearest the pump first.
6. Analysis:
The gas collecting tube sample is analyzed directly by gas chromatography.
7. Shipping Instructions:
The gas collecting tube should be wrapped with cushioning material, placed in the shipping case and shipped via Air Mail to the OSHA laboratory, Salt Lake City.

Source: NIOSH Recommended Occupational Health Standard For The Manufacture Of Synthetic Polymer from VCM, March 11, 1974.

EXHIBIT III - 14(2)

USDOL/OSHA

POLYVINYL CHLORIDE MAJOR MARKETS
1970 - 1973 (million pounds)

<u>Markets</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>
Packaging				
Blow molded bottles	70.0	50.6	70.4	79.2
Closure liners and gaskets	12.0	15.4	17.6	19.8
Coatings	15.0	15.4	17.6	19.8
Film	115.0	110.0	130.4	129.8
Sheet	60.0	75.9	88.0	77.0
Recreation				
Records	140.0	132.0	149.6	145.2
Sporting goods	25.0	39.6	50.6	55.0
Toys	60.0	59.4	74.8	83.6
Transportation				
Auto mats	35.0	37.4	39.6	39.6
Auto tops	30.0	33.0	35.2	33.0
Upholstery and seat covers	150.0	169.4	180.4	182.6
Miscellaneous				
Agriculture	21.0	24.2	116.6	145.2
Credit cards	11.0	11.0	15.4	17.6
Laminates	38.0	37.4	48.4	50.6
Medical tubing	32.0	35.2	46.2	50.6

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EXHIBIT III - 14(3)

USDOL/OSHA

POLYVINYL CHLORIDE MAJOR MARKETS
1970 - 1973 (million pounds)

<u>Market</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>
Novelties	10.0	8.8	13.2	15.4
Stationery supplies	27.0	26.4	35.2	39.6
Tools and hardware	10.0	11.0	13.2	17.0
Export (Net)	190.0	165.0	160.6	138.6
Other	94.0	193.9	107.8	99.0
Total	<u>3027.0</u>	<u>3456.2</u>	<u>4345.0</u>	<u>4776.2</u>

Sources: Modern Plastics, January 1971, 1972, 1973, 1974

EXHIBIT III - 15

USDOL/OSHA

END USE FORECASTS OF POLYVINYL CHLORIDE
MARKET, 1974 and 1978 - 1980Polyvinyl Chloride End Use Market
(million lbs.)

<u>End Uses</u>	<u>1974</u>	<u>1978-1980</u>
Construction	2,250	3,500 - 3,800
Household Uses	640	650 - 735
Packaging	320	440 - 475
Electrical Uses	410	520 - 540
Consumer Goods	520	570 - 625
Transportation	300	250 - 295
Miscellaneous	200	240 - 250
Exports	150	100
	<u>4,750</u>	<u>6,330 - 6,820</u>

Source: Disch, G. E., Plastics -- Raw Materials to End Markets and Coatings -- New Technology and Markets,
American Chemical Society, Brooklyn, 1974, p. 3.

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EXHIBIT III - 16(1)

USDOL/OSHA

POLYVINYL CHLORIDE CONSUMPTION BY
MAJOR FABRICATION PROCESS - 1970 TO 1973
(000 LBS. DRY WEIGHT)

(P) = Production
(S) = Sales
(U) = Internal Use

<u>Resin Kind & Use</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>
Total Polyvinyl Chloride & Copolymers (P)				
(Dry Resin Content)	3,115,204	3,437,323	4,253,719	4,531,500
Homopolymer Resins	2,232,008	2,474,900	3,149,421	3,432,677
Copolymer Resins	519,026	504,461	559,338	539,627
Dispersion Resins, Latexes, & Blending	364,170	457,961	545,960	559,196
Total Polyvinyl Chloride & Copolymers (S & U)				
(Dry Resin Content)	2,985,214	3,394,183	4,233,880	4,732,157
Total Exports	187,994	169,454	155,910	143,361
Total Domestic	2,797,220	3,224,731	4,180,970	4,588,796
Calendering, Total	705,184	835,114	903,404	913,160
Flooring	247,227	274,544	332,681	292,250
Textile	-	60,934	74,519	72,627
All Other Calendering Uses	457,957	473,636	556,204	518,073
Coating, Total	253,808	349,139	425,273	483,533
Flooring	75,074	116,629	132,645	150,326
Textile & Paper Coating	93,396	142,465	173,237	190,331
Protective Coatings	-	41,060	59,358	71,000
Adhesives & All Other Coating Uses	85,339	49,035	59,033	71,328

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EXHIBIT III - 16(2)

USDOL/OSHA

POLYVINYL CHLORIDE CONSUMPTION BY
MAJOR FABRICATION PROCESS - 1970 TO 1972
(000 LBS. DRY WEIGHT)

<u>Resin Kind & Use</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>
Extrusion, Total	1,094,775	1,291,664	2,051,008	2,297,991
Wire & Cable	408,726	312,919	499,055	413,78
Film & Sheet	193,620	173,935	220,145	234,26
Rigid Pipe & Tubing (Except Fittings)	-	497,082	1,009,077	1,254,01
All Other Extrusions	492,429	275,768	381,331	425,02
Molding, Total	253,945	309,070	410,275	511,01
Bottles	-	36,119	77,254	87,08
Sound Records	140,580	137,848	148,028	141,11
Fittings (Rigid Pipe & Tubing)	-	-	(1)	83,00
All Other Molding	113,365	135,105	134,993	131,91
Paste Processes (Except Coatings)	113,054	105,945	150,099	155,577
Plastisol Formulation	113,054	105,945	91,337	86,14
All Other	-	-	58,762	69,42
All Other Uses	376,394	330,729	180,311	224,59

- Notes:
- (1) Comparable 1972 data not available
 - (2) Not comparable because fittings were included in all other moldings in 1972

Sources: "Synthetic Organic Chemicals", U. S. Tariff Commission, Annual Reports 1971 and 1972.
Monthly Statistical Report, The Society of the Plastics Industry, Inc., April 6, 1973 and March 20, 1974.

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EXHIBIT III - 17

USDOL/OSHA

MAJOR RESIN TYPES AND THEIR TYPICAL
FREE MONOMER LEVELS RELATED TO
FABRICATION CATEGORY

(Million Pounds)

<u>Resin Type</u>	<u>Typical Average Mid-1974 Residual VCM Levels (1) (ppm)</u>	<u>Calendering</u>	<u>Coating</u>	<u>Extrusion</u>	<u>Molding</u>	<u>Paste</u>	<u>All Other</u>	<u>Total</u>
<u>Suspension</u>								
Pipe Grade	150			1,255				1,255
General Purpose	less than 500	550	215	840	185			1,790
Copolymer	1,000 - 7,000	290			90		160	540
Overall	500							
<u>Dispersion</u>								
Latex	400		200					200
Other	less than 25				240	155		395
Overall	10							
<u>Bulk</u>								
High Porosity	25	70		205				275
Overall	25							
<u>Solution</u>								
Overall	1.5							
		<u>910</u>	<u>485</u>	<u>2,300</u>	<u>515</u>	<u>155</u>	<u>65</u>	<u>4,500</u>

Note: (1) Individual data points around the averages can vary by a factor of three or more. Before steps were taken to comply with the Emergency Temporary Standard these averages were significantly higher. Improved stripping is believed to have been achieved using state-of-the-art technology and operating procedures. Some major producers reported average VCM levels in general purpose resin significantly lower than 500 ppm and as low as 50 ppm.

Sources: Snell estimates and Exhibit III-14 and III-16 based on industry interviews.

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IV. TECHNOLOGY OVERVIEW

SECRET

IV. TECHNOLOGY OVERVIEW

The previous chapter defined the economic infrastructure of the vinyl chloride (VCM) and polyvinyl chloride (PVC) industries. This chapter presents a technological overview of VCM and PVC manufacture to provide broad engineering and operational perspective to the information of Section V, which presents findings and conclusions.

This chapter is divided into two sections:

Section IVA, Vinyl Chloride

Section IVB, Polyvinyl Chloride

PVC is given significantly greater discussion emphasis than VCM since the study is primarily of PVC

IVA. VINYL CHLORIDE

This section discusses the technology of vinyl chloride (VCM) manufacture. Exhibits appear sequentially at the end of the text.

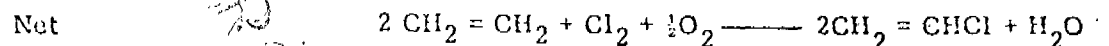
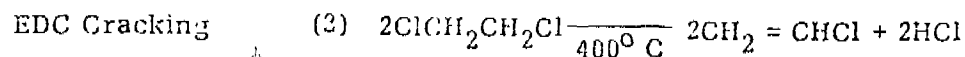
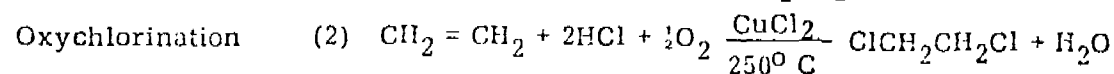
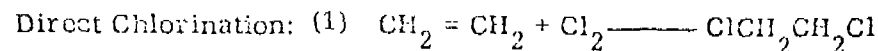
1. THE OXYCHLORINATION PROCESS ACCOUNTS FOR APPROXIMATELY 80% OF VCM CAPACITY

The table below summarizes estimated U.S. VCM capacity in 1974 as a function of the manufacturing process.

<u>VCM Process</u>	<u>Estimated 1974 Nameplate Capacity (Million Lbs.)</u>	<u>Percent of Total</u>
Oxychlorination	5,450	81%
Direct Chlorination Only	900	14
Acetylene	<u>350</u>	<u>5</u>
Total	<u>6,700</u>	<u>100%</u>

Source: Exhibit III - 1

The balanced oxychlorination process is described by the following equations:



Source: Brownstein, A. M., U. S. Petrochemicals. Tulsa, Oklahoma;
The Petroleum Publishing Co., 1971, p. 250.

Exhibits IV-1 and IV-2 provide representative flow diagrams for the balanced oxychlorination process based on the Stauffer Chemical and B. F. Goodrich Chemical designs, respectively. Unit operations are similar in balanced oxychlorination plants, although design details can vary appreciably regarding mass and heat balances, particularly in fractionation steps.

Exhibit IV-3 provides a general process description related to the Stauffer design. The Exhibit also provides a more detailed description of unit operations involving VCM.

The American Chemical plant is believed to feature unbalanced oxychlorination, using only reactions (2) and (3) in the preceding table.

The Ethyl plants and Dow's Plaquemine plant are believed to feature direct chlorination and cracking only, using reactions (1) and (3) in the preceding table.

The Monomchem plant, the only substantial acetylene-based process still operating, is believed to be balanced type employing both ethylene and acetylene. The HCl produced by pyrolysis of ethylene dichloride is added to acetylene for further VCM production, instead of oxychlorination.

The newest process is the Transcat process (Lummus Co., and Armstrong Cork Co.) with the potential to compete strongly with the ethylene process. It is one step synthesis of VCM by oxychlorination of ethane. VCM is produced by passing ethane, HCl and air (1 to 1 to 2.5 vol) through a molten catalyst of KCl and CuCl/CuCl_2 at 875°F .

2. VCM PRODUCTION COSTS WERE ESTIMATED FOR 1974 TO PROVIDE THE BASIS FOR THE ECONOMIC IMPACT ASSESSMENT

Exhibit IV-4 summarizes estimated 1974 VCM economics.

The data is provided in terms of unit costs of manufacture and profitability to enable sensitivity analysis of the potential impacts upon price of various VCM exposure limitation scenarios.

3. GENERALLY, VCM PRODUCTION CAN PRESENT RELATIVELY LIMITED CHANGES OF EXPOSURE TO THE OPERATING PERSONNEL DUE TO AUTOMATION AND REMOTE CONTROL AND OUTDOOR CONSTRUCTION SIMILAR TO REFINERIES

However, localized hazard areas are associated on a routine basis with the loading of tank cars, the cleaning of tank cars and of other equipment. Maintenance operations may be also a source of personnel exposure.

(1) The VCM Production Plants Are Highly Automated, Continuous And Closed Systems

A typical VCM production plant consists of an island of process units, principally fractionation and similar towers, cracking furnaces, and sometimes compressors. Day tanks, providing storage space during testing, are also included.

Long-term storage is provided by Hortonspheres which are located in tank farms and connected to the loading racks where the tank cars are filled.

The flow of material through the production train (or trains) is controlled from control rooms, which, especially in newer installations, are fairly removed from the actual production units.

The operators spend much of their time in the control room, mostly monitoring the operation of automatic controllers and from time to time making necessary set point adjustments. Normally there is little need for the operating personnel to be physically present in the production area.

However, inspection trips may be necessary from time to time and are usually motivated by some abnormality in the operation. While most of the abnormalities are usually traceable to instruments or control malfunction, significant leaks could be occurring and result in appreciable exposure risk.

(2) The VCM Plants Are Usually Completely Outdoor Operations

All production equipment is generally installed out-of-doors. There is limited chance of VCM accumulation and area concentrations may remain low even in the presence of significant leaks, particularly when atmospheric conditions are not stagnant.

However, significant exposure may be encountered by the greaser. Since his function is to fill up the lubricating devices of pumps and compressors, which in some instances may have to be done daily, he comes into close proximity of seals which may be leaking, and his own personal exposure may be in considerable excess to what would be surmised from the general background.

(3) Tank Car Loading And Tank Car Cleaning Present Critical Areas Of Routine Exposure In Monomer Plants

While there are some "over-the-fence" pipeline deliveries and some marine shipments, the bulk of the VCM is moved in railroad tank cars. Significant VCM exposure risk can result from disconnecting transfer lines and from the historical practice to use "dip tubes" to determine the level in the tank car.

The "dip tube" method consists in allowing a minute amount of VCM gas continuously to escape through an adjustable tube dipping into the tank. When the level of the liquid in the car reaches the bottom of the tube liquid VCM is discharged resulting in a visible "plume" from the tube. Usual practice has been to raise further the dip tube at this point and to complete the filling carefully at a lower rate until the permissible level was reached. Under certain atmospheric conditions this method is known to have given significant VCM concentrations even at some distance from the tank car dome. A solution to this problem has been to re-equip larger fleets of tank cars with more elaborate, non-emitting gauging devices.

Tank car cleaning operations put men in close contact with cars which may contain residual amounts of monomer. But thorough venting and incineration can be installed and personal protection used. Thus, exposure hazard to personnel can be minimized.

(4) Maintenance Operations, While Serious Potential Sources Of Personnel Exposure, Can Be Controlled By Appropriate Depressurization And Venting Procedures

Catastrophic failures involving rupture of large volume containers or massive leaks upstream of the main control device are rare.

Other situations requiring maintenance action (such as pulling a unit off the line for repair) divide into two categories: scheduled and unscheduled, with the former more easily accomplished using proper procedures to minimize VCM exposure risks.

Appropriate operating procedures and additional venting equipment can be used to reduce or to virtually eliminate the risk of exposure. Exhibit IV-5 shows an example of current operating procedure for maintenance action of the Dow Chemical Company.

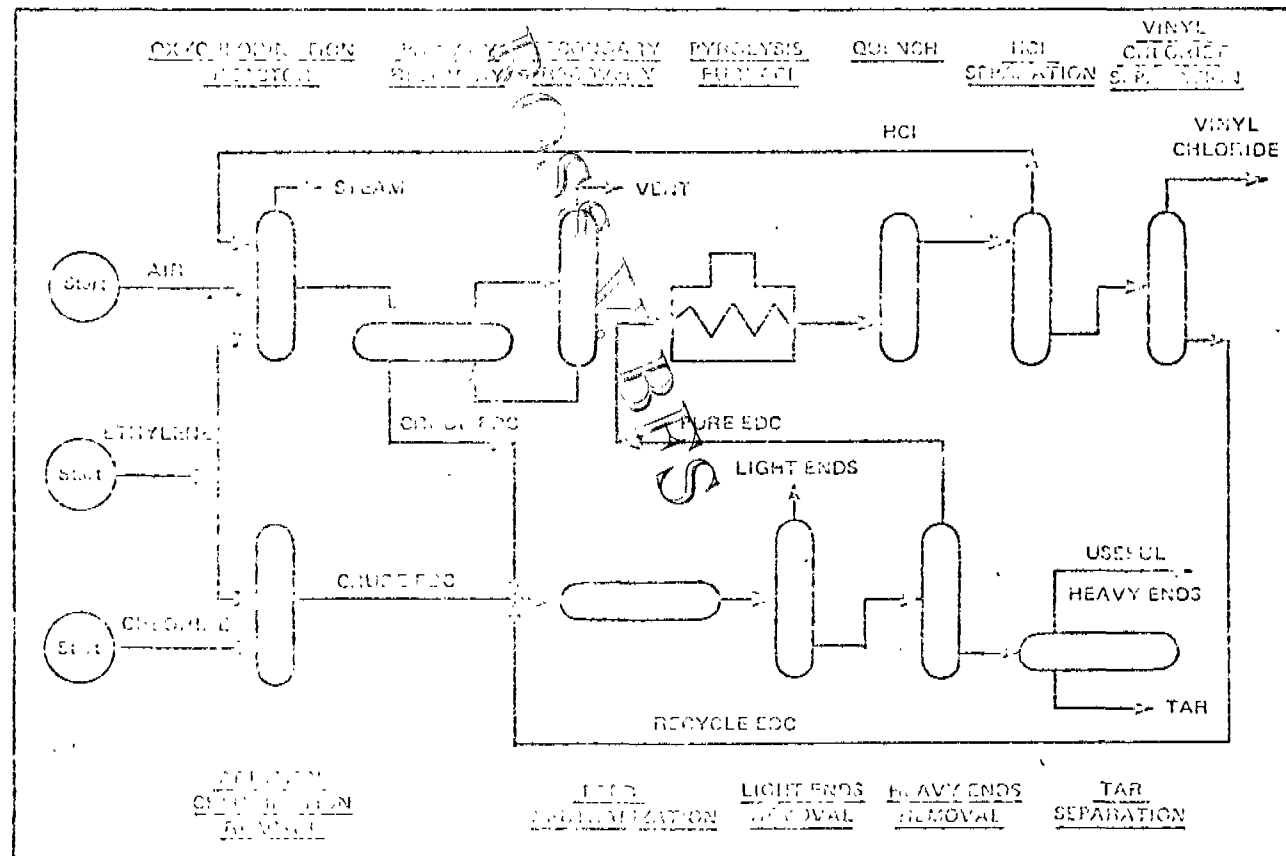
* * * * *

Section IVB, following, provides a similar overview of polyvinyl chloride technology.

EXHIBIT IV-1

USDOL/CSHA

THE STAUFFER PROCESS FOR VINYL CHLORIDE

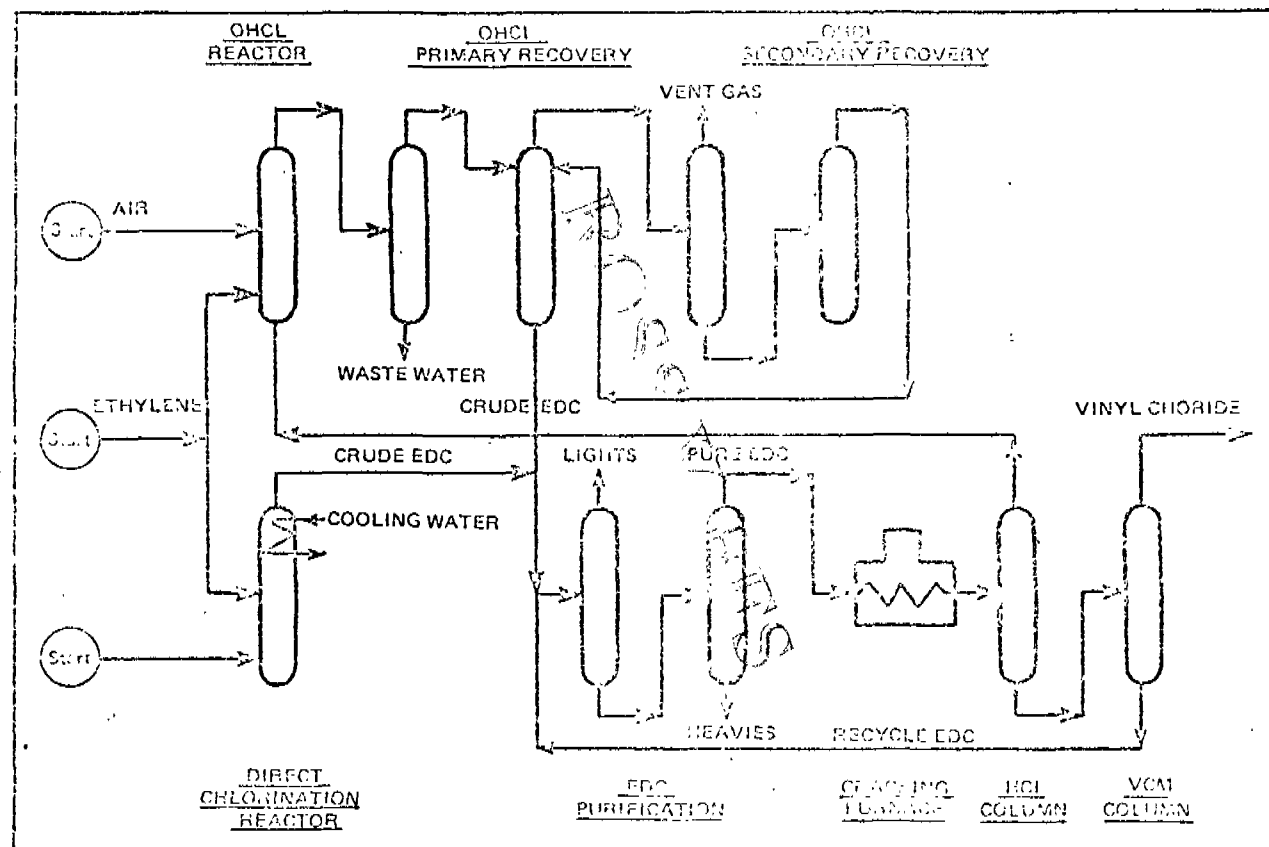


Source: Stauffer Chemical Co.: Vinyl Chloride. Hydrocarbon Processing 52: 194, November 1973.

EXHIBIT IV-2

USDOL/OSHA

THE B. F. GOODRICH PROCESS FOR VINYL CHLORIDE



Source: B. F. Goodrich Chemical Co.: Vinyl Chloride. Hydrocarbon Processing 52: 191, November 1973.

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EXHIBIT IV-3 (1)

USDOL/OSHA

VINYL CHLORIDE PROCESS DESCRIPTION

General Description⁽¹⁾

Ethylene dichloride (EDC) is produced in both addition (direct) chlorination and oxychlorination units. In the addition chlorination unit ethylene and chlorine are combined to produce EDC in a liquid phase reactor. In the oxychlorination unit ethylene, air and byproduct HCl from the EDC cracking unit are reacted to produce EDC. An efficient catalyst in the vapor phase oxychlorination reactor is used to promote high yields. High pressure steam generated in the oxy reactor removes reaction heat and is used as heat medium in other points in the process. EDC is separated from vent gas by condensation in two recovery units. There are no moving parts in the entire oxy process except in the air compressor and refrigeration units.

Crude EDC from the addition and the oxychlorination units is combined with recycle EDC from the cracking unit and purified by removal of small quantities of light and heavy materials. Aqueous effluents separated from the crude EDC are steam stripped and are suitable for biological treatment. Both light and heavy ends may be treated for further use as feed to other chlorination processes.

Vinyl chloride monomer (VCM) is produced by cracking purified EDC in the pyrolysis furnace.

Description of Unit Operations Involving VCM⁽²⁾

Dry EDC is dehydrochlorinated to vinyl chloride as it passes through the packed tubes of a cracking furnace.

The tubes are normally packed with pumice, charcoal or some other "contact" type catalyst. At 900 to 950° F and 50 PSIG, EDC conversion is about 50% and yield to vinyl chloride is 94 to 97 mole %. The hot effluent gases are then quenched, and partially condensed, by direct contact with cold EDC in a quench tower.

Effluent fractionation and product purification are generally accomplished in three additional towers, where each producer of VCM has its own modification of this process.

Hydrogen chloride and light chlorinated hydrocarbons are rejected overhead in the "HCL" and "Light Ends" towers. The hydrogen chloride is normally recovered by water scrubbing and recycled to the EDC plant. Trichloroethane, chlorinated C's and other heavy ends are rejected from the bottom of either the "quench tower" or the "vinyl tower". Contained EDC is recovered by fractionation and recycled to both the quench tower and the feed storage tank. The light and heavy ends are either further processed or disposed of by, for example, incineration. Vinyl chloride monomer is taken overhead in the "vinyl" column, generally caustic washed, and then sent to the product storage facilities.

VINYL CHLORIDE PROCESS DESCRIPTION

General Description⁽¹⁾

After quenching, the furnace products are separated into HCl, which is recycled to the oxy unit, and high purity VCM. Unreacted EDC is recycled through the EDC purification system.

The overall process is balanced so that only VCM is produced without byproduct HCl. Design is easily adapted to produce HCl for other uses, to use HCl from other sources, or to make EDC as a separate product.

The process is highly automated for stable, fail-safe operation at high yields over a wide turn-down range. Startup is easy and rapid. Units combine simplicity of operation with low manpower, capital, operating and maintenance costs.

Notes:

- (1) Related to the Stauffer process, Exhibit IV-1
- (2) Reflects generalized practice

Sources:

- (1) Stauffer Chemical Co.: Vinyl Chloride. Hydrocarbon Processing 52: 194, November 1973.
- (2) Air Products & Chemicals, Inc. (Honey Division), Survey Report on Vinyl Chloride Monomer Production Via Dichloroethane Pyrolysis. Prepared for Environmental Protection Agency; Durham, North Carolina; 1972.

EXHIBIT IV - 4 (1)

USDOL/OSHA

ESTIMATED VINYL CHLORIDE MONOMER
ECONOMICS - 1974
(¢/lb.)Unit Production Costs For A 500 Million Lb. Ethylene Oxychlorination Plant of 1974
Construction With Total Fixed Capital of \$20.4 Million

Plant Investment	4.08
<u>Cost of Manufacture</u>	
Raw Materials	
Ethylene (0.49 lb/lb @ 6.0¢/lb)	2.94
Chlorine (0.67 lb/lb @ 3.0¢/lb)	<u>2.01</u>
Subtotal	<u>4.95</u>
Labor	0.12
Utilities	0.25
Maintenance	0.20
Overhead	0.15
Taxes & Insurance	0.06
Depreciation	<u>0.40</u>
Total cost of manufacture	<u>6.13</u>

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EXHIBIT IV - 4(2)

USDOL/OSHA

ESTIMATED VINYL CHLORIDE MONOMER
ECONOMICS - 1974
(¢/lb.)

Unit Production Costs For A 500 Million Lb. Ethylene Oxychlorination Plant of 1974
Construction With Total Fixed Capital of \$20.4 Million

Profitability

Net selling price (FOB plant)	7.41
Cost of manufacture	(6.13)
Selling, general and administrative expenses	~ (0.30)
Pretax profit	0.98
Pretax return on total investment (@ 1.2 plant investment)	20%

-
- Sources:
- (1) Snell estimates based on Brownstein, A. M., U. S. Petrochemicals, Tulsa, Oklahoma, The Petroleum Publishing Co., 1971, p. 25
 - (2) Snell estimates based on mid-1974 Chemical Marketing Reporter posted prices

EXHIBIT IV- 5 (1)

USDOL/OSHA

EXAMPLE OF A STANDARD OPERATING PROCEDURE FOR
MAINTENANCE AT DOW CHEMICAL CO. VINYL CHLORIDE WORKS

SAFETY PROCEDURE

Subject: BLEED-DOWN OF VINYL CHLORIDE CONTAINING EQUIPMENT

Problem: At present, pumps, sections of piping, and some equipment are partially or otherwise bled down to atmosphere. This exposes personnel to vinyl vapors if care is not taken.

Situation: Obviously, there are numerous situations that occur in the plant, where exposure to vinyl vapors is possible when preparing equipment for repair or entry. Most equipment is either already tied into the vent recovery system for bleed-down, or can be, with limited temporary piping. Almost all bleed-downs can be done through the vent recovery system and all personnel exposures to vinyl vapors must be eliminated. Elimination of exposure to the vapors should extend to any final low pressure bleed-down of equipment that has already been relieved through the vent recovery system. Also, preventative measures should be taken when opening equipment with stagnated vapors in it. In these two cases, proper respirators should be used to prevent exposures due to change of wind direction or otherwise.

Solution:

1. All seal repair work done on vinyl furnace pumps should utilize the vent recovery system for the primary bleed-down. Any small final bleed-down should involve personal respirator protection. In some cases, it may be necessary to use a full face mask, rather than a mouth-bite respirator.
2. Temporary piping to the vent recovery system should be run when necessary to vent an isolated piece of equipment, or run of piping.
3. When breaking into a vessel or piping system containing vinyl that has been depressured, use a respirator. (Hose-Line Mask). In the case of breaking vinyl containing system, the use of respirators should parallel the policy of using monogoggles.

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EXHIBIT IV- 5 (2)

USDOL/OSHA

EXAMPLES OF A STANDARD OPERATING PROCEDURE FOR
MAINTENANCE AT DOW CHEMICAL CO. VINYL CHLORIDE WORKS

4. All vessels will be purged to D-234 vent recovery system before opening. Considerable exposure to vinyl vapors is possible working around these openings due to trapped liquid vaporization inside the vessel. Therefore, fresh air-supplied masks should be used around such openings for exposures of any length.
5. When breaking into vinyl containing equipment, the immediate supervisor of that area should advise the type of respiratory equipment to be used, and issue a safe work permit in some cases.

Source: Dow Chemical Corporation

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IVB. POLYVINYL CHLORIDE

This chapter discusses the technology of polyvinyl chloride (PVC) manufacture in broad terms. Appendix A provides more detailed data from contacts with industry, from submissions to OSHA related to the "Proposed Standard" and other sources. All exhibits appear sequentially at the end of the chapter.

There are four basic processes which can be used for producing PVC.

- . Suspension Polymerization
- . Emulsion Polymerization
- . Bulk Polymerization
- . Solution Polymerization

These processes are presented in a "capsule" summary in Exhibit IV-6.

*Process
Suspension = 78% of
production*

1. OF THE FOUR PROCESSES FOR THE MANUFACTURE OF PVC THE SUSPENSION PROCESS IS THE MOST ECONOMICALLY IMPORTANT, ACCOUNTING FOR 78 PERCENT OF PRODUCTION

The table on the following page summarizes the relative contribution of each process to the total production for 1973.

<u>Process</u>	<u>1973 Production (Million Lbs.)</u>	<u>Percent of Production</u>
Suspension	3,558	78
Emulsion	593	13
Bulk	274	6
Solution	137	3
Total	<u>4,562</u>	<u>100%</u>

Source: Exhibit III-9

The importance of the suspension process is reflected in subsequent discussion.

Exhibit IV-7 presents a flow diagram for a representative suspension process.

Principal unit operations include

- monomer receiving and storage. This is discussed in Appendix A, where Exhibit A-1 presents operating procedures while Exhibit A-2 shows a flow sheet.
- polymerization
 - .. this is also discussed in Appendix A, where a technological assessment was developed by Snell addressing reactor design and cleaning in Exhibit A-3.
 - .. a comparison is also presented of large versus small reactor technology in Exhibit A-4.
 - .. Exhibit A-5 shows the schematic of an older polymerizer, while Exhibit A-6 shows that of a newer design.
- stripping and in-process storage. Stripping technology is broadly discussed in Exhibit A-7.
- drying
- finished product handling

- Exhibit A-8 in Appendix A provides a representative plant layout with typical operator movements.

Exhibit A-9 in Appendix A presents a flow diagram of emulsion polymerization.

It is seen from Exhibit IV-8, at the end of this chapter, providing a technological overview of suspension polymerization, emulsion polymerization and their copolymer production variants that suspension and emulsion polymerization are very similar in terms of gross equipment used. Differences in detail are summarized in the Exhibit.

Exhibit IV-9 presents an overview of the polymerization cycle for the suspension and emulsion processes. Differences principally concern time requirements, detailed in the Exhibit.

Exhibit IV-10 provides a checklist of potential VCM sources contributing to local or area type VCM exposure risk in suspension polymerization. The most important potential sources are identified in the Exhibit.

Exhibit IV-11 shows a flow diagram and process description for bulk polymerization.

Exhibit IV-12 presents a summary discussion of copolymers manufacture, which involves the suspension, emulsion or solution processes.

2. ESTIMATES WERE DEVELOPED BY SELL OF PVC INDUSTRY ECONOMICS AND THE TIME REQUIRED TO ACHIEVE VARIOUS ENGINEERING GOALS

- . Exhibit IV-13 presents typical time requirements for implementing various engineering control methods.
- . Typical delivery times were also estimated for key equipment items and these are presented in Appendix C, Exhibit C-1.
- . Exhibit C-2 presents Snell's overview of time requirements in implementing engineered controls of VCM exposure in PVC plants.
- . Exhibit IV-14, at the end of this chapter, summarizes 1974 PVC economics. Total cost of manufacture is estimated at 14.4¢/lb. at a 20% pretax return on total investment. This cost profile is used in the next chapter in economic impact evaluations of various VCM compliance scenarios.

* * * * *

This chapter discussed the technology and basic production economics of VCM and PVC manufacture. The next chapter presents findings and conclusions.

Exhibit IV-6

USDOL/OHA

CAPSULE OVERVIEW OF POLYVINYL CHLORIDE PROCESSES

Suspension Polymerization (1,3)

Suspension polymerization uses water as a medium for VCM with a suspending agent such as polyvinyl alcohol and a catalyst such as benzoyl peroxide. Buffers such as sodium carbonate or phosphate can be used to maintain pH at 5 to 9 during the reaction and prevent hydrochloric acid evolution. Polymerization under nitrogen increases reaction rate as well as controls acid release.

The charge to a reactor might be composed of:

- 100 part VCM
- 200 parts water
- 0.1-0.2 part catalyst
- 0.005-0.1 part suspension agent

The VCM/water ratio is limited by the rheology of the suspension to enable proper removal of the heat of polymerization. Vigorous agitation aids heat exchange and maintains VCM as fine droplets suspended in water. After drying the polymer "pearls" range from 90 to 120 microns for general purpose applications, and smaller for specialty products.

Process temperatures range from 30 to 45°C, and the time to turn around a polymerizer can range from 5 to 15 hours.

Major uses of suspension polymerized PVC are in calendered film; extruded film, wire coatings, pipe and profile; and molded products.

Emulsion Polymerization (1,2,3)

Emulsion (dispersion or paste) polymerization is very similar to the suspension process. Recipe differences principally concern the use of emulsifiers and initiators. The time to turn around a reactor can range from 10 to 24 hours.

A colloid dispersion of PVC particles in an aqueous phase is produced in this process. These particles, approximately 0.5 microns in size, can be utilized directly from the dispersion, or latex, either plasticized or unplasticized, or they can be spray dried to a powder for use in plastisols, rigidols, plast gels, or organosols. Processes utilizing PVC dispersion resins include slush molding, casting, dipping, spray coating, roll and knife coating, and rotational molding.

Plastisols are vinyl dispersions containing little or no volatile liquids and thus are essentially 100% solids. Organosols are similar in composition to plastisols except for the presence of volatile liquids used to extend the liquid phase and thus reduce viscosity.

Polyvinyl chloride for plastisols and organosols is polymerized in emulsion systems that provide colloidal water dispersions containing ultrafine particles of approximately 0.2 to 2.0 microns in size. Spray drying of the water dispersion produces the commercial product, a dry powder of approximately 2 microns average particle size, with some particles as large as 15 to 20 microns. About 10% of the PVC used in the U.S. is dispersion grades.

Most vinyl dispersion resins find use in the two broad areas of coating and moldings.

Organosols are used to produce thin films of higher hardness than can generally be obtained from plastisols.

Latex liquid systems of vinyl chloride homopolymers and copolymers are also available. These systems are colloidal dispersions in water. The average particle size is usually less than 0.3 micron.

Latexes are effectively used to coat, impregnate or saturate fabrics, paper and leather with polymeric dispersions of lower viscosity than most plastisols.

Bulk Polymerization (1)

A more recently developed process is carried out in specially designed reactors in the absence of water and suspension additives. Because bulk resins are polymerized in a monomer matrix, the unused portion of which is recycled, they are free of the polluting processing residues to the environment as pollutants. While capable of producing both general-purpose and specialty types of PVC, the bulk or mass polymerization process can also produce very pure PVC, the structure of which differs considerably from resins polymerized via suspension. Because PVC particles polymerized in bulk are free of additives used in suspension and emulsion polymerization, they lack mercurianous coatings. The excellent clarity inherent in bulk resins has made them preferred in many transparent product markets, including packaging film, bottles, and coatings.

Solution Polymerization (1)

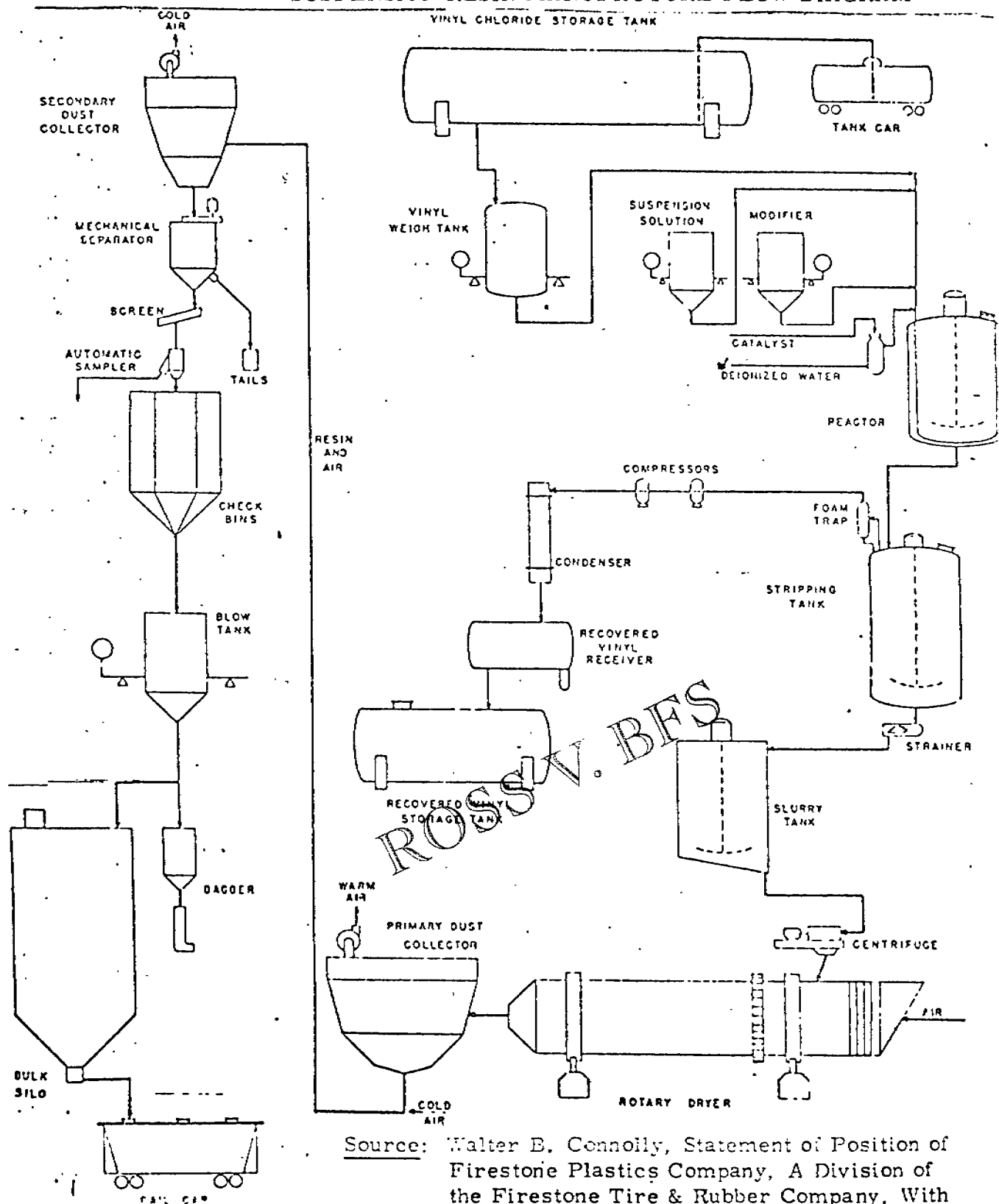
A process of lesser commercial importance than the others discussed has been utilized in preparing specialty copolymers and terpolymers of vinyl chloride. Polymerization occurs in organic solvents which then must be usually removed and recovered. The solution polymers are generally higher priced and used in product applications such as coatings and adhesives.

- Sources: (1) 1972-1973 Modern Plastics Encyclopedia, p. 104.
(2) 1973-1974 Modern Plastics Encyclopedia, p. 113.
(3) Snell.

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REPRESENTATIVE POLYVINYL CHLORIDE SUSPENSION RESIN MANUFACTURE FLOW DIAGRAM



Source: Walter B. Connolly, Statement of Position of Firestone Plastics Company, A Division of the Firestone Tire & Rubber Company, With Respect to the Proposed Permanent Standard Dealing With Occupational Exposure to Vinyl Chloride to Occupational Safety and Health

TECHNOLOGICAL OVERVIEW OF SUSPENSION (S),
EMULSION (E) AND CO-POLYMERIZATION
(S & E TYPE)

Process Step	Process Where Used	Most Commonly Used Equipment	Less Commonly Used Equipment	Comments
(1) VCM Unloading	S, E, Co	Tank car	Barge	Some plants have pipe line delivery with or without local storage. Tank cars: 10 to 38,000 gals.; Barges: Up to 300,000 gals.
	S, E, Co	Flexible hoses	Rigid pipe with flexible couplings	
(2) VCM Storage	S, E, Co	Transfer pump	Vacuum pump	Some low capacity plants are said to use nitrogen displacement for unloading. This practice can cause venting problems on return cars at the VCM plant, and at the unloading facility. Sometimes used to vent hoses prior to disconnect.
	S, E, Co	Evaporator		
	S, E, Co	Evaporator feed pump		
	S, E, Co	Unloading compressor		
(3) VCM Transfer and Metering	S, E, Co	Hortonspheres	Horizontal tanks	Hortonspheres: 500-800,000 gals.; Tanks: Up to 80,000 gals. Sometimes storage is under refrigeration 15°C.
	S, E, Co	Transfer pump	Line strainer Metering tank and reactor Loading pump or metering pump Premix tank Addition pot	Some plants particularly those using weigh tanks omit the day tank. Used occasionally. In copolymerization the other monomer is introduced here.
	S, E, Co	Day tank		
	S, E, Co	Weigh tank and reactor		
	S, E, Co	Loading pump		
(4) Polymerization	S, E, Co	Stirred reactor (polymerizer, autoclave)		Sometimes used. Suspending agents and catalysts are sometimes premixed and added through a specially designed addition pot. Often ingredients are manually poured into the reactor.
	S, E, Co			Glass lined or stainless steel: From 2,000 to 5,000 gals. historically. New technology: To 35,000 gals. ss. to 18,000 gals. G.L.
(5) Stripping	S, E, Co	Stripper	Blowdown tank	Stripping is sometimes carried out in the reactor, most simply through deaeration and monomer recovery. The use of steam jets is more advanced, while vacuum pumps are also used. Heating and steam sparging is sometimes practiced. Separate strippers at approximately twice the volume of the reactor are used. Developing technology is likely to feature multi-stage stripping using steam to reduce free monomer in the product and hinder in-plant and dryer exhaust emitters.
(6) Monomer Recovery	S, E, Co	Foam knock out pot	Several hot in series	Monomer recovery is tied in to stripping. Jet exhaust is usually vented to atmosphere. Vacuum pump exhaust can go through monomer recovery unit. Most processors do not separate the comonomer but recycle the mixed recovered stream. The most commonly used of the rotary compressors is the flush water seal, said to have less maintenance problem than the reciprocating. Slight proprietary technological differences exist in the handling of the recovered monomer stream. The recovered monomer is returned to the day or the weigh tank.
	S, E, Co	Vacuum steam jet	And/or vacuum pumps	
	Co		Condenser	
	Co		Comonomer separator	
		Reciprocating compressor	Rotary compressor	
	S, E, Co	Condenser	Recovery still	
	S, E, Co	Recovered VCM tank		
	S, E, Co	Chilled vent condenser		
	S, E, Co	Recovered VCM pump		

Process Step	Process Where Used	Most Commonly Used Equipment	Less Commonly Used Equipment	Comments
(7) Product Transfer	S, E, Co	Transfer pump		Some reactors are gravity dropped using flexible coupling or permanent piping.
	S, E, Co	Strainer	Filter or wet filter	Basket strainers have been removed in some suspension plants. Open strainers sometimes used in emulsion plants require significant operator attention. Newer type strainers are equipped with backflush. In some installations, the straining equipment is spot vented.
	S, E, Co	Blend tank		Usually 2 to 5 times the size of the reactor. Sometimes open to the atmosphere (out-of-line), usually vented, sometimes with blower and vent stack.
(8) Drying	S, E, Co			If a latex product is desired, steps 8, 9, and 10 are omitted.
	S, E, Co	Feed pump		Suspension slurry is 20 - 30% solids.
	S	Centrifuge		Usually continuous solid bowl.
	S	Wet cake conveyor		Wet cake contains about 30 - 35% water.
	E		Concentrator	Sometimes used before spray dryer. Usual wiped film type.
	E	Spray dryer	Coagulation tank	
	E		Rotary vacuum filter	This equipment combination has been reported.
(9) Product transfer and storage	S		Apron dryer	
	S	Rotary dryer	Flash or fluid bed dryer	50,000 to 70,000 CFM of drying air. Final moisture: 0.2 - 0.5%.
	S, E, Co	Dust collector		
	S, E, Co	Intermediate storage		for holding product while Q. C. tests are performed.
	S, E, Co	Pneumatic conveyor		
	S, E, Co	Grinder		There is a large variety of alternate types of equipment and configurations for the conveying of dry product. Several alternate systems exist in the same plant.
(10) Packaging and Shipping	S, E, Co	Dust collector		
	S, E, Co	Storage silos		
	S, E, Co	Bulk loading	Bagging	Bagging equipment is usually automatic or semi-automatic fluidized valve bag type.
	S, E, Co	Hopper cars	Tote bins	Bulk carriers sometimes use some form of fluidizing for unloading.
		Tank trucks		

Source: Snell analysis based on industry interviews.

THE POLYMERIZATION CYCLE IN THE SUSPENSION AND EMULSION PROCESSES

Cycle Step	Time	Most Common Practice	Alternate Practice	Comments
Charging		Manway open, exhaust via "elephant hose".		
- Water addition	10-20 minutes	Fill the reactor with the required amount of water. Usually by observing the level in the reactor on metering.	Sometimes the water is metered in with manway secured.	In most plants the operator is in close proximity to the reactor during the charging operations. In most cases the displaced atmosphere is vented by means of the elephant hose during water fill.
- Ingredients addition	5 minutes	Add manually through open manway. Close the valves, secure the manway.	Premixed amounts dissolved or suspended in water are introduced to an addition pot.	A newer practice is to have the ingredients dissolved or suspended in appropriate weigh tanks and added through a manifold, sometimes with computerized controls.
- Monomer addition	10-20 minutes	Prior to monomer addition the reactor atmosphere is vented through a steam jet or a vacuum pump. The monomer is metered through a weigh tank or other metering device.	Sometimes, in addition, nitrogen is used either at atmospheric or under reduced pressure.	In some cases the ingredients, particularly the catalyst(s), are held in a specially designed addition pot. After monomer addition the atmosphere of the pot is connected with that of the reactor and the ingredient charge is dropped by gravity into the reactor.
Reaction				
- Initiation	15-20 minutes	Steam or hot water is admitted to the jacket to bring the temperature to 35-45°C.	Direct steam sparging into the reaction mixture.	
- Cooling	5-20 hours	During the reaction, cold water is circulated through the jacket to carry away the heat evolved.	Sometimes the rate of circulation of the cooling water is adjusted by an automatic closed loop control.	
Stripping (Blow down)	15-60 minutes	Some plants use only depressurization through the recovery unit, via foam knock-out pot, followed by steam jet.	Use vacuum pump at the end of depressurization, venting to the recovery system. A newer practice is to sparge steam to enhance the stripping and reduce the amount of free monomer going to the next steps.	Unreacted monomer is recovered either in the reactor itself or after transfer of the charge to a stripper or blow down tank.
Reactor inspection	5-10 minutes	To determine that the reactor is empty.	Sometimes the manway is opened and residual material is hosed out of the reactor.	Newer automatic cleaning methods have been devised to eliminate the need to open the manway, or at least to minimize manual cleaning by a man entering the reactor.
Cleaning	20 minutes to 4 hours	In most operations this is done every 3rd to 5th cycle.	Newer methods are used: - In-place water cleaning - Solvent cleaning	The most commonly used methods of automatic cleaning are described in Appendix A.
	1-1.5 hours	A man enters the reactor and chips or scrapes away the accumulated material. Since January 1974 the man is equipped with a fresh air breathing device while in the reactor, and wears protective clothing.	A man enters the reactor and uses a hand-held high pressure water hose.	Prior to entry and while the man is in the reactor the atmosphere of the tank is renewed through an exhaust system connected to an elephant hose. With reactors equipped with flexible connection the discharge hose is left open. With permanently connected reactor, a separate blower is lowered in the reactor to assist the air circulation in the reactor.

Source: Snell engineering assessment based on industry interviews.

EXHIBIT IV-10 (1)

USDOL/OSHA

POTENTIAL EXPOSURE CHECKLIST BASED ON SUSPENSION
POLYVINYL CHLORIDE MANUFACTURE

1. Tank Farm (VCM Storage)

• Rail car unloading

- Gasketing at hose connections
- Pump seals*
- Compressors*
- Flanges at pipe joints
- Valves*
- Venting pressure off hoses before disconnecting

• Transfer operation (from storage tanks, to weight tanks)

- Pipe flanges
- Pump seals*
- Valves*
- Compressors*
- Airing out tanks for pressure inspection or cleaning*

2. Polymerization - Reactor and Stripper Level

- Pump seals*
- Flanged pipe joints or vessel connections
- Reactor and stripper heads*
- Reactor and stripper seals
- Valves*
- Opening reactor and stripper heads for flushing*
- Flushing reactors and strippers*
- Cleaning reactors and strippers*
- Cleaning buildup from valves, lines, etc.*
- Maintenance on various pieces of equipment

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2. Polymerization - Reactor and Stripper Level (continued)

- . Airing out equipment in preparation for entry
- . Operator errors*
- . Plugged lines resulting in gasket failure*
- . Ventilation of reactors during flushing operation (vapors discharged on roof)
- . Airing out vessels containing poorly degassed material as a result of plugged discharge line, setup, etc.*
- . Purging of reactors prior to charging (vapors discharged on roof)
- . Purging of stripping vessels (vapors discharged on roof)

3. Polymerization Building - Pump Out Level (Relief Area)

- . Pump seals
- . Compressor*
- . Leaking pipe flanges resulting in spills
- . Leaks in VCM filtering vessels*
- . Drains from top floor*
- . Reclaim water containing dissolved vinyl chloride discharging inside building*
- . Draining of foam traps on compressors*
- . Draining water off the condensed recovered vinyl chloride*
- . Moving polymer chips outside building and dumping drums
- . Changing and handling VCM filters*

4. Blend Tank Area (Work-in-Process Storage)

- . Monomer evolution during storage*
- . Flushing blend tanks
- . Leaks (pump seals, hoses, pipe flanges)

5. Rotary Drying Operation

- . Rotary dryer exhaust air
- . Leaks from pump seals, pipe flanges
- . Centrifuge liquid discharge (effluent)

5. Rotary Drying Operation (continued)

Any operation involving handling or storage of finished resin or where dried resin accumulates

- Bagging
- Housekeeping
- Dried product screening
- Changing dust collector bags
- Cleaning equipment
- Pneumatic transfer of resin to storage or into bulk trucks and rail cars
- Maintenance operations in areas where large masses of resin are stored, primarily silos

6. Warehouse Area

- Space where resin is stored in a manner that restricts air circulation
 - Plastic shrouded pallets
 - Resin (and compound) in sealed drums or boxes, etc.
 - Resin (and compound) in semi-bulk containers (metal tote bins, etc.)
- Storage of resin in bags

7. Lab Area

- Testing of finished resin (and compound)
- Testing of resin slurry prior to drying (suspension resins)*
- Testing of VCM

* Likelihood of relatively greatest exposure.

Source: Firestone and Snell assessment.

EXHIBIT IV-11

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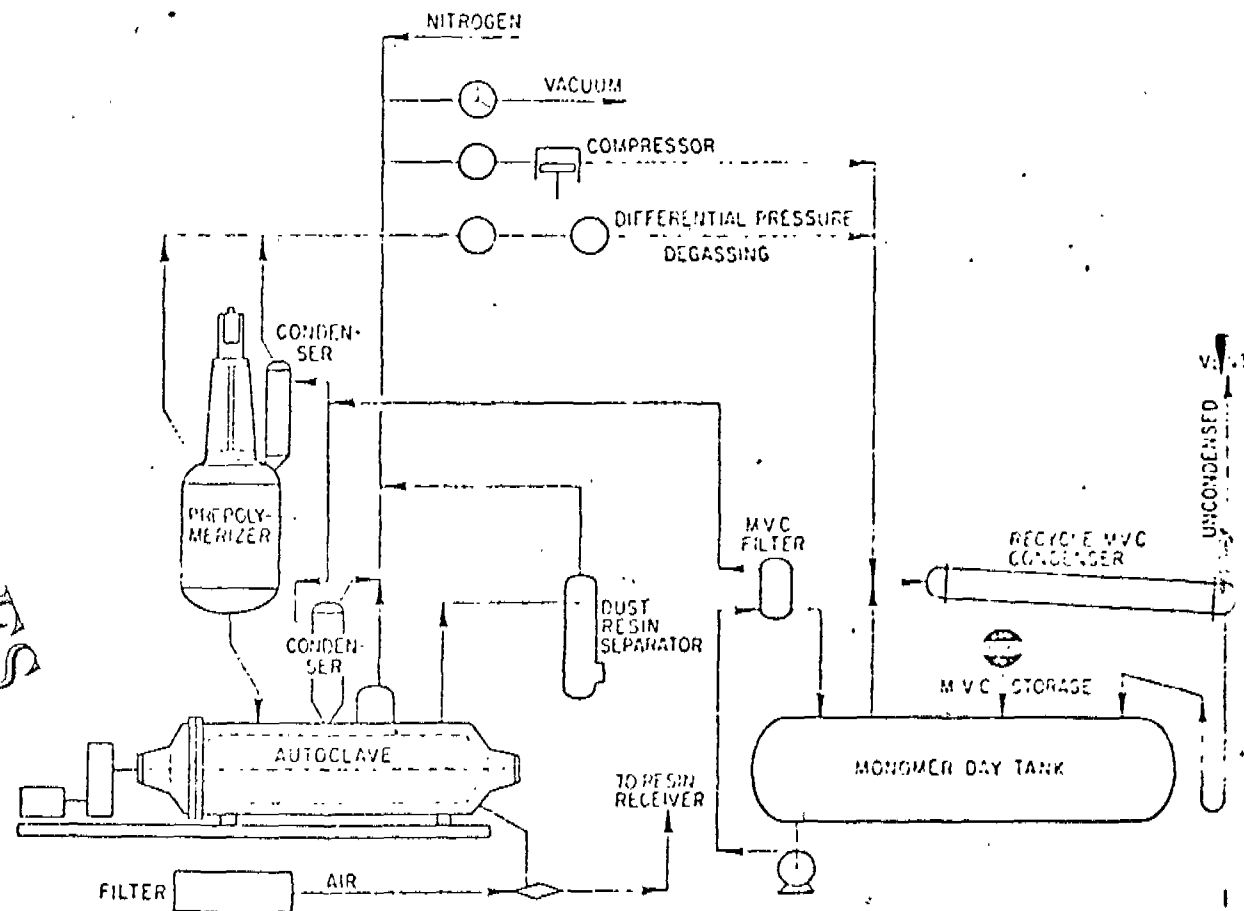
TYPICAL FLOW DIAGRAM FOR
THE BULK PROCESS

The two-step batch polymerization process carried out in two reactors in series. During the first step polymerization proceeds in a liquid medium of vinyl chloride monomer; it is a bead formation phase rate in the range of 10 to 12%. For this initial phase, a stainless clad, vertical autoclave equipped with very turbulent agitation is used. Operating pressure and agitation conditions set the particle size distribution and the shape of the bead used thereafter as a seed in the second step.

The second step is a growing phase for the seeds; it is performed in stainless clad autoclaves designed for efficient agitation of a powdery medium. At the end of the polymerization cycle the unreacted monomer is recovered by condensation and directly reused for further polymerization. PVC resin is then discharged from the horizontal autoclave to a classification unit which screens the product to the desired specification. Oversize amounting to 5-10% of total is reduced in size with an appropriate grinder designed not to affect the product properties.

Since mass process produces a dry free flowing resin prior to classification the normal capital expenditures associated in suspension PVC process for dewatering and drying are not necessary. The plant is run by a sequential program; the automatic control of operating procedures results in excellent reproducibility of products manufactured.

Source: Hydrocarbon Processing, November 1968, p. 193.



COPOLYMERS ARE MANUFACTURED BY THE SUSPENSION, THE EMULSION, OR THE SOLUTION PROCESS

Based on Exhibit III-16 data, copolymers represented 12% of PVC resin output in 1973. Copolymers are obtained by the simultaneous polymerization of vinyl chloride and up to 15-20% of other monomers such as vinyl acetate, vinylidene chloride and acrylics. The vinyl acetate copolymers are most important in terms of volume. The production processes differ only in details from the standard polymerization processes. Main points of difference are in the charging and recovery areas.

(1) Suspension And Emulsion Copolymerizations With Vinyl Acetate Are Carried Out In The Same Equipment As Used For Homopolymerization

The only differences are the addition of a feed line from vinyl acetate storage tank to the monomer weigh tank and a slight modification to the recovery system as indicated below.

- Stripping of the unreacted monomers is carried out by venting the unreacted VCM to a recovery line modified to permit separate recovery of the vinyl acetate. When most of the unreacted VCM has been vented to the recovery, steam is sparged through the slurry until a vapor stream containing VCM, vinyl acetate and a substantial amount of water vapor is obtained. The recovery line is equipped with two condensers in series upstream of the recovery compressor.
- A two phase system of liquid vinyl acetate and water is discharged from the bottom of the condensers. The vinyl acetate, separated by decantation is returned to the process via the weigh tank and the water phase is discarded. Some processes are designed to recycle the mixed monomer stream back to the reaction without separation.

(2) Copolymerizations Involving Vinylidene Chloride As A Comonomer Differ From Homopolymerizations In The Recovery Process

A separation column is usually incorporated in the recovery train to separate the unreacted vinylidene chloride. The column is designed to take advantage of the lower volatility of the vinylidene chloride (B.P. 760=31.7°C). The recovered monomers are returned separately to the process and the charges adjusted accordingly.

Source: Snell assessment based on industry interviews.

EXHIBIT IV - 13 (1)

USDOL/OSHA

TYPICAL TIME REQUIREMENTS FOR
IMPLEMENTING VARIOUS ENGINEERING CONTROL METHODS
FOR POLYVINYL CHLORIDE PLANTS

<u>Method</u>	<u>Rationale</u>	<u>Time to Complete</u>
Major ventilation project	Increase rate of air changes in closed buildings	18 months
Minor ventilation	Install spot ventilation on a piece of equipment: pump, strainer, etc.	1/2 - 2 months
Venting of temporary tank car connection lines	Decrease release of VCM trapped between tank car valve, using vacuum and/or nitrogen flush	1 - 2 months
Installation of new gauging systems on tank car fleet	Eliminate the continuous emission of VCM which occurs with the dip tube system	12 - 24 months
Replacement or reconditioning of reactors (polys)	Reduce leakage at manholes, seals, etc.	18 - 24 months
Installation of solvent cleaning of reactors	Reduce need to clean manually	30 months
Installation of automatic water cleaning of reactors	(Alternative to solvent cleaning)	24 months
Additional stripping not requiring new steam generating facilities	Reduce VCM emissions downstream from the polymerization step	18 months
Additional stripping requiring new steam generating facilities	Reduce VCM emissions downstream from the polymerization step	36 months
Replacement of strainers	Eliminate open strainers and/or substitute closed self cleaning units	3 - 8 months

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EXHIBIT IV - 13 (2)

USDOL/CSHA

TYPICAL TIME REQUIREMENTS FOR
IMPLEMENTING VARIOUS ENGINEERING CONTROL METHODS
FOR POLYVINYL CHLORIDE PLANTS

<u>Method</u>	<u>Rationale</u>	<u>Time to Complete</u>
Installation of rotary compressors to replace reciprocating compressors	Reduce VCM leakage during operation	18 months
Modifications to the piping	Reduce the number of flanged connections, etc.	1 - 12 months
Major processing change requiring R & D and demonstration	e.g. Change over from the batch to a continuous process	4 - 7 years
New plant construction	Install a complete, redesigned facility	2.5 - 3 years

Sources: Snell's estimates based on interviews with producers, equipment manufacturers and engineering know-how

who ARE they?

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POLYVINYL CHLORIDE ECONOMICS⁽¹⁾ - 1974

Designed plant capacity (MM lb. /year)	200
Plant investment (MM \$)	20
Production (MM lb. /year @ 90% utilization)	180
Plant investment per unit of production (¢/lb.)	11.1
<u>Cost of Manufacture</u>	<u>¢/lb.</u>
Vinyl chloride monomer (1.06 lb. @ 8¢/lb.)	8.5
Operating labor and supervision	0.4
Capital recovery (7.125 - 10 years)	2.0
All other costs (catalysts, utilities, maintenance, etc.)	3.5
Total cost of manufacture	14.4
<u>Profitability</u>	
Net selling price (FOB plant)	18.6
Cost of manufacture	(14.4)
Selling, general and administrative expense	(1.5)
Pretax profit	2.7
Pretax return on total investment (@ 1.2 plant investment)	20%

(1) Grass roots plant, located on Gulf Coast, producing general purpose suspension resin, prior to the Emergency Temporary OSHA Standards.

Source: Snell estimates based on Milgrom, Jack; Incentives for Recycling and Reuse of Plastics, Washington, Environmental Protection Agency, 1972; Industry interviews; and mid-1974 Chemical Marketing Reporter posted prices for monomer and polymer.

Who is Jack Milgrom, what industry

V. FINDINGS AND ECONOMIC ANALYSIS

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V. FINDINGS AND ECONOMIC ANALYSIS

This chapter presents the findings and economic analysis drawn from aggregation of plant-by-plant economic data, and the detailed data appearing in Chapters III and IV dealing with industry structure and technology respectively, as well as from the appendices.

Information is presented in individual sections topically addressing each of the key regulatory considerations of primary concern to the study (See Exhibit II-1). Sections follow as shown:

- . VA - Economic Impact Assessment
- . VB - Personal Protective Equipment Availability and Costs
- . VC - Monitoring Equipment Availability and Costs
- . VD - Medical Surveillance Costs
- . VE - Exposure Data

VA. ECONOMIC IMPACT ASSESSMENT

This section presents the estimated economic impact of various regulatory standards on the vinyl chloride monomer (VCM) and polyvinyl chloride (PVC) industries. For this study, economic impact is defined only as the direct cost impact on the VCM and PVC industries resulting from compliance with proposed OSHA levels of VCM exposure. As shown in Exhibit II-1, study of economic impacts in other sectors and evaluation of PVC substitutability were not included in the scope of work. The specific study methodology employed and the indicators of economic impact are detailed in the respective discussions for the VCM and PVC industries.

1. METHODOLOGY FOR ESTIMATING THE ECONOMIC IMPACT IS BASED ON SNELL AUDITS OF INDUSTRY ASSESSMENTS OF REQUIRED ENGINEERING, PERSONAL PROTECTIVE AND MONITORING EQUIPMENT

- . Information for assessing the economic impact under various VCM regulatory levels was collected through an industry survey conducted by Snell.
- . The cost estimates are developed for various compliance levels.
 - plant-by-plant costs reported by industry for various VCM exposure levels provided the data base
 - individual plant information was aggregated to provide the estimated impact per pound of VCM or PVC produced for the industry
- . Cost estimates of specified equipment were checked by Snell for order of magnitude validity.

- monitoring and personal protective equipment information were compared with equipment supplier quotations
- specific items such as compressors, pumps, etc. were validated with supplier quotations

Major cost items for the required engineering steps were reviewed by Snell engineers to determine their accuracy.

Exhibit V-1, on the following page, summarizes the economic impact indicators used.

2.. FINDINGS FROM ECONOMIC IMPACT ANALYSIS RELATED TO THE VCM INDUSTRY ARE BASED ON SUBSTANTIAL DATA TO A TARGET LEVEL OF 10 PPM VCM CEILING AND 2 - 5 TWA

Snell assessed industry costs of reducing VCM levels in VCM plants were separated into five categories which include:

- engineering costs, including:
 - .. ventilation
 - .. vapor recovery
 - .. stripping (product purification)
 - .. loading for shipping
 - .. other (pumps, piping, etc.)

EXHIBIT V-1
USDOL-OSHA
ECONOMIC IMPACT INDICATORS
USED FOR THE STUDY

Indicator	Definition	Comments
- Estimated Industry Costs of Achieving Various VCM Target Levels - Engineering) - Personal Protective Equipment) - Monitoring and Other) - Productivity Loss	- Based on capacity weighted aggregation of industry reported costs audited by Snell - These are defined in the text of the Economic Impact Assessment for VCM and PVC plants, respectively - Productivity loss is the cost of additional capacity needed to maintain industry-wide capacity at levels unimpacted by OSHA regulations	- Expressed as unit capital and annual costs in Exhibits V-2 to V-4 for VCM and Exhibits V-7 to V-10 for PVC - Exhibit C-3 in Appendix C provides further explanation of productivity loss - Based on data for the plant sample at each level
Price Impact Analysis	The impact of the costs of compliance relative to a standard unimpacted price element	- Does not consider potential shifts in supply/demand configurations - See Exhibits V-13 and 14 for VCM and PVC, respectively
Industry Claimed Time to Reach VCM Target Levels	Analysis of the distribution of the times claimed for each plant	See Exhibits V-5 and V-11 for VCM and PVC, respectively
Percent of Industry "Endangered" As A Function of Target Levels	The level at which management will seriously consider plant shutdown based on distribution of industry responses	- Actual decisions to shut down plants are based on a complex set of factors plant-by-plant - See Exhibits V-6 and V-12 for VCM and PVC, respectively
Change in Emphasis of Engineering Controls in PVC Plants As A Function of Target Levels	Analysis of the distribution of the major categories of engineering action in the industry responses	See Exhibit V-17 and Exhibit C-5 in Appendix C.

Source: Snell

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- personal protective equipment costs, including:
 - .. shower and eating facilities
 - .. breathing equipment (respirators, air lines and bottled air)
 - .. clothing (uniforms and protective clothing)
- monitoring costs, including:
 - .. personnel monitoring equipment
 - .. area and leak monitoring equipment
 - .. medical testing
 - .. record keeping
- productivity loss
 - .. the continued cost of keeping at the levels unimpacted by OSHA capacity otherwise derated as a result of regulation
 - .. the cost includes equipment, personnel, etc. but does not include the costs of temporary shutdowns
- expensed items
 - .. these include consultant costs, management time, etc.
 - .. out-of-pocket expenses of 0.01¢/lb are not included since these are considered as one time only costs

For VCM plants, engineered OSHA compliance steps are judged to be significantly the same as those for air pollution control.

Summarized estimates of VCM industry cost impacts and timing to meet selected VCM compliance levels follow in Exhibits V-2 through V-6.

- Exhibit V-2 presents the case of the 50 ppm VCM ceiling
- Exhibit V-3 presents the case of the 25 ppm ceiling
- Exhibit V-4 presents the case of the 10 ppm ceiling and 2 to 5 ppm TWA (time weighted average)
- Snell assessment in these Exhibits of VCM levels potentially achieved is based upon the exposure data in Section VE and Appendix B
- Exhibit V-5 presents the industry claimed time requirements for compliance
- Exhibit V-6 serves as a summary discussion of these findings

EXHIBIT V-2

USDOL/OSHA

ESTIMATED INDUSTRY COSTS OF ACHIEVING A 50 PPM VCM
CEILING LEVEL IN VCM PLANTS AS CLAIMED BY INDUSTRY
AND ASSESSED BY SNELL

Snell assessment of VCM level potentially achieved⁽¹⁾ less than 50 ppm ceiling with 15 ppm TWA.

Total plants in sample: 9

Processes represented⁽²⁾: O, STO, DO, DC, G

Location of plants in sample⁽³⁾: 8W, 1C

Capacity in Sample - Millions lbs. per year (Percent 1974 U. S. nameplate capacity): 5, 125 (77%)

Percent Industry claimed capacity from sample for which management will seriously consider plant shutdown at a 50 ppm ceiling VCM level: 0%

Snell estimate of percent capacity from sample for which management will seriously consider plant shutdown at a 50 ppm ceiling VCM level: 0%

<u>Direct Costs</u>	<u>Capital (\$/1,000 lb.)</u>	<u>Annual (\$/1,000 lb.)</u>	<u>Percent of Total Annual Cost</u>
I. Engineering Costs ⁽⁴⁾	\$0.66	\$0.29 ⁽⁵⁾	43%
II. Personal Equipment Costs ⁽⁶⁾	0.03	0.02 ⁽⁷⁾	2
III. Monitoring	0.08	0.13 ^(7, 8, 9)	19
Total Direct Costs ⁽¹⁰⁾	\$0.77	\$0.44	64%
Productivity Loss	\$0.16	\$0.24	36%
Total Costs	\$0.93	\$0.68	100%

Note: (1) Snell estimate of VCM levels achieved in plants incorporating the level of control effort represented in the Exhibit. Monitoring data is detailed in Appendix B.

(2) O = Oxychlorination, STO = Stauffer Oxychlorination, DO = Dow Oxychlorination, DC = Direct Chlorination, G = Goodrich Oxychlorination.

(3) W = Sited in warm climate, C = Sited in cold climate.

(4) Includes ventilation, vapor recovery, stripping, loading and other (piping, general pumps, maintenance, etc.)

(5) Includes capital amortized @ 12% - 10 yrs. and O&M charges.

(6) Includes breathing equipment and clothing.

(7) Includes capital amortized @ 12% - 5 yrs. and O&M charges.

(8) Includes area and personal monitoring equipment.

(9) Includes medical and recordkeeping costs.

(10) Productivity loss is the industry average cost of additional capacity, personnel, etc. to maintain industry capacity levels unimpacted by OSHA regulations, an example is provided in Exhibit C-3.

Source: Industry interviews and Snell estimates.

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EXHIBIT V-3

USDOL/OSHA

ESTIMATED INDUSTRY COSTS IN ACHIEVING A 25 PPM VCM
CEILING LEVEL IN VCM PLANTS AS CLAIMED BY INDUSTRY
AND ASSESSED BY SNELLSnell assessment of VCM level potentially achieved⁽¹⁾ 25 ppm ceiling with 15 ppm TWA.Total plants in sample: 7⁽²⁾Processes represented⁽³⁾: O, STO, DO, DC, GLocation of plants in sample⁽⁴⁾: 8W, 1C

Capacity in Sample - Millions lbs. per year (Percent 1974 U.S. nameplate capacity): 3,625 (54%)

Percent Industry claimed capacity from sample for which management will seriously consider plant shutdown
at a 25 ppm ceiling VCM level: 0%Snell estimate of percent capacity from sample for which management will seriously consider plant shutdown
at a 25 ppm ceiling VCM level: 0%

<u>Direct Costs</u>	<u>Capital (\$/1,000 lb.)</u>	<u>Annual (\$/1,000 lb.)</u>	<u>Percent of Total Annual Cost</u>
I. Engineering Costs ⁽⁵⁾	\$1.72	\$0.69 ⁽⁶⁾	58%
II. Personal Equipment Costs ⁽⁷⁾	0.05	0.04 ⁽⁸⁾	3
III. Monitoring	0.17 ⁽⁹⁾	0.21 ^(8,9,10)	17
Total Direct Costs	\$1.94	\$0.94	78%
Productivity Loss ⁽¹¹⁾	\$0.18	\$0.26	22%
Total Costs	\$2.12	\$1.20	100%

- Notes: (1) Snell estimate of VCM level achievable in plants incorporating the level of control effort represented in the Exhibit. Monitoring data is detailed in Appendix B.
- (2) Two plants not in this cost sample did not report cost estimates for a 25 ppm VCM ceiling target but provided an analysis for a lower target VCM level.
- (3) O = Oxychlorination, STO = Stauffer Oxychlorination, DO = Dow Oxychlorination, DC = Direct Chlorination, G = Goodrich Oxychlorination.
- (4) W = Sited in warm climate, C = Sited in cold climate.
- (5) Includes ventilation, vapor recovery, stripping, loading and other (piping, general pumps, maintenance, etc.).
- (6) Includes capital amortized @ 12% - 10 yrs. and O&M charges.
- (7) Includes breathing equipment and clothing.
- (8) Includes capital amortized @ 12% - 5 yrs. and O&M charges.
- (9) Includes area and personal monitoring equipment.
- (10) Includes medical and recordkeeping costs.
- (11) Productivity loss is the industry average cost of additional capacity, personnel, etc. to maintain industry capacity levels unimpacted by OSHA regulations, an example is provided in Exhibit C-3.

Source: Industry interviews and Snell estimates.

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EXHIBIT V-4

USDOL/OSHA

ESTIMATED INDUSTRY COSTS OF ACHIEVING A 10 PPM VCM TARGET
CEILING AND 2-5 PPM TWA LEVELS IN VCM PLANTS AS CLAIMED
BY INDUSTRY AND ASSESSED BY SNELL

Snell assessment of VCM level potentially achieved⁽¹⁾. Same as industry claimed.

Total plants in samples: 9

Processes represented⁽²⁾: O, STO, DO, DC, G

Location of plants in sample⁽³⁾: 8W, 1C

Capacity in Sample - Millions lbs. per year (percent 1974 U. S. nameplate capacity): 5, 125 (77%)

Percent industry claimed capacity from sample for which management will seriously consider plant shutdown at a

10 ppm ceiling and 2-5 ppm TWA VCM level: 0%

BASED ON WHAT

Snell estimate of percent capacity from sample for which management will seriously consider plant shutdown at a

10 ppm ceiling and 2-5 ppm TWA VCM level: 0%

BASED ON WHAT

<u>Direct Costs</u>	<u>Capital (\$/1,000 lb.)</u>	<u>Annual (\$/1,000 lb.)</u>	<u>Percent of Total Annual Cost</u>
I. Engineering Costs ⁽⁴⁾	\$3.68	\$1.44 ⁽⁵⁾	45%
II. Personal Equipment Costs ⁽⁶⁾	0.09	0.07 ⁽⁷⁾	2
III. Monitoring	0.22 ⁽⁸⁾	0.24 ^(7,8,9)	7
Total Direct Costs	<u>\$3.99</u>	<u>\$1.75</u>	<u>54%</u>
Productivity Loss ⁽¹⁰⁾	\$1.04	\$1.46	46%
Total Costs ⁽¹¹⁾	<u>\$5.03</u>	<u>\$3.21</u>	<u>100%</u>

Notes: (1) Snell estimate of VCM levels achievable in plants incorporating the level of control effort represented in the Exhibit. Monitoring data is detailed in Appendix B.

(2) O = Oxychlorination, STO = Stauffer Oxychlorination, DO = Dow Oxychlorination, DC = Direct chlorination, G = Goodrich Oxychlorination.

(3) W = Sited in warm climate, C = Sited in cold climate.

(4) Includes ventilation, vapor recovery, stripping, loading and other (piping, general pumps, maintenance, etc.).

(5) Includes capital amortized @ 12% - 10 yrs. and O&M charges.

(6) Includes breathing equipment and clothing.

(7) Includes capital amortized @ 12% - 5 yrs. and O&M charges.

(8) Includes area and personal monitoring equipment.

(9) Includes medical and recordkeeping costs.

(10) Productivity loss is the industry average annual cost of additional capacity, personnel, etc. to maintain capacity levels unimpacted by OSHA regulations. An example is provided in Exhibit C-3.

(11) Cost estimates include analysis for two plants with a reported 2 ppm VCM TWA (8 hr.) level.

Source: Industry interviews and Snell estimates.

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EXHIBIT V-5

USDOL/OSHA

U. S. INDUSTRY CLAIMED TIME TO REACH SELECTED VCM LEVELS
IN VCM PLANTS THROUGH ENGINEERED CONTROLS

VCM Target Level Claimed by Industry	Sample Total		End of Year									
	Number of Plants	Capacity (Million Lbs.)	1974		1975		1976		1977		1978	
			Number of Plants	Percent ⁽¹⁾ Capacity	Number of Plants	Percent ⁽¹⁾ Capacity	Number of Plants	Percent ⁽¹⁾ Capacity	Number of Plants	Percent ⁽¹⁾ Capacity	Number of Plants	Percent ⁽¹⁾ Capacity
50 ppm ceiling	9	5,125	9	100%								
25 ppm ceiling	7 ⁽²⁾	3,625	1	7			6	93%				
10 ppm ceiling and 2 - 5 ppm TWA		5,125					3	49	5	46%	1	5%

Notes: (1) Percent of sample 1974 capacity.

(2) Two plants did not report cost estimates for a 25 ppm VCM ceiling target, but provided an analysis for a lower target VCM level.

Source: Industry interviews by Snell.

Where ARE other 27
PLANTS?

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EXHIBIT V-6

USDOL/OSHA

SUMMARY OF VCM INDUSTRY COST IMPACTS, COMPLIANCE
TIME AND CAPACITY ENDANGERED

VCM Target Level Claimed by Industry	Snell Assessment of VCM Target Level	Annual Unit Costs, ¢/Lb. ⁽¹⁾			Industry Claimed Compliance Period Required for Engineered Controls	Percent of Industry "Endangered" ⁽³⁾ Based on Sample
		Direct Costs of Compliance	Costs To Make Up for Loss of Productivity	Total Costs ⁽²⁾		
50 ppm ceiling	< 50 ppm ceiling and 15 ppm TWA	0.04¢	0.03¢	0.07 ± 10%	In compliance now	0%
25 ppm ceiling	25 ppm ceiling and 15 ppm TWA	0.09	0.03	0.12 ± 20%	2 years	0%
10 ppm ceiling with 2 - 5 ppm TWA	10 ppm ceiling and 2 - 5 ppm TWA	0.17	0.15	0.32 ± 40%	3 years	0%
"No detectable"						100%

Not feasible
based on engineering controls.

Notes: (1) Costs at each VCM level represent the cumulative costs incurred to reach the target level.

(2) The percentage ranges of total costs represent Snell's estimates.

(3) Endangered = Management will seriously consider plant shutdown.

Source: Exhibits V-1 through V-5.

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is
OSHA
TARGET

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3. FINDINGS FROM ECONOMIC IMPACT ANALYSIS RELATED TO THE PVC INDUSTRY ARE
BASED ON SUBSTANTIAL DATA TO A TARGET LEVEL OF 15 - 25 PPM VCM CEILING AND
10 - 15 PPM TWA

Snell assessed industry costs of reducing VCM levels in PVC plants
were separated into five categories which include:

- engineering costs including:

- .. VCM unloading
- .. ventilation
- .. reactor cleaning
- .. stripping and VCM recovery (possibly to meet a 100 ppm
residual VCM target, but definitely to facilitate meeting
the PVC industry exposure target level)
- .. other (pumps, piping, etc.)

- personal protective equipment costs, including:

- .. showers and eating facilities
- .. breathing equipment (respirators, air lines and bottled air)
- .. clothing (uniforms and protective clothing)

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- monitoring costs, including:
 - .. personnel monitoring equipment
 - .. area and leak monitoring equipment
 - .. medical testing
 - .. record keeping
- productivity loss
 - .. the continued cost of keeping at the levels unimpacted by OSHA capacity otherwise derated as a result of regulation
 - .. the cost includes equipment, personnel, etc. but does not include the costs of temporary shutdowns
- expensed items
 - .. these include consultant costs, management time, etc.
 - .. out-of-pocket expenses of 0.033¢/lb are not included in the cost summaries since these are considered to be one time only expenses.

Summarized estimates of PVC industry cost impacts and timing to meet selected VCM concentration levels follow in Exhibits V-7 through V-12.

- Exhibit V-7 presents the case of the 50 ppm VCM ceiling
- Exhibit V-8 presents the case of the 25 to 40 ppm ceiling and 15 to 25 ppm TWA
- Exhibit V-9 presents the case of the 15 to 25 ppm ceiling and 10 to 15 ppm TWA
- Exhibits V-7, V-8, V-9 follow page V-7

EXHIBIT V-7

USDOL/OSHA

ESTIMATED INDUSTRY COSTS OF ACHIEVING A 50 PPM TARGET VCM CEILING LEVEL
IN PVC PLANTS AS CLAIMED BY INDUSTRY AND ASSESSED BY SNELLSnell assessment of VCM level potentially achieved⁽¹⁾. Same as industry claimed.

Total plants in sample: 23

Processes represented⁽²⁾: S, E, B, SOLocation of plants in sample⁽³⁾: SW, 18C

Age of plants in sample:	Range, Years	0 - 5	6 - 10	11 - 15	16 - 20	21 - 25	> 26
	No. of Plants	2	10	2	4	2	3

Capacity of sample - millions lbs. per year (percent 1974 U.S. nameplate capacity): 3,750 (69%)

Percent industry claimed capacity from sample for which management will seriously consider plant shutdown at a 50 ppm VCM ceiling: 0%

Snell estimate of percent capacity from sample for which management will seriously consider plant shutdown at a 50 ppm VCM ceiling: Negligible

	<u>Direct Costs</u>	<u>Capital</u> <u>(\$/1,000 Lb.)</u>	<u>Annual</u> <u>(\$/1,000 Lb.)</u>	<u>Percent of Total Annual Cost</u>
I. Engineering Costs ⁽⁴⁾		\$1.69	0.93 ⁽⁵⁾	17%
II. Personal Equipment Costs ⁽⁶⁾		0.16	0.23 ⁽⁷⁾	4
III. Monitoring		<u>0.70⁽⁸⁾</u>	<u>0.74^(7, 8, 9)</u>	<u>14</u>
Total Direct Costs		<u>\$2.55</u>	<u>\$1.90</u>	<u>35%</u>
Productivity Loss ⁽¹⁰⁾		\$6.53	\$3.48	65%
Total Costs		\$9.08	\$5.38	100%

Notes: (1) Snell estimate of VCM levels achieved in plants incorporating the level of control effort represented in the Exhibit. Monitoring data is detailed in Appendix B.

(2) S = Suspension, E = Emulsion, Dispersion, B = Bulk, SO = Solution.

(3) W = Sited in warm climate, C = Sited in cold climate (U.S. 26C, 10W).

(4) Includes ventilation, loading, reactor cleaning, stripping and other (piping, general pumps, maintenance, etc.).

(5) Includes capital amortized @ 12% - 10 yrs. and O&M charges.

(6) Includes breathing equipment and clothing.

(7) Includes capital amortized @ 12% - 10 yrs. and O&M charges.

(8) Includes area and personal monitoring equipment.

(9) Includes medical and recordkeeping costs.

(10) Productivity loss is the industry average annual cost of additional capacity, personnel, etc. to maintain industry capacity levels unimpacted by OSHA regulations; an example is shown in Exhibit C-3.

Source: Industry interviews and Snell estimates.

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EXHIBIT V-8

USDOL/OSHA

ESTIMATED INDUSTRY COST OF ACHIEVING A 25-40 PPM VCM TARGET
 CEILING AND 15-25 PPM TWA LEVEL IN PVC PLANTS AS CLAIMED
 BY INDUSTRY AND ASSESSED BY SNELL

Snell assessment of VCM level potentially achieved⁽¹⁾ same as industry claimed

Total plants in sample: 17⁽²⁾

Processes represented⁽³⁾: S, E, B

Location of plants in sample⁽⁴⁾: 5W, 12C

Age of plants in sample:	Range, Years	0 - 5	6 - 10	11 - 15	16 - 20	21 - 25	> 26
	No. of Plants	2	8	1	3	2	1

Capacity in Sample - Millions lbs. per year (Percent 1974 U.S. nameplate capacity): 2,801 (52%)

Percent industry claimed-capacity from sample for which management will seriously consider plant shutdown at a

25-40 ppm ceiling and 15-25 ppm TWA VCM level: $\approx$ 4% of original 23 plant sample

	Direct Costs	Capital (\$/1,000 lb.)	Annual (\$/1,000 lb.)	Percent of Total Annual Cost
I. Engineering Costs ⁽⁵⁾		\$7.18	\$2.19 ⁽⁶⁾	26%
II. Personal Equipment Costs ⁽⁷⁾		1.01	0.70 ⁽⁸⁾	8
III. Monitoring		0.67 ⁽⁹⁾	0.76 ^(8,9,10)	9
Total Direct Cost		\$8.86	\$3.65	43%
Productivity Loss ⁽¹¹⁾		\$9.38	\$4.87	57%
Total Costs		\$18.24	\$8.52	100%

Notes: (1) Snell estimate of VCM levels achievable in plants incorporating the level of control effort represented in the Exhibit. Monitoring data is detailed in Appendix B.

(2) Four plants not in this cost sample did not report cost estimates for these conditions but provided an analysis for a lower target VCM level. Two plants not in this sample did not provide cost estimates for this and lower levels; one reported being endangered, the other had not completed an analysis.

(3) S = Suspension, F = Emulsion, Dispersion, B = Bulk, SO = Solution.

(4) W = Sited in warm climate, C = Sited in cold climate (U. S. 26C, 10W).

(5) Includes ventilation, loading, reactor cleaning, stripping and other (piping, general pumps, maintenance, etc.).

(6) Includes capital amortized @ 12% - 10 yrs. and O&M charges.

(7) Includes breathing equipment, clothing, showers, and eating facilities.

(8) Includes capital amortized @ 12% - 5 yrs. and O&M charges.

(9) Includes area and personal monitoring equipment.

(10) Includes medical and recordkeeping costs.

(11) Productivity loss is the industry average cost of additional capacity, personnel, etc. to maintain industry capacity levels

unimpacted by OSHA regulations, excluding plants which reported inability to meet the standard. An example is presented in Exhibit C-3.

Source: Industry interviews and Snell estimates.

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EXHIBIT V-9

USDOL/OSHA

ESTIMATED INDUSTRY COST OF ACHIEVING A 15-25 PPM VCM CEILING AND 10-15 TWA PPM TARGET
LEVEL IN PVC PLANTS AS CLAIMED BY INDUSTRY AND ASSESSED BY SNELLSnell assessment of VCM level potentially achieved⁽¹⁾. Same as industry claimed.Total plants in sample: 16⁽²⁾Processes represented⁽³⁾: S, E, BLocation of plants in sample⁽⁴⁾: 4W, 12C

Age of plants in sample:	Range, Years	0 - 5	6 - 10	11 - 15	16 - 20	21 - 25	26
	No. of Plants	1	7	1	3	2	2

Capacity in sample - millions lbs. per year (percent 1974 U.S. nameplate capacity): 2,600 (48%)

Percent industry claimed capacity from sample for which management will seriously consider plant shutdown at a

25 ppm ceiling and 10-15 ppm TWA VCM level: 26% of original 23 plant sample

Snell estimate of percent capacity from sample for which management will seriously consider plant shutdown at a

25 ppm ceiling and 10-15 ppm TWA VCM level: 26% of original 23 plant sample

Direct Costs	Capital (\$/1,000 lb.)	Annual (\$/1,000 lb.)	Percent of Total Annual Cost
I. Engineering Costs ⁽⁵⁾	\$26.44	\$7.30 ⁽⁶⁾	45%
II. Personal Equipment Costs ⁽⁷⁾	0.48	0.76 ⁽⁸⁾	5
III. Monitoring	0.86 ⁽⁸⁾	0.95 ^(8, 9, 10)	6
Total Direct Costs	\$27.78	\$9.01	56%
Productivity Loss ⁽¹¹⁾	\$14.41	\$7.03	44%
Total Costs	\$42.19	\$16.04	100%

Notes: (1) Snell estimate of VCM levels achieved in plants incorporating the level of control effort represented in the Exhibit. Monitoring data is detailed in Appendix B.

(2) The four plants not included in Exhibit V-8 provided cost estimates for this VCM target level. Five additional plants not in this cost sample reported endangered status at this level and did not provide cost estimates.

(3) S = Suspension, E = Emulsion, Dispersion, B = Bulk, SO = Solution.

(4) W = Sited in warm climate, C = Sited in cold climate.

(5) Includes ventilation, loading, reactor cleaning, stripping and other (piping, general pumps, maintenance, etc.)

(6) Includes capital amortized @ 12% - 10 yrs.

(7) Includes breathing equipment, clothing, showers, and eating facilities.

(8) Includes capital amortized @ 12% - 5 yrs.

(9) Includes area and personal monitoring equipment.

(10) Includes medical and recordkeeping costs.

(11) Productivity loss is the industry average annual cost of additional capacity, personnel, etc. to maintain industry capacity level, unimpacted by OSHA regulations. This is based on those plants that expected ability to meet the claimed level, shown in the Exhibit. An example is presented in Exhibit C-3.

Source: Industry interviews and Snell estimates.

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- At these levels (particularly at the high VCM target levels) engineering controls reported by industry principally addresses OSHA compliance but substantial air pollution control is judged to be an indirect benefit from "buttoning-up" of the plant, improved stripping, etc.
- Snell assessment in these Exhibits of VCM levels potentially achieved is based upon the exposure data in Section VE and Appendix B
- Exhibit V-10 provides cost analyses based on data provided by Firestone for an attempt to reach "no detectable" target VCM levels primarily using engineering controls

*Who ARE
they kidding*

.. Firestone was the only PVC producer reporting an analysis related to a "no detectable" VCM standard primarily using engineering controls

.. Firestone concluded that meeting a "no detectable" standard primarily using engineering controls is not feasible

*

.. The two Firestone plants were not included in the industry summaries for higher VCM target levels based on the findings from the statistical analysis presented in Exhibit C-4 in Appendix C for the 50 ppm ceiling target; at this level Firestone cost estimates are inconsistently high with respect to those provided by the rest of the industry, possibly because these estimates include costly environmental protection measures not directly related to OSHA compliance.

*

*

- Exhibit V-10 follows page V-8.

USDOL/OSHA

COST ANALYSES BASED ON DATA PROVIDED BY FIRESTONE FOR AN
ATTEMPT TO REACH "NO DETECTABLE" TARGET VCM LEVELS
USING ENGINEERING CONTROLS PRIMARILY

Snell assessment of VCM level potentially achieved⁽¹⁾. This represents an analysis of an attempt to approach "no detectable" levels with actually achieving the level judged not feasible, based on engineering controls primarily.

Total plants in sample: 2 (Portstown, Pa. and Perryville, Md.)

Process represented⁽²⁾: S and E

Location of plants in sample⁽³⁾: 2C

Age of plants in sample: Range, Years 0 - 5 6 - 10 11 - 15 16 - 20 21 - 25 > 26

Plants: Perryville Portstown

Capacity of plant - millions lbs. per year (percent 1974 U.S. capacity): 507 (9%)

	Capital		Annual		Two Plant Average	
	Portstown, Pa. (\$/1,000 lb.)	Perryville, Md. (\$/1,000 lb.)	Portstown, Pa. (\$/1,000 lb.)	Perryville, Md. (\$/1,000 lb.)	Capital (\$/1,000 lb.)	Annual (\$/1,000 lb.)
<u>Direct Costs</u>						
I. Engineering ⁽⁴⁾	\$142.56	\$55.94	\$53.60 ⁽⁵⁾	\$25.79 ⁽⁵⁾	\$88.40	\$36.21
II. Personal Equipment ⁽⁶⁾	8.19	0.32	1.88 ⁽⁷⁾	1.81 ⁽⁷⁾	3.27	1.84
III. Monitoring	3.85 ⁽⁸⁾	1.29 ⁽⁸⁾	3.20 ^(7,8,9)	1.40 ^(7,8,9)	2.25	2.07
Total Direct Costs	\$154.60	\$57.55	\$58.68	\$29.00	\$93.92	\$40.12
Productivity Loss ⁽¹⁰⁾	\$139.84	\$20.35	\$67.05	\$15.79	\$63.52	\$30.66
Total Costs	\$294.44	\$77.90	\$125.73	\$44.79	\$157.44	\$70.78

Notes: (1) Snell estimates of VCM levels achievable in plants incorporating the level of control effort represented in the Exhibit.

(2) S = Suspension, E = Emulsion, Dispersion.

(3) W = Sited in warm climate, C = Sited in cold climate.

(4) Includes ventilation, loading, reactor cleaning, stripping and other (piping, general pumps, maintenance, etc.)

(5) Includes capital amortized @ 12% - 10 years and O&M charges.

(6) Includes breathing equipment and clothing.

(7) Includes capital amortized @ 12% - 5 years and O&M charges.

(8) Includes area and personal monitoring equipment.

(9) Includes medical and recordkeeping costs.

(10) Productivity loss is the industry average annual cost of additional capacity, personnel, etc. to maintain industry capacity levels unimpacted by OSHA regulations; an example is presented in Exhibit C-3.

Source: Firestone Case I (0-1 ppm VCM level) presentation to June 1974 OSHA hearing and Snell estimates of costs of productivity loss.

- Exhibit V-11 presents the PVC industry claimed time requirements for compliance , following page V-9
- Exhibit V-12, following Exhibit V-11, serves as a summary discussion of these findings

4. INCREASINGLY STRICT VCM COMPLIANCE REQUIREMENTS ARE EXPECTED TO RESULT IN SIGNIFICANTLY GREATER PRICE ESCALATIONS FOR PVC THAN FOR VCM

- . Price analysis did not include consideration of supply/demand changes due to potential plant shutdowns at lower levels.
- . The price analyses are relative to a standardized price pro forma unimpacted by OSHA compliance requirements and assess price sensitivity of OSHA compliance steps based substantially upon engineering controls.
- . Exhibit V-13, following Exhibit V-12, presents the estimated impact of selected VCM standards on VCM prices.
- . Exhibit V-14, following Exhibit V-13, presents the estimated impact of selected VCM standards on PVC prices.
- . Exhibit V-15, following Exhibit V-14, presents estimated capital and annual costs for VCM target levels for the VCM industry.
- . Exhibit V-16, following Exhibit V-15, presents estimated capital and annual costs for VCM target levels for the VCM industry.

EXHIBIT V-11

USDOL/OSHA

U. S. INDUSTRY CLAIMED TIME TO REACH SELECTED VCM LEVELS
IN PVC PLANTS THROUGH ENGINEERED CONTROLS⁽¹⁾

Goodyear

VCM Target Levels Claimed By Industry	End of Year									
	1974		1975		1976		1977		1978	
	Number of Plants	Percent Capacity	Number of Plants	Percent Capacity	Number of Plants	Percent Capacity	Number of Plants	Percent Capacity	Number of Plants	Percent Capacity
50 ppm ceiling	23	100%								
25 - 40 ppm ceiling and 15 - 25 ppm TWA	-	-	1	3%	7	35%	12	48%	1	5%
15 - 25 ppm ceiling and 10 - 15 ppm TWA	-	-	-	-	5	24%	7	27(1)	4	18%
Attempt to reach "No detectable"										

Not feasible based on engineering controls

Notes: (1) Percent of sample 1974 capacity, 23 plants reporting with a total capacity of 3,750 million lbs. per year.

Source: Industry Interviews by Snell

EXHIBIT V-12

USDOL/OSHA

SUMMARY OF PVC INDUSTRY COST IMPACTS, COMPLIANCE
TIME AND CAPACITY ENDANGERED BY VCM TARGET LEVEL

VCM Target Level Claimed by Industry	Annual Unit Costs, ¢/Lb. ⁽¹⁾			Industry Claimed Compliance Period Required for Engineered Controls	Percent of Industry "Endangered" ⁽³⁾ Based on Sample
	Direct Costs of Compliance	Costs To Made Up for Loss of Productivity	Total Costs ⁽²⁾		
50 ppm ceiling	0.19	0.35	0.54 ± 20%	0 to 6 months	Negligible ⁽⁴⁾
25 - 40 ppm ceiling with 15 - 25 TWA	0.36	0.49	0.85 ± 35%	2.5 years	4%
15 - 25 ppm ceiling with 10 - 15 TWA	0.90	0.70	1.60 ± 50%	2.5 years	26%
Attempt to reach "No detectable" ⁽⁵⁾	4.01	3.07	7.08 ± 75%	2.5 to 4 years	100%

Notes: (1) Does not include additional VCM costs resulting from OSHA standard.

(2) The percentage ranges of total costs represent Snell's estimates based on partial statistical analysis of data.

(3) Endangered = Management will seriously consider plant shutdown.

(4) Temporary shutdowns for installation of controls were reported. In addition, one plant (not in sample) accelerated a planned shutdown by six months resulting in a loss of ≈ 50 million lbs. of PVC.

(5) Economic data based on average data shown in Exhibit V-10 for the Firestone plants which were not included in the sample for the reason explained in the text. These figures represent the costs estimated for an attempt to reach a "no detectable" VCM level, but reaching this level is judged not feasible based on engineering controls.

Source: Exhibits V-7 through V-11.

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EXHIBIT V-13

USDOL/OSHA

ESTIMATED VINYL CHLORIDE ECONOMICS IMPACTED BY
SELECTED VCM LEVEL STANDARDS
(1974 DOLLARS)

<u>Item</u>	<u>Unimpacted by OSHA (¢/Lb.)</u>	<u>50 ppm Ceiling (¢/Lb.)</u>	<u>25 ppm Ceiling (¢/Lb.)</u>	<u>10 ppm Ceiling 2 - 5 ppm TWA (¢/Lb.)</u>	<u>Extrapolated Costs of Attempt To Reach a VCM Level⁽²⁾</u>
Plant investment ⁽¹⁾	4.08¢	4.16	4.27	4.48	11.58¢
Cost of manufacture	6.13	6.17	6.27	6.31	9.63
Selling, general and administrative expenses	0.30	0.30	0.30	0.30	0.30
Pretax profit on total investment @ 20% at 1.2 x plant investment)	<u>0.98</u>	<u>1.00</u>	<u>1.02</u>	<u>1.08</u>	<u>2.78</u>
Net selling price (FOB plant)	<u>7.41¢</u>	<u>7.47¢</u>	<u>7.59¢</u>	<u>7.69¢</u>	<u>12.71¢</u>

Notes: (1) Unit production costs for a 500 million lb. ethylene oxychlorination plant of 1974 construction with total fixed capital of \$20.4 million unimpacted by OSHA costs include production loss replacement.

(2) Based on log-log straight line extrapolation of existing data to a 1 ppm VCM ceiling. This does not imply technical feasibility of engineering controls. Extrapolated costs are for attempting to reach a "no detectable" level and are used for cost sensitivity analyzing purposes only.

Source: Exhibit IV-4 for basic economics and Snell estimates for compliance levels based on Exhibits V-1 through V-4.

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EXHIBIT V-14

USDOL/OSHA

POLYVINYL CHLORIDE ECONOMICS IMPACTED BY
SELECTED VCM LEVEL STANDARDS
(1974 DOLLARS)

Item	(	50 ppm	50 ppm	25 ppm	25 ppm	10 ppm Ceiling	Extrapolated Costs
VCM Standard	(Unimpacted	Ceiling	Ceiling	Ceiling	Ceiling	2- 5 ppm TWA	To Attempt To Reach a "No
PVC Standard	(by OSHA	50 ppm	25-40 ppm	25-40 ppm	25 ppm	15-25 ppm Ceiling	Detectable" VCM Level ⁽¹⁾
	(	Ceiling	Ceiling	Ceiling	Ceiling	10-15 ppm TWA	Firestone Analysis of Attempt
		15-25 ppm	15-25 ppm	15-25 ppm	10-15 ppm		To Reach "No Detectable"
		TWA	TWA	TWA	TWA		VCM Level ⁽²⁾
Designed PVC plant capacity (millions lbs./year)	200	200	200	200	200	200	200
PVC plant investment (dollars millions ⁽³⁾)	20	21.6	23.3	23.3	27.6	27.6	48.7
PVC production (millions lbs./ year @ 90% utilization)	180	180	180	180	180	180	180
Plant investment per unit of production (\$/lb.)	11.1	12.0	12.9	12.9	15.3	15.3	27.0
Cost of Manufacture							
Vinyl chloride monomer ⁽⁴⁾	8.5¢	8.4¢	8.5¢	8.6¢	8.6¢	8.7¢	12.7¢
Operating labor and supervision	0.4						
Capital recovery (@ 12% - 10 years)	2.0	6.4	6.6	6.6	7.6	7.5	13.0
All other costs (catalyst, utilities, maintenance, etc.)	3.5						
Total cost of manufacture	14.4¢	14.9¢	15.1¢	15.2¢	16.1¢	16.2¢	25.7¢
Profitability							
Cost of manufacture	14.4¢	14.9¢	15.1¢	15.2¢	16.1¢	16.2¢	25.7¢
Selling, general and administrative	1.5	1.5		1.5	1.5	1.5	1.5
Pretax profit (@ 20% x 1.2 plant investment)	2.7	2.9		3.1	3.7	3.7	6.5
Net selling price (FOB plant)	18.6¢	19.3¢	19.7¢	19.8¢	21.3¢	21.4¢	33.7¢

Notes: (1) Based on log-log, straight line extrapolation of existing data to a 1 ppm VCM ceiling. This does not imply technical feasibility of engineering controls. Extrapolated costs are for attempting to reach a "no detectable" level and are used for cost sensitivity analysis purposes only.

(2) Based on Firestone data presented in Exhibit V-10. These figures represent the costs estimated for an attempt to reach a "no detectable" VCM level, but reaching this level is judged not feasible based on engineering controls primarily.

(3) Gram roots plant, located on Gulf Coast, producing general purpose suspension resin.

(4) VCM at price shown on Exhibit V-12 x 1.06 production shrinkage + 0.50¢/lb. transport.

Source: Small estimates based on industry interviews and prices for VCM presented in Exhibit V-13.

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EXHIBIT V-15
USDOL/OSHA
ESTIMATED CAPITAL AND
ANNUAL COSTS FOR VCM
TARGET LEVELS FOR THE
VCM INDUSTRY AT 1974
CAPACITY (1)
(1974 DOLLARS)

Industry Claimed VCM Target Level (2)	Snell Assessed VCM Target Level (3)	Capital Costs ⁽⁴⁾ (\$ Millions)			Annual Costs ^(4, 5) (\$ Millions)		
		Direct Costs	Productivity Loss	Total	Direct Costs	Productivity Loss	Total
50 ppm ceiling	<50 ppm ceiling and 15 ppm TWA	\$ 5.2	\$ 1.1	\$ 7.2	\$ 3.0	\$ 1.6	\$ 4.6
25 ppm ceiling	25 ppm ceiling and 15 ppm TWA	13.0	1.2	14.2	6.3	1.7	8.0
10 ppm ceiling and 2-5 ppm TWA	10 ppm ceiling and 2 - 5 ppm TWA	26.7	7.0	33.7	11.7	9.8	21.5

(1) 1974 capacity estimated at 6,695 million lbs. per year in Exhibit III-1

(2) Compliance actions are based primarily on engineering control methods.

(3) Based upon the exposure data in Section VE and Appendix B

(4) Estimates include costs of engineering controls, personal protective and monitoring equipment. Costs presented represent the estimated cumulative compliance costs for the VCM level shown in the Exhibit and were estimated by multiplying the costs presented in Exhibits V-2 through V-4 by the 1974 VCM industry capacity.

(5) Includes capital costs amortized at 12%

Source Industry interviews and Snell estimates

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EXHIBIT V-16
USDOL/OSHA
ESTIMATED CAPITAL AND
ANNUAL COSTS FOR VCM
TARGET LEVELS FOR THE PVC
INDUSTRY AT 1974 CAPACITY⁽¹⁾
(1974 DOLLARS)

Industry Claimed and Snell Assessed VCM Target Level (2, 5)	Capital Costs (3) (\$ Millions)			Annual Costs (3, 4) (\$ Millions)		
	Direct Costs	Productivity Loss	Total	Direct Costs	Productivity Loss	Total
50 ppm ceiling	\$13.9	\$ 35.5	\$ 49.4	\$ 10.3	\$18.9	\$29.2
25-40 ppm ceiling and 15-25 ppm TWA	48.1	51.0	99.1	19.8	26.5	46.3
15-25 ppm ceiling and 10-15 ppm TWA	151.0	78.3	229.0	49.0	38.2	87.2

(1) 1974 capacity estimated at 5,435 million lbs. per year from Exhibit III-4.

(2) Compliance actions are based primarily on engineering control methods.

(3) Estimates include costs of engineering controls, personal protective and monitoring equipment. Costs presented represent the estimated cumulative compliance costs for the VCM levels shown in the Exhibit and were estimated by multiplying the costs presented in Exhibits V-7 through V-9 by the 1974 PVC industry capacity.

(4) Includes capital costs amortized at 12%.

(5) If the PVC industry expended the capital funds represented by the Firestone analysis of attempting to reach the infeasible "no detectable" levels, total capital costs are estimated to be of the order of \$856 million based on Exhibit V-10 data.

Source: Industry interviews and Snell estimates

*These estimates
don't include
environmental
data*

*We need
facts to
rebut this*

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5. SHIFTS IN ENGINEERING CONTROL METHODS WERE REPORTED FOR DECREASING VCM
TARGET LEVELS IN THE PVC INDUSTRY

- . Exhibit V-17 on the following page summarizes the distribution of engineering controls for selected VCM levels.
- . Exhibit C-5 in Appendix C provides a detailed discussion of the distribution of engineering controls for selected VCM levels.

* * * * *

This section presented economic impact details. The next section discusses personal protective equipment.

EXHIBIT V-17 (1)

USDOL/OSHA

SUMMARY OF THE DISTRIBUTION OF REPORTED
ENGINEERING CONTROL METHODS ESTIMATED FOR
SELECTED VCM LEVELS IN POLYVINYL CHLORIDE PLANTS

Engineering Control Method

Comments for 50 ppm Ceiling: 25-40 ppm Ceiling with 15-25 ppm TWA;
and 15-25 ppm Ceiling with 10-15 ppm TWA

VCM Unloading (1)

- Modification to transport equipment may be completed by VCM supplier

Ventilation (2)

- Ventilation is used at all levels
- Substantial costs are estimated to reach all target levels
- Most plants have ventilation at the 50 ppm level

Reactor Cleaning (3)

- 5 of 19 plants install reactor cleaning equipment for the 50 ppm level
- Most plants have reactor cleaning for the 25-40 ppm ceiling with 15-25 ppm TWA target level

Stripping (4-5)

- Three plants report expenditures > \$380,000 at the 50 ppm ceiling level, probably for new systems
- Seven plants report expenditures > \$70,000 to reach a 25-40 ppm ceiling with 15-25 ppm TWA target level. These expenditures represent improvement to existing equipment. Three plants estimate expenditures > \$350,000, probably for new systems.
- At the 15-25 ppm ceiling with 10-15 ppm TWA 7 plants report expenditures > \$1 million, for R&D and new systems.

Other (6)

- Extensive modification to physical plant are estimated for all levels.
- At 15-25 ppm VCM ceiling with 10-15 ppm TWA expenditures of > \$400,000 are estimated for such items as emergency reactor pressure relief systems (to VCM recovery) and computerized control systems.

Notes follow (Exhibit V-17 (2))

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EXHIBIT V-17 (2)

USDOL/OSHA

Notes:

- (1) Fans, ducting, etc.
- (2) Additions to unloading racks, modifications to VCM piping, unloading pumps and compressors.
- (3) High and low pressure water systems and solvent cleaning systems.
- (4) Tanks, pumps, piping, compressors and condensers.
- (5) At the 50 ppm and 25 ppm ceiling levels stripping expenditures generally address improvements to present system to meet in plant requirements. The much larger expenditures at the 15-25 ppm ceiling and 10-15 ppm TWA levels reflect an effort to also improve the residual free monomer levels in the product.
- (6) Non specific pumps, compressors piping, seals, etc.

Source:

Industry Interviews and Snell estimated from Exhibit C-5.

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VB. PERSONAL PROTECTIVE EQUIPMENT AVAILABILITY AND COSTS

This section presents the estimated costs, the procurement lead times, and a summary of the available types of equipment as required by the proposed permanent standard.

1. TWO OF THE FOUR TYPES OF RESPIRATORS LISTED UNDER THE PROPOSED PERMANENT STANDARD (PPS) ARE READILY AVAILABLE FROM AT LEAST ONE EQUIPMENT MANUFACTURER

Two of the types of OSHA listed respirators are normally available from the manufacturer in approximately 60 days from the placement of the order. These types are:

- pressure demand full-facepiece self-contained breathing apparatus (PD)
- combination pressure demand full-facepiece respirator and pressure demand self-contained breathing apparatus (CPD)

If sudden orders were placed for 500 to 700 of these units, a 60 day lead time is quoted by one supplier but another indicated up to 40 weeks.

The two other types of breathing apparatus listed in the PPS are not currently produced. Interviews with manufacturers indicate that these devices are considered wasteful of compressed air. These types are:

- positive pressure full-facepiece self-contained breathing apparatus
- combination continuous flow respirators and a pressure demand self-contained breathing apparatus.

2. THE REQUIRED TYPES OF RESPIRATORS PURCHASED UNDER THE 50 PPM TEMPORARY STANDARD MAY BE USED UNDER LOW VCM CEILING CONCENTRATIONS

The purchase costs for types PD and CPD from exhibit D-8 are \$515 and \$615, respectively.

The operating and maintenance costs from Exhibit D-10 range between \$500 to \$1,000 per man per year, with an average of data estimated at \$900.

For example, the cost of grade D or better breathable air is \$15 per 310 SCF cylinder. With an air flow of 4 CFM, this amounts to a cost of \$0.20/minute.

3. INDUSTRY AND THE EMPLOYEES PREFER HALF-MASK AIR LINES, CANISTER OR CARTRIDGE TYPE RESPIRATORS OVER THOSE REQUIRED BY OSHA IN THE PPS

Industry and worker preferences and human factors are detailed in Exhibits D-1 through D-4.

Self-contained devices are heavy, bulky, and require highly trained individuals.

Air line respirators are much lighter than self-contained, but they require a long hose for the air supply and a complicated air distribution system.

Cartridge and canister types are the lightest and least expensive of the three, but lifetime has not yet been fully established for atmospheres containing VCM.

Users of cartridge or canister type masks have no way of knowing when their air purifier is no longer effective.

Half-face mask types are more comfortable to wear than those with full-facepieces, however, they do not provide complete facial protection.

4. THE NUMBER OF COVERED WORKERS NEEDING RESPIRATORY PROTECTION INCREASES WITH A DECREASE IN PERMISSIBLE VCM CONCENTRATION LEVELS OR REQUIRE HIGHER RESPIRATORY WEARING TIMES

The following table summarizes case studies of the percentage of workers needing respiratory protection as a function of VCM permissible levels, climate of plant location, and plant type (VCM or PVC). More data appears in Exhibit D-11 of Appendix.

<u>Plant Type</u>	<u>Climate of Plant Location</u>	<u>Ceiling VCM Level (ppm)</u>	<u>Percent Of Workers Needing Respiratory Protection</u>	<u>Percent Of Time Respiratory Protection Needed</u>	<u>Comments</u>
VCM	Warm	50	15%	50%	With Engineering Controls
		25	15	50	With Engineering Controls
		10	30	75	Without Engineering Controls
		10	14	50	With Engineering Controls
		1	100	100	With Engineering Controls
PVC	Warm	50	75	1	With Engineering Controls
		25	100	3	With Engineering Controls
		10 ppm TWA	100	25	With Engineering Controls
		+25 ppm ceiling			
		1	NA	NA	With Engineering Controls
	Cold	50	100	10	Without Engineering Controls
		25	100	25	Without Engineering Controls
		1	100	100	Without Engineering Controls

Source: Exhibit D-11 and Snell Assessment

*600 X 350 + 900 X 350 = Total Cost of Respirators
at 25 ppm at Firestone = 525,000*

5. MOST OF THE TYPES OF PROTECTIVE CLOTHING ARE AVAILABLE WITHIN FOUR WEEKS FROM ORDER PLACEMENT

Disposable clothing, hoods, shoe covers, gloves and overalls are available within one week from the manufacturers including one piece pressurized suits, as shown in Exhibit D-9.

Permanent (reusable) work clothing is also available within one month of order.

Full impervious pressurized suits however, have a procurement lead time of at least two months.

*For
Respirators
at Pittman
only*

6. COSTS FOR PROTECTIVE CLOTHING VARY WITH TYPE, WITH A LOW OF \$3.50 FOR DISPOSABLE CLOTHING TO A HIGH OF \$178 FOR A PERMANENT, IMPERVIOUS, FULL PRESSURIZED SUIT

- . A full suit of disposable clothing including coveralls, hoods, shoe covering, and gloves costs approximately \$3.50.
- . Permanent work clothing costs in the neighborhood of \$40.00 per worker for a full suit of clothing including coveralls, gloves and boots.
- . A permanent impervious full pressurized work suit which can be worn with an air mask costs \$178. Industry believes that routine use of these is not feasible on grounds of human factors, indicated in Exhibit D-5 and concluded from the Snell industry interviews.
- . The cost of cleaning a suit of permanent work clothes is in the range of \$1.00 to \$1.50 per suit, per worker, per day.

* * * * *

The next section deals with monitoring equipment.

* * * * *

VC. MONITORING EQUIPMENT AVAILABILITY AND COSTS

This section summarizes the available types of VCM monitoring equipment, their costs, and procurement lead times needed to determine worker VCM exposure under the provisions of the proposed permanent standard.

1. THE THREE MAJOR CLASSES OF VCM MONITORING DEVICES: PERSONAL, AREA, AND LEAK, ARE ALL AVAILABLE TO THE VCM AND PVC PRODUCING INDUSTRIES

Personal monitoring, which is the technique recommended to OSHA by NIOSH (see Exhibit E-3), is available to industry from the manufacturer within two months from time of order. The gas chromatograph needed for the analysis of their samples can be received from the manufacturer in two to three months time.

Area monitoring systems of the automatic sequential or continuous type can be obtained for installation within six months from time of order. Installation could take upwards of two months.

Manual area monitoring systems comprising a gas chromatograph with a flame ionization detector (FID) and Mylar or Tedlar bags for sample collection can be obtained from the manufacturer within three months. These devices require little or no set-up time.

Leak detection devices such as portable gas chromatographs or infrared spectrophotometers can be received from suppliers within two months.

If demand for these devices suddenly increase, it is Snell's judgment that procurement lead times could double, especially for the more sophisticated types of equipment such as the area monitoring systems.

2. THE COSTS OF MONITORING EQUIPMENT RANGE WIDELY DEPENDING ON TYPE, HOWEVER, MOST EQUIPMENT PURCHASED UNDER THE TEMPORARY 50 PPM STANDARD MAY BE USED AT LEVELS DOWN TO AND BELOW ONE PPM VCM

Personnel monitoring equipment vary in cost from \$300 for automated charcoal tube/pump system to \$70 for colorimetric tube devices. For the automated system, a back-up gas chromatograph is required at a cost upwards of \$7,000 including basic chromatograph, columns, recorder, and mechanical integrator as shown in Appendix Exhibit D-5.

Area monitoring systems of the sequential gas chromatograph type cost in the neighborhood of \$12,000 per 10 point instrument system without installation. Those operating under the FID total hydrocarbon principle can be purchased for \$8,000, again without installation charges.

Leak detection equipment, which are either of the portable gas chromatograph, total hydrocarbon FID, and infrared types cost from \$3,000 to \$5,000. No installation is required for these devices.

3. EXPENDITURES FOR MONITORING EQUIPMENT FOR A TYPICAL VCM OR PVC PLANT AVERAGE \$100,000 IN CAPITAL WITH ANNUAL OPERATING EXPENSES OF \$80,000

Personal monitoring equipment of the colorimetric types do not require a chemist for back-up due to their instantaneous reading capability. The charcoal tube types, however, require a trained chemical technologist for analysis of samples due to the necessity of using a gas chromatograph. At least one chemist per plant is needed at an annual cost of \$15,000 to \$20,000. Overhead, general and administrative and chemical costs in support of the chemist could approximately double his annual cost.

*Just to pass
our figures
with theirs*

The cost of installation for automated sequential or continuous area monitoring systems is approximately \$15,000 per 10 point unit with operating and maintenance costs of about \$30,000 per year with an operator. A mini-computer can be interfaced with the system for alarming and recordkeeping for an additional \$10,000 to \$15,000 and O&M costs of \$4,000 per year.

Leak detection devices cost in the area of \$2,000 to \$3,000 for O&M including a part-time operator for each instrument.

4. THE INDUSTRY AS A WHOLE SHOWS NO PREFERENCE FOR PARTICULAR TYPES OF MONITORING EQUIPMENT, ALTHOUGH THE CONCEPT OF AREA MONITORING APPEARS WELL ACCEPTED

The VCM and PVC producing industries employ a variety of different types of monitoring equipment in each classification.

In personal monitoring, both the colorimetric and charcoal tube system are employed. However, the charcoal tube type are sensitive to lower VCM concentrations than colorimetric devices.

For area monitoring, both gas chromatographs (GC) and total hydrocarbon analyzers and combustion conductivity detectors are used.

- gas chromatographs provide concentration values which are specific for vinyl chloride monomer
- total hydrocarbon analyzers, as their name suggests, are not specific for VCM but give the total hydrocarbon concentration in the sample air.
- combustion conductivity detectors have also shown great utility in VCM detection at low concentration levels.

5. AUTOMATIC SEQUENTIAL MONITORING SYSTEMS (ASMS) CAN SERVE AS A LONG TERM DATA COLLECTION SYSTEM FOR AN ENTIRE PLANT

- . The ASMS can analyze an air sample from a particular point in the plant in 1 to 3 minutes with potential for at least 10 point monitoring.
- . A system installed in the polymerization building can provide warning to work personnel in that area if VCM levels have gone above ceiling levels.
- . Personal monitoring data can provide the statistical basis for locating sampling points for the ASMS.
 - TWAs can be determined by the personnel monitors for critical areas
 - these values can provide a calibration for the ASMS and determine the points within an area where the greatest VCM exposures are most likely to occur.
- . The ASMS can be used to provide correlation with personnel monitoring data of actual worker exposure. In addition, it can be used to provide a permanent record of VCM levels, provide alarms in case of exceeding ceiling values, serve as a means to initially identify the general sources of VCM releases, and to monitor progress in complying with OSHA requirements.

6. THE AUTOMATIC SEQUENTIAL MONITORING SYSTEM CAN PROTECT WORKERS AND ALERT MAINTENANCE PERSONNEL WHEN EXCESSIVE VCM CONCENTRATIONS OCCUR

- . VCM emissions can occur from two sources:
 - slowly developing minor continuous leakage, such as a worn pump seal

- serious leakage, such as resulting from an operating error (e.g. valve left fully or partially open) or a serious sudden leak (e.g. blown gasket, sight glass breakage, etc.)

In both cases, the system can prove useful in alarming the potentially affected people.

In the case of a minor leak however, (with localized effects) the sample point nearest the leak will register the localized concentration and alarm on the next sampling indicating localized concentration above the limit.

Response to either type of alarm can be standardized. These steps could include donning of personal protective equipment, investigation using leak detectors, isolating the point of VCM release and corrective maintenance.

* * * * *

The next section deals with medical surveillance costs.

VD. MEDICAL SURVEILLANCE COSTS

This section presents the annual costs to industry for medical surveillance essentially based on the NIOSH recommendations to OSHA.

1. THE AVERAGE TIME REQUIRED PER EMPLOYEE FOR THE REQUIRED MEDICAL EXAMINATION IS FOUR HOURS WHEN PERFORMED OUTSIDE THE PLANT

From the information presented in the Appendix Exhibit F-2, the time allowance per employee is itemized as follows:

- . Travel to and from examination facility -- 2.5 hours
- . Examination and laboratory tests - 1.5 hours
- . Maximum time required - 4 hours or 1/2 working day

2. THE SNELL ESTIMATE FOR TOTAL EXAMINATION COST PER EMPLOYEE IS \$160

- . The cost estimate developed by Snell is based primarily on the tests and examination procedures recommended to OSHA by NIOSH as detailed in Exhibit F-3.
- . The costs were estimated for examination and tests completed outside the plant for a manufacturing facility with 500 covered workers. The total cost for such a plant would be approximately \$82,000/year.

3. INDUSTRY ESTIMATES OF THEIR PRESENT MEDICAL SURVEILLANCE COSTS AVERAGE
\$140 PER WORKER PER YEAR

It was assumed by Snell that the examinations performed by the reporting plants were based on the NIOSH recommendations to OSHA.

VE. VINYL CHLORIDE EXPOSURE DATA

This section presents the analyses of ambient air monitoring data taken under the Emergency Temporary Standard and supplied to Snell by industry and OSHA. In addition, the limitations of these data are discussed together with the summary of probable worker exposure for both monomer and PVC plants.

1. INDUSTRY AND OSHA SUPPLIED DATA ARE LIMITED, HOWEVER, THEIR ANALYSES BY SNELL PROVIDED AN INDICATION OF AVERAGE VCM LEVELS FOR THE MONOMER AND PVC PLANTS

The following points describe the data limitations:

- . Sample locations for area monitoring or spot sampling within the plants are not clearly identified. However, the data allowed general association with job classifications.
- . The measuring techniques employed for the OSHA data were 10 minute Sippin pump carbon tube samples with a total ambient air volume collection of 1 liter. Industry data were collected by organic vapor analysers (OVA), bag samples, charcoal tube pumps, or area monitoring. Some of the data levels represent averages of individual samples gathered at random time intervals.
- . In general, Snell did not receive raw data from industry, but rather the averages of individual data points without data point statistics (i.e., No. of individual data points, mean, standard deviation, etc.). The OSHA data submitted to Snell are in terms of individual data points, but these are not related to job classifications or unit operations.
- . In both the industry and OSHA cases, the data population is small.

- . The data base is judged inadequate to quantitatively differentiate suspension polymerization from emulsion polymerization which are the main processes of the PVC industry.
- . Snell arranged the available data in two major categories
 - VCM Plants
 - PVC Plants
- . The available data were averaged and then correlated to the various job classifications. The data presented average levels of VCM for individual plants which were then used to develop an industry-wide profile of average VCM concentrations.

2. IN PVC PLANTS THE HIGHEST EXPOSURE OCCURS IN JOB CLASSIFICATIONS DIRECTLY INVOLVED IN THE MANUFACTURE OF PVC; WITH VCM LEVELS AVERAGING APPROXIMATELY 15 PPM ACCORDING TO DATA SUBMITTED TO SNELL BY INDUSTRY

The following table summarizes the average VCM levels by job classification as presented in Exhibit B-22 in Appendix B.

		<u>Range PPM</u>		
		<u>Average</u>	<u>High</u>	<u>Low</u>
I.	Production			
	VCM Unloading			
	VCM Unloaders	16	40	6
	PVC Processing			
	Supervisors	10	22	5
	Senior Reactor Operators	9	20	1
	Reactor Operators	17	30	5
	Chargers	19	70	7
	Stripper Operators	35	90	5
	Centrifuge Operators	NA	120	3
	Dryer Operators	13	51	1
	Utility Men (Cleaners, Laborers, etc.)	25	78	6
	Baggers	7	20	1
	Warehouse	8	20	1
	Overall Production	16	-	-
II.	Maintenance	24	92	2
III.	Laboratory			
	Professionals	NA	6	1
	Technicians	63	184	1
	Overall Laboratory	42	-	-
IV.	Management & Support	< 1	2	< 1

Source: Exhibit B-22

3. ANALYSIS OF THE MONITORING DATA SUBMITTED TO SNELL BY THE PVC PRODUCING INDUSTRY INDICATES THAT 92% OF AVERAGE MEASUREMENTS HAD VALUES OF 50 PPM VCM OR LESS

As summarized in Exhibit B-23

3% of averages had values of 1 ppm or less
22% of averages had values of 5 ppm or less
58% of averages had values of 10 ppm or less
67% of averages had values of 15 ppm or less
75% of averages had values of 20 ppm or less
80% of averages had values of 25 ppm or less
83% of averages had values of 30 ppm or less
84% of averages had values of 40 ppm or less
92% of averages had values of 50 ppm or less

4. ANALYSIS OF THE MONITORING DATA TAKEN BY OSHA AT PVC PLANTS AND CONFIDENTIALLY SUBMITTED TO SNELL INDICATES THAT 93% OF ALL SPOT SAMPLES HAD VALUES OF 50 PPM; WITH VCM LEVELS AVERAGING APPROXIMATELY 14 PPM

As summarized in Exhibit B-24

3% of samples had values of 1 ppm or less
46% of samples had values of 5 ppm or less
56% of samples had values of 10 ppm or less
64% of samples had values of 15 ppm or less
72% of samples had values of 20 ppm or less
76% of samples had values of 25 ppm or less
79% of samples had values of 30 ppm or less
86% of samples had values of 35 ppm or less
90% of samples had values of 45 ppm or less
93% of samples had values of 50 ppm or less

Overall, agreement exists between the OSHA data and those submitted by industry to Snell. However, the OSHA data contains approximately twice as many more values, on a percentage basis, in the range of 5 ppm or less. The OSHA data do not specify the unit operations or job classifications associated with each reading.

5. ANALYSIS OF THE MONITORING DATA TAKEN BY OSHA AT VCM PLANTS AND CONFIDENTIALLY SUBMITTED TO SNELL INDICATES THAT 96% OF ALL SPOT SAMPLES HAD VALUES OF 35 PPM OR LESS; WITH VCM LEVELS AVERAGING APPROXIMATELY 8 PPM

From Appendix B-108

15% of samples had values of 1 ppm or less
62% of samples had values of 5 ppm or less
77% of samples had values of 10 ppm or less
84% of samples had values of 15 ppm or less
89% of samples had values of 20 ppm or less
94% of samples had values of 25 ppm or less
96% of samples had values of 35 ppm or less

6. INDUSTRY AND OSHA DATA INDICATE THAT AVERAGE VCM CONCENTRATIONS IN PVC PLANTS ARE LESS THAN 50 PPM FOR THE FOUR BROAD JOB CLASSIFICATIONS

The following table summarizes PVC industry-wide VCM average exposure levels as a function of broad job classifications in relation to industry employment in each worker category.

<u>Broad Job Classification</u>	<u>Approximate 1974 Number of Workers</u>	<u>Percent of Total</u>	<u>Average of Concentration</u>
Production (1)	3,030	55%	16
Maintenance (1)	1,350	24	24
Laboratory	390	7	42
Management and Support (2)	<u>805</u>	<u>14</u>	<u>1</u>
Total (3)	<u>5,575</u>	<u>100%</u>	<u>15</u> ⁽⁴⁾

- Notes: (1) Includes line supervisors, such as foremen
 (2) Includes plant managers, engineering staff, clerical, etc.
 (3) Personnel associated with compounding and fabrication in integrated facilities are not included.
 (4) Average VCM concentration for all job classifications

Sources: Exhibit III-10, B-22, and Snell assessment of data.

7. INDUSTRY AND OSHA DATA INDICATE THAT AVERAGE VCM CONCENTRATIONS IN VCM PLANTS ARE LESS THAN 10 PPM FOR THE FOUR BROAD JOB CLASSIFICATIONS

The following table summarizes VCM industry-wide average VCM exposure levels as a function of broad job classifications in relation to industry employment in each worker category.

<u>Broad Job Classification</u>	<u>Approximate 1974 Number of Workers</u>	<u>Percent of Total</u>	<u>Average VCM Concentration</u>
Production (1)	410	44%	4
Maintenance (2)	250	27	2
Laboratory	60	6	4
Management and Support (2)	<u>220</u>	<u>23</u>	<u>1</u>
Total	<u>940</u>	<u>100%</u>	<u>3 (3)</u>

- Notes: (1) Includes line supervisors, such as foremen
 (2) Includes plant managers, engineering staff, clerical, etc.
 (3) Average VCM concentration for all job classifications

Sources: Exhibits III-3, B-107, and Snell assessment of data.

Based on the assessment of the limited data supplied to Snell by industry and OSHA, it appears that average VCM concentrations for the four broad job classifications in both the VCM and PVC producing industry are below 50 ppm. Furthermore, the average VCM concentration in vinyl chloride plants is in the range of 3 to 8 ppm while for PVC plants the average concentration is approximately 15 ppm.

The next chapter provides conclusions and recommendations.

VI. CONCLUSIONS AND RECOMMENDATIONS

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VI. CONCLUSIONS AND RECOMMENDATIONS

This chapter addresses the conclusions and recommendations of the report based on the findings and economic analysis of the previous section.

1. ACHIEVING "NO DETECTABLE" LEVELS OF VCM PRINCIPALLY THROUGH ENGINEERING MEANS IS JUDGED NOT FEASIBLE WITH PRESENT TECHNOLOGY BOTH IN THE VCM AND PVC SECTORS

Based on the industry surveys and Snell's independent assessments of the state-of-the-art of the technology, it is concluded that achieving "no detectable" (0 - 1 ppm) VCM levels in the VCM industry is not feasible principally through engineering means. Reasons include the following:

- technology, including state-of-the-art developments, is not available to eliminate VCM leaks and fugitive losses
- existing plants have not been designed for total VCM containment
- there is no design or operating experience in the industry aimed at maintaining very low VCM levels
- no direct technology transfer opportunities are known to enable development of designs for "no detectable" levels in new plants.

Based on the industry surveys and Snell's independent assessments of the state-of-the-art of the technology, it is concluded that achieving "no detectable" (0 - 1 ppm) VCM levels in the PVC industry is not feasible principally through engineering means. Reasons include the following:

- PVC manufacture is a batch operation
- Technology, including state-of-the-art developments is not available to eliminate VCM leaks and fugitive losses

- existing plants have not been designed for total VCM containment
- there is no design or operating experience in the industry aimed at maintaining very low VCM levels
- no direct technology transfer opportunities are known to enable development of designs for "no detectable" levels in new plants.

Up to four years of development is estimated to reduce residual VCM levels below 100 ppm in PVC products on the basis of output volume.

The technology including state-of-the-art developments is not available to reach very low or "no detectable" residual VCM levels on the basis of output volume.

2. THE COSTS OF COMPLIANCE INCREASE RAPIDLY WITH DECREASING VCM TARGET LEVELS AND REPRESENT SIGNIFICANT ENGINEERING UNCERTAINTY OR INFEASABILITY BEYOND 10 PPM CEILING AND 2 - 5 PPM TWA FOR THE VCM INDUSTRY AND 15 - 25 PPM CEILING AND 10 - 15 TWA FOR THE PVC INDUSTRY

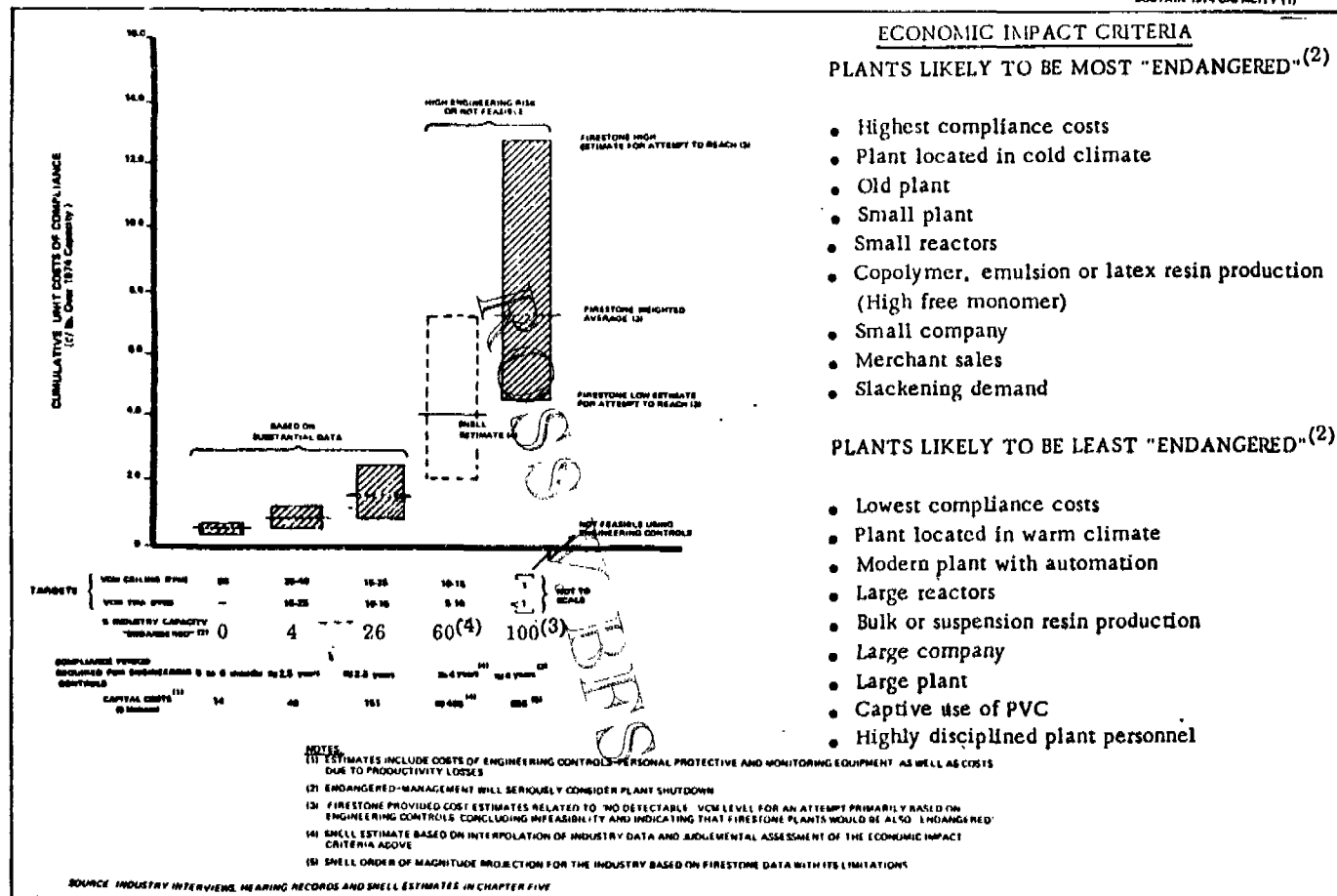
The analysis which follows indicates the cost sensitivity of attempting to reach very low VCM levels in the VCM industry.

<u>VCM Target Level (ppm)</u>	<u>Standard Price (¢/lb.)</u>	<u>Price Index</u>	<u>Percent of VCM Industry Capacity Endangered</u>	<u>Time To Reach Level Via Engineering Controls (years)</u>
Historical Practice	7.41	1.00	Not Applicable	Not Applicable
50 ceiling	7.47	1.01	0%	0.5
25 ceiling	7.59	1.02	0%	2.5
10 ceiling and 2-5 TWA	7.69	1.04	0%	3.0
Extrapolated Attempt to Reach "No Detectable" Levels	12.71	1.72	100% @ "No Detectable" Levels	Not Estimated

Source: Exhibits V-15 and V-13

The table indicates the rapid rise in costs associated with attempting to reach the technologically infeasible "no detectable" levels beyond the 10 ppm ceiling and 2 - 5 ppm TWA target level.

Exhibit VI-1, on the following page, presents a similar discussion for the PVC industry.



For the VCM industry, the engineering control steps for OSHA compliance are significantly the same as those potentially used for air pollution control. Therefore, appreciable air pollution control costs are automatically accounted for by OSHA compliance.

For the PVC industry, engineering control steps from the 50 ppm VCM ceiling level to the 15 - 25 ppm ceiling with 10 - 15 ppm TWA primarily address OSHA compliance, but significant air pollution control benefits are gained, especially at lower levels.

3. AREA MONITORING, PARTICULARLY IN PVC PLANTS IS RECOMMENDED TO OSHA AS A COMPLIANCE REQUIREMENT REGARDLESS OF THE TARGET LEVEL SELECTED BY OSHA

Automatic Sequential Monitoring Systems (ASMS) can serve as a long term data collection system for an entire plant.

- The ASMS can analyze an air sample from a particular point in the plant in 1 to 3 minutes with potential for at least 10 point monitoring.
- The ASMS can be used to provide correlation with personnel monitoring data of actual worker exposure. In addition, it can be used to provide a permanent record of VCM levels, provide alarms in case of exceeding ceiling values, serve as a means to initially identify the general sources of VCM releases, and to monitor progress in complying with OSHA requirements.
- A system installed in the polymerization building can provide warning to work personnel in that area if VCM levels have gone above ceiling levels.
- Response to alarm can be standardized. These steps could include donning of personal protective equipment, investigation using leak detectors, isolating the point of VCM release and corrective maintenance.

4. IT IS RECOMMENDED THAT OSHA ESTABLISH PHASED REQUIREMENTS FOR REACHING VCM TARGET LEVELS TO ALLOW THE COLLECTION OF ADDITIONAL VCM MONITORING DATA TO FULLY ASSESS THE EFFICIENCY OF THE CORRECTIVE STEPS, SUBJECT TO REVIEW IN LIGHT OF CURRENT MEDICAL FINDINGS, AND AS THEY BECOME AVAILABLE

The currently available data base particularly for VCM monitoring, is relatively small. In addition, the technology required for compliance with the lower VCM levels is not yet proven. Consequently, considerable risks exist as to the efficacy of engineering controls even for levels other than "no detectable", which is not technologically feasible.

A phased compliance plan would allow for the assessment of the efficiency of corrective steps already taken by industry. In any event, significant lead times exist for hardware required for engineering controls.

The phased compliance plan should be reviewed in light of current and emerging medical findings.

A possible result of a phased compliance plan would be to spread the costs of compliance over periods of time. This may be desirable considering that the VCM and PVC price impacts may be of the same order of magnitude as the price results of the "energy crisis".

Developmental efforts should be encouraged to improve techniques in personal protective devices, monitoring systems, and residual monomer reductions.

* * * * *

The Appendices supporting the report follow in a separate volume.

APPENDICES
TO
DRAFT FINAL REPORT

ECONOMIC IMPACT STUDIES OF THE EFFECTS OF PROPOSED
OSHA STANDARDS FOR VINYL CHLORIDE

Contract No. L/A 74-167

Mr. James Kallenborn
Acting Director of Planning, Evaluation and Research
OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

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September 13, 1974

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APPENDICES

- A - DETAILED PROCESS DESCRIPTIONS AND PROCEDURES
- B - EXPOSURE DATA FOR POLYVINYL CHLORIDE (PVC) AND VINYL CHLORIDE MONOMER (VCM) PLANTS
- C - ECONOMIC DETAILS
- D - PERSONAL PROTECTIVE EQUIPMENT AND HYGIENE
- E - MONITORING EQUIPMENT
- F - MEDICAL SURVEILLANCE OF EMPLOYEES
- G - SAFETY AWARENESS PROGRAMS
- H - NIOSH RECOMMENDED OCCUPATIONAL HEALTH STANDARD FOR THE MANUFACTURE OF SYNTHETIC POLYMER FROM VINYL CHLORIDE

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APPENDIX A

DETAILED PROCESS DESCRIPTIONS AND PROCEDURES

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APPENDIX A

DETAILED PROCESS DESCRIPTIONS AND PROCEDURES

This Appendix presents design details, discussion of critical technological aspects and operating procedures regarding polyvinyl chloride (PVC) manufacture. A list of exhibits follows:

- . Exhibit A-1 presents the receiving, storing and distributing of vinyl chloride monomer (VCM) as it reaches the Union Carbide Corporation. Monitoring for the vinyl chloride concentration is noted. The unloading mechanism along with the storage parameters are also noted in this exhibit. The special features that are provided to minimize personnel exposure is summarized herein.
- . Exhibit A-2 presents a flow diagram of tank car unloading. This schematic is of advanced practice using spot ventilation.
- . Exhibit A-3 deals with reactor design showing a technological overview by Snell.
- . Exhibit A-4 provides a comparison of Conoco's large reactor PVC technology with historical reactor technology.
- . Exhibit A-5 presents a detailed diagram of an older polymerizer design.
- . Exhibit A-6 presents a Pfaudler Glasteel Polymerizer, a modern polymerizer design.
- . Exhibit A-7 is a broad discussion of monomer stripping technology.
- . Exhibit A-8 is a typical schematic for polyvinyl chloride operator movements and plant layout.
- . Exhibit A-9 presents a flow diagram for the PVC emulsion process.

EXHIBIT A-1(1)

USDOL/OSHA

RECEIVING, STORING AND DISTRIBUTING
VINYL CHLORIDE MONOMER-AFTER UNION CARBIDE

1. DESCRIPTION

Union Carbide Corporation receives vinyl chloride at South Charleston, West Virginia in 48,000-gallon tank cars shipped from Freeport, Texas. Due to the size of the car only five tank cars are unloaded per week in an open area used for unloading various chemical tank cars. Monitoring this operation on three consecutive car unloadings yielded the following results:

Date	Operation	Time Required minutes	Sample Time minutes	Concentration ppm
June 28, 1974	Hookup Car	20	20	4
	Disconnect Car	15	15	15
July 2, 1974	Hookup Car	19	19	6
	Disconnect Car	8	8	< 1
July 3, 1974	Hookup Car	22	22	8
	Disconnect Car	5	5	< 1

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Vinyl chloride monomer is received by railroad tank car into a storage area located outside the boundaries of the plant proper. It is unloaded into a refrigerated sphere from which it is pumped to the consuming units.

Unloading is accomplished by equalizing the pressures in the tank car and the storage sphere and then applying vaporized vinyl chloride to the vapor space in the tank car. This provides positive suction pressure on the pump which transfers vinyl chloride to the storage sphere. After all the liquid has been removed from the tank car, a compressor pumps vinyl chloride vapors from the car to a condenser and the condensed liquid is then pumped to the sphere. The vapor pressure in the car is reduced to 5 psig, and the car is then returned to the vinyl chloride supplier for refilling.

The vinyl chloride in the sphere is maintained under its own vapor pressure (maximum of 29 psig) at a maximum temperature of 15° C by the use of refrigeration, with vinyl chloride serving as the refrigerant.

Transfer pumps and piping transfer vinyl chloride to the consuming units as required.

2. SPECIAL FEATURES PROVIDED TO MINIMIZE
EXPOSURE OF PERSONNEL

General

- (1) The receiving and storage area is remote from the consuming units.
- (2) A high degree of automation is employed, so that there is little need for operators to be near the tank car or the sphere while unloading proceeds.
- (3) Nitrogen is not employed as a pressurizing medium, so there is very little venting to rid the system of inert gas during unloading or loading by the supplier.
- (4) Safety valve discharges and other vent streams are piped to a remote, elevated location for discharge.
- (5) All pumps handling vinyl chloride are provided with mechanical seals to minimize leakage.
- (6) Vent and drain valves not required for normal operation are maintained in closed position and plugged with pipe plugs.

Tank Cars

- (7) The tank cars are provided with dip tubes for top discharge only. The dip tubes are provided with excess-flow check valves; if the flow exceeds a pre-established value, the valve automatically closes.
- (8) The tank cars are provided with a tape liquid-level device, which eliminates the need for venting vinyl chloride in determining the liquid level in the car.

Sphere

- (9) The sphere is located in a separately diked area, with sufficient capacity to contain the entire contents of the sphere.
- (10) Lines leading into the sphere are provided with check valves, and discharge lines from the sphere are provided with excess-flow check valves.
- (11) The sphere and associated piping is insulated for 15°C maximum temperature; the insulation is such that it will not decompose if subjected to fire.
- (12) The sphere is provided with water spray protection.
- (13) The sphere is equipped with a refrigerated vent condenser (-20°C) through which inert gases are vented to the atmosphere.

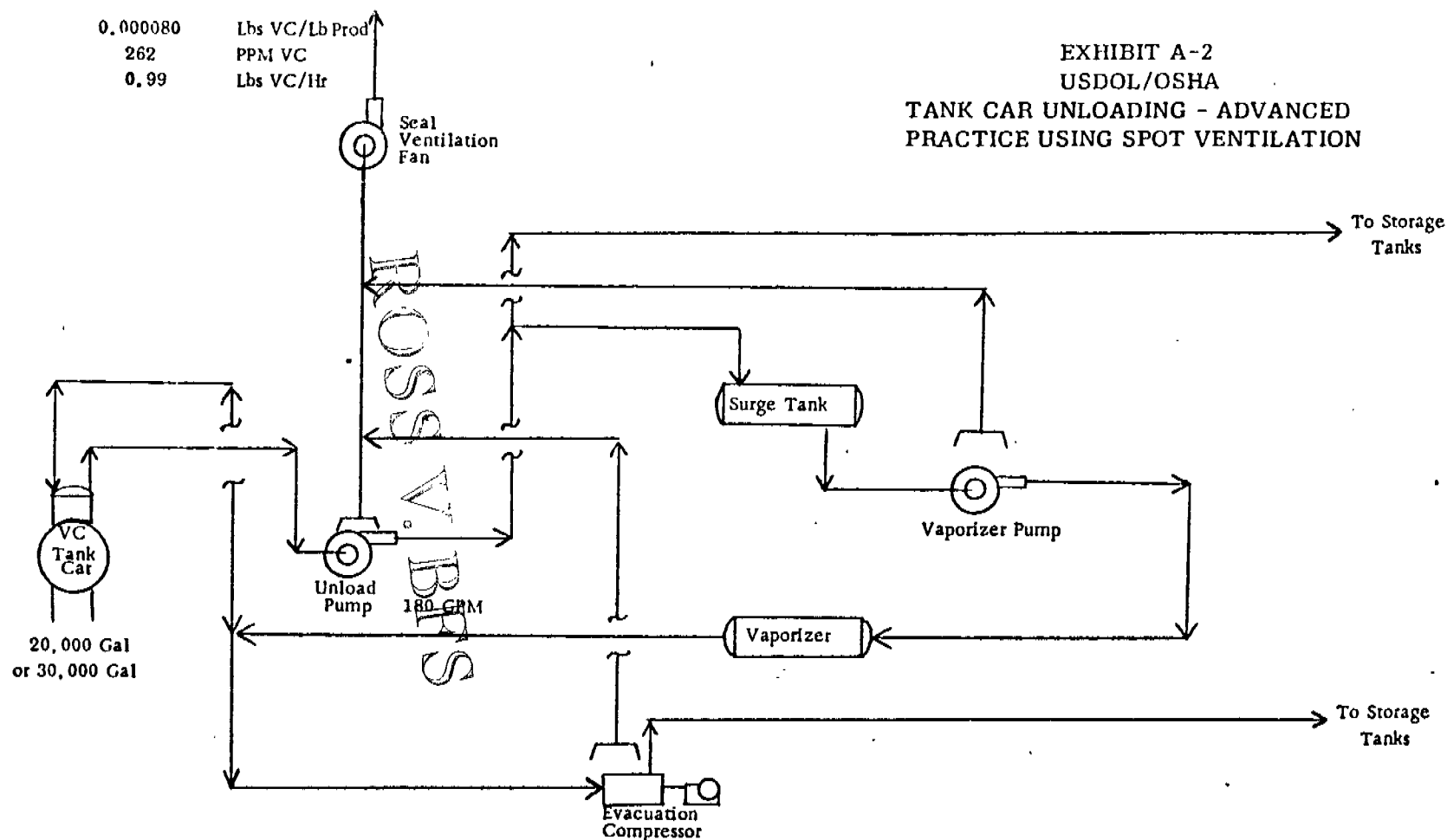
Scavenging System

- (14) A scavenger compressor system is provided to remove vinyl chloride from lines or hoses which must be disconnected during loading or unloading operations. When scavenging is completed, such lines or hoses are purged with nitrogen to a remote vent stack.

Source: Testimony of Richard T. Hughes, Vice President, Union Carbide Corporation, before OSHA, on Vinyl Chloride Occupational Exposure Standard, July 5, 1974.

0.000080 Lbs VC/Lb Prod
 262 PPM VC
 0.99 Lbs VC/Hr

EXHIBIT A-2
 USDOL/OSHA
 TANK CAR UNLOADING - ADVANCED
 PRACTICE USING SPOT VENTILATION



Wall Fan (C1002)
 0.000066 Lbs VC/Lb Prod
 .7 PPM VC
 0.821 Lbs VC/Hr

BASIS 12,400 LBS/HR PVC

Source: Snell industry interview

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EXHIBIT A - 3(1)

USDOL/OSHA

SNELL'S REACTOR DESIGN AND CLEANING OVERVIEW

1. REACTOR DESIGN CAN SIGNIFICANTLY REDUCE CHANCES OF EMISSIONS OF VCM

Recent changes have been incorporated to the design of reactors which will contribute in several ways to minimize chances of emission.

(1) The Trend To Larger Size Reactors Diminishes The Number Of Leakage Points

In early designs, 1947-1967, the reactors were kettles, usually glass lined, ranging in size from two to five thousand gallons. The bulk of the equipment still in use falls in this category.

However, new designs have been developed together with manufacturing methods and the most recent equipment incorporates reactors which can be as large as 18,000 gallons if glass lined and even 35,000 gallons (Shinetsu) if stainless. Hülls in Germany is reported to be using a 55,000 gallon reactor.

Glass lining techniques, transportation restrictions, and heat transfer considerations will limit the size of glass lined equipment to 18,000 gallons.

The factory cost of an 18,000 gallon glass lined reactor is \$350,000, including agitator and drive. The cost of a stainless reactor (clad construction) of 18,000 gallon capacity should be competitive.

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EXHIBIT A - 3(2)
USDOL/OSHA

Exhibit A - 4, following this Exhibit, summarizes the advantages and development needs of large reactor technology.

Design steps such as elimination of the manual charging of minor ingredients, the possible use of ball and plug valves, reduction of the number of flanges can aid in limiting leaks from peripherals.

(2) The Newer Design Bottom Entering Agitators And Baffles Can Significantly Reduce Possible Monomer Leakage

In the older design, shown in Exhibit A - 5, following Exhibit A - 4, the agitator usually enters the reactor from the top, so that the seal around the shaft is containing the high pressure VCM atmosphere. High Pressure Dual Seal design is used, but since the sealing depends in large part on the oil pressure in the ring, a problem may arise in case of power failure.

The same problem arises (with lesser severity) with the top entering baffles. Seal deterioration around the baffles has been observed in several instances and creates a particularly insidious problem.

A newer design, shown in Exhibit A - 6, following Exhibit A - 5, incorporates bottom entering agitator and baffles; thus the seals are containing liquid. It has the double advantage of making the containment easier and to give visual warning of leakages.

EXHIBIT A - 3(3)
USDOL/OSHA

Furthermore, the newer design of the bottom entering seals used in glass lined reactors incorporates a pre-seal in which water at a pressure slightly higher than in the reactor is deliberately allowed to leak in at about 15 g. p. h., thus precluding the possibility of leakage to the outside.

For the baffle installation, a new flush glass-to-glass seal has been developed; this design could not be used with the conventional nozzle entering baffle.

In the larger size reactors, baffles are used as an auxiliary cooling surface, adding an extra 25 sq. feet of heat exchange area to an 18,000 gallon reactor.

(3) The Indirect Effects Of Bottom Entering Baffles And Agitator May Be More Important From The Standpoint Of General VCM Levels In The Plant

The main reason which prompted the design change was the attempt at eliminating, or minimizing, the "Bath Tub Ring" effect.

This is the formation at the gas liquid interface of agglomerates which cling to the solid surfaces and tend to build up to considerable size, sometimes breaking out in multipound chunks. This phenomenon is particularly bothersome at the comparatively low clearance between baffles and wall. With bottom entering baffles and agitator these effects are virtually eliminated since there is no hydraulic dead space for the agglomerates to form and grow. The reduction or elimination of formation of agglomerates lowers the frequency of strainer cleaning and thus significantly minimizes a source of potential exposure. Pipe clogging is less frequent. Perhaps the main advantage is that the need to open the reactor for inspection and cleaning is greatly reduced.

EXHIBIT A - 3(4)
USDOL/OSHA

2. MANUAL REACTOR CLEANING IS A MAJOR CAUSE OF EMISSION PROBLEMS AROUND THE REACTOR

While the most obvious problems associated with manual cleaning of the reactor are the possible emission of VCM upon opening the manhole and the exposure of the man entering the reactor, these do not constitute major engineering difficulties. Adequate venting procedures either are in force or can be implemented to significantly limit exposure to VCM upon opening the manhole. Personal protective devices eliminate the risk of exposure of the man entering the reactor.

But there are two more serious and long-lasting effects of the manual cleaning operation:

- . the deterioration of the manhole cover sealing surfaces due to unavoidable chipping from repeated opening and closing
- . the possibility that during hand cleaning operations a sight glass may be chipped leading to subsequent bursting under pressure

Several methods have been proposed to reduce or eliminate the need to enter the reactor for cleaning.

(1) Deterioration Of The Manhole Cover Seal Is A Significant Cause Of Leakage

Every time a manhole is opened in a glass lined reactor, there is a chance for the glass covering the outer part of the manhole nozzle to become chipped.

EXHIBIT A - 3(5)
USDOL/OSHA

In addition, there is a possibility of deterioration of the gasket. A combination of a faulty gasket and a chipped manhole lip is a frequent source of a significant leak. Until recently, little attention was paid to this feature due to the comparatively high ppm level considered acceptable around the reactor.

(2) Design Improvements Have Been Developed To Reduce The Risk Of Deterioration Of The Manhole Cover Seal

Recently designed glass lined reactors are equipped with an Inconel overlay which is fused to the glass lining in the vertical portion of the nozzle.

This design eliminates the chances of chipping the glass lining and permits a tighter tongue and groove metal-to-metal seal which, combined with a compressed asbestos gasket, insures a much more durable and positive seal. Unfortunately this design cannot be applied to older reactors unless they are sent to the factory for reglassing. The turnaround time for this can be 60 weeks.

Replacing the conventional manheads with Lenape's can alleviate leaks around the manhole.

(3) Another Danger Area Is The Rupture Of The Sight Glass

During manual cleaning it is often necessary to free the nozzles holding sight glasses from accumulated solids. In the process sight glasses may be accidentally chipped, which may induce an undetected hairline crack resulting in a bursting of the sight glass when the reactor is pressurized.

EXHIBIT A - 3(6)
USDOL/OSHA

Another source of sight glass rupture is the removal of the sight glass for cleaning. Upon re-installation, uneven tightening of the bolts is known to have induced stress in the glass with the result that when the pressure stresses were added the sight glass burst. A novel design incorporated in the late models of glass lined reactors eliminates this possibility.

3. IN SITU CLEANING METHODS SHOULD PROVIDE A SOLUTION TO THE LEAKAGES CAUSED BY FREQUENT OPENING OF THE REACTORS

The ideal solution would be to eliminate the need for opening the reactor. Complete in situ cleaning would provide this solution if it could be made thorough enough. Several methods exist or are under development and a brief review of their characteristics is given here.

(1) Historical Changes Have Already Reduced The Frequency Of Cleaning

In all reactors involving a change from a liquid to a solid phase, such as encountered in PVC production, there is a tendency for the solid to agglomerate and adhere to solid surfaces under certain conditions. This tendency is a function of:

- nature of the solid and liquid phase(s)
- quality of the reactor surface
- presence of stagnant zones in the reactor
- "Bath Tub Ring" effect

EXHIBIT A - 3(7)
USDOL/OSHA

It has been observed that in the course of the development of PVC production from its beginning in the 1940's to the present, two changes have contributed to reduce the frequency of cleaning:

- a trend to larger reactors has reduced the tendency for the agglomerates to bridge, say between baffles and side
- formula changes seem also to have resulted in a lower tendency for the solids to agglomerate

The result has been that the cleaning frequency has gone down from once every batch to once every four or five batches. Yet this still may constitute an unacceptable frequency.

Furthermore, with the trend to large reactors (10,000 gallons plus), structures had to be erected in the reactor to allow for reaching the required areas (usually in the nozzles on the top cover and at the liquid gas interface). A development was the use of hand directed high pressure (up to 10,000 psi) nozzles. This is in fairly widespread use.

(2) There Are Two Basic Methods For Automatic Cleaning With Some Variants: Water Wash And Solvent Wash

One method uses water under pressure and relies on the mechanical impact of high kinetic energy water particles.

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- By and large the problem with water consists simply in separating the solid polymer from the water stream. In fact, for large volume applications, water re-use may be justified.

The solvent method has two variants:

- in one method the solvent is allowed to completely fill the reactor
- the other solvent method is the use of an automatically controlled solvent spraying

The main drawback of the solvent methods is the need to recover the solvent (they are quite expensive, on the order of \$0.50 to \$1.00 a pound), and to a certain extent it displaces the problem to the cleaning of the heat exchangers or other solvent recovery devices. This is a major reason for which proprietary rights and patents cover these methods.

EXHIBIT A - 3(9)
USDOL/OSHA

(3) The Cleaning Methods Are Proprietary But Are Offered For Licensing

At present there are several methods offered for licensing. Two of them are basically water methods:

GOODRICH HRC
High Pressure Water -

the method involves the use of very high pressure, retractable, multi-directional water sprays; manual cleaning is required approximately after every ten batches

- the equipment cost is about \$100,000 (one unit needed per reactor size class); there is a \$50,000 usage fee; believed to be non-recurring

- the method drawback is that reactors have to be opened to install the portable equipment, causing deterioration of the manhole cover seal

- the time lag for the institution of this method depends on delays in construction of the specialized equipment, and in acquisition of the ancillary equipment, pumps, tanks, etc. It is estimated at about 6 to 8 months

EXHIBIT A - 3(10)
USDOL/OSHA

PFAUDLER Low
Pressure Water

- the method involves the use of a patented retractable nozzle assembly which is permanently installed in the reactors. Its advantage is that with twenty minutes of cleaning after each batch, at least twenty-five batches can be processed before another type of cleaning is required. An interesting variant is the use of solvent on, say, every twentieth cleaning. This is claimed to make it unnecessary to enter the reactor for other than annual or semi-annual routine inspection

- the spray nozzle assembly is estimated to cost about \$25,000

- ancillary piping and equipment varies widely depending on the number of reactors and such other factors as plant layout, etc. Probably \$10,000 per installed reactor is a good approximate figure.

- installation delays may be on the order of 10 to 12 months

- the cost of adding solvent capability may double the capital investment costs

EXHIBIT A - 3(11)

USDOL/OSHA

The other proprietary methods involve the use of solvents:

STAUFFER EDT

- the heart of the method is the solvent recovery unit. A drawback is that it is a soak method in which the reactor is completely filled. Turn around time for a 5,000 gallon reactor is about three hours
- the required equipment involves essentially circulation pumps, solvent storage tank and a solvent recovery unit
- a license fee based on capacity entitles the licensee to flow diagrams, thermodynamics and energy data, operating manuals, etc.
- the cost of the recovery unit is said to vary from \$75,000 to \$150,000 depending on solvent handling capacity. This does not include the engineering costs nor the storage. For a 5,000 gallons per year of solvent purification a total installed cost of \$250,000 to \$300,000 appears reasonable
- such an installation may require up to 2 years and significant shut downs of production facilities have to be anticipated
- American Chemical is believed to use the Stauffer method with EDC as the solvent. This may be an interesting solution for integrated plants, where EDC is available

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EXHIBIT A - 3(12)
USDOL/OSHA

GAF Process

- this process uses a trademarked solvent M-Pyrol and retractable spray devices permanently installed on the reactor. The cleaning devices are installed typically in 4" nozzles. They retract behind a quick opening gate valve during reaction

- a problem with this equipment is that gate valves are not very reliable as closing devices in presence of solids, so that leakage cannot be ruled out under pressure. The design does not incorporate the elaborate seals required to contain VCM should the gate valve not close completely

- the costs of equipment are similar to those for the Stauffer process and subject to about the same installation delays

SHINETSU Process

- this is a proprietary process which is an integral part of the Shinetsu Large Reactor Technology. It requires specific design features which may not be economically installed in existing reactors. In addition, the process cannot be used in glass lined reactors.

Source: Snell Analyses

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EXHIBIT A-4 (1)

USDOL/OSHA

COMPARISON OF LARGE REACTOR
TECHNOLOGY WITH HISTORICAL
REACTOR TECHNOLOGY-AFTER CONOCO

A new Conoco PVC plant based on the large reactor technology came on stream in 1971 in Oklahoma City, Oklahoma. Conoco also operates a small reactor PVC plant in Aberdeen, Mississippi, and the following data are related to small reactor plants based on our experience at the latter plant. Approximately 32 to 34 small 2200 gallon reactors are needed to provide the same capacity that is obtained in 4 large reactors at Oklahoma City. This means that 8 times as many reactors must be charged, polymerizations contained, stripped, dumped, cleaned, etc. The number of mechanical entities (valves, flanges, pumps, etc.) requiring maintenance (leak problems) is substantially less in the large reactor plant, a strong positive factor in its favor. Moreover, most of the mechanical steps in the new plant are carried out by remote control while the operator keeps all phases under observation by means of charts, schematic diagrams, lights, and closed circuit TV cameras. These comparisons are also based on considerations of the cooling water availability, product mix and the particular chemical and engineering approach in use.

Most of the small reactor plants have been constructed with the reactors contained in buildings. Our large reactor plant has only a roof over the reactor building. The associated piping, instrumentation, etc. are enclosed on the sides by a protective metal screen-like structure which covers only about two-thirds of the vertical rise. Therefore, the reactor area is essentially "open air".

The large reactor technology, when producing construction type resin, requires personnel entry only about once every thirty days; in small reactors, entry for cleaning is about every 4 or 5 days. Reduced entry frequency is obviously preferred until the goal of zero personnel entry can be achieved by additional research on "clean wall" polymerization formulations. Until that time a combination of solvent cleaning followed by periodic personnel entry in the reactor to manually chip away polymer will be required.

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EXHIBIT A-4(2)
USDOL/OSHA

Our large reactor plant provides about a 98% yield of PVC based on vinyl chloride monomer charged whereas small reactor plant yield is only about 94 to 95%. While the distribution of the yield loss is not fully defined, we believe a significant reduction in atmospheric emissions is being obtained. In addition to the differences in product mix, this difference in yield reflects the fact that fewer operational steps are required in large reactor technology which minimizes the loss of both solid PVC and gaseous VCM. This should provide a workplace with a lower risk for the employee of VCM exposure.

Large reactor manpower requirements are approximately one half that of small reactors on an equal production basis. Two large reactors require two reactormen per shift. Sixteen small reactors, the number necessary to equal the production of two large reactors, require four reactormen per shift. On a per pound basis, large reactors require 0.084 reactormen per million pounds per year while small reactors require 0.168.

In view of what we believe to be positive advantages for large reactor plants, we plan to install additional large reactors to replace the small reactor sections of the Aberdeen plant when appropriate technology is available. At the present time, large reactor technology is limited to a very specific range of resins which find application in the construction industry. These types of resins do not have rigorous requirements on several important PVC properties; e.g. "fisheyes". Although higher quality resins suitable for wire and cable, calendaring and other applications have been demonstrated to be technically feasible in our large reactor technology, significant additional developmental effort will be required to demonstrate production of these resins on a commercially practical basis. To accomplish the goal of replacing our small reactors at Aberdeen and of providing resins required by the market, we believe that the following is a very realistic timetable:

EXHIBIT A-4 (3)
USDOL/OSHA

..... Basic R & D Program - 1 year.

..... Engineering design and obtaining bids - 1 year

..... Plant construction and start up - 3 years

This engineering analysis indicates that 5 years are required to implement technology required to satisfy market demands while maintaining our employee VCM exposure in keeping within our proposed standards. In the interim, we plan to meet the proposed standards by restricting work practices (by use of protective equipment, etc.), until such time as we are able to implement the replacement of small reactors with large reactors.

Source: Submission to Docket Officer, Docket OSH-36, OSHA, by R. W. Genwig,
Vice President, Continental Oil Co., June 27, 1974.

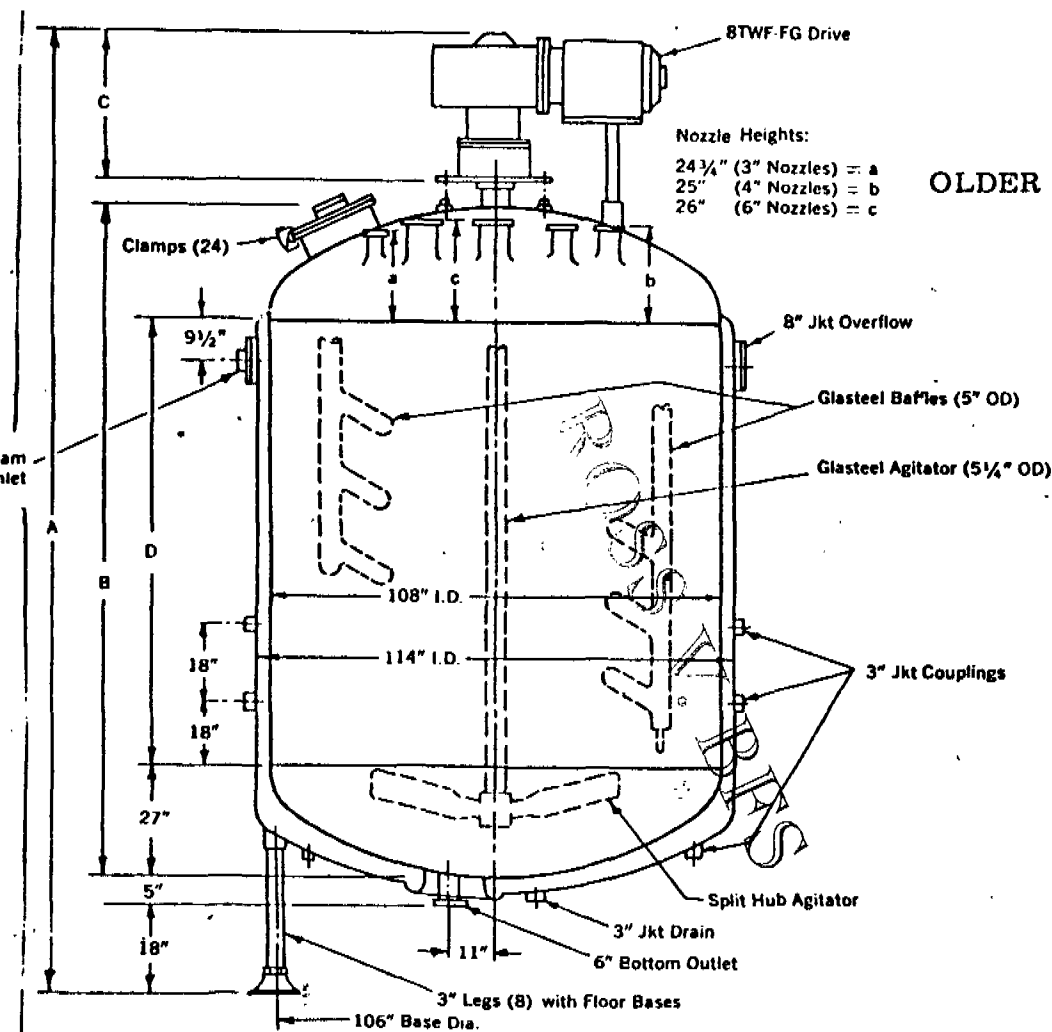


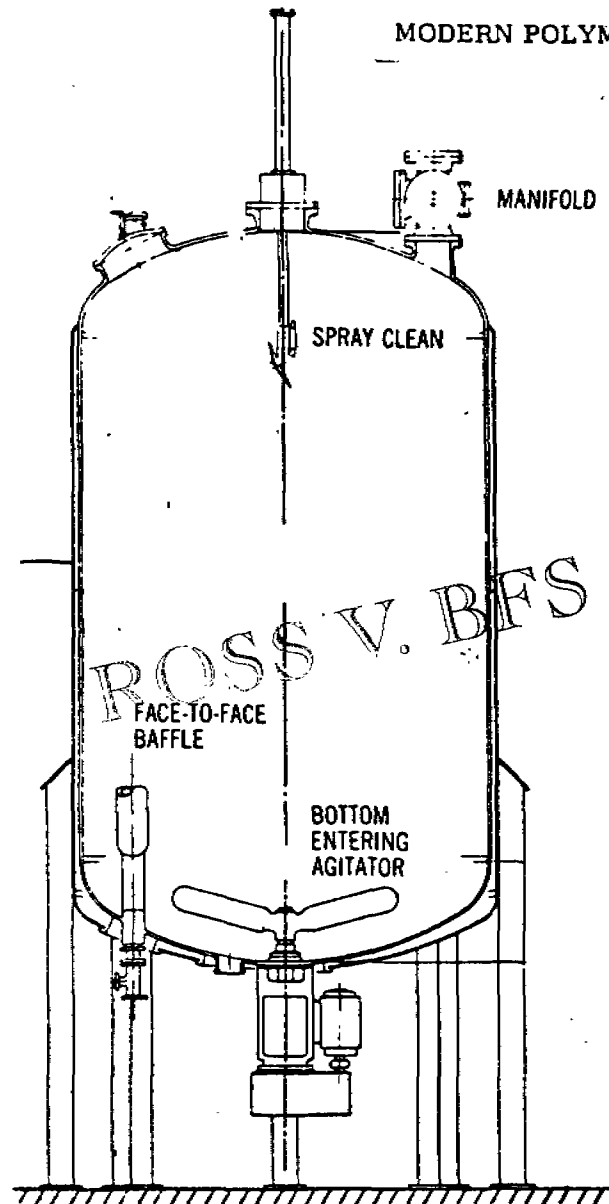
EXHIBIT A-5
USDOL/OSHA
OLDER POLYMERIZER DESIGN

Source: Pfaudler Bulletin 1051, Glasteel Polymerizers

EXHIBIT A - 6

USDOL/OSHA

MODERN POLYMERIZER DESIGN



THE FRAUDLER

GLASS-STEEL POLYMERIZER

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EXHIBIT A-7(1)
USDOL/OSHA

BROAD DISCUSSION OF MONOMER
STRIPPING TECHNOLOGY

IMPROVEMENTS TO THE STRIPPING STEP IN PVC PRODUCTION WILL MINIMIZE
VCM EXPOSURE HAZARD DOWNSTREAM FROM THE REACTORS

Residual VCM in PVC slurry downstream of the reactor causes problems of potential VCM emission through "degassing" of the finished products. Furthermore, there is the possibility of emission in blending and in-process storage, centrifugation, drying and product handling if there is a significant concentration of unreacted VCM in the PVC slurry or resin.

Historically, the stripping operation was tailored to minimize VCM losses and thus increase the production yields. A new dimension has been introduced to this operation by the recognition of the hazards which may be created by the existence of significant VCM concentrations in the atmosphere as a result of residual monomer.

Limiting residual monomer in the resin can reduce exposure risk from unit operations downstream of stripping, limit air pollution from dryer exhausts and other downstream sources and limit the exposure risks of compounders and fabricators.

Thus, improvements to the stripping, which are not economically justified by the value of the VCM recovered, have become necessary. This discussion addresses itself broadly to the technology of stripping.

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(1) For Economic Reasons The Stripping Method Which Was Found Historically Practical Was The Depressurization Of The Reactors Through A Recovery Unit

A substantial VCM pressure exists at the end of the polymerization cycle. The reactor atmosphere, which is essentially composed of VCM vapors, is vented through a system in which the VCM is cooled and recompressed to a liquid phase which can then be returned to the process. Up to 10-12% of the initial charge can thus be readily returned to the process. However, at atmospheric or near atmospheric pressure a significant concentration of VCM (2 to 3%) remains in the slurry. Slow liberation of VCM occurs when the atmosphere in contact with the slurry is renewed, but the bulk of the free VCM is dissipated during the drying step.

Additional treatment of the slurry via, for instance, reduced pressure, heating, etc., requires both equipment and energy, the costs of which are not justified by the value of the minor amount of VCM thus recovered.

The geometry of the reactor, which is favorable to agitation and heat exchange is not the most favorable for stripping due to a low ratio of free area to liquid volume. This aggravates the foaming problem which is often encountered and requires the use of knockout pots on the recovery lines. Thus, some plants have incorporated an additional vessel in which the stripping takes place. Usually this vessel has about twice the capacity of the reactor and can be of a different geometry (horizontal cylindrical tank) with the liquid level near the center line. This offers not only a better area volume ratio, but also a considerable extra capacity for whatever foam layer is formed. The stripping rate and degree of completion can thus be improved.

- (2) An Improvement To The Stripping Which Has Been Implemented In Some Plants Is Pressure Reduction By Steam Jet Or Vacuum Pump

Reduction of the pressure of VCM over the slurry will result in a reduction of VCM concentration in the slurry itself. The advantage of using a vacuum pump is that the discharge of the pump can be handled directly via the recovery system. Steam jet exhaust has to be vented to the atmosphere, thus creating a potential environmental problem.

- (3) A Further Refinement Is The Sparging Of Live Steam Into The Slurry, Preferably Under A Reduced Pressure

A further refinement of technology consists in the application of heat to increase the partial pressure of the remaining VCM. This, coupled with reduced pressure over the slurry, should result in a greatly enhanced stripping, bringing the unreacted VCM level in the slurry itself to perhaps 100 ppm. This would have the added advantage of reducing drastically the amount of VCM in the dryer exhaust gas, thus alleviating a potential environmental problem.

(4) More Sophisticated Stripping Methods Are Under Development, But This Work Is Highly Proprietary

As a result of the Emergency Temporary Standard, the industry has been engaged in a vigorous development program addressing itself to the problem of residual monomer in the finished product. In the table below are presented some typical residual monomer concentrations in the major resins since the promulgation of the Emergency Temporary Standard.

<u>Resin Type</u>	<u>Reported Range of Residual VCM (ppm)</u>	<u>Representative Average (1) (ppm)</u>
Suspension	50 - 4,000	500
Emulsion	1 - 400	10
Bulk	0 - 35	20
Solution	---	1.5
Copolymers	10 - 14,000	1,000 - 7,000

- (1) Average value considered by industry sources to represent residual VCM levels in common resins of the type indicated. Specialty resins, which represent 10% to 15% of production (generally suspension resins) were reported to contain up to 8,000 ppm.

Source: Industry interviews by Snell

It is seen from the table that considerable reductions are needed in free VCM levels in some resin categories to reach the 100 ppm levels advocated at the OSHA Hearings.

A considerable amount of development work is being carried out, principally addressing itself to the stripping step, to achieve a drastic reduction of residual monomer levels. However, it is reported that for many products increases in the stripping efficiency, e.g., through steam sparging, results in unacceptable deterioration of product characteristics such as, for instance, coagulation of latex. Thus, the development program has also to incorporate changes in the polymerization steps, such as reformulations. The nature and type of the information handled in this development work makes it so confidential that no technical details are publicly available.

Very generally, sophisticated stripping methods such as countercurrent or cascade stripping are said to be under study.

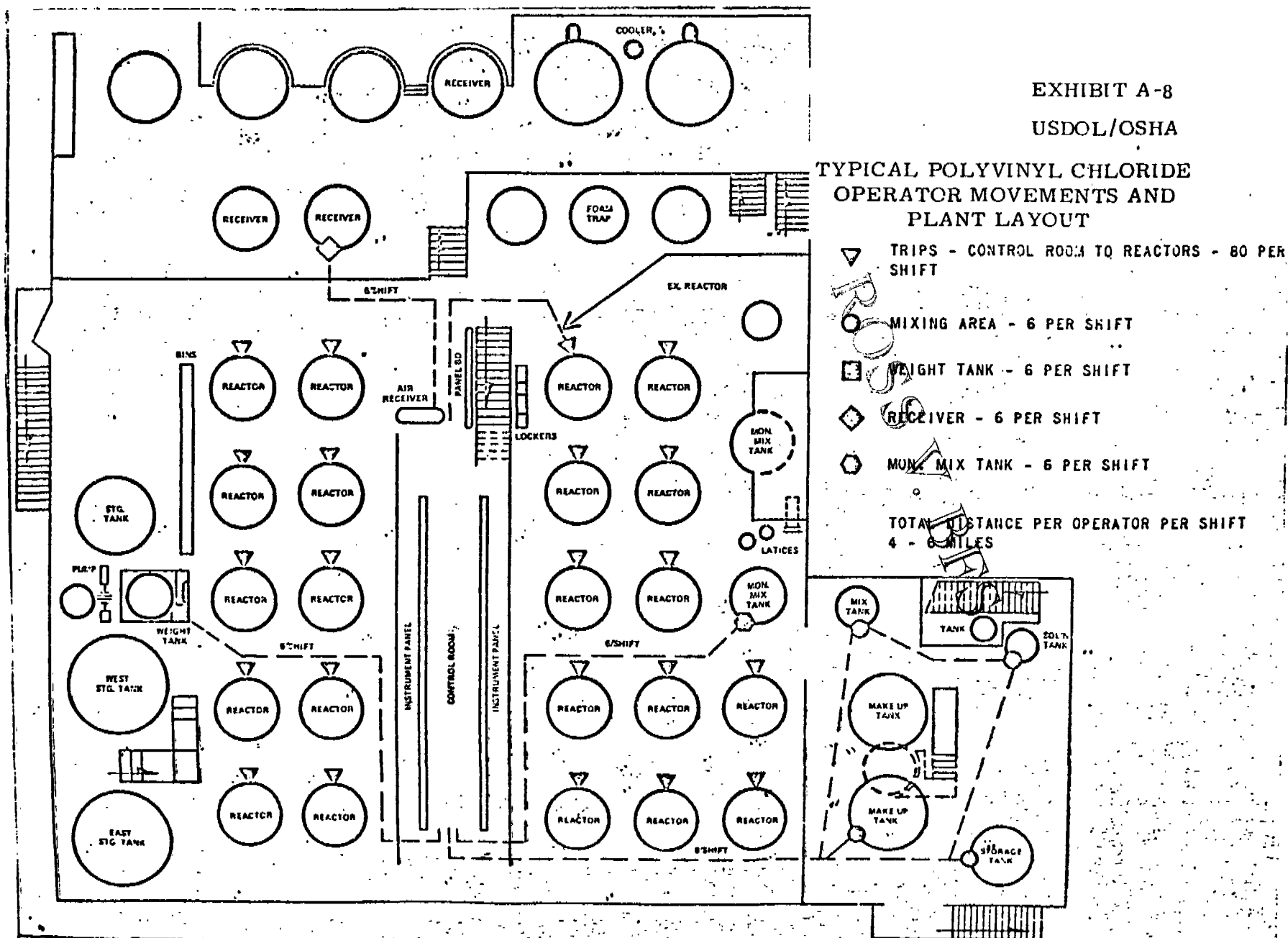
(5) Implementation Time For Stripping Improvements Are Variable

Introduction of vacuum stripping is comparatively easy and will result in immediate improvement in the few remaining plants which do not have this capability. Implementation time of the order of six months is required.

Steam sparging will require more time due to the added requirements of the recovery system which will have to incorporate reflux condensers for the water vapor. From 1.5 to 3 year implementation time can be expected. Time requirements are greatest for those plants which will require additional steam generating capacity.

Stripping of copolymer and latex products to below 100 ppm free monomer levels is reported to require significant technological development.

Newer, more sophisticated methods may already be in the implementation state or, on the other hand, be only at the earliest phase of development. Levels of residual monomer below 100 ppm for all products on a quality controlled continued basis are probably years away.



Source: Industry Interview by Snell.

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[illegible]

Source: Industry Interview by Snell.

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APPENDIX B

EXPOSURE DATA FOR POLYVINYL CHLORIDE (PVC) AND VINYL CHLORIDE MONOMER (VCM) PLANTS

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APPENDIX B

EXPOSURE DATA FOR POLYVINYL CHLORIDE (PVC) AND VINYL CHLORIDE MONOMER (VCM) PLANTS

This appendix presents exhibits summarizing the exposure data from a number of PVC and VCM plants. The appendix also contains a confidential inventory of PVC workers for 1974 (see Exhibit B-1), used for reference purposes in Chapter III discussions of employment.

An explanation of the elements of the coding that is assigned to the data sources follows:

Random leading numbers only appear for VCM plants

Random leading numbers appear for PVC plants followed by possible symbols as shown

- PVC plant capacity

S = small, less than 100 million lbs

M = medium, 100 to 200 million lbs

L = large, over 200 million lbs

- PVC plant age

New = 0 to 10 years

Int. = 11 to 12 years

Old = over 20 years

- PVC plant siting

C = cold climate

W = warm climate

The exhibits presented in this appendix are arranged in the following manner for clarity of presentation.

- . Exhibits presenting PVC industry submitted VCM monitoring data are numbered B-2 through B-21.
- . Exhibits B-22 through B-24 present the Snell assessment of the industry data and data submitted to Snell by OSHA.
- . Exhibits numbered B-100 through 106 contain VCM industry submitted VCM monitoring data.
- . Exhibits B-107 and B-108 show the Snell assessment of the industry data and data submitted to Snell by OSHA.

The data contained herein will provide general location of VCM source in a plant, VC concentration in ppm, number of employees exposed at given work posts, and in most cases the measurement methods.

There is some evidence that data obtained from manual sampling versus area monitoring may be biased downward. A PVC producer presented data showing the comparative results of sampling in the same area by manual methods and by means of five twenty points automatic sequential sampling chromatographs. The results are presented below.

	<u>Number of Samples</u>	<u>Average</u>	<u>Point Range (95%)</u>
Manual Sampling	218	10.14	0 - 46
Automatic Sampling	one full day	16.30	0 - 64

Without a statistical analysis of the population it is premature to affirm that a bias exists between manual and automatic sampling, particularly since one deals with a one-sided distribution. However, in view of the magnitude of the difference of the averages a real bias is likely.

EXHIBIT B-1
USDOL/OSHA
CONFIDENTIAL INVENTORY OF POLYVINYL
CHLORIDE WORKERS - 1974

<u>Plant Start-Up Date</u>	<u>No. of Workers</u>	<u>Plant Start-Up Date</u>	<u>No. of Workers</u>
1957	64	1947	140
1963	46	1959	74
1961	80	1955	150
1963	155	1950	74
1946	75	1971	30
1960	158	1953	241
1968	120	1965	200
1954	130	1947	350
1953	300	1965	70
1960	40	1965	180
1970	55	1942	266
1946	300	1969	90
1956	80	1955	98
1956	27	1968	150
1956	76	1965	95
1966	140	1967	160
1963	187	1957	70
1926	272	1949	322
			<u>5,045</u>

(1) Since the data is coded and confidential according to the source, it is not clear to Snell what the precise definition of "PVC Worker" is.

Source: Statement of PVC Producers in the United States Relative to Health Experience of Workers in Plants Polymerizing Vinyl Chloride, Draft No. 3, 5/28/74, per private communication with Snell by Arthur B. Steele, Operations Manager, Union Carbide Corporation Chemicals and Plastics, July 26, 1974.

EXHIBIT B-2 (1)
USDOL/OSHA
MONITORING RESULTS FOR
12 - M - INT. - C

<u>Job Classification</u>	<u>Average Exposure (ppm VCM)</u>	<u>Number of Data Points</u>
Suspension		
Area Foreman	8.4	39
Homopolymer Reactor Operator	10.0	79
Copolymer Reactor Operator	26.1	76
Dryer Operator	5.6	24
Bagger/Cleaner	5.0	59
Labor Pool/Cleaner	5.3	63
Plastisol		
Area Foreman	16.2	32
Shift Foreman	3.7	27
Tower Operator	19.0	176
Laborer	7.6	100
Bagger	2.5	71
Atomizer Dryer Operator	2.0	26
Additive Dryer Operator	2.2	23
Laboratory		
Q.C. Lab. Supv.	2.5	6
Analytical Chemist	0.7	6
Colorist	16.2	6
Q.C. Technician/Days	0.8	5
Q.C. Technician/Shift	3.9	46
Maintenance		
Maintenance Foreman	3.0	28
Mechanic/Shift	3.7	130

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EXHIBIT B-2 (2)
USDOL/OSHA

<u>Job Classification</u>	<u>Average Exposure (ppm VCM)</u>	<u>Number of Data Points</u>
Warehouse and Miscellaneous		
Warehouse Supv.	0.5	7
Warehouse Shipping Clerk	1.8	6
Warehouse Receiving Clerk	1.7	5
Warehouseman	0.7	23
Effluent Plant Operator	1.9	22
Boiler Operator	0.9	26
Utility Man	11.0	36
Yard Man and Service Man	0.3	9

Source: Snell summary of industry data

EXHIBIT B - 3(1)

USDOL/OSHA

17 - S - INT. - W

<u>Job Description</u>	<u>Duties</u>	<u>Number of Employees</u>	<u>Average⁽¹⁾ 8 Hr. TWA PPM</u>	<u>Type of Exposure</u>
Supervisor	General Supervisory	8	5	Intermittent
Senior Operator	General Roving Duties	4	8	Intermittent
Reactor Operator	Reactor Charging, Dumping	4	22	Continuous
Solutions Operator	Reactor Charging, Dumping	4	19	Continuous
Utility	Reactor Cleaning	4	16	Intermittent Wear Masks
Recovery Operator	Stripping, Transfer Slurry	4	17	Continuous
Finishing Operator	Drying	4	7	Intermittent
Bulk Operator	Bulk Loading Resin Transfer	5	7	Intermittent
Bagger	Bagging	6	14	Intermittent
Artisan Operator	Monomer Unloading Duties	4	6	Intermittent
Mechanic	Maintenance	5	3	Intermittent
Bulk Loader	Material Handler	3	7	Intermittent
Lab Technician	Analytical	4	1	Intermittent

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EXHIBIT B-3(2)
USDOL/OSHA

<u>Job Description</u>	<u>Duties</u>	<u>Number of Employees</u>	<u>Average⁽¹⁾ 8 Hr. TWA PPM</u>	<u>Type of Exposure</u>
Supervisor	General Supervisory	8	5	Intermittent
3rd Floor. Operator	Reactor Charging	8	22	Continuous
Utility	Reactor Cleaning	6	16	Intermittent Wear Masks
2nd Floor Operator	Stripping Transfer of Slurry	4	17	Continuous
Dryer	Drying	4	7	Intermittent
Dryer	Bulk Loading Resin Transfer	4	7	Intermittent
Bagger	Bagging	6	14	Intermittent
Area 5 Operator	Monomer Unloading Utilities	4	6	Intermittent
Maintenance Mechanic	Maintenance	6	3	Intermittent
Material Handler	Warehouse Work	3	7	Intermittent
Lab Technican	Analytical	8	1	Intermittent

Note: (1) Data collected May 1 - July 15, 1974

Source: Snell summary of industry data

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EXHIBIT B -4 (1)
USDOL/OSHA
MONITORING RESULTS FOR
19-L-NEW-W

<u>Unit Operation</u>	(1) <u>Current VC, ppm</u>	<u>How Measured</u>	<u>Historical VC, ppm</u>	<u>How Measured</u>
VCM Unloading	Typical = 40 ppm Ceiling = 500 ppm	Gas Chromatograph Organic Vapor Analyser	N/A (2)	N/A
Reactor Operation	Typical = 25 ppm Ceiling = 300 ppm	"	N/A	N/A
Drying & Product Transfer	Typical = 20 ppm Ceiling = 75 ppm	"	N/A	N/A
Mechanical Repairs (Flange Breaking, etc.)	Typical = 30 ppm Ceiling = 1000 ppm	"	N/A	N/A

(1) Five minute average

(2) None Available

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EXHIBIT B-4(2)
USDOL/OSHA

I. VCM UNLOADING AREA

<u>Activity Area</u>	<u>VCM</u>	<u>LEVEL</u>	<u>ppm</u>
Under Compressor Shed	10	-	>200
Guaging VCM Storage Tanks		80	
VCM Transfer Pumps	10	-	>100
VCM Unloading Platforms	10	-	>200

II. V-11 VINYL BUILDING

<u>Activity Area</u>	<u>VCM</u>	<u>LEVEL</u>	<u>ppm</u>
Recovery System	5	-	>100
Building Exposure	5	-	>100
At the Dump Strainers	5	-	>100
Water Blasting Reactor		40-180	
Fresh Air System		0-10	

III. V-12 VINYL BUILDING

<u>Activity Area</u>	<u>VCM</u>	<u>LEVEL</u>	<u>ppm</u>
Recovery System	5	-	>100
Building Exposure	5	-	>100
At the Dump Strainers		5-65	
Water Blasting Reactor		40-180	
Charging Control Panel		5-65	

IV. V-11 DRYER BUILDING

<u>Activity Area</u>	<u>VCM</u>	<u>LEVEL</u>	<u>ppm</u>
Centrifuge discharge	0	-	>100
Sifter deck		10-100	
Bird deck		10-100	
Slurry Hook-up Station	10	-	>100
Resin Hook-up Station	6	-	>100
Cleaning Dryer		25-35	
In Dust Collector		8-80	
Taking Silo Readings		10-90	
Sifter Overflow		10-35	
Resin Bagging		10-100	
Resin Warehouse		10-20	

V. LARGE REACTORS

<u>Activity Area</u>	<u>VCM</u>	<u>LEVEL</u>	<u>ppm</u>
Recovery	5	-	>100
Sweço	5	-	>100
VCM Charge Pumps		0-30	

Source: Snell summary of industry data

EXHIBIT B - 5 (1)

USDOL/OSHA

MONITORING RESULTS FOR
40 - L - NEW - W

<u>Unit Operation</u>	<u>Current VC, ppm</u>	<u>How Measured</u>	<u>Historical VC, ppm</u>	<u>How Measured</u>
V-12 Charge Operation	21	Gas Bag	N/A	N/A
V-12 Recovery Operation	7	Gas Chromatograph		
V-12 Maintenance Mechanic	12			
V-12 Utility	11			
V-11 Charge Operation	42			
V-11 Recovery Operation	50			
V-11 Utility	102			
Large Reactor Lead Operator	1			
Large Reactor Operation	5			
Resin Bagger	13			
Vinyl Area Maing. Shop	3			

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EXHIBIT B - 5(2)
USDOL/OSHA

Fork Lift Operator	17
Receptionist Office	1
Engineering Offices	1
Maintenance Shop	1

Note: 1) Continuous monitoring data shown in attached table. This data is as yet experimental.

2) ABD & OKC are presented separately because of difference of equipment and technique.

Source: Snell summary of industry data

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EXHIBIT B - 6(1)

USDOL/OSHA

MONITORING RESULTS FOR

4 - M - NEW - W

Table I -- Vinyl Chloride Levels
(non-respirator areas -- grab samples) May 1 -- June 26, 1974

<u>Location</u>	<u>Operation</u>	<u>Vinyl Chloride -- ppm</u>		
		<u>Median</u>	<u>Low</u>	<u>High</u>
Day Tank Area	Pumping VC	3.4	0.0	71.6
Compressor 1K-1	De-gas	7.0	0.0	136.
Compressor 2K-1	De-gas	3.0	0.6	31.4
VP Seal Discharge	De-gas	8.4	0.3	159.
Blower Discharge	During Cleaning	7.0	0.9	34.0
Popo Sampling	Before Discharge	4.5	0.0	46.5
109/209 Blind	Changing Blind	9.3	0.4	137.
Warehouse (2)	Aisle	5.2	0.0	7.7
Laboratory (3)	Workbench	4.0	Not Applicable	
" (3)	Office	1.7	"	"
" (3)	Compositing Samples	6.4	"	"
Office (3)	Center of Area	2.1	"	"

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Table II -- Distribution of Data --
110 Grab Samples(1)

May 1 to June 26, 1974

VC Levels

Minimum Value 0.0 ppm
Maximum Value 159 ppm

10% of samples showed VC levels of 0.5 ppm or less									
20%	"	"	"	"	"	1.1	"	"	"
30%	"	"	"	"	"	1.7	"	"	"
40%	"	"	"	"	"	2.9	"	"	"
50%	"	"	"	"	"	4.0	"	"	"
60%	"	"	"	"	"	6.4	"	"	"
70%	"	"	"	"	"	9.7	"	"	"
80%	"	"	"	"	"	14.9	"	"	"
90%	"	"	"	"	"	26.2	"	"	"
95%	"	"	"	"	"	39.7	"	"	"
97.5%	"	"	"	"	"	71.6	"	"	"

EXHIBIT B - 6 (3)
USDOL/OSHA

Similarly:

3.64%	showed	VC	levels	greater	than	50	ppm
4.55%	"	"	"	"	"	40	"
11.8%	"	"	"	"	"	25	"
30.0%	"	"	"	"	"	10	"
42.7%	"	"	"	"	"	5	"
81.8%	"	"	"	"	"	1	"

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Table III -- Distribution of 8-HR TWA Levels

May 15 - June 11, 1974

Median 4.9 ppm
Range < 0.1 -- 27.9 ppm

10%	of employees had TWA values of 1.2 ppm or less								
20%	"	"	"	"	"	1.5	"	"	"
30%	"	"	"	"	"	2.3	"	"	"
40%	"	"	"	"	"	3.2	"	"	"
50%	"	"	"	"	"	4.9	"	"	"
60%	"	"	"	"	"	5.9	"	"	"
70%	"	"	"	"	"	7.8	"	"	"
80%	"	"	"	"	"	10.2	"	"	"
90%	"	"	"	"	"	14.0	"	"	"
95%	"	"	"	"	"	21.1	"	"	"
97.5%	"	"	"	"	"	27.9	"	"	"

EXHIBIT B - 6(5)
USDOL/OSHA

Similarly:

None had TWA values greater than 50 ppm

2.2%	"	"	"	"	"	25	"
22.2%	"	"	"	"	"	10	"
44.5%	"	"	"	"	"	5	"
91.1%	"	"	"	"	"	1	"

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Table IV

<u>Job Classification</u>	<u>Number of Values</u>	<u>Vinyl Chloride -- ppm as TWA</u>		
		<u>Median</u>	<u>Low</u>	<u>High</u>
*Reactor Cleaner	21	6.3	1.4	27.9
*Poly Area Operator	4	11.4	4.2	23.7
*Outside Operator	4	3.4	1.9	14.3
Finish. Bldg. Operator	5	1.6	0.4	3.2
Loading Rack Operator	4	3.6	1.2	9.6
Control Room Operator	4	0.9	0.1	6.0
Supervisor	2	3.7	2.5	4.9
Tech. Supt. (in plant)	<u>1</u>	<u>6.9</u>	<u>Not Applicable</u>	
TOTAL	45	4.9	< 0.1	27.9

*TWA mean for reactor building 8.5 ppm -- range 1.4 to 27.9 ppm

Notes: (1) Concentration measurements were obtained from samples taken in 250 ml. glass tubes. Aliquots of these samples were injected directly into a gas chromatograph. Samples absorbed on carbon were desorbed in carbon disulfide prior to injection into the chromatograph.

(2) Four samples only

(3) One sample only

Source: Snell summary of industry data

EXHIBIT B-7(1)
USDOL/OSHA
MONITORING RESULTS FOR
22-M-OLD-C

VINYL CHLORIDE LEVELS

TABLE I

VCM TEST METERS

1946-1967	MSA Explosimeter Lowest reading on scale, 2% of LEL, or 720 ppm - not accurate at this level.
1968-1971	Davis Vaportester Lowest reading on a X10 scale was 0.2% of LEL or 72 ppm - not accurate at this level.
1972-1973	Johnson & Williams SS PK Tester Scale reads 26 ppm per division but not accurate below 50 ppm. Zero drift often in excess of 50 ppm.
1974	Century OVA #98 Portable FID Testers Not specific for VCM. Reads down to 1 ppm. We calibrate with certified gas at 50 and at 5 ppm.

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TABLE 2

EXHIBIT B-7(2)
USDOL/OSHAVinyl Chloride Levels in Operating Buildings

<u>Time Span</u>		<u>C-1</u>	<u>C-2</u>	<u>E-1</u>	<u>E-2</u>	<u>F-1</u>	<u>F-3</u>	<u>K</u>
1946-1972	TWA	500	140	500	150	20	-	-
1973	Number of Readings	77	73	582	597	222	73	85
	TWA (ppm)	50	5	50	25	125	5	175
	Maximum reading (ppm)	2800	200	3000	2800	2460	200	2240
Jan, 1974	Number of Readings	9	9	63	80	27	8	9
	TWA (ppm)	64	8	25	17	93	44	17
	Maximum Reading (ppm)	300	60	504	168	840	300	100
April 8, 1974 to May 21, 1974	Number of Readings*	306	131	935	1068	528	328	132
	TWA (ppm)	8	4	7	6	10	8	7
	Maximum Reading (ppm)	246	35	43	34	50	65	46

*Exclusive of Reactor Cleaning

Work Functions:

- C-1 - Tank Car Unloading, VC pumping, VCM production until 1967
 C-2 - " " " " " " " " " " " "
 E-1 - Polymerization, Monomer Recovery
 E-2 - " " " " " " " " " " " "
 F-1 - Filter, Apron driers
 F-3 - Filter, Rotary drier
 K - Filter, Spray drier

Table 3 -- Area Sampling Results --
 April 8 - June 27, 1974
 (Century OVA Meter)

EXHIBIT B-7(3)
 USDOL/OSHA

Building Readings								
<u>Time Period - 1974</u>	<u>Upwind Reading</u>	<u>E-1</u>	<u>E-2</u>	<u>F-1</u>	<u>C-1</u>	<u>C-2</u>	<u>K</u>	<u>F-3</u>
<u>Average of All Readings (as ppm Vinyl Chloride)</u>								
4/8-4/17	4.9	14.7	12.6		38.9	9.1	14.2	14.7
4/27-5/7	6.2	11.7	11.4		10.1	10.6	14.2	12.8
5/17-5/25	4.8	9.3	9.2		6.7	7.9	10.3	10.9
6/5-6/13	3.7	7.0	7.9	8.2	5.5	5.7	6.2	10.5
6/14-6/27	3.8	7.6	7.7	9.2	5.5	6.0	7.3	7.0
4/8-6/27	4.8	10.5	9.7	13.1	7.2	7.9	10.5	11.6
Number of Readings	240	1678	1229	398	310	153	154	215

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Table 3 (continued)

Maximum Reading Recorded (as ppm Vinyl Chloride)

4/8-4/17	7	45	32	-	500	30	45	42
4/27-5/7	13	28	40	-	24	40	49	33
5/17-5/25	18	35	40	-	21	22	27	45
6/5-6/13	6	20	35	40	10	10	16	55
6/14-6/27	5	27	45	35	12	11	50	20
4/8-6/27	18	50	45	275	500	40	50	55

Note: These data do not cover excursions, but represent routine conditions.

Table 4 -- Vinyl Chloride Levels

April 8 -- June 27, 1974

EXHIBIT B-7(5)
USDOL/OSHA

<u>Time Period - 1974</u>	<u>Century OVA Readings as ppm Vinyl Chloride</u>					
	<u>Average*</u>		<u>Maximum*</u>		<u>Minimum*</u>	
	<u>E-1</u>	<u>E-2</u>	<u>E-1</u>	<u>E-2</u>	<u>E-1</u>	<u>E-2</u>
4/8-4/17	33.0	27.1	115	35	15	14
4/18-4/26	27.5	--	40	--	15	--
4/27-5/7	29.8	33.1	48	46	6	15
5/8-5/16	34.2	--	45	--	10	--
5/17-5/25	25.9	29.8	46	45	7	10
5/26-6/4	20.8	--	45	--	7	--
6/5-6/13	21.8	31.0	41	60	4	15
6/14-6/27	20.3	29.7	40	48	5	10
4/8-6/27	26.5	30.6	115	60	4	10

* A total of 193 readings were taken in E-1 reactors; 98 readings in E-2 reactors.

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Table 5 -- Personnel Monitoring Data --

April 17 -- June 28, 1974

EXHIBIT B-7(6)
USDOL/OSHA

<u>Description of Value</u>	<u>250 ml Glass</u>	<u>10 min Carbon</u>	<u>All Short- Term Samples</u>	<u>8-HR TWA</u>
Number of Samples	94	74	168	31
Minimum Value -- ppm	0.1	Nil	Nil	< 0.04
Maximum Value -- ppm	160	55	160	100
VCM (ppm) -- 10% of samples	0.6	1	< 1	3
20 "	1	< 1	< 1	4
30 "	2	1	1.8	5
40 "	2	2	2	8
50 "	3	3	3	12
60 "	5	3.8	5	14
70 "	7	6	6	16
80 "	12	9	10	20
90 "	22	12	15	24
95 "	42	25	37	28
97.5 "	60	44	55	100

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EXHIBIT B -7 (7)
USDOL/OSHA

Table 5 (continued)

Percentage of values above	50 ppm	4.3	1.4	3.0	6.5
" " " "	40	6.4	2.7	4.8	6.5
" " " "	25	9.6	4.1	7.1	9.7
" " " "	10	20.2	16.2	18.5	51.7
" " " "	5	39.4	31.6	35.7	67.8
" " " "	1	73.4	66.2	70.2	93.7

EXHIBIT B-7(8)
USDOL/OSHA

Table 6 -- Distribution of Personnel Monitoring Data By
Job Function and/or Area

Work Area or Function	Ten Minute-Glass & Carbon Tubes						8-HR TWA					
	Total Samples	No. > 40 ppm	No. > 25 ppm	Vinyl Chloride Ave ppm	Max ppm	Min ppm	Total Samples	No. > 25 ppm	No. > 10 ppm	Vinyl Chloride Ave ppm	Max ppm	Min ppm
Reactor Cleaning	20	6	9	23.1	160	2	6	0	5	15.7	22	8
Batch Transfer	23	1	2	8.3	75	1	3	0	1	7.7	12	4
Reactor Area	23	0	0	5.0	22	1	5	0	2	10.0	24	3
Pump Room	12	0	0	5.8	9	1	1	0	0	5.0	--	--
Control Room	11	0	0	6.9	12	2	2	1	1	18.0	23	9
E-Bldg. Supervisor	--	--	--	--	--	--	3	1	1	22.0	51	4
Bagger	13	0	0	4.9	13	1	2	0	0	4.5	6	3
P&S Dryer	9	1	1	14.6	60	3	3	0	3	17.3	24	13
Break Room	7	0	0	1.2	2	1	--	--	--	--	--	--
Locker Room	7	0	0	1.3	2	0.4	--	--	--	--	--	--
Lunch Room	6	0	0	1.8	7	Nil	--	--	--	--	--	--
Main Office	7	0	0	1.7	5	Nil	1	0	0	0.04	--	--
Warehouse	7	0	0	2.0	5	1	2	0	0	2.1	3.6	0.6
Telex	10	0	0	1.3	10	0.1	--	--	--	--	--	--
Laboratory	6	0	0	0.6	1	Nil	--	--	--	--	--	--
Maintenance Shop	7	0	0	0.6	2	0.1	--	--	--	--	--	--
Shift Monitor	--	--	--	--	--	--	3	1	3	44.0	100	16

Source: Snell summary of industry data

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EXHIBIT B-8

USDOL/OSHA

MONITORING RESULTS FOR

31-M-MEW-C

<u>Location</u>	<u>Total Employees</u>	<u>Current Estimated VCM Exposure Levels (PPM) (1)</u>
. Outside, Tank Car Unloading.	1	0 - 5
. Outside, Storage Area	1	0 - 5
. Reactor Building	60	25 - 30 (w/excursions to 50)
. Centrifuge and Dryer Building	8	0 - 5
. Outside, PVC Silos	6	0 - 5
. Bulk Pack Bagging Building	6	0 - 5
. Bagging Warehouse	15	0 - 5

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Note:

(1) Monitoring performed with Ovameter

Source: Snell summary of industry data

EXHIBIT B-9
 USDOL/OSHA
 MONITORING RESULTS FOR
 45-M-INT-C

<u>Unit Operation</u>	<u>Current Range</u> VCM (PPM)	<u>How Measured</u>
VC Unloading (1)	0 - 200	Gas Chromatograph
Polymerization	10 - 50	Gas Chromatograph
Kettle Cleaning (1)	10 - 175	Gas Chromatograph
Drying	5 - 40	Gas Chromatograph
Packaging (1)	5 - 125	Gas Chromatograph
Shipping	0 - 70	Gas Chromatograph

Note: (1) Type C continuous flow air masks required while performing this function.

Source: Snell summary of industry data

EXHIBIT B-10
USDOL/OSHA
MONITORING RESULTS FOR
30-M-NEW-C

<u>Unit Operation</u>	<u>Current VC, PPM</u>	<u>How Measured</u>	<u>Historical VC, PPM</u>	<u>How Measured</u>
1. VC Unloading	<50	GC		
2. Prepolymerizer			<200	Odor ⁽¹⁾
Charging	20 - 40	GC		
Opening	>100	GC		
Cleaning	25 - 100	GC		
3. Postpolymerizer				
Charging	<25	GC		
Opening	50 - 150	GC		
Cleaning	<50	GC		
Transfer	>50	GC		
4. Bagging	<50	GC		

Note: (1) Not a reliable measurement

Source: Snell summary of industry data

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EXHIBIT B-11
USDOL/OSHA

MONITORING RESULTS FOR

41-L-OLD-W

<u>Job Description</u>	<u>Number of Samples</u>	<u>Average Worker Exposure to VCM in PPM</u>	<u>Range of Worker Exposure to VCM in PPM</u>
Maintenance	42	1.9	< 0.1 - 26.6
Poly Scrubber	16	14.4	2 - 49.7
Lab Technician	13	184.1	0.2 - 2375
Bagger	6	2.5	0.1 - 8.4
Compounding Operator	19	1.7	0.1 - 8.7
Dryer Operator	34	78.8	0.5 - 915.7
HRC Operator	10	3.8	< 1.0 - 18.4
Head Operator	17	4.9	1.0 - 26.4
Poly Head Operator	21	6.6	0.3 - 45.9
Poly Drop Operator	26	5.7	0.9 - 52.7
Drop Operator	6	2.5	1.0 - 5.6

Note: Snell average of data for the months of March through June 1974.

Source: Snell summary of industry data

EXHIBIT B-12
USDOL/OSHA
MONITORING RESULTS FOR
28-L-NEW-C

<u>Unit Operation</u>	<u>Current VCM Concentration Since July, 1974 (PPM)</u>	<u>How Measured</u>	<u>Historical VCM Concentration Since April, 1974 (PPM)</u>	<u>How Measured</u>
. Polymerization and Setting	5 - 10 11 - 10	FID (1) Carbon Tube	7 - 90 20 - 130	FID Carbon Tube
. Centrifugation	100 - 160	FID	100 - 160	FID
. VC Recovery and Unloading	7 - 180 27	FID Carbon Tube	Up to 10,000 Up to 10,000	FID Carbon Tube
. Reactor Entry For Cleaning	4 - 42	Carbon Tube	40 - 200	FID
. Transfer and Loading	0 - 3	FID	0 - 3	FID
. Warehousing	0 - 3	FID	0 - 3	FID

Note:

(1) FID = Flame Ionization Detector

Source: Snell summary of industry data

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EXHIBIT B-13(1)
USDOL/OSHA
MONITORING RESULTS FOR
54-M-NEW-C

Job/Location	No. of Data Points	Vinyl Chloride Monomer Concentrations (PPM)		
		Avg. (1)	High	Low
Scrubbing	20	65	199	8
Bagger and Bag Operators	17	20	70	0.4
Operator and Operator Workmen	72	24	239	0.6
Control Man/Control Room	27	27	343	0.2
Sampling and Checking	26	61	1021	0.3
Reclaim Operator	7	55	227	3
Waste Lake	2	2	4	0.8
Maintenance	17	10	34	0.2
Washing and Cleaning	42	65	1389	0.3
Perimeters	48	2	11	0.5
Loading Operators	16	31	213	0.6
River Discharge	1	1	X	X
Dicer	6	3	8	0.5
Dropping and Charging	23	70	671	0
Blending and Milling/Mill	9	6	36	0.6
Intakes, Exhausts, Vents	9	22	104	0.4
Dust Collectors	10	16	76	1
Office Areas	7	2	4	0.3
Work Areas and Decks	33	8	74	0.7
Dryers and Vicinity	7	51	168	0.8
Product Collectors	2	10	16	3
FCM Rotors	2	1827	2141	1512

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EXHIBIT B-13(2)
USDOL/OSHA

Notes:

• X = Not Applicable

(1) Snell averaging of reported data.

Source: Snell summary of industry data

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EXHIBIT B-14(1)
USDOL/OSHA

MONITORING RESULTS FOR
5-L-OLD-C

Atmospheric Concentration Vinyl Chloride During Cleaning
of 4,000 Gal.
Suspension Process

<u>Sample Location</u>	<u>Air Concentration Vinyl Chloride ppm</u>
1. Operator breathing zone when entering polymerizer	19
2. Operator breathing zone while scraping walls of polymerizer	22
3. Operator breathing zone while scraping walls of polymerizer	19

August-September 1967

Monomer Concentration in Polymerizer Atmospheres

<u>Polymer Type</u>	<u>Poly No.</u>	<u>Poly Size "</u>	<u>Total Evacuation Time</u>	<u>VCl ppm Monomer</u>	
				<u>10 Min.*</u>	<u>30 Min.**</u>
Suspension	120	1100	20"	84	72
"	130	1100	18"	50	46
"	151	1100	25"	42	32
"	102	1100	35"	99	78
"	124	1100	20"	230	123
"	128	1100	20"	77	80
"	150	1100	50"	20	25
"	150	1100	20"	76	80
"	121	1100	40"	34	34
"	128	1100	40"	104	63
"	136	1100	45"	56	62

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EXHIBIT B-14(2)
USDOL/OSHA

"	130	1100	90"	93	32
"	133	1100	25"	146	97
"	114	1100	25"	375	250
"	113	1100	30"	147	107
"	117	1100	25"	234	264
"	135	1100	25"	180	185
"	132	1100	40"	147	104
"	136	1100	40"	118	64
"	116	1100	60"	76	59
Dispersion	25	1100	22"	74	100
"	32	1100	20"	56	114
"	29	1100	30"	34	84
"	48	1100	25"	417	391
"	28	1100	55"	36	68
"	45	1100	55"	78	100
"	42	1100	60"	100	189
"	43	1100	25"	75	148
"	32	1100	30"	211	279
"	25	1100	35"	55	39
"	6	1100	25"	102	37
"	25	1100	30"	62	41
"	19	1100	25"	94	88
"	34	1100	25"	40	29
"	6	1100	40"	35	44
"	20	1100	30"	165	168
"	9	1100	25"	120	99
"	12	1100	25"	60	78
"	4	1100	30"	271	152

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August-September 1967

Monomer Concentration in Polymerizer Atmospheres
con't.

Polymer Type	Poly No.	Poly Size	Total Evacuation Time	VCl ppm Monomer	
				10 Min.*	30 Min.**
Dispersion	8	1100	60"	27	80
"	12	1100	25"	174	320
"	21	1100	18"	102	104
"	12	1100	30"	142	168
"	17	1100	35"	38	68
Suspension	137	3300	20"	374	134
"	143	3300	45"	405	142
"	137	3300	25"	62	112
"	141	3300	35"	138	123
"	113	1100	15"	54	59
"	127	1100	10" & 30"	32	498
"	116	1100	10" & 5"	440	390
"	106	1100	30"	192	188
"	146	3300	30"	162	200
"	142	3300	35"	147	139
"	124	1100	30"	128	101
"	142	3300	35"	106	113
"	105	1100	30"	52	47
"	148	3300	45"	26	24

* Sample collected 10 minutes after operator enters poly,
operator breathing zone sample.

**Sample collected 30 minutes after operator enters poly or
after cleaning, if cleaning time was less than 30 minutes;
operator breathing zone sample.

EXHIBIT B-14(4)
USDOL/OSHA

Monomer Concentration in Room Air

<u>Date</u>	ppm VC	
	<u>Dispersion Resin</u> <u>Bldg. 451</u>	<u>Suspension Resin</u> <u>Bldg. 461</u>
8-29-67		53
9-5-67	16	27
9-7-67	58	45
9-11-67		26
9-12-67	450	18
9-25-67		31
9-26-67		48
9-28-67	6	32

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Monomer Concentration in Polymerizer Atmospheres
October 1967

Polymer Type	Poly No.	Poly Size	Total Evacuation Time	VCl ppm Monomer	
				10 Min.	30 Min.
Suspension	25	1100	65"	71	95
"	43	1100	45"	59	50
"	33	1100	45"	48	70
"	29	1100	35"	73	117
"	41	1100	35"	75	38
"	25	1100	30"	73	98
"	30	1100	65"	66	114
"	45	1100	80"	30	23
"	34	1100	65"	35	43
"	46	1100	35"	56	55
Dispersion	16	1100	50"	115	210
"	18	1100	20"	156	114
"	14	1100	30"	53	74
"	18	1100	35"	58	62
"	2	1100	25"	58	56
Suspension	142	3300	45"	50	35

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EXHIBIT B-14(6)
USDOL/OSHA

Monomer Concentration in Room Air
ppm VCl

<u>Date</u>	<u>Dispersion Resin</u> Bldg. 451	<u>Suspension Resin</u> Bldg. 461
10-16-67	142	26
10-17-67	14	
10-23-67	28	
10-30-67	44	

Ambient Concentrations of Vinyl Chloride ppm

<u>Year</u>	<u>Date</u>	<u>Dispersion Resin</u> <u>Building 451</u>	<u>Suspension Resin</u> <u>Building 461</u>	<u>Suspension Resin</u> <u>Building 464</u>
1967	8-29		53	
	9-5	16	27	
	9-7	58	45	
	9-11		26	
	9-12	450	18	
	9-25		31	
	9-26		48	
	9-28	6	32	
	10-16	142	26	
	10-17	14		
	10-23	28		
	10-30	44		
1968	9-18	21	47	
			49	
			30	
	9-23	21	47	22
		42		
		24		
	9-30	59	68	

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EXHIBIT B-14 (7)
USDOL/OSHA

		72	88	
			65	
			76	
	10-8	28		
		133		
	10-30		24	
	11-12		18	
			62	
			61	
			63	
	11-13			14
				27
				15
				7
	11-19		29	13
			73	
1972	6-29			
			41	
			41	
			3	
			16	
			41	
			41	
Average		72	38	16

Atmospheric Vinyl Chloride Concentrations in Charging Area

Dispersion Resin
Building 451

Tuesday, 8-22-72; 11 a.m.

West Side	82 ppm
East Side	155 ppm
Control Room	8 ppm

Tuesday, 8-22-72; 3 p.m.

West Side	89 ppm
East Side	378 ppm
Control Room	64 ppm

Thursday, 8-24-72; 9 a.m.

West Side	78 ppm
East Side	13 ppm
Control Room	5 ppm

Thursday, 8-24-72; 11 a.m.

West Side	73 ppm
Center	104 ppm
East Side	30 ppm

Thursday, 8-24-72; 1 p.m.

West Side	97 ppm
Center	72 ppm
East Side	10 ppm

EXHIBIT B-14-(9)
USDOL/OSHA

Thursday, 8-24-72; 3 p.m.

West Side	33 ppm
Center	33 ppm
East Side	13 ppm

Friday, 8-25-72; 9 a.m.

West Side	135 ppm
Center	22 ppm
East Side	148 ppm

Friday, 8-25-72; 11 a.m.

West Side	24 ppm
Center	24 ppm
East Side	131 ppm

Dispersion Resin
Building 451
con't.

Friday, 8-25-72; 1 p.m.

West Side	47 ppm
East Side	95 ppm
Control Room	54 ppm

Thursday, 9-7-72; 1 p.m.

West Side	23 ppm
East Side	440 ppm

EXHIBIT B-14 (10)
USDOL/OSHA

Suspension Resin
Building 461

Tuesday, 8-22-72; 11 a.m.

West Side	531 ppm
East Side	131 ppm
Control Room	49 ppm

Tuesday, 8-22-72; 3 p.m.

West Side	48 ppm
East Side	32 ppm
Control	24 ppm

Thursday, 8-24-72; 9 a.m.

West Side	29 ppm
East Side	288 ppm
Control Room	26 ppm

Thursday, 8-24-72; 11 a.m.

West Side	329 ppm
Center	762 ppm
East Side	70 ppm

Thursday, 8-24-72; 1 p.m.

West Side	20 ppm
East Side	72 ppm

Thursday, 8-24-72; 3 p.m.

West Side	33 ppm
Center	107 ppm
East Side	87 ppm

EXHIBIT B-14 (11)
USDOL/OSHA

Friday, 8-25-72; 9 a.m.

West Side
Center
East Side

369 ppm
364 ppm
135 ppm

Suspension Resin
Building 461

Friday, 8-25-72; 11 a.m.

West Side
Center
East Side

168 ppm
186 ppm
156 ppm

Fri

Friday, 8-25-72; 1 p.m.

West Side
East Side

358 ppm
122 ppm

Thursday, 9-7-72; 1 p.m.

West Side
East Side

51 ppm
74 ppm

Suspension Resin
Building 464

Tuesday, 8-22-72; 11 a.m.

North End

82 ppm

Tuesday, 8-22-72; 3 p.m.

North End
Center
South End

5 ppm
32 ppm
32 ppm

EXHIBIT B-14(12)
USDOL/OSHA

Thursday, 8-24-72; 9 a.m.

North End	8 ppm
Center	13 ppm
South End	5 ppm

Thursday, 8-24-72; 11 a.m.

North End	5 ppm
Center	7 ppm
South End	7 ppm

Thursday, 8-24-72; 1 p.m.

North End	5 ppm
Center	15 ppm
South End	15 ppm

Thursday, 8-24-72; 3 p.m.

North End	7 ppm
Center	47 ppm
South End	67 ppm

Suspension Resin
Building 464

Friday, 8-25-72; 9 a.m.

North End	36 ppm
Center	9 ppm
South End	9 ppm

Friday, 8-25-72; 11 a.m.

North End	24 ppm
Center	12 ppm
South End	36 ppm

EXHIBIT B-14(13)
USDOL/OSHA

Friday, 8-25-72; 1 p.m.

North End
Center
South End

47 ppm
108 ppm
115 ppm

Area Measurements Using Portable and Fixed
Instrumentation, Measuring Total Hydrocar-
bons by the Flame Ionization Method

<u>Building</u>	<u>Product</u>	<u>Month</u>	<u>Average</u> ppm	<u>% Readings</u> <u>Above 50 PPM</u>	<u>% Readings</u> <u>Under 10 PPM</u>
451	Dispersion Resin	JAN. 74	29.5	3.5	8.7
		FEB. 74	23.7	3.9	14.4
		MAR. 74	15.3	2.6	23.4
		APR. 74	17.1	4.9	42.9
		MAY 74	17.8	2.7	65.2
		JUNE 74	11.3	4.7	72.5

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EXHIBIT B-14(14)
USDOL/OSHA

461	Suspension Resin	JAN. 74	25.6	4.7	24.1
		FEB. 74	17.8	3.3	37.9
		MAR. 74	19.1	2.5	21.7
		APR. 74	18.7	3.4	14.6
		MAY 74	15.4	2.2	59.3
		JUNE 74	11.9	4.9	57.8
464	Suspension Resin	JAN. 74	31.4	5.1	11.1
		FEB. 74	22.7	3.1	10.3
		MAR. 74	18.3	1.1	34.8
		APR. 74	12.7	0.0	58.9
		MAY 74	8.8	2.8	71.2
		JUNE 74	6.0	2.8	82.5
463	PVC Latex	JAN. 74	8.1	0.0	70.9
		FEB. 74	8.2	0.2	91.7
		MAR. 74	7.4	0.0	97.5
		APR. 74	7.6	0.7	97.6
		MAY 74	9.6	0.4	86.3
		JUNE 74	8.1	1.9	82.3

EXHIBIT B-14(15)
USDOL/OSHA

PERSONNEL MONITORING DATA - MAY-JULY, 1974

<u>Location and Type</u>	<u>Operation</u>	<u>No. of Samples</u>	<u>TWA</u>	<u>PPM VCI</u>	
			<u>Average</u>	<u>Maximum</u>	<u>Minimum</u>
East Bldg. 464 Suspension Resin	Charging	5	10	23	3
	Cleaning	4	12	23	2
	Recovery	6	14	31	3
West Bldg. 451 Dispersion Resin	Charging	5	8	18	4
	Cleaning	7	19	42	6
	Recovery	3	9	15	3
	Drying and Bagging	4	1	2	1
West Bldg. 461 Suspension Resin	Charging	3	10	22	3
	Cleaning	6	22	80	5
	Recovery	4	17	26	6
	Supervisory	1	12		
West Bldg. 453 Latex	Charging	4	14	23	2
	Cleaning	3	47	126	4
	Recovery	2	80	154	6
	Supervisory	1	3		

Notes:

Everyone wears respiratory equipment where the work atmosphere is greater than 25 ppm or where operations and experience show there is a risk of exceeding 25 ppm.

Personnel monitoring samples are taken over a period of time generally 4 hours (some data represents 20 minute samples) to obtain the time weighted average for employee exposure. All samples are collected by absorption on carbon tubes and tested using gas chromatography.

Source: Snell summary of industry data

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EXHIBIT B-15(1)

USDOL/OSHA

MONITORING RESULTS FOR

8-L-NEW-C

Atmospheric Concentrations of Vinyl Chloride
- Building 731

<u>Sample Location</u>	<u>Vinyl Chloride Concentration (ppm)</u>
Near Manhole, Poly No. 2 - Suspension Resin	15
Near Manhole, Poly No. 7 " "	18
Near Manhold, Poly No. 11 " "	24
Near Manhold, Poly No. 21 - Dispersion Resin	34

Atmospheric Concentrations of Vinyl Chloride
2nd Floor Bldg. 731

Tuesday, April 4

VCl ppm

12:50 PM

Aisleway paste* line proceeding North to South Poly #36 & 35	102
Aisleway paste line proceeding North to South Poly #29 & 30	98
Aisleway paste line proceeding North to South Poly #22 & 21	41

1:05 PM

Aisleway pearl* line proceeding North to South Poly #15 & 17	268
Aisleway pearl line proceeding North to South Poly #9 & 11	271
Aisleway pearl line proceeding North to South Poly #3 & 5	124

1:30 PM

Aisleway pearl line proceeding North to South Poly #15 & 17 (approx.)	737
Aisleway pearl line proceeding North to South Poly #9 & 11	76
Aisleway pearl line proceeding North to South Poly #3 & 5	50

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EXHIBIT B-15(2)
USDOL/OSHA

2:58 PM to 3:02 PM

Aisleway pearl line proceeding North to South Poly #9 & 10 (Approx.)	550
Aisleway pearl line proceeding North to South Poly #2 & 1	62
Outside control room by metering station	260

3:53 PM

Aisleway pearl line proceeding North to South Poly #15 & 17	40
Aisleway pearl line proceeding North to South Poly #9 & 11	50
Aisleway pearl line proceeding North to South Poly #3 & 5	5
Outside control room by metering station	30

4:15 PM

Aisleway paste line proceeding North to South Poly #36 & 35	68
Aisleway paste line proceeding North to South Poly #22 & 21	68
Aisleway paste line proceeding North to South Poly #15 & 17	58
Outside control room by metering station	55

4:25 PM

Aisleway paste line between Poly #36 & 35	68
Outside control room by metering station	35

4:50 PM

Aisleway paste line proceeding North to South Poly #36 & 35	39
Aisleway paste line proceeding North to South Poly #29 & 30	48
Aisleway paste line proceeding North to South Poly #22 & 21	39
Aisleway pearl line at South end of Poly #3 & 5	45

* "Paste" means dispersion resin
"Pearl" means suspension resin

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EXHIBIT B -15(3)
UCDOL/OSHA

Atmospheric Concentrations of Vinyl Chloride
2nd Floor Bldg. 731

Wednesday, April 5

VC1 ppm

12:13 PM to 12:19 PM

Just inside doorway to 2nd floor poly area	250
Aisleway paste* line proceeding North to South Poly #35 & 36	318
Aisleway paste line proceeding North to South Poly #30 & 29	462
Aisleway pearl* line proceeding North to South Poly #20 & 19	332
Aisleway pearl line proceeding North to South Poly #14	474
Aisleway pearl line proceeding North to South Poly #4	122

12:42 PM to 12:48 PM

Inside control room	15
Outside control room by metering station	130
Aisleway pearl poly line between Polys #9 & 10	130
Doorway to compound room near freight elevator	145
Aisleway paste poly line by Poly #24	133
By Bldg. exit door located behind control room	117

3:00 PM to 3:06 PM

Inside control room	5
Outside control room by metering station	45
Aisleway pearl line; North end by Polys #15 & 16	38
Aisleway pearl line; South end by Polys #1 & 2	23
Aisleway paste line; North end by Polys #33 & 34	90
Aisleway paste line; South end by Polys #21 & 22	108

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EXHIBIT B-15(4)
USDOL/OSHA

3:30 PM to 3:40 PM

At manhead to pearl Poly #6; just off recovery, fumes seen venting to room	(approx.)	550
In aisleway in front of pearl Poly #6		438
At manhead to pearl Poly #2; exhaust hose had just been removed		470
At manhead to paste poly #34; after HRC cleaning		400
At manhead to paste Poly #30; poly filled with cleaning solution		5
In aisleway between paste Polys #27 & 38		5

5:00 PM to 5:15 PM

Inside control room	10
Outside control room by metering station	45
Aisleway pearl line proceeding North to South Polys #15 & 16	40
Aisleway pearl line proceeding North to South Polys #5 & 6	15
Aisleway paste line proceeding North to South Polys #35 & 36	77
Aisleway paste line proceeding North to South Polys #21 & 22	65

* "Paste" means dispersion resin
"Pearl" means suspension resin

Atmospheric Concentrations of Vinyl Chloride
In Bldg. 731

Thursday, April 6

VC1 ppm

9:30 AM to 9:40 AM

Inside control room	2
Outside control room by metering station	8
Aisleway pearl* line proceeding North to South Polys #19 & 20	148
Aisleway pearl line proceeding North to South Polys #1 & 2	268
Aisleway paste* line proceeding North to South Polys #35 & 36	25
Aisleway paste line proceeding North to South Polys #21 & 22	45

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EXHIBIT B-15 (5)
USDOL/OSHA

10:45 AM to 11:00 AM

Inside control room	15
Outside control room by metering station	28
Aisleway pearl line proceeding North To South Polys #19 & 20	25
Aisleway pearl line proceeding North to South Polys #14 & 13	28
Aisleway pearl line proceeding North to South Polys #3 & 4	27
At manhead pearl Poly #8; opened for cleaning	300
Aisleway paste line proceeding North to South Polys #35 & 36	30
Aisleway paste line proceeding North to South Polys #31 & 32	30
Breathing zone of man hose washing #25 paste poly	100
Aisleway by paste premix poly	18

1:45 pm to 2:05 PM.

Outside control room by metering station	32
By doorway to compounding room; near freight elevator	27
Aisleway pearl line proceeding North to South Polys #15 & 16	14
Aisleway pearl line proceeding North to South Polys #3 & 4	30
At manhead of pearl Poly #9	33
At manhead of pearl Poly #14	22
Aisleway paste line proceeding North to South Polys #33 & 34	30
Aisleway paste line proceeding North to South Polys #29 & 30	26
Aisleway paste line proceeding North to South Polys #23 & 24	31
At manhead paste Poly #31	163
At manhead paste Poly #34	168
By bldg. exit door behind control room	35
On mezzanine level by #9 blowdown tank	20
On mezzanine level by #6 blowdown tank	31
On Mezzanine level at South end paste blowdown area	26

* "paste" means dispersion resin
"pearl" means suspension resin

EXHIBIT B-15(6)
USDOL/OSHA

Thursday, April 6 -- Con't.

VC1 ppm

8:40 PM to 8:50 PM

Outside control room by metering station	108
At doorway to compound room; near freight elevator	95
Aisleway pearl line proceeding North to South Polys #15 & 16	43
Aisleway pearl line proceeding North to South Polys #5 & 6	72
Aisleway paste line proceeding North to South Polys #33 & 34	98
Aisleway paste line proceeding North to South Polys #23 & 24	21

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VCL MONITORING DATA

Area Measurements Using Portable and Fixed
Instrumentation, Measuring Total Hydrocar-
bons by the Flame Ionization Method

<u>Building</u>	<u>Product</u>	<u>Month</u>	<u>Average</u> ppm	<u>% Readings</u> <u>Above 50 PPM</u>	<u>% Readings</u> <u>Under 10 PPM</u>
731	Suspension and Dispersion Resins	JAN. 74	90.7	33.0	20.3
		FEB. 74	31.4	10.0	17.4
		MAR. 74	18.3	2.0	27.9
		APR. 74	16.8	4.8	69.1
		MAY 74	8.6	2.3	82.0
		JUNE 74	8.3	2.9	79.1

EXHIBIT B -15(8)
USDOL/OSHA

PERSONNEL MONITORING DATA

May - July, 1974

<u>Location and Type</u>	<u>Operation</u>	<u>No. of Samples</u>	<u>TWA</u>	<u>PPM VCI</u>	
			<u>Average</u>	<u>Maximum</u>	<u>Minimum</u>
Suspension Resin	Charging	7	6	13	2
	Cleaning	7	4	8	2
	Recovery	4	6	9	4
Dispersion Resin	Charging	5	5	8	2
	Cleaning	3	12	26	2
	Recovery	3	4	5	3

Everyone wears respiratory equipment where the work atmosphere is greater than 25 ppm or where operations and experience show there is a risk of exceeding 25 ppm.

Personnel monitoring samples are taken over a period of time generally 4 hours to obtain the time weighted average for employee exposure. All samples are collected by absorption on carbon tubes and tested using gas chromatography.

Source: Snell summary of industry data

EXHIBIT B 1C(1)

USDOL/OSHA

MONITORING RESULTS FOR

49-M-OLD-C

CHROMATOGRAPHIC ANALYSIS DATA

Ambient Concentrations Vinyl Chloride, ppm

<u>Year</u>	<u>Date</u>	COPOLYMER RESIN Building 3rd Floor	SUSPENSION RESIN Building 1	SUSPENSION RESIN Building 111	DISPERSION RESIN & LATEX Building 121 3rd Floor
		<u>3rd Floor</u>			
1965	10-27	17			
	11-10	117			
	11-10	51			
	11-11	183			
		182			
	12-8	99			
	12-10	75			
1966	1-10	47			
	1-12	30			
	1-13	18			
	1-14	2			
		38			
		98			
		97			
		68			
	9-2	55			
		28			
	9-13	111			

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EXHIBIT B-16(2)
USDOL/OSHA

<u>Year</u>	<u>Date</u>	COPOLYMER RESIN Building 15 <u>3rd Floor</u>	SUSPENSION RESIN Building 1 <u> </u>	SUSPENSION RESIN Building 111 <u> </u>	DISPERSION RESIN & LATEX Building 121 <u>3rd Floor</u>	
1967	2-8	26				
	2-14	32				
	2-15	12				
	2-17	24				
	12-9	28	41	80	231 632	
	11-2	10				
	12-11				52 374 110	
	12-12					
	12-15	51 49				
	12-18	42				
	1968	1-9				135 130 138 97 85 81 72 114
		12-16	26	23	36	
		12-17	2	20	42	

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EXHIBIT B-16 (3)
USDOL/OSHA

Ambient Concentrations Vinyl Chloride, ppm

Year	Date	COPOLYMER RESIN			SUSPENSION RESIN		DISPERSION RESIN & LATEX
		Building 15 3rd Floor	Building 15 2nd Floor	Building 15 1st Floor	Building 1 3rd Floor	Building 111 3rd Floor	Building 121 3rd Floor
1969	1-31	194					
	2-3	92					
	2-14	12					
	3-26	199					
	9-30	77					
		58					
1972	3-21	4			1	0.5	2
		1			1	0.5	4
					0.5	1	1
	3-22					7	1
						1	6
		4					0.5
		1			7	7	6
		5			5	3	5
		2			0.5	5	4
		2			2	10	3
		6			4	9	5
		2			4	10	3
					3	12	3
					1	11	6
					4	12	
1973	3-22	132	10	3			
		57	19	7			
		44	22				
		33					
		28					
		12					

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EXHIBIT B-16(4)
USDOL/OSHA

Exhaust Time - 15 Min.
- 30 Min.

Polymerizer Vapor Concentrations: Vinyl Chloride, ppm

<u>Year</u>	<u>Date</u>	<u>Copolymer Resin Building 15</u>	<u>Suspension Resin Building 1</u>
1964		93	
		153	
		150	
		120	30
		120	30
1965	3-1	310	30
		145	
		150	
	10-27	28	
		31	
		77	
		134	
		29	
		21	
	11-8	55	
	11-9	48	
	11-10	132	
	12-8	92	
	12-10	32	

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EXHIBIT B-16(5)
USDOL/OSHA

<u>Year</u>	<u>Date</u>	<u>Copolymer Resin Building 15</u>	<u>Suspension Resin Building 1</u>
1966	1-7	26	
	1-10	50	
	1-12	18	
	1-13	23	
	1-14	94	
	3-29	49	
		164	
	9-6	34	
	9-13	60	
1967	2-8	42	
	2-9	79	
	2-10	61	
	2-14	45	
	2-15	20	
	2-17	126	
	2-20	129	
		106	
	4-14	40	
	6-30	20	
	4-26	100	

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EXHIBIT B-16 (C)
USDOL/OSHA

Polymerizer Vapor Concentrations: Vinyl Chloride, ppm

<u>Year</u>	<u>Date</u>	<u>Copolymer Resin</u>	<u>Suspension Resin</u>		<u>Dispersion Resin & Latex</u>
		<u>Building 12</u>	<u>Building 1</u>	<u>Building 111</u>	<u>Building 121</u>
1967	5-15	100			
		120			
	5-16	73			
	9-8	32			
		12			
	9-14	46			
	9-18	46			
	9-27	14			
	12-4	55	75	79	628
		105	34	109	555
		75	46	122	490
		18	74	134	219
		36	34	60	
		32	55	70	
			67	100	
			58	105	
			55	30	
			59	59	
	10-26	36			
		13			
	11-1	20			
		19			
	11-2	16			
	12-18	77			

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EXHIBIT B-16(7)
USDOL/OSHA

<u>Year</u>	<u>Date</u>	<u>Copolymer Resin</u>	<u>Suspension Resin</u>		<u>Dispersion Resin & Latex</u>
		<u>Building</u>	<u>Building</u>	<u>Building</u>	<u>Building</u>
		15	1	111	121
1969	1-31	131			
	2-3	38			
	2-14	11			
	3-26	34			
	9-22	181			
		101			
	9-29	84			
		176			
1973		143			
	9-30	107			
		217			
	3-22	2			
		10			
		3			

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VCL MONITORING DATA

Area Measurements Using Portable and Fixed
Instrumentation, Measuring Total Hydrocarbons
by the Flame Ionization Method

<u>Building</u>	<u>Product</u>	<u>Month</u>	<u>Average PPM</u>	<u>% Readings Above 50 PPM</u>	<u>% Readings Under 10 PPM</u>
121	Dispersion Resin and Latex	JAN. 74	24.8	10.9	0.2
		FEB. 74	20.8	3.2	5.9
		MAR. 74	13.1	0.6	40.8
		APR. 74	12.4	1.7	62.0
		MAY 74	9.5	1.0	86.2
		JUNE 74	4.2	0.9	88.3
111	Suspension Resin	JAN. 74	35.6	9.1	0.2
		FEB. 74	20.8	2.0	5.9
		MAR. 74	15.6	1.5	36.0
		APR. 74	12.1	1.8	71.0
		MAY 74	8.9	1.7	90.2
		JUNE 74	3.4	1.5	90.5

EXHIBIT B-16 (9)
USDOL/OSHA

<u>Building</u>	<u>Product</u>	<u>Month</u>	<u>Average PPM</u>	<u>Z Readings Above 50 PPM</u>	<u>Z Readings Under 10 PPM</u>
1	Su pension Resin	JAN. 74	24.9	3.0	0.4
		FEB. 74	18.9	0.6	7.8
		MAR. 74	16.6	1.3	21.0
		APR. 74	12.1	1.3	73.8
		MAY 74	7.1	1.2	90.9
		JUNE 74	5.5	1.1	91.2
15	Copolymers	JAN. 74	30.0	6.4	0.7
		FEB. 74	22.0	2.2	5.1
		MAR. 74	15.7	1.2	29.4
		APR. 74	13.1	2.2	64.7
		MAY 74	15.0	4.6	62.9
		JUNE 74	10.2	1.7	78.6
115	VCl Recovery Purification	JAN. 74	----	- Data Not Taken -	
		FEB. 74	27.0	3.0	0.5
		MAR. 74	29.0	5.0	9.3
		APR. 74	15.5	1.9	34.7
		MAY 74	20.2	5.4	33.3
		JUNE 74	17.6	0.8	25.2

PERSONNEL MONITORING DATA - MAY-JULY, 1974 -

<u>Location and Type</u>	<u>Operation</u>	<u>No. of Samples</u>	<u>TWA</u>	<u>PPM VC1</u>	
			<u>Average</u>	<u>Maximum</u>	<u>Minimum</u>
Building 121 Latex and Dispersion Resin	Charging	4	5	5	2
	Cleaning	2	-	2	1
	Recovery	2	-	6	1
	Pipefitter	1	4	-	-
Building 111 Suspension Resin	Charging	2	-	19	7
	Cleaning	3	4	7	2
	Recovery	2	-	3	<.5.
	Bagging and Drying	3	1	1	<.5
Building 15 Copolymer Resin	Charging	2	-	4	2
	Cleaning	2	-	11	6
	Bagging	2	-	10	7
	Pipefitter	1	14	-	-
Building 1 Suspension Resin	Charging	2	-	3	2
	Cleaning	1	-	-	1
	Recovery	3	15	42	1
	Bagging	1	3	-	-

Notes:
Everyone wears respiratory equipment where the work atmosphere is greater than 25 ppm or where operations and experience show there is a risk of exceeding 25 ppm.

Personnel monitoring samples are taken over a period of time generally 4 hours to obtain the time weighted average for employee exposure. All samples are collected by absorption on carbon tubes and tested using gas chromatography.

Source: Snell summary of industry data

EXHIBIT B-17(1)
USDOL/OSHA

MONITORING RESULTS FOR
44-M-NEW-C

Atmospheric Vinyl Chloride Concentrations
Suspension and Dispersion Resins

<u>Sample Description</u>	<u>Vinyl Chloride Concentration, ppm</u>
Wednesday, 7-19-72; 11:20 a.m.	
North Area	
East	1.
Middle	6.
West	4.
Center Area	
East	6.
Middle	4.
West	8.
South Area	
East	27.
Middle	19.
West	6.

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EXHIBIT B 17(2)
USDOL/OSHA

Wednesday, 7-19-72; 3:30 p.m.

North Area	
East	4.
Middle	6.
West	6.
Center Area	
East	4.
Middle	4.
West	4.
South Area	
East	2.
Middle	4.
West	6.

Wednesday, 7-19-72; 9:30 p.m.

North Area	
East	96.
Middle	19.
West	55.
Center Area	
East	78.
Middle	29.
South Area	
Middle	110.
West	78.

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Suspension and Dispersion Resin
con't.

Thursday, 7-20-72; 10:00 a.m.

North Area	
East	16.
Middle	4.
West	8.
Center Area	
East	12.
Middle	8.
West	12.
South Area	
East	12.
Middle	20.
West	20.

Thursday, 7-20-72; 4:00 p.m.

Mass Poly Building	
Bottom of Prepoly (Charging VC1)	9.
First Level of Prepoly	6.
Second Level of Prepoly	12.
Third Level of Prepoly	
Near Vinyl Pumps (Outside)	6.
Tank Farm	
Near Vinyl Pumps	1. (N.D.)
Under Vinyl Storage Sphere	23.

EXHIBIT B-17(4)
USDOL/OSHA

VCL MONITORING DATA

Area Measurements Using Portable and Fixed
Instrumentation, Measuring Total Hydrocar-
bons by the Flame Ionization Method

<u>Building</u>	<u>Product</u>	<u>Month</u>	<u>Average</u> ppm	<u>% Readings</u> <u>Above 50 PPM</u>	<u>% Readings</u> <u>Under 10 PPM</u>
512	Mass Polymerization	JAN. 74	23.8	5.1	35.7
		FEB. 74	15.5	2.0	46.5
		MAR. 74	11.5	1.1	69.3
		APR. 74	10.5	0.6	76.2
		MAY 74	8.7	1.4	79.3
		JUNE 74	8.9	0.6	80.7
513	Suspension and Dispersion Resins	JAN. 74	17.1	3.8	39.1
		FEB. 74	14.5	2.4	66.0
		MAR. 74	11.0	1.0	81.3
		APR. 74	8.8	0.7	78.8
		MAY 74	9.4	1.2	75.2
		JUNE 74	8.8	0.5	75.9

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PERSONNEL MONITORING DATA

<u>Location and Type</u>	<u>Operation</u>	<u>No. of Samples</u>	<u>TWA PPM VCI</u>		
			<u>Average</u>	<u>Maximum</u>	<u>Minimum</u>
Mass Resin	Charging	4	9	27	2
	Cleaning	5	22	46	6
	Recovery	4	11	23	2
Suspension and Dispersion Resin	Charging	7	11	20	1
	Cleaning	3	33	32	4
	Recovery	3	7	8	5
	Drying and Bagging	2	1	-	-
	Tank Farm	2	-	1	Nil

Everyone wears respiratory equipment where the work atmosphere is greater than 25 ppm or where operations and experience show there is a risk of exceeding 25 ppm.

Personnel monitoring samples are taken over a period of time generally 4 hours to obtain the time weighted average for employee exposure. All samples are collected by absorption on carbon tubes and tested using gas chromatography.

Source: Snell summary of industry data

EXHIBIT B-18(1)

USDOL/OSHA

MONITORING RESULTS FOR

3-M-INT-C

Sample Point Number	Location	Breathing Zone	Fans	No. Of Measurements	VCM Concentration ⁽¹⁾ PPM		
					Average ⁽²⁾	Range	
						High	Low
38	SE Corner, Lower Polymer Building	Facing Toward Center of Building	On	4	6	19	1
			2 Off	17	8	19	1
39	SW Corner, Lower Polymer Building	Facing Toward Center of Building	On	4	1	1	0
			2 Off	17	6	23	0
40	SW Lower Polymer Building	Fan Level, in Front of Small Exhaust Fan	On	4	6	15	1
			2 Off	17	5	28	0
41	Center of Lower Polymer Building	Breathing Zone	On	4	4	8	1
			2 Off	17	27	325	0
42	NW Lower Polymer Building	Fan Level, in Front of Small Exhaust Fan	On	4	4	8	1
			2 Off	17	15	175	0
43	NE Corner, Lower Polymer Building	Facing Toward Center of Building	On	4	3	3	0
			2 Off	17	8	38	1
44	NW Corner, Lower Polymer Building	Facing Toward Center of Building	On	4	1	3	1
			2 Off	17	7	31	0
45	Outside NE Polymer Building	Facing Toward Fan	On	21	6	43	0
46	Front of Polymer Pit - Outside	In Front of 4 ft. Fan Facing Toward Fan	On	21	10	32	0
47	Lower Polymer Outside	In Front of 4 ft. Fan Facing Toward Fan	On	21	12	115	1

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Sample Point Number	Location	Breathing Zone	Fans	No. Of Measurements	VCM Concentration ⁽¹⁾ PPM		
					Average ⁽²⁾	Range	
						High	Low
48	On Slurry Platform By Shack - Westside	Breathing Zone		21	28	105	0
49	Upstairs Polymer Center of Locker Room	Breathing Zone	On Off	16 5	5 3	17 5	1 2
50	SE Corner, Upstairs Polymer Across From Locker Room	Breathing Zone	On	21	7	25	0
51	SE Corner Upstairs Polymer By Ice Tank	Facing Toward Center	On	21	16	134	1
52	SW Corner Upstairs Polymer	Facing Toward Center	On	3	16	22	6
52	SW Corner Upstairs Polymer	Facing Toward Center		18	17	52	2
53	Center Polymer Control Room	Breathing Zone		3	2	2	1
53	Center Polymer Control Room	Breathing Zone		18	14	101	0
54	Center of Upstairs Polymer By Reactor 307-308	Breathing Zone		21	16	100	2
55	NE Corner, Upstairs Polymer	Facing Toward Center	On	21	12	45	2
56	NW Corner, Upstairs Polymer	Facing Toward Center	On	3	7	11	4
56	NW Corner, Upstairs Polymer	Facing Toward Center	On	18	22	325	0
57	West Center Monomer Pump House	Breathing Zone	On Off	17 4	6 27	24 52	1 1
58	Center of Monomer Pump House	Breathing Zone	On Off	17 4	4 24	16 62	0 2

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EXHIBIT B-18 (3)
USDOL/OSHA

Sample Point Number	Location	Breathing Zone	Fans	No. Of Measurements	VCM Concentration ⁽¹⁾ PPM		
					Average ⁽²⁾	Range	
						High	Low
59	East Center Monomer Pump House	Breathing Zone	On	17	9	23	1
			Off	4	37	62	9
79	Hose Connect House on Slurry Tank Platform	Breathing Zone		16	46	186	3
80	Wind Vector Opposite Side of Property	Facing Toward Wind		5	1	1	0

Note:

- (1) Measurements taken by Century Organic Vapor Analyzer
- (2) Snell average of data submitted

Source: Snell summary of industry data

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EXHIBIT B-19
USDOL/OSHA
MONITORING RESULTS FOR
9-S-INT-C

<u>Process</u>	<u>Exposure (1)</u> <u>(ppm - VCM)</u>
VCM Tank Car	
VCM Storage	unloading - up to 100
Measuring Tanks	
Reactors	up to 100
Blowdown	
Centrifuge & Drying	25-30
Bagging	25-30

Source: Snell summary of industry data

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EXHIBIT B-20(1)
USDOL/OSHA
MONITORING RESULTS FOR
42-S-INT-C

4 Shifts - Textile Workers

<u>Classification</u>	<u>Number</u>	<u>% Exposure</u>
Production		
Reactor Operator (clean reactor)	16	100
Dryer Operator	12	100
Lead Operator	8	100
Service Operator (material handling)	4	100
Utility Operator (reactor guard)	8	100
Maintenance		
Maintenance Workers	5	100
Instrument Maintenance (part time)	4	50 - 60
Electrical Maintenance	3	10 - 20
Supervisory and Support		
Q. C. Supervisor	1	
Q. C. Technician	4	
Engineer	4	30
Plant Manager	1	
Foreman	5	100
Safety Engineer	1	80 - 90
Lab Technician	2	
Analytical Chemist	1	
R & D Resin Chemist	2	

EXHIBIT B-20 (2)
USDOL/OSHA

<u>Location</u>	<u>Level ppm</u>
Monomer Pump Station (open air)	0
Pump House (open building)	0 - 150
Storage Tanks (underground outside)	0
Day Tank (outside)	0
Reactor Room #1	0 - 40 (30 avg.)
Reactor Room #2	35 avg.
Open Manhole-reactor (momentary)	70 - 80
Open Manhole -exhaust in place	5 - 6
Reactor during rinsing	0 - 20
Reactor during scraping	600
Screen (open once per shift)	1000
Slurry Tanks (open manhead)	3000 - 10,000
Slurry Tanks (closed)	0
Slurry Tanks while rinsing	200
Centrifuge	0 - 35
Dryers	less than 20
Bagging	0 - 100
Storage Area	
walkway	0
between bags	85
Bulk Storage Transfer Vessels	10 - 20

Source: Snell summary of industry data

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EXHIBIT B-21
USDOL/OSHA

MONITORING RESULTS FOR
14-M-INT-W

Area Measurements Using Portable and Fixed
Instrumentation, Measuring Total Hydrocar-
bons by the Flame Ionization Method

<u>Building</u>	<u>Product</u>	<u>Month</u>	<u>Average</u> ppm	<u>% Readings</u> <u>Above 50 PPM</u>	<u>% Readings</u> <u>Under 10 PPM</u>
812	Suspension Resin	JAN. 74	27.4	2.6	25.1
		FEB. 74	14.8	1.8	24.4
		MAR. 74	18.1	2.4	57.0
		APR. 74	15.9	2.2	49.5
		MAY 74	13.4	0.5	23.1
		JUNE 74	11.2	1.3	90.7

EXHIBIT B-22

USDOL/OSHA

AVERAGE VINYL CHLORIDE MONOMER CONCENTRATIONS (PPM)
JOB CLASSIFICATION AND POLYVINYL CHLORIDE PLANT⁽¹⁾

Job Classification	Plant														Range		
	12M-Int.-C	17B-Int.-W	19L-New-W	40L-New-W	41M-New-W	22M-Old-C	31M-New-C	41L-Old-W	28L-New-C	54M-New-C	5L-Old-C	8L-New-C	48M-Old-C	44M-New-C	Average	High	Low
I. VCM Unloading																	
VCM Unloaders	NA	6	40	NA	NA	NA	3	NA	NA	NA	NA	NA	NA	NA	10	40	6
II. PVC Production																	
Supervisors	12	8	NA	NA	4	22	NA	NA	NA	NA	7	NA	NA	NA	10	22	6
Senior Reactor Operators	NA	8	NA	1	NA	NA	NA	5	8	20	NA	NA	NA	NA	9	20	1
Reactor Operators	18	22	25	5	11	NA	30	NA	NA	20	NA	NA	NA	NA	17	30	5
Chargers	NA	19	NA	21	NA	NA	NA	7	NA	70	10	6	6	10	19	70	7
Stripper Operators	NA	17	NA	27	NA	NA	NA	NA	90	65	30	5	NA	9	36	90	5
Centrifuge Operators	NA	NA	NA	NA	NA	NA	3	NA	120	NA	NA	NA	NA	NA	NA	120	3
Dryer Operators	8	7	25	NA	NA	17	3	NA	NA	51	1	NA	NA	1	13	51	1
Utility (Cleaners, Laborers, etc.)	9	10	NA	54	6	16	NA	76	24	NA	26	9	9	26	26	76	6
Baggers	4	14	NA	13	NA	6	3	3	2	20	1	NA	5	1	9	20	1
III. Warehouse Operations ⁽²⁾	1	7	20	17	4	NA	NA	NA	2	NA	NA	NA	NA	NA	9	20	1
IV. Maintenance ⁽³⁾	4	3	30	12	NA	NA	NA	92	NA	2	NA	NA	NA	NA	24	92	1
V. Laboratory																	
Professionals ⁽⁴⁾	6	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	6	1
Technicians	2	1	NA	NA	NA	NA	NA	164	NA	61	NA	NA	NA	NA	62	164	1
VI. Management and Support ⁽⁵⁾	NA	NA	NA	1		<1	NA	NA	NA	2	NA	NA	NA	NA	<1	2	<1
Average of Reported Data	7	10	27	17		16	8	62	41	35	12	6	7	9	19	60	3

Notes: (1) Data believed to be obtained from OVA, bag samples, charcoal tube pumps or area monitoring on a mixed time basis.

(2) Includes supervisors and clerks, but based primarily on warehousemen.

(3) Includes supervisors and maintenance men.

(4) Includes supervisors and chemists.

(5) Includes plant managers, engineers and clerical personnel.

Source: Exhibits B-1 through B-21 and small amounts of industry submitted monitoring data.

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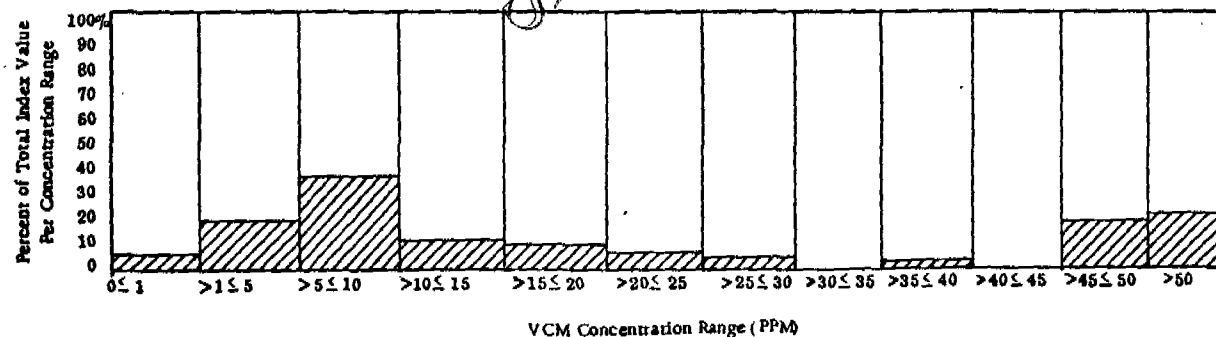
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EXHIBIT B-23

USDOL/OSHA

SUMMARY OF POLYVINYL CHLORIDE PRODUCING INDUSTRY
VINYL CHLORIDE MONOMER MONITORING DATA SUBMITTED TO SNELL

	Number of VCM Concentration Measurements Giving Values in Concentration Range (PPM)												Total Points For Plant	Type of Data Base ²⁾
Plant	0 ≤ 1	>1 ≤ 5	>5 ≤ 10	>10 ≤ 15	>15 ≤ 20	>20 ≤ 25	>25 ≤ 30	>30 ≤ 35	>35 ≤ 40	>40 ≤ 45	>45 ≤ 50	>50		
12-M-Int. -C Index (1)	76 6.45	449 38.12	327 22.78	36 3.06	214 18.17	0	76 6.45	0	0	0	0	0	1,178 100	Average TWA Values.
22-M-Old-C Index (1)	0	131 3.82	3,297 96.18	0	0	0	0	0	0	0	0	0	3,428 100	
41-L-Old-W Index (1)	0	100 47.29	47 22.18	16 7.62	0	0	0	0	0	0	0	0	210 100	Average of Instantaneous Readings.
54-M-New-6 Index (1)	1 0.28	63 18.63	61 15.14	0	27 6.70	81 20.10	27 6.70	0	16 3.97	0	0	127 31.51	403 100	Average of Instantaneous Readings.
5-L-Old-6 Index (1)	4 3.64	16 0.88	16 14.16	24 21.24	13 11.60	6 5.31	0	0	0	0	47 41.59	2 1.77	113 100	Average Twa Values.
8-M-Int-6 Index (1)	13 3.99	15 4.60	138 42.35	53 19.33	42 12.88	18 5.52	21 6.44	0	0	0	16 4.91	0	326 100	Average of Instantaneous Readings.
Total No. of Points	94	759	3,886	139	296	105	124	0	16	0	63	176	5,658	
Total Index Value	15	111	213	51	49	31	20	0	4	0	47	56	600	
% of Total Index Value For Concentration Range	3%	19%	36%	8%	8%	5%	3%	0	1%	0	8%	9%	100%	



Notes: (1) Index(1) developed from the formula: No. of Points in range/total number of points reported by Plant = 1/100.

(2) Data believed to be obtained from OVA, bag samples, charcoal tube pumps or area monitoring on a mixed time basis.

Sources: Exhibits B-2, B-7, B-11, B-13, B-18 and Snell assessment of reported data in exhibits.

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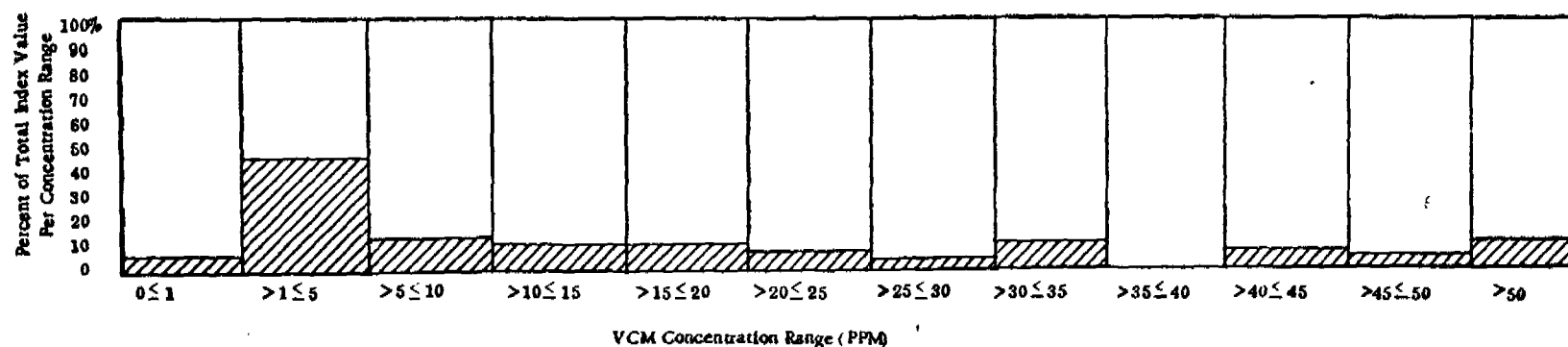
EXHIBIT B-24

USDOL/OSHA

SUMMARY OF OSHA VINYL CHLORIDE MONOMER MONITORING DATA OF
POLYVINYL CHLORIDE PRODUCING PLANTS

Plant	Number of VCM Concentration Measurements ⁽¹⁾ Giving Values in Concentration Range (PPM)												Total Points For Plant
	0 ≤ 1	>1 ≤ 5	>5 ≤ 10	>10 ≤ 15	>15 ≤ 20	>20 ≤ 25	>25 ≤ 30	>30 ≤ 35	>35 ≤ 40	>40 ≤ 45	>45 ≤ 50	>50	
I(2) Index(3)	3 3.87	13 16.77	6 7.74	4 5.16	1 1.29	1 1.29	1 1.29	0 0	0 0	1 1.29	0 0	1 1.29	31 40
II(2) Index(3)	0 0	8 26.64	2 6.66	1 3.33	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 3.33	12 40
7(2) Index(3)	0 0	0 0	1 4	0 0	2 8	1 4	1 4	2 8	0 0	1 4	1 4	1 4	10 40
Total No. of Points	3	21	9	5	3	2	2	2	0	2	1	3	53
Total Index Value	4	43	12	9	9	5	4	8	0	5	4	9	120
% of Total Index Value For Concentration Range	3%	43%	10%	8%	8%	4%	3%	7%	0	4%	3%	8%	100%

Average VCM Concentration for Reported 53 Samples = 14 PPM



Notes: (1) Data based on approximately 10 min. sippin type samples with 1 liter ambient air collection over charcoal tubes analyzed by the NIOSH method.

(2) Plant codes are those developed by OSHA.

(3) Index (1) developed from the formula: No. of Points in range/total number of points reported = I/40.

Sources: OSHA data submitted to Snell; Snell assessment of data.

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EXHIBIT B-100
USDOL/OSHA
MONITORING RESULTS FOR 13

<u>Operation</u>	<u>No. of Samples</u>	<u>TWA PPM VC1</u>		
		<u>Average</u>	<u>Maximum</u>	<u>Minimum</u>
Furnace Operator	13	2	11	Nil
EDC Synthesis	5	0.2	0.4	Nil
Purification	17	1	4	Nil
Tank Farm	10	10	25	1

NOTES:

Everyone wears respiratory equipment where the work atmosphere is greater than 25 ppm or where operations and experience show there is a risk of exceeding 25 ppm.

Personnel monitoring samples are taken over a period of time generally 4 hours to obtain the time weighted average for employee exposure. All samples are collected by absorption on carbon tubes and tested using gas chromatography.

Source: Snell summary of industry data

EXHIBIT B-101 (1)
USDOL/OSHA
MONITORING RESULTS FOR 24

<u>Operation</u>	<u>No. of Employees Exposed</u>	<u>VCM Exposure Level (PPM)</u>
VCM Production	20	10 - 15
Tank Car Loading	2	6 - 16
Control Room	N.A. (1)	< 0.3

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PERSONNEL MONITORING DATA MAY - JULY, 1974

<u>Location and Type</u>	<u>Operation</u>	<u>No. of Samples</u>	<u>TWA</u>	<u>PPM VCL</u>	
			<u>Average</u>	<u>Maximum</u>	<u>Minimum</u>
Suspension Resin	Charging	3	3	6	1
	Cleaning	3	3	4	2
	Recovery	3	2	4	1

Notes:

N.A. = Not Available

- (1) Operations personnel spend 75% of time in control room

Everyone wears respiratory equipment where the work atmosphere is greater than 25 ppm or where operations and experience show there is a risk of exceeding 25 ppm.

Personnel monitoring samples are taken over a period of time generally 4 hours to obtain the time weighted average for employee exposure. All samples are collected by absorption on carbon tubes and tested using gas chromatography.

Source: Snell summary of industry data

EXHIBIT B-102(1)
USDOL/OSHA
MONITORING RESULTS FOR 15

TABLE 1

Current VCM Exposure Levels (TWA)

<u>Area</u>	<u>VCM. (ppm ave.)</u>	<u>VCM (ppm range)</u>	<u>No. of Data Pts.</u>	<u>Measuring Device</u>
Block I	2.0	.1 to 15	28	(2)
Block II	1.2	.1 to 8.6	24	(2)
Offsites	3.5	.1 to 66	43	(2)
Control Room	0.7	.1 to 9.5 ⁽¹⁾	56	(2)
Office	1.4	.1 to 29 ⁽¹⁾	52	(2)
Maintenance	2.8	.1 to 50	129	(2)
Laboratory	4.3	.2 to 50	42	(2)
Ship Loading	3.1	1.4 to 5.5	4	(2)

TABLE 2

Current Results of VCM Area Monitoring

<u>Area</u>	<u>VCM (ppm ave.)</u>	<u>VCM (ppm range)</u>	<u>No. of Data Pts.</u>
Block I	8.6	0 - 119	270
Block II	6.9	0 - 124	270
Offsites	15.3	0 - 898	260
Control Room	1.6	0 - 16.2	18
Office	4.9	0 - 2.1	25
Maintenance	1.4	0 - 4.9	14
Laboratory	3.7	0 - 28	23
Ship Loading	13.7	0 - 278	73

Notes:

- (1) Employees in these areas are periodically in the process unit.
- (2) The measuring device used is a Bendix Environmental Science Division Permissible Air Sampling Pump. This device is worn by employees for time periods of 20 minutes to 8 hours. It detects VCM by carbon adsorption and is analyzed by flame ionization GLC.

Source: Snell summary of industry data

EXHIBIT B-103 (1)
USDOL/OSHA
MONITORING RESULTS FOR 34

INDUSTRIAL HYGIENE SURVEYS OF VINYL CHLORIDE
LEVELS IN MONOMER PLANT NO. 1

JOB CLASSIFICATION	TWA, PPM VINYL CHLORIDE		
	1971	1972	1973
A CONTROL - SECTION I	3.7	} 0.7 (3)	2.1 (2)
C CONTROL - SECTION I	8.2		3.6
A CONTROL - SECTION II	1.8	1.3 (3)	1.0 (3)
B CONTROL - SECTION III	1.1	N.D.* (3)	0.6 (3)
A CONTROL - SECTION IV	6.9	0.6 (3)	8.9 (4)
CLASS I OPERATOR	1.8		

() No. of SAMPLES

*N.D. = NOT DETECTED

EXHIBIT B-103 (2)

JOB CLASSIFICATION

TWA, PPM VINYL CHLORIDE

	<u>1971</u>	<u>1972</u>	<u>1973</u>
A CONTROL - SECTION V	1.6	} 0.2 (3)	5.2 (2)
B CONTROL - SECTION V	3.5		3.3
SR. ASST. CHEM. B	5.1	14 (3)	17.6 (2)
SUPERVISION	2.8	1.3 (3)	1.2 (3)
MAINTENANCE		1.7 (3)	2.0 (5)
LOADING OPERATOR		45. (3)	1.1 (3)
OVERALL AVERAGE	3.7 (10)	7.0 (27)	4.2 (29)
() No. OF SAMPLES			

*N.D. = NON DETECTED

INDUSTRIAL HYGIENE SURVEYS OF VINYL CHLORIDE

LEVELS IN MONITOR PLANT NO. 1

JOB CLASSIFICATIONTWA, PPM VINYL CHLORIDE
1974

	<u>1ST QTR</u>	<u>2ND QTR</u>
A CONTROL - SECTION I	1.0	4.1
C CONTROL - SECTION I	5.4	11.5
A CONTROL - SECTION II	1.8	0.6
B CONTROL - SECTION III	0.9	0.9
A CONTROL - SECTION IV	0.4	5.9
CLASS I OPERATOR	10.8	< 0.1
A CONTROL - SECTION V	0.7	1.4
C CONTROL - SECTION V	1.0	—

JOB CLASSIFICATIONTWA, PPM VINYL CHLORIDE
1974

	<u>1ST QTR</u>	<u>2ND QTR</u>
Sr. Asst. Chem. B	12.7	*
SUPERVISION	2.9 (4)	2.7 (5)
MAINTENANCE	1.7 (4)	2.5 (4)
LOADING OPERATOR	16.5 (3)	6.8*
DEV. LAB.	0.9 (4)	0.9 (3)
OVERALL AVERAGE	4.4 (24)	1.9 (20)
() No. of samples		

*PEAK EXPOSURE MEASUREMENTS WERE MADE FOR THIS JOB.