



POLYVINYL CHLORIDE RESINS

BY H. E. FREY

PLASTICS AND RESINS

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STATUS AND OUTLOOKStatus

In 1972, at least 97% of the nearly 4.6 billion pounds of vinyl chloride consumed in the United States was used to produce polyvinyl chloride (PVC) homopolymer and copolymer resins. Production of these resins totalled over 4.2 billion pounds and, at an estimated average unit sales value of 13.0 cents per pound, the production value was approximately 550 million dollars.

The status of vinyl chloride and PVC resins in 1972 is summarized in the following table.

Status of Vinyl Chloride and PVC Resins--1972^a
(Millions of Pounds)

	<u>Vinyl Chloride</u>	<u>PVC Resins</u>
Annual Capacity as of February 1, 1972	5,565	4,375
Production	5,175	4,258 ^b
Domestic Consumption	4,554	4,180 ^b
Exports	621	151 ^b

a. Data in this table are taken from the PRODUCING COMPANIES, PRODUCTION, CONSUMPTION, and INTERNATIONAL sections of this report.

b. The difference between Production and the sum of Domestic Consumption and Exports is believed to be largely due to stock changes (imports were only 4 million pounds).

About 93% of the vinyl chloride manufactured in the United States in 1972 was produced by eight companies from ethylene dichloride made by the oxychlorination of ethylene (CEH estimate). The other 7% was made by the only two producers who are still producing vinyl chloride by the addition of hydrogen chloride to acetylene. Total U.S. vinyl chloride capacity as of January 1, 1973, is believed to have been 5,765 million pounds per year (CMR, January 1, 1973, p. 30). The three largest vinyl chloride producers (Dow Chemical U.S.A., PPG Industries, Inc., and Shell Chemical Company) made vinyl chloride only whereas the others also produced polyvinyl chloride resins. Production problems at the PPG plant in Puerto Rico led to a shortage of vinyl chloride during the first half of 1973.

U.S. production of vinyl chloride had an average annual growth rate of 14.9% between 1961 and 1971, and of 10.9% between 1966 and 1971. In 1972, U.S. vinyl chloride production was 19% higher than in 1971. Although almost all vinyl chloride domestically consumed is used in the production of PVC resins, some (believed to amount to less than 3% of total

production) is used in the production of methyl chloroform, as an additive in specialty coatings, and as an additive in certain aerosol mixtures (CEH estimate).

The list price of vinyl chloride decreased from 8 cents per pound in 1962 to 4.75 cents per pound in 1972. In early 1972, actual selling prices are believed to have been close to this list price. In December 1972, vinyl chloride prices climbed to 5 cents per pound, and in early 1973, they climbed further. Most long-term contract holders, however, are believed to obtain the monomer at prices far below those list prices (CMR, March 2, 1973, p. 12).

Exports of vinyl chloride were not officially reported until 1970 when they amounted to 664 million pounds (Belgium received almost half of the total). In 1972, vinyl chloride exports amounted to 621 million pounds. Norway was the largest importer (with over 20% of the total), followed by Belgium and Spain. U.S. imports of vinyl chloride have been negligible.

In 1972, PVC resins were made by 22 U.S. companies using one of four basic processes--suspension, emulsion, bulk, and solution polymerization.

About 78% of all PVC resins (both homopolymers and copolymers) produced in the United States in 1972 were produced by suspension polymerization and about 13% by emulsion polymerization. In the United States, all PVC resins produced by emulsion polymerization are used in plastisols (fluid dispersions of resins in plasticizers) or as latex.

Bulk polymerization, a relatively new process in large-scale PVC production, was used to make 6% of the 1972 U.S. PVC production. Bulk-polymerized resins perform with excellence in calendaring, extrusion, and molding.

Solution polymerization (which is carried out in an organic solvent such as n-butane or cyclohexane) is used exclusively for the production of certain copolymers of vinyl chloride with vinyl acetate (usually those containing 10-25% acetate). In 1972, about 3% of the PVC resins produced in the United States were made by this process. They are mostly used in protective coatings and, to a minor extent, in adhesives.

PVC resin production grew at an average annual rate of 13.4% between 1961 and 1971, but since 1966, the growth rate averaged only 9% per year. Then in 1972 alone, production grew almost 23%.

Production of polyvinyl chloride resins in the first three months of 1973 was 1,175 million pounds--17.8% higher than in the comparable 1972 period, based on SPI statistics (Monthly Statistical Report, The Society of the Plastics Industry, Inc., March 1973).

Most large PVC resin manufacturers are also involved in the production of either compounded PVC resins or PVC end products or both. Data for the captive consumption of PVC resins by resin manufacturers have been reported by the U.S. Tariff Commission in recent years but it is believed that the reported data are understated in all years. For example, in 1970 the reported data indicate that only 138 million pounds of resin were captively consumed. However, one source (MP, March 1971, p. 63) has estimated that as much as 800 million pounds of PVC resins went into captive consumption. Captive PVC resin consumption for end products



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(not counting compounded resins) in 1971 is believed to have been again about 800 million pounds (CEH estimate based on communication with industry).

PVC resin consumption is considered from two standpoints in the following discussion:

(1) by the type of process employed in converting the resin to end products and (2) by the ultimate end use.

PVC resin consumption in the major process categories in 1972 is summarized in the following table.

U.S. Consumption of PVC Resin by Process--1972

	Millions of Pounds	Percent of Total PVC Consumption
Extrusion	2,052	49%
Calendering	963	23
Dispersions	457 ^a	11
Molding	410 ^b	10
Solutions	118 ^c	3
All Other	180	4
Total	4,180	100%

a. Components are: Coating--Flooring, and Textile and Paper Coating; Paste Processes--Plastisol Formulation, and All Other.

b. Components are: Bottles (blow molding), 77 million pounds; Sound Records (compression molding), 148 million pounds; All Other Molding (believed to be substantially all injection molding), 185 million pounds.

c. Reported as "Protective Coatings" (59 million pounds) and "Adhesives and All Other Coating Uses" (also 59 million pounds). Believed to include mostly solutions but also some dispersion and powder coatings.

Source: Annual Statistical Report, Plastics & Resins Materials, 1972, The Society of the Plastics Industry, Inc., April 1973.

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The average annual growth rate for total domestic PVC resin consumption by process between 1961 and 1971 was 13.2%. However, the average annual growth rate between 1966 and 1971 was only 9.4% per year. Then, an over 27% leap occurred in 1972 alone.

Growth in domestic PVC resin consumption in 1972 was over 27%, a phenomenal increase. In the January through March period of 1973, domestic PVC resin consumption was 1,213 million pounds, another 24.9% advance over the comparable 1972 period (Monthly Statistical Report, The Society of the Plastics Industry, Inc., March 1973).

Historical trends of the 1961-1971 period are briefly discussed below.

PVC consumption in extrusion processes has shown particularly impressive growth--18.5% per year between 1961 and 1971 and 17.7% between 1966 and 1971. Rigid extrusions (which consumed approximately 740 million pounds of PVC resins in 1971) have been the growth leader, mostly with pipe and conduit, where about 500 million pounds of PVC resins were used in 1971 (CEH estimate). Two large PVC resin producers are also leading PVC pipe producers. Other rigid extrusions, each consuming over 100 million pounds of PVC resins in 1971, include: (1) siding and other rigid profiles, and (2) rigid film and sheet.

Flexible extrusions (in which approximately 560 million pounds of PVC resins were used in 1971) consist mostly of (1) wire and cable (343 million pounds in 1971), (2) a variety of profile extrusions such as cove base, gaskets and weather stripping, medical tubing, and garden hose, and (3) packaging film for food.

PVC consumption in calendering processes approximately doubled from 1961 to 1971 but the average annual growth from 1966 to 1971 was only 2.5% because there was no growth in calendered flooring and calender-coated textiles in recent years. The share of total PVC resin consumption represented by calendering declined from 44% in 1961 to 36% in 1966 and to 26% in 1971. Of the 835 million pounds used in calendering processes in 1971, 474 million pounds were used in film and sheeting, 274 million pounds in flooring, and 87 million pounds in the production of calender-coated textiles.

PVC consumption in dispersion processes grew at an average rate of 15.3% per year between 1961 and 1971 but only at a rate of 7.7% between 1966 and 1971, largely because of very slow growth in textile and paper coating uses. These processes employ liquid dispersions of PVC resins in plasticizers (called plastisols in their most common form) and also PVC latexes, which are used to a minor extent. These liquid dispersions are converted into end products by dipping, spraying, rotational casting (slush molding) or coating--usually in thick layers (with plastisols). Coating substrates may be metal objects (e.g., tool handles) or textiles, paper, or felt (for cast flooring).

PVC resin consumption in molding processes had an average annual growth of 15.7% from 1961 to 1971, and a rate of only 5.6% between 1966 and 1971. The compression molding of phonograph records consumed 138 million pounds of resin in 1971 but this use has not grown in recent years. PVC resin consumption in injection molding more than doubled in 1971 to reach 135 million pounds--most of the recent growth took place in the injection molding of pipe fittings. Another growth field is that of the blow molding of PVC bottles, where PVC resin usage rose from about 5 million pounds in 1965 to an estimated level of 70 million pounds in both 1970 and 1971.



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PVC resin consumption in the form of solutions had an average annual growth rate of 9.6% between 1961 and 1971; these solutions (including some other forms of coatings, e.g., dispersion and powder coatings) are used in adhesives and protective coatings.

Most of the poundage reported under the U.S. Tariff Commission "All Other" category is believed to have been consumed by the various previously specified processes in mostly unknown proportions. In addition, relatively minor amounts of PVC resins may be included that may not have been covered by the major process categories, e.g., rigid PVC foams.

PVC resin consumption by end use in 1972 is summarized in the following table.

U.S. Consumption of PVC Resins by End Use--1972
(Millions of Pounds)

Building and Construction	1,739
Household Uses	630
Consumer Goods	504
Electrical Uses	439
Packaging	357
Transportation	255
Miscellaneous Uses and Other, Unspecified Uses	256
Total	4,180

Source: MP, January 1973, p. 58, and Annual Statistical Report, Plastics & Resins Materials, 1972, The Society of the Plastics Industry, Inc., April 1973.

After the over 27% leap of the year 1972, which resulted in the consumption figures listed in the foregoing table, an analysis of the trends during the 1966-1971 period may still be useful (older data of relevance are not available).

The average annual growth rate of PVC consumption by end use was 9.9% between 1966 and 1971.

PVC resin consumption in building and construction grew at an average annual rate of 13.7% between 1966 and 1971. As a percent of total PVC resin consumption by end use, it grew from 20% in 1966 to 35% in 1971. Over half of the resin consumed in 1971 (600 million pounds) was used in the production of pipe, conduit, and pipe fittings, which had a combined average growth rate of 34% per year between 1966 and 1971. In 1971, PVC is estimated to have had well over half of the total plastic pipe and conduit business. Almost 60% of this PVC was used in water supply pipe for residential and irrigation uses.

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The other major component of PVC resin consumption in building and construction is flooring. Although 325 million pounds of PVC were used in 1971, this market was down from 370 million pounds in 1966. The decrease is generally attributed to the very large increase in the use of carpets in recent years.

Smaller end-use areas within building and construction that have shown outstanding growth in recent years include siding (60 million pounds in 1971) and windows and other rigid profiles (55 million pounds in 1971). The remaining components are swimming pool liners, weather stripping, waterstops, lighting, and rain gutters, with a combined consumption of 115 million pounds in 1971. A new and important market is in extruded, foamed PVC rigid profiles.

PVC resin consumption in household uses grew at an average annual rate of 5% between 1966 and 1971. As a percent of total PVC resin consumption by end use, it declined from 21% in 1966 to 17% in 1971. Some 260 million pounds (almost half of the total PVC resin consumption in household uses) was in furniture upholstery in 1971 (almost all of this was used in coated fabrics). The next largest household use is in vinyl wall coverings (85 million pounds in 1971). The other components include garden hose, tablecloths and placemats, shower curtains, closet accessories, appliances, wood-surface films, and other uses, with a combined consumption of 219 million pounds of PVC resins in 1971.

PVC resin consumption in consumer goods grew at an average annual rate of less than 5% between 1966 and 1971. As a percent of total PVC resin consumption, it declined from 17% in 1966 to 13% in 1971. The largest market in this category, phonograph records, consumed an estimated 125 million pounds of PVC resin in 1971 but this market had shown little growth in recent years and actually declined slightly in 1971. The next largest consumer goods end use is in footwear (a good growth market in recent years), where 115 million pounds of PVC resin were consumed in 1971. Other uses, with a combined consumption of 197 million pounds of PVC resin in 1971, include toys, outerwear, sporting goods, baby pants, and other uses.

PVC consumption in electrical uses grew at an average annual rate of 11% between 1966 and 1971 and remained at 11-12% of total PVC resin consumption by end use. Practically all of the consumption in 1971 was in wire and cable and close to half of this was in building wire.

PVC resin consumption in packaging grew at an average annual rate of 26% between 1966 and 1971. As a percent of total PVC resin consumption by end use, it was 4% in 1966 and almost 9% in 1971. Most of the PVC resin consumption in packaging is in film and sheet (185 million pounds in 1971). PVC consumption in packaging film and sheet has been a rapid growth area since 1967. Resin consumption in film has doubled and in sheet it has increased five-fold. Plasticized extruded film has captured a large part of the produce and meat packaging market, and rigid sheet goes mostly into blister packaging. The second largest packaging use is in bottles (70 million pounds of PVC resin in 1971), where consumption more than tripled from 1967 to 1970. However, uncertainties from considerations of environmental protection have resulted in a flat performance in 1971. (PVC liberates hydrogen chloride when incinerated. It has been asserted that hydrogen chloride is not only a serious pollutant but it can also damage conventional incinerators, and that without incineration, PVC packaging materials represent a solid waste problem after use). Can



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coatings, bottle cap liners, and gaskets represent additional, relatively small, packaging uses, which together consumed 31 million pounds of PVC resin in 1971.

PVC resin consumption in transportation grew at an average annual rate of 7.7% between 1966 and 1971. As a percentage of total PVC consumption, it was 8.5% in 1966 and 7.7% in 1971. The bulk of the consumption is for automotive upholstery and seat covers, auto floor mats, and vinyl auto tops.

Miscellaneous uses, which advanced at an average annual rate of 4% between 1966 and 1971, include laminates (believed to include primarily luggage, covered plywood and wallboard), medical tubing (a rapid growth area), stationery supplies, and various other smaller end uses.

Prices of polyvinyl chloride resins vary depending upon the type. The overall unit sales value was 18 cents per pound in 1962 and is believed to have been about 13.5 cents per pound in 1972. As of April 1973, general-purpose PVC moved at 13 cents per pound, and dispersion resins at 22 cents per pound (communication with industry).

Exports of polyvinyl chloride resins are relatively small, although they increased from the 30-40 million pounds-per-year range of the early 1960's to an estimated level of 160-190 million pounds in the 1969-1971 period. Imports of polyvinyl chloride resins have been negligible in recent years.

An estimate of 1972 world production and production capacity for PVC resins by region is given in the following table.

World Production and Production Capacity for PVC Resins--1972
(Millions of Pounds)

	Production	Annual Capacity ^a
Western Europe	6,500	7,900
United States	4,300	4,400
Japan	2,400	3,500
Eastern Europe	1,900	1,800
Other Areas	1,200	1,800
Total	16,300	19,400

a. Estimated capacities as of mid-1972.

Source: CEH estimates.

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Outlook

PVC resin consumption in the United States is expected to grow at an average annual rate of about 14% between 1972 and 1975, leading to a consumption level of about 6.2 billion pounds per year by 1975. U.S. production of PVC resins is expected to essentially parallel this domestic consumption (with exports and imports remaining very small) and to show an average annual growth of 14-15% from 1972 to 1975, and to reach a level of 6.2-6.4 billion pounds in 1975. This is projected on a demand basis. The vinyl chloride monomer shortage that prevailed in mid-1973 largely because of the prolonged production difficulties at the large PPG plant in Puerto Rico is expected to end in the last quarter of 1973.

Outlook for Vinyl Chloride and PVC Resins--1975

	Vinyl Chloride		PVC Resins	
	1975 (millions of pounds)	Average Annual Growth Rate 1972-1975	1975 (millions of pounds)	Average Annual Growth Rate 1972-1975
Annual Capacity	7,200	8.7%	7,000	16.7%
Production	6,700	8.8%	6,300	14.0%
Domestic Consumption	6,500	13.5%	6,230	11.0%

Source: CEH estimates.

Future production of vinyl chloride is expected to be all based on ethylene as the raw material and characterized by very large plants. This underlines the importance of a large raw material base. Even though some marginal producers may be forced out in the next few years, total U.S. vinyl chloride production capacity is expected to increase to over 6 billion pounds per year with the addition of a 700 million pounds-per-year plant by Shell Oil Company, Shell Chemical Company, division, at Norco, Louisiana, in late 1973.

Production of PVC resins is expected to continue to be based largely on the established methods of suspension and emulsion polymerization (the efficiency of these methods may be improved by new catalyst systems), but a continuous increase in bulk polymerization capacity is foreseen. If the installation of large new capacity based on bulk polymerization begins in the next few years, this process could account for as much as 30% of U.S. capacity by the end of the decade (CEH estimate).

The prospect of tight PVC resin supply for the 1973-1974 period, because of the slowness in capacity expansions, has been generally linked to PVC resin prices. At 1971 price levels, expansions were not economically feasible for producers.

Between mid-1972 and mid-1973, when PVC resin prices were increased stepwise, several capacity expansions were announced. Some of these were expected to be operational in late



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1973 (Borden, B.F. Goodrich) and others in 1974 (American Chemical, Firestone). Georgia-Pacific announced plans to produce PVC. Additional substantial capacity must be on the way if the projected 1975 consumption of 6.2 billion pounds is to be backed by a corresponding production.

Estimated domestic PVC resin consumption by process in 1975 is given in the following table.

Estimated Domestic PVC Resin Consumption by Process--1975

	Millions of Pounds	Average Annual Growth Rate 1972-1975
Extrusion	3,540	20%
Calendering	1,180	7
Dispersions	560	7
Molding	850	11
Solutions, Coatings	195	9
All Other	235	9
Total	6,230	14.2%

Source: CEH estimates.

According to these estimates, extrusion is expected to consume more than half of all PVC resins used by 1975 (mostly in the production of pipe and conduit). In calendering, the production of rigid film and sheet is expected to grow strongly, and injection molding and blow molding are expected to provide substantially all of the growth in molding. Thus, all rigid vinyl processing is expected to grow strongly except for compression molding.

Estimated domestic PVC resin consumption by end use in 1975 is given in the following table.

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Estimated Domestic PVC Resin Consumption by End Use--1975

	<u>Millions of Pounds</u>	<u>Average Annual Growth Rate 1972-1975</u>
Building and Construction	3,080	21%
Household Uses	750	6
Packaging	570	17
Wire and Cable	550	8
Consumer Goods	620	7
Transportation	300	6
Miscellaneous Uses	360	12
Total	<u>6,230</u>	<u>14.2%</u>

Source: CEH estimates.

A breakdown for the estimated 1975 consumption of PVC resins in building and construction is given in the following table.

Estimated Domestic PVC Consumption in Building and Construction--1975

	<u>Millions of Pounds</u>	<u>Average Annual Growth Rate 1972-1975</u>
Pipe, Conduit, and Pipe Fittings	2,140	25%
Flooring	420	7
Siding, Panels	140	25
Windows and Other Rigid Profiles	110	25
Foam Profiles	100	25
Other Uses	170	10
Total	<u>3,080</u>	<u>21%</u>

Source: CEH estimates.



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Many segments of the market are expected to contribute to the growth in consumption in pipe, conduit, and pipe fittings, but pipe fittings are expected to have particularly strong growth. Leading in the expected continued expansion of PVC pipe will be low pressure pipe, particularly large-diameter water pipe (12 inches and larger). Other segments that are expected to grow vigorously include telephone conduit and residential hot water pipe--the latter is made from post-chlorinated PVC. In DWV pipe, PVC's market share is expected to gradually increase further from an estimated 50% of the plastic DWV pipe market as of mid-1973 (CEH estimate based on communication with industry).

A breakdown for the estimated 1975 consumption of PVC resins in household uses is given in the following table.

Estimated Domestic PVC Consumption in Household Uses--1975

	Millions of Pounds	Average Annual Growth Rate 1972-1975
Furniture Upholstery	830	4%
Wall Coverings and Wood Surface Film	180	12
Tablecloths, Placemats, Shower Curtains, and Closet Accessories	117	4
Garden Hose	51	5
Appliances	43	7
Total	750	6%

Source: CEH estimates.

As these estimates suggest, only marginal growth is expected in most of the household uses. Exceptions are vinyl wall coverings (which are becoming widely accepted in institutions, restaurants, public and business buildings, as well as homes) and wood surface films (a rather new application of printed semi-rigid film, used in the production of low-priced furniture).

The growth potential of PVC film and sheet, the largest component of the packaging market for PVC resins, is believed to be very good for the 1972-1975 period. The market is expected to reach a consumption level of 570 million pounds by 1975--an average annual growth rate of 17% (CEH estimate).

The use of PVC resins in blow-molded containers has been under the cloud of disputed acceptability from a waste disposal point of view. However, recently the use of PVC resins in liquor bottles of all sizes has received the endorsement of the Alcohol, Tobacco and Firearms Division of the Internal Revenue Service. This is taken as a very encouraging development by most industry observers (MP, May 1972, pp. 16 and 18). Thus, a resumption in the growth of PVC resin consumption in blow-molded containers was in full swing in 1972 and consumption is expected to grow at a minimum rate of 21% annually and

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to reach a level of at least 140 million pounds per year by 1975 (CEH estimate). However, the growth beyond that is, at this point, difficult to predict with any degree of reliability because this field is so new.

Wire and cable production constitutes substantially all PVC consumption in electrical uses. Building wire and communication wire together account for 65% of all PVC usage in wire and cable and are expected to consume a total of 390 million pounds of PVC resins by 1975--a growth rate of 10-12% per year (CEH estimate). Building wire is expected to remain the largest application for PVC because of the anticipated continuing strength of the construction business. However, PVC's inroads into communication wire are also expected to deepen (PW, May 1969, pp. 31 and 32). Other wire applications are expected to be marginal growth areas for PVC (CEH estimate).

Phonograph records, the largest component of consumer goods, are expected to show only modest growth, approximately 5% per year, to reach approximately 173 million pounds of PVC resin consumption by 1975 (CEH estimate).

The second largest consumer application of PVC resins, footwear (mostly in lower priced children's shoes, and in innersoles, socklining, and soling), is expected to grow about 10% annually to reach 190 million pounds in 1975 (CEH estimate).

All other consumer goods applications of PVC, including toys, outerwear, baby pants, sporting goods and various unspecified other uses in this area (such as home movie screens), are expected to continue in their established patterns and are expected to grow at rates between 5 and 8% per year. However, there are two exceptions: wigs and plastic Christmas trees. Both are relatively small and recent consumer applications which are expected to show above average growth in the next several years.

Diverse miscellaneous uses that are believed to have a growth potential of greater than 10% per year between 1972 and 1975 include foamed carpet underpadding, biomedical applications, credit cards, and rigid PVC foams (CEH estimates). One industry source believes that future PVC consumption for rigid foams could become substantial.

PVC resin prices are expected to remain firm as resin supply tightens in the second half of 1973. Further gradual increases across the board are likely in the 1973-1975 period (CEH estimate based on communication with industry).

DESCRIPTIONVinyl Chloride

Vinyl chloride,* a gaseous reactive intermediate which is derived from ethylene or acetylene, is essentially all consumed in the production of polyvinyl chloride and copolymer resins. Only a minor amount is consumed in other uses (e.g., as a chemical intermediate).

Polyvinyl Chloride Resins

The term "polyvinyl chloride (PVC) resins" is meant to include vinyl chloride homopolymers with the repeating unit $-\text{CH}_2\text{CHCl}-$ and copolymers of vinyl chloride with minor amounts of vinyl acetate, ethylene, propylene, vinylidene chloride, or acrylates. Most are available in the form of white powders that, after compounding with a number of auxiliary ingredients, are converted into a large variety of plastic or resinous end products through several types of processes. Because PVC resins are thermoplastic, all but one of these processes for converting PVC powders employ heat to make the end product (coating resins are processed by dissolving the resin and applying it from solution).

Industrial development of PVC resins began some 40 years ago. Production on a full commercial scale began in Germany in 1931 and in the United States in the late 1930's, after W. Semon at The B. F. Goodrich Company had discovered that polyvinyl chloride, when heated in the presence of a suitable high-boiling liquid (a plasticizer), formed a flexible plastic material that resembled rubber or leather. Because plasticized PVC showed itself to be a good insulator, resistant to the weather, and nonflammable, it was put to military uses in World War II. Diversified compounding and processing technology, which developed particularly in the late 1940's and early 1950's, quickly led to many broad-scale commercial uses.

The processing and performance characteristics of PVC resins can be varied with the molecular weight, which for most commercial PVC resins lies between 50,000 and 120,000. Equally important to the characteristics of the resins is the presence or absence of plasticizer. Most PVC plastics produced in past decades were flexible types, containing plasticizer. While the many processes for plasticized PVC are relatively easy to carry out, the processing of PVC compounds containing essentially no plasticizer (for the production of rigid PVC plastics) is technically more demanding. The properties of plasticized PVC plastics depend greatly on the exact amounts and chemical types of plasticizers used; it is common to employ mixtures to achieve the desired properties.

The general performance characteristics of PVC plastics include mechanical toughness, weather resistance, resistance to water and to many chemicals (including strong mineral acids), fairly good electrical insulating properties, and a pronounced thermoplastic character, i.e., the manufactured articles tend to be soft in a warm environment and increasingly stiff in colder surroundings. Those PVC plastics which contain less than 10% by weight of plasticizer tend to exhibit poor impact strength at low temperatures.

* Details about the properties and industrial handling and storage of vinyl chloride may be found in the article by Shelley, P. G., and E. J. Sills, "Monomer Storage and Protection," CEP, April 1969, pp. 29-36.

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Major use areas for plasticized PVC include flexible film and sheeting, flooring, furniture and automobile upholstery, and electrical wire insulation. Typical uses for rigid PVC are mostly construction materials such as pipe, conduit and pipe fittings, siding, and window sashes. It is also used to form rigid film and sheet such as is used in blister packaging, for credit cards, and in the blow molding of bottles.

Although the great majority of PVC resins used in the various processes to manufacture PVC plastics are homopolymers of vinyl chloride, copolymers are still essential in some processes, where they are used alone or in admixture with homopolymers.

The most important commercial copolymers of vinyl chloride are those with vinyl acetate. The higher molecular weight resins with an acetate content of about 2-8% are used for calendaring and extrusion, where somewhat faster processing is possible because of their better flow properties compared with those of conventional homopolymers. Copolymers containing over 8% vinyl acetate flow even more readily under the application of heat and pressure and are, therefore, favored in the production of phonograph records. These copolymers are also capable of binding particularly large amounts of mineral fillers and pigments, a capability utilized in the production of vinyl-asbestos floor tile. Because the solubility in esters and ketones of vinyl chloride copolymers with an acetate content of 10-20% is much greater than that of homopolymers, these resins are used in solution coatings.

The commercial copolymers of vinyl chloride with ethylene and propylene contain 1-8% of ethylene or propylene and are predominantly used in the manufacturing of unplasticized (rigid) PVC products. Such copolymers can be processed faster and have better impact strength than comparable homopolymers, without any sacrifice in dimensional stability and other important performance properties.

Copolymers of vinyl chloride with vinylidene chloride are more soluble in solvents than homopolymers and they are good film formers. The few resins of this type that are on the market today are, therefore, mostly used in specialty coatings (in solution and, in some applications, in latex form).

A few emulsion (latex) copolymers of vinyl chloride and ethyl, n-butyl, or 2-ethylhexyl acrylate are used in the production of wall coverings, nonwovens, and house paint.

Post-chlorinated PVC homopolymer resins have long been in existence but were of little commercial importance until recently. Products made from them have better heat resistance (and higher densities) than products made from ordinary PVC resins. The main application for these resins is in residential hot water pipe.

MANUFACTURING PROCESSES

Vinyl Chloride

About 93% of the vinyl chloride produced in the United States in 1972 was produced from ethylene dichloride made by the oxychlorination of ethylene (CEH estimate). In this process, ethylene is reacted with hydrogen chloride and oxygen to give ethylene dichloride, which is subsequently cracked to produce vinyl chloride monomer and hydrogen chloride (the



latter is recycled to the oxychlorination reactor). The other 7% of the vinyl chloride produced in the United States in 1972 was made by the addition of hydrogen chloride to acetylene (see the CEH report on Acetylene for additional information on this process).

A new version of the route from ethylene (called the Chloe process) of improved versatility and efficiency was developed by Produits Chimiques Pechiney-Saint-Gobain S.A.* It is characterized by the following stages: (1) hot chlorination of ethylene; (2) oxychlorination yielding dichloroethane, trichloroethane, and tetrachloroethane; (3) cold chlorination of ethylene dichloride; and (4) distillation of the products of oxychlorination and cold chlorination.

A new process (called the Transcat process), described as an essentially single-step process beginning with ethane feedstock and integrating the reactions of chlorination, oxychlorination, and dehydrochlorination into a single reactor system employing a novel molten salt catalyst, was developed jointly by the Lummus Company and Armstrong Cork Company (P/CE, April 1971, p. 5). The process has been operated on a pilot-plant scale for some time. Plans for its commercialization have not been reported thus far.

See the CEH report on Ethylene Dichloride for additional information on the manufacturing processes used to make vinyl chloride.

Polyvinyl Chloride Resins

Vinyl chloride, a gas at room temperature, is used in liquid form under pressure when it is polymerized by one of the four basic processes--suspension, emulsion, bulk, and solution polymerization--described in the following discussion.[†]

In all processes, the polymerization is initiated by free radicals (produced by the thermal decomposition of such initiators as peroxides of persulfates) and proceeds at temperatures of 40-70°C with the evolution of heat. The rate of polymerization is particularly sensitive to the reaction temperature and the concentration of initiators. The molecular-weight distribution of the final product, which is of key importance to the processing characteristics of the resin, is influenced substantially by the temperature of reaction.

* Details of this process were reported in Informations Chimie, May-June 1971, pp. 37-47, and O&GJ, November 8, 1971, pp. 64 and 65.

† The following is a listing of references recommended for supplemental reading. Encyclopedia of Polymer Science and Technology, Volume 14, Interscience Publishers, New York, 1971, pp. 320-358; ECN PVC Process Survey, January 29, 1971; Thomas, J. C., "New Improved Bulk PVC Process," HP, November 1968, pp. 192-196; "Huels PVC Batch Process Does Well Under Computer Control," O&GJ, December 16, 1968, pp. 78-81; and Schroeter, G., Kunststoffe, June 1970, pp. 363-366.

A. Polymerization of PVC Resins

1. Suspension Polymerization

About 78% of all PVC resins (both homopolymers and copolymers) produced in the United States in 1972 were produced by suspension polymerization. The polymerization is carried out in an aqueous system in which monomer droplets are maintained in suspension by means of a protective colloid in conjunction with brisk agitation. Typical protective colloids are polyvinyl alcohol, gelatin, and substituted celluloses (e.g., carboxymethylcellulose).

Generally, suspension polymerization is operated as a batch process employing glass-lined reactors (having a capacity of 2-6 thousand gallons in older plants and larger in newer plants). The reactor is first charged with deionized water, and then a protective colloid (0.05 to 2% of the weight of the monomer), a buffer (e.g., sodium acetate) and an initiator (e.g., lauryl peroxide, azobisisobutyronitrile, or isopropyl peroxydicarbonate*) are added. The vinyl chloride and, in the case of copolymer production, the second monomer (e.g., vinyl acetate, propylene, or vinylidene chloride) are then intermittently introduced in controlled ratios. The mixture is then brought to the polymerization temperature (about 50°C) and, after variable induction periods depending on the initiator used, the polymerization starts. The heat of polymerization is removed from the system to maintain the desired reaction temperature. When lauryl peroxide is used as the initiator, the polymerization is substantially complete after a period of about 16 hours.

A dispersion of relatively large polymer particles in water is obtained by the suspension polymerization process. After unreacted monomer is driven out of the slurry and recovered, the slurry is centrifuged and the polymer is dried in a flash dryer, in which it is subjected to an air stream at about 80°C; complete drying usually requires more than one passage. The dry polymer is screened, generally through a 40-mesh screen, and shipped in bulk or packed in multiwall paper bags.

2. Emulsion Polymerization

About 13% of the PVC resins produced in the United States in 1972 were produced by emulsion polymerization which is basically very similar to the suspension process except that relatively large amounts of emulsifying agents are used, usually in pairs where one agent is soluble in the monomer and the other in water. Such systems, combined with powerful agitation, very effectively prevent the coalescence of polymer particles and, as a result, resins of a very small particle size are obtained. The drying methods are also designed to maintain a small particle size; spray dryers are frequently used. Complete removal of emulsifiers is never achieved in resins produced by this process, so that articles of high clarity (as needed in packaging film) or of very low water absorption (as needed in wire

* Uniroyal, Inc., has licensed the use of this catalyst to a number of leading U.S. PVC producers (C&EN, August 26, 1968, p. 22).



insulation) cannot be produced from such resins. The generally higher price of emulsion-polymerized resins compared to that of suspension-polymerized resins is, nevertheless, accepted by users who need compounds in liquid form (fluid dispersions of PVC resins in plasticizers, called plastisols) for the manufacturing of end products. In the United States, all resins produced by emulsion polymerization are used for plastisols (and, to a minor extent, in latex form). In Europe, emulsion polymerization processes have been refined further than in the United States so that general-purpose resins (useful for calendering and extrusion) are also produced there by variations of the emulsion process.

3. Bulk Polymerization

In this relatively new process,* which was used to make about 6% of the PVC resin produced in the United States in 1972, vinyl chloride is polymerized without the addition of other liquids. A two-stage version of the process, which was developed in recent years by Pechiney-Saint-Gobain of France, is so attractive that it has been licensed all over the world (ECN, April 3, 1970, p. 14). (U.S. licensees are Occidental Petroleum Corporation, Hooker Chemical Corporation, subsidiary; The Goodyear Tire & Rubber Company, Chemical Division; and The B. F. Goodrich Company, B. F. Goodrich Chemical Company, division.)

In the two-stage bulk polymerization process, a suitably shaped reactor is provided for the initial liquid phase of the reaction, and a differently designed autoclave is then used to agitate the dry, powdery mass effectively until the conversion from monomer to polymer reaches a level of about 90%. Heat exchange is provided by the distillation of monomer and its recondensation within the reactor and in external condensers. The rate of output of the two-stage bulk polymerization plants† is said to be more than twice as high as that of good suspension process plants of comparable size (i.e., with a comparable number and size of reactors). It is generally expected that two-stage bulk polymerization of vinyl chloride will be widely used world-wide in the next several years.

Bulk polymerized PVC resins resemble the suspension resins in appearance and are characterized by high particle uniformity and purity. This results in end products of unusually good optical clarity (important for packaging uses). Also, these resins have remarkably good heat stability and improved fusion properties, i.e., they can be processed with the ease of conventional vinyl chloride-vinyl acetate copolymers.

* Union Carbide Corporation's so-called nonsolvent process is basically also a bulk polymerization process. It has been operated on a small scale (about 25 million pounds per year) at Texas City, Texas, for about 20 years.

† An indication of the possible future technology of bulk polymerization is the work on low-temperature, low-pressure systems (e.g., as described by Mazzolini, C., L. Patron, A. Moretti, and M. Campanelli, I&EC Product Research and Development, December 1970, pp. 504-511).

4. Solution Polymerization

Although solution polymerization is over 40 years old, only about 3% of the PVC resins produced in the United States in 1971 were produced by this method. In this process, the monomers are first dissolved in an organic solvent (such as n-butane or cyclohexane) in an autoclave. After the addition of a peroxide initiator and heating of the stirred solution to 40°C, polymerization begins and the polymer precipitates as the reaction proceeds.

Solution polymerization is used exclusively for the production of copolymers of vinyl chloride with vinyl acetate (usually those containing 10-25% acetate). These solution-polymerized copolymers are remarkably pure and uniform and their chief value lies in their unique solubility and film-forming characteristics. A greatly improved form of the original process, developed by Union Carbide Corporation, is used for the production of these specialty coating resins.

B. Compounding of PVC Resins

PVC resins are compounded with a number of auxiliary materials before they are converted to end products. In the case of flexible or plasticized PVC products, the chemical types and exact amounts of plasticizers used are most important--the amount may range from about 10% (for semirigid sheet) to 100% (for very soft film) of the weight of the resin. The plasticizers are chiefly higher alcohol esters of phthalic acid (e.g., dioctyl phthalate). Dialkyl esters of dibasic aliphatic acids (e.g., dioctyl adipate) are used in conjunction with phthalates when flexibility at low temperatures is a requirement. Polyester plasticizers (e.g., adipic acid-glycol polyesters) and epoxy plasticizers (e.g., epoxidized soybean oil) confer the permanence and resistance to leaching needed in food packaging and in baby pants. (See the CEH reports on Higher Alcohols (C₆ and Up), Phthalic Anhydride, and Adipic Acid and the CEH data sheets on plasticizers for further information on plasticizers.) Secondary plasticizers, such as highly chlorinated paraffins, are sometimes also used as extenders (see the CEH report on Linear Alkylate Sulfonates for additional information). Other important compounding ingredients are light stabilizers and heat stabilizers. Among the most frequently used are heavy metal salts (e.g., of lead, tin, barium-zinc and cadmium-zinc) or organo-tin compounds: Less than 0.1% to 2%, depending on the type and the fabricating process used, is added.*

Pigments and fillers are incorporated depending on the end use. Where flexibility and toughness are needed in an end product, vinyl compounds tolerate only relatively light filler loadings.

* The following book is recommended for supplemental reading on vinyl stabilizers, in particular, and vinyl compounding, in general: Sarvetnick, Harold A., Polyvinyl Chloride, Van Nostrand Reinhold Company, New York, 1969.



Compounding begins with pre-mixing and is followed by very intense mixing because uniform distribution (especially of stabilizers) is mandatory for trouble-free processing and uniform product quality. Recently, work has been reported on performing compounding steps in the polymerization vessel prior to discharging the resin. This method is believed to be in use in the large-scale production of certain rigid compounds and is believed to be very economical.

Most compounds, plasticized as well as unplasticized, are relatively dry in the pre-mix stage and have a free-flowing, sandy consistency. To achieve intimate mixing, they are generally subjected to a hot mixing step at fusing temperature; this may be done on a two-roll mill or mixing extruder. In the case of plastisols, compounding is strictly a stir-in process (except that pigments are predispersed with plasticizer over a three-roll paint mill). Organosols (which are PVC resin dispersions in plasticizers and a balanced mixture of solvents and diluents) are usually prepared in enclosed ball mills.

C. Processing of Compounded PVC Resins Into End Products

PVC compounds are converted to end products by several processes. Extrusion (employing mostly multiple-screw machines in Europe and mostly single-screw machines in the United States) is used to produce both rigid extrusions (e.g., pipe and conduit, siding, and window sashes) and flexible extrusions (e.g., electrical wire insulation, garden hose, and packaging film). To feed a large extruder, preheated, mixed compound in chip form may be conveyed from storage or directly from a mixing extruder.

Extrusion lines are engineered for the types of products to be extruded, from electrical wire insulation to pipe of 18 inches diameter. The extruders are continuously fed with compound, which is either purchased or prepared in an on-site compounding plant. The approximate cost of a single extrusion line varies considerably depending on the size of the extruder, its type, and the auxiliary equipment; a typical cost range is \$300,000 to \$800,000.

Rigid and flexible vinyl sheets are generally produced on four-roll calenders. The sheets may be combined with a fabric as it leaves the calender, or this may be done subsequently in a separate laminating step.

A typical calender train costs 2 to 3 million dollars. Today's calenders run widths usually to 72 inches and some as broad as 92 inches, and they produce film and sheet at rates averaging more than 8 million pounds per year of compound (equivalent to 5.5-6 million pounds of resin), depending on thickness (e.g., 2.5 million pounds per year for light gauge rigid film, 4.5 million pounds per year for heavier flexible film, and higher rates for flexible sheeting--MP, April 1969, p. 24).

Dispersions or plastisols are used for fabric coating (either on knife machines, roller coaters, or casting machines), and in the production of a low-cost type of vinyl floor tile where plastisol is cast on a felt base. Plastisols are also used in rotational molding (e.g., for toys and traffic cones) and in the dipping and hot-spraying of tool handles and appliance parts.

POLYVINYL CHLORIDE RESINS - CONTINUED

The use of compression molding for PVC resins is restricted to the production of phonograph records. Injection molding of rigid PVC has been developed largely in the 1960's and is mostly employed in the production of pipe fittings, and to a much smaller extent in the production of parts for communications equipment, business machines, and toys.

A complex and still-emerging technology in the processing of compounded PVC resins is the blow molding of containers.

PRODUCING COMPANIES, PLANT LOCATIONS, AND CAPACITIESVinyl Chloride

For a list of vinyl chloride producers and their plant locations and capacities, see the CEH report on Ethylene Dichloride. As indicated there, the total U.S. vinyl chloride production capacity was 5,565 million pounds per year as of October 1971 with 90% of this based on production from ethylene dichloride. Only Monochlor Inc. (a joint venture of Borden Inc., and Uniroyal, Inc.), with a capacity of 300 million pounds per year at Geismar, Louisiana, and Tenneco Chemicals, Inc. (a major component of Tenneco Inc), Chemicals Division, with a capacity of 225 million pounds per year at Houston, Texas, were still producing vinyl chloride monomer from acetylene as of February 1, 1972. As of January 1, 1973, U.S. vinyl chloride capacity was estimated to have totaled 5,765 million pounds per year (CMR, January 1, 1973, p. 30).

The 700 million pounds-per-year vinyl chloride plant of Shell Oil Company, Shell Chemical Company, division, at Deer Park, Texas, was expanded to a capacity of 840 million pounds per year, and the company expects to complete a second 700 million pounds-per-year plant at Norco, Louisiana, in late 1973.

Of the ten domestic vinyl chloride producers in 1973, three produced vinyl chloride only--Dow Chemical U.S.A., PPG Industries, Inc., and Shell Chemical Company--whereas the others also produced polyvinyl chloride resins.

A shortage of vinyl chloride had been widely predicted for the second half of 1973. Contributing to this trend was the reported curtailment of vinyl chloride production for lack of naphtha feedstock and other reasons at the large PPG plant at Guayanilla, Puerto Rico (CMR, April 30, 1973, pp. 3 and 14). As of mid-1973, the anticipated monomer shortage was a reality as production problems, linked to insufficient electrical power supply for the south shore region of Puerto Rico, were still not all resolved. Newly installed generators are expected to become operational in October 1973 (industry source).

Polyvinyl Chloride Resins

The U.S. producers of PVC resins and the annual capacities of their plants are listed in the following table.



POLYVINYL CHLORIDE RESINS - CONTINUED

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<u>Company and Plant Location</u>	<u>Capacity as of Mid-1972 (Millions of Pounds per Year)</u>
Air Products and Chemicals, Inc. Plastics Division Calvert City, Kentucky	120
Pensacola, Florida	50
American Chemical Corporation (jointly owned by ARCO Chemical Company, division of Atlantic Richfield Company, and Stauffer Chemical Company) Long Beach, California	125
Borden Inc. Borden Chemical, division Illiopolis, Illinois Leominster, Massachusetts	285
Continental Oil Company Conoco Plastics Division Aberdeen, Mississippi Oklahoma City, Oklahoma	220 80
Diamond Shamrock Corporation Diamond Shamrock Chemical Company, subsidiary Plastics Division Delaware City, Delaware Deer Park, Texas	250
Ethyl Corporation Industrial Chemicals Division Baton Rouge, Louisiana	180
The Firestone Tire & Rubber Company Firestone Plastics Company, division Perryville, Maryland Pottstown, Pennsylvania	130 140
The General Tire & Rubber Company Chemical/Plastics Division Ashtabula, Ohio	100
The B. F. Goodrich Company B. F. Goodrich Chemical Company, division Long Beach, California Henry, Illinois Louisville, Kentucky Avon Lake, Ohio Pedricktown, New Jersey	125 125 275 125 130



POLYVINYL CHLORIDE RESINS - CONTINUED

<u>Company and Plant Location</u>	<u>Capacity as of Mid-1972 (Millions of Pounds per Year)</u>
The Goodyear Tire & Rubber Company Chemical Division	
Plaquemine, Louisiana ^a	100
Niagara Falls, New York	100
Great American Chemical Corporation Fitchburg, Massachusetts	40
Keysor-Century Corporation Saugus, California	35
Monsanto Company Monsanto Polymers & Petrochemicals Company Springfield, Massachusetts	150
National Starch and Chemical Corporation Meredosia, Illinois	10
Occidental Petroleum Corporation Hooker Chemical Corporation, subsidiary Ruco Division	
Burlington, New Jersey	180
Hicksville, New York	10
Olin Corporation Thompson Plastics Company, division Assonet, Massachusetts	150
Pantasote Company Passaic, New Jersey Point Pleasant, West Virginia	120
Robintech, Inc. Painesville, Ohio	220 ^b
Stauffer Chemical Company Plastics Division Delaware City, Delaware	160
Tenneco Chemicals, Inc. (a major component of Tenneco Inc.) ^c Tenneco Plastics Division	
Burlington, New Jersey	165
Flemington, New Jersey	60



POLYVINYL CHLORIDE RESINS - CONTINUED

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SEPTEMBER 1973

<u>Company and Plant Location</u>	<u>Capacity as of Mid-1972 (Millions of Pounds per Year)</u>
Union Carbide Corporation	
Chemicals and Plastics Division	
Texas City, Texas	200
South Charleston, West Virginia	120
Uniroyal, Inc.	
Uniroyal Chemical, division	
Painesville, Ohio	140
Total	4,420

- a. This plant was acquired from The Dow Chemical Company in 1969 and subsequently expanded. Another expansion to 200 million pounds per year is planned (Plastics Technology, May 1973, p. 20).
- b. This plant was acquired from Allied Chemical Corporation in 1972 and capacity has been increased to 250 million pounds per year in 1973 (MP, May 1973, p. 12).
- c. Construction of a 300 million pounds-per-year plant at Pasadena, Texas, has been started. Completion is due in 1974 (MP, May 1973, p. 12).

Source: CEH estimates based on trade publications and communication with industry.

Additional new plants under construction include: Certain-Teed Products Corporation, at Lake Charles, Louisiana (200 million pounds per year, due on stream in late 1974); Georgia-Pacific Corporation at Plaquemine, Louisiana (200 million pounds per year, in late 1974); and Shintech, Inc. (owned jointly by Robintech, Inc. and Shin-Etsu Chemical Industry Co., Ltd. of Japan), at Freeport, Texas (250 million pounds, in mid-1975) (MP, May 1973, p. 12).

It is generally recognized that published capacity figures frequently do not correspond very closely to actual plant capacity. Published capacities are often overstated because (1) design capacities presume the continuous production of one type of resin and all producers make various types of resins in each plant and (2) there are scheduled and unscheduled shutdowns which are not taken into consideration in so-called nameplate capacity figures.

Of the total 1972 PVC capacity, it is estimated that 78%, or about 3,400 million pounds, was based on the suspension process, which is used by all producers. Some 12%, or about 530 million pounds, was based on the emulsion process, which is used by B. F. Goodrich, Conoco, Diamond Shamrock, Ethyl, Firestone, Goodyear, Monsanto, Olin, Tenneco, Union Carbide, and Uniroyal. Also, National Starch and Chemical Corporation produces its vinyl chloride copolymer latices by the emulsion process. About 6% of total PVC capacity or 280 million pounds, was based on the bulk polymerization process of Pechiney-Saint-Gobain of France; the following table gives a breakdown of that bulk polymerization capacity.

POLYVINYL CHLORIDE RESINS - CONTINUED

U.S. Polyvinyl Chloride Bulk Polymerization Capacity as of Mid-1972

	<u>Millions of Pounds per Year</u>
The B. F. Goodrich Company	
B. F. Goodrich Chemical Company,	
division	
Pedricktown, New Jersey	40
The Goodyear Tire & Rubber Company	
Chemical Division	
Plaquemine, Louisiana	80
Occidental Petroleum Corporation	
Hooker Chemical Corporation, subsidiary	
Ruco Division	
Burlington, New Jersey	160
Total	<u>280</u>

Source: CEH estimates based on communication with industry.

Less than 4%, or about 150 million pounds of the total capacity, was based on solution polymerization--estimated to consist of 120 million pounds for Union Carbide, 10 million pounds for Firestone, and 20 million pounds for Goodrich (CEH estimates).

As of early 1973, total U.S. capacity for PVC resins is estimated to have been near the 5 billion pounds-per-year level. In 1973, existing PVC capacity is believed to be used to the limit although a monomer shortage in the second half of 1973 may force some output reductions in some plants. The B. F. Goodrich Company announced a 30% incremental expansion of its PVC capacity in existing plants in 1973 and 1974 (CMR, October 30, 1972, p. 3). Other new PVC capacity that has been reported includes the following: American Chemical Corporation, additional 40 million pounds at Long Beach, California; Georgia Pacific Corporation, a new 200 million pounds-per-year plant; The Firestone Tire & Rubber Company, to expand to a total capacity of 400 million pounds per year; and Borden, Inc., to add 60 million pounds at existing plants (CMR, November 20, 1972, pp. 5 and 35). However, additional substantial capacity must be on the way if the projected 1975 consumption of 6.2 billion pounds is to be backed by a corresponding production.

Most large resin manufacturers also produce compounds for sale, or for feeding their own end-product manufacturing operations. For example, Continental Oil Company, Conoco Chemicals Division, has a compound production capacity of 175 million pounds per year at Aberdeen, Mississippi (1970 Annual Report, Continental Oil Company). The Plastics Division of Diamond Shamrock Chemical Company has two compound plants with a combined capacity of 175 million pounds per year. B. F. Goodrich Chemical Company has long operated several large compound facilities. Among the numerous other large suppliers of compounded resins are Allied Chemical Corporation (particularly dry-blends), Ethyl Corporation, Monsanto Company, Pantasote Company (particularly pelletized compounds), Tenneco Chemicals, Inc., and Union Carbide Corporation.

PRODUCTION AND SALESVinyl Chloride

The following table provides data on U.S. vinyl chloride production and sales.

Production and Sales of Vinyl Chloride
(Millions of Pounds)

	<u>Production</u>	<u>Sales</u>
1952	321.4	59.5
1953	401.7	--
1954	393.2	--
1955	528.6	76.0
1956	596.5	103.9
1957	627.1	149.8
1958	691.4	200.5
1959	977.3	329.4
1960	1,037.0	352.3
1961	1,044.0	424.3
1962	1,311.5	515.5
1963	1,435.2	500.8
1964	1,615.0	597.1
1965	2,000.0	687.8
1966	2,499.5	836.2
1967	2,423.6	951.7
1968	2,968.9	1,463.1
1969	3,735.9	2,358.7
1970	4,040.2	2,720.2
1971 ^a	4,335.8	3,003.6
1972 ^a	5,175.3	--

See MANUAL OF CURRENT INDICATORS for additional data.

a. Data for 1971 and 1972 are preliminary.

(continued)

POLYVINYL CHLORIDE RESINS - CONTINUED

- Sources: (A) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission (Production and Sales data for 1952-1970).
- (B) Synthetic Organic Chemicals, U.S. Production and Sales of Miscellaneous Chemicals, 1971 Preliminary, U.S. Tariff Commission (preliminary data for 1971).
- (C) Preliminary Report on U.S. Production of Selected Synthetic Organic Chemicals, S.O.C. Series C/P-73-1, U.S. Tariff Commission (preliminary Production datum for 1972).

For data on production of vinyl chloride by process, see the CEH reports on Ethylene Dichloride and Acetylene.

Polyvinyl Chloride Resins

The following table presents data on U.S. production, sales (including sales for export), and captive use of polyvinyl chloride resins as reported by the U.S. Tariff Commission. The continuous growth of production from 1945 to 1969 proceeded at an average annual rate of 16%; however, between 1966 and 1971, this growth rate averaged only 9% per year. Then, in 1972 alone, PVC production advanced over 23%.

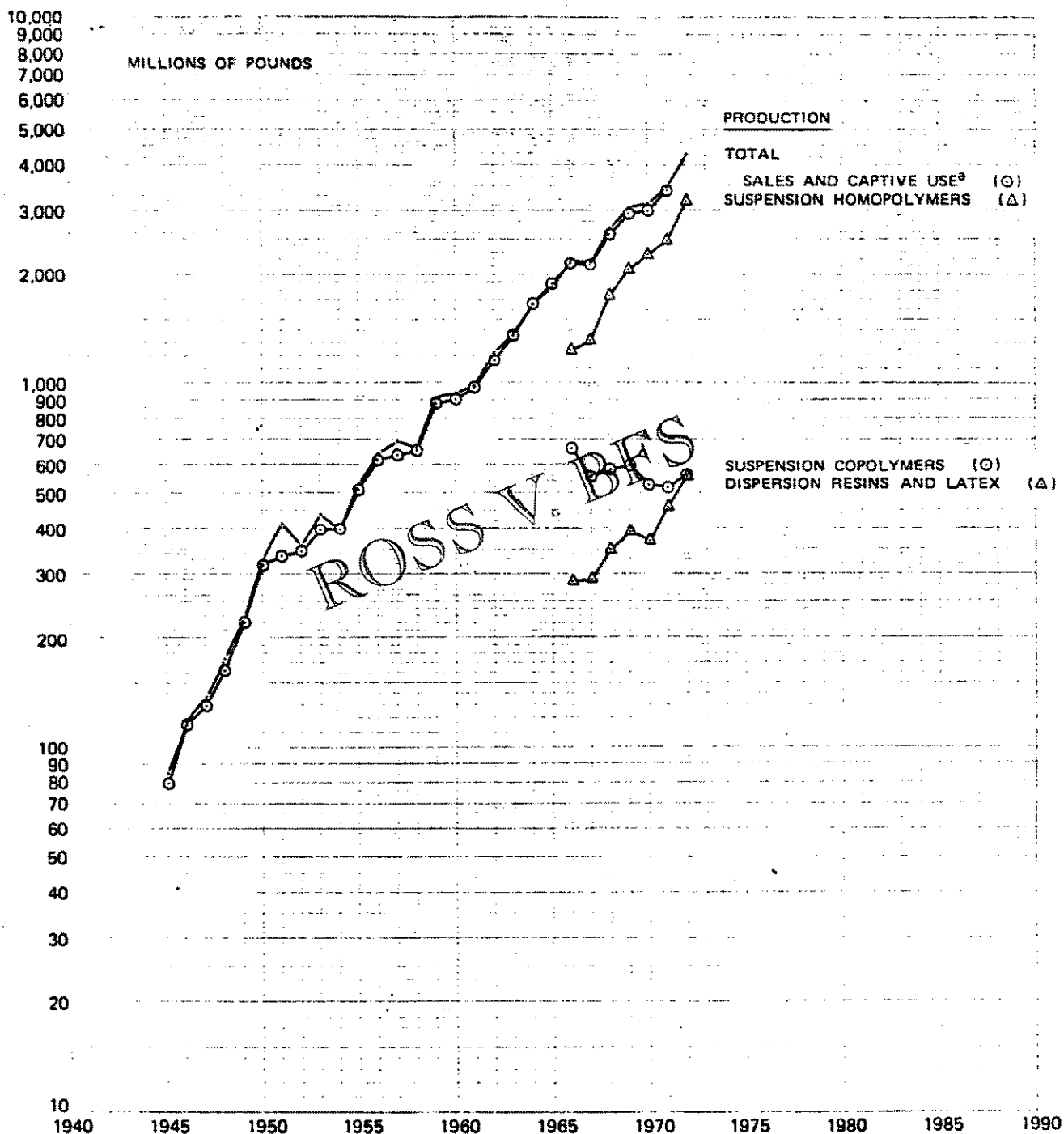


POLYVINYL CHLORIDE RESINS - CONTINUED

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a. A breakdown of SALES AND CAPTIVE USE is included in the table.

POLYVINYL CHLORIDE RESINS - CONTINUED

U.S. PRODUCTION, SALES, AND CAPTIVE USE OF PVC RESINS
(Millions of Pounds)

	Production				Sales and Captive Use		
	Suspension Homopolymers	Suspension Copolymers	Dispersion Resins and Latex	Total	Sales	Captive Use By Resins Producers	Total
1945	-	-	-	84	79	-	79
1946	-	-	-	117	115	-	115
1947	-	-	-	136	128	-	128
1948	-	-	-	173	162	-	162
1949	-	-	-	227	220	-	220
1950	-	-	-	325	315	-	315
1951	-	-	-	411	333	-	333
1952	-	-	-	356	342	-	342
1953	-	-	-	435	394	-	394
1954	-	-	-	392	397	-	397
1955	-	-	-	527	506	-	506
1956	-	-	-	637	612	-	612
1957	-	-	-	690	634	-	634
1958	-	-	-	657	648	-	648
1959	-	-	-	905	876	-	876
1960	-	-	-	936	900	-	900
1961	-	-	-	977 ^a	966	-	966
1962	-	-	-	1,215	1,151	-	1,151
1963	-	-	-	1,386	1,207	159	1,366
1964	-	-	-	1,637	1,374	273	1,647
1965	-	-	-	1,838	1,715	140	1,855
1966	1,224	658	282	2,164	1,816	310	2,126
1967	1,303	550	289	2,142	1,928	184 ^b	2,112
1968	1,713	578	344	2,635	2,330	220 ^b	2,550
1969	2,052	592	388	3,032	2,748	168 ^b	2,916
1970	2,247	521	366	3,115	2,847	138 ^b	2,985
1971	2,475	512	453	3,440	-	-	3,394
1972	3,149	559	550	4,258	-	-	-

See MANUAL OF CURRENT INDICATORS for additional data.

a. Includes 678 million pounds of PVC homopolymer, 283 million pounds of vinyl chloride-acetate copolymer, and 16 million pounds of other PVC copolymers in this year.

b. Calculated as "Sales and Use" minus "Sales."

- SOURCES: (A) SYNTHETIC ORGANIC CHEMICALS, U.S. PRODUCTION AND SALES, U.S. Tariff Commission (data for 1945-1970 and data in footnote a).
 (B) MONTHLY STATISTICAL REPORT, The Society of the Plastics Industry, Inc., December 1971 (data for 1971).
 (C) ANNUAL STATISTICAL REPORT, PLASTICS & RESINS MATERIALS, 1972, The Society of the Plastics Industry, Inc., April 1973 (data for 1972).



Production of polyvinyl chloride resins in the first three months of 1973 was over 1,175 million pounds, 17.8% more than in the comparable 1972 period (Monthly Statistical Report, The Society of the Plastics Industry, Inc., March 1973).

Data on production of PVC resins by process in the preceding table indicate that most of the growth has been in suspension homopolymer resins--an average growth rate of 15.5% from 1966 to 1972 (an estimated 200-250 million pounds of resins produced by bulk polymerization are believed to be included in the production reported for suspension homopolymers in each of the years 1971 and 1972--CEH estimate). The production of dispersion resins and latex (made by the emulsion process and known to include small amounts of copolymers) rose at an average annual rate of 18.2% in the same period, and the production of suspension copolymers declined at an average annual rate of 5.5% between 1966 and 1971, and then increased 9% in 1972, according to these statistics. In the future, resins produced by bulk polymerization are expected to account for a steadily increasing share of total production (CEH estimate).

It is believed that the reported data for captive consumption in the preceding table are understated in all years. For example, in 1970 the reported data indicate that only 138 million pounds of resin were captively consumed. However, one source estimated that in 1970 as much as 800 million pounds of PVC resins were captively consumed (MP, March 1971, p. 63) leaving resin sales (including compounded resins) on the open market at 2.0-2.2 billion pounds. Captive PVC resin consumption for end products (not counting compounded resins) in 1971 is believed to have been again about 800 million pounds (CEH estimate based on communication with industry). Particularly well known are the large captive PVC end-product manufacturing operations of Borden, Diamond Shamrock, Stauffer, Uniroyal, and the captive PVC pipe manufacturing facilities of Ethyl Corporation and Olin Corporation.

CONSUMPTION

Vinyl Chloride

Vinyl chloride is used almost entirely for the production of polyvinyl chloride homopolymer and copolymer resins. The remainder, estimated at less than 3% of total production or between 100 and 150 million pounds in 1972 (CEH estimate), was used in a variety of applications such as (1) the production of methyl chloroform (see the CEH report on Methyl Chloroform for more information), (2) as an additive to specialty coatings, and (3) as an additive in certain aerosol mixtures (see DS, June 1970, pp. 26, 28, 35, and 36 for information on vinyl chloride in aerosols).

Polyvinyl Chloride Resins

The consumption of PVC resins in the United States was over 3.2 billion pounds in 1971 compared with 2 billion pounds in 1966--an average annual growth of over 9% in the five-year period. In 1972, a phenomenal 4,180 million pounds of PVC resins were consumed, more than a 27% advance in one year alone.

POLYVINYL CHLORIDE RESINS - CONTINUED

Except for the solution grade and other coating resins (consumption of which was under 100 million pounds or less than 4% of total consumption), and PVC latices, both of which are mostly used in coatings, all PVC resins are used in the production of plastics products. These PVC products are produced by some 8,000 fabricators, either from purchased compounded resins (most merchant compounded resins are produced by the PVC resin manufacturers in large, highly automated plants) or from compounded resins that the fabricators prepare themselves.

Processing of the compounded resins to the end products requires (with the exception of some plastisol uses) specially designed and highly capital-intensive operations.* This fact, and the very competitive nature of the PVC plastics business in all of its segments, explains the specialization by process of most PVC plastics producers.

Consumption of PVC resins by the processes used to make end products is discussed in the next section. This is followed by another section which gives a breakdown of PVC resin consumption by end use and a discussion of these end-use markets.

A. Consumption by Process

The following table summarizes reported domestic PVC resins consumption according to Tariff Commission categories. After this table, detailed breakdowns of this consumption are given, accompanied by brief discussions.

	Extrusion	Calendering	Dispersions ^a	Molding ^a	Solutions ^b	Miscellaneous	Total
1960	230	392	89	70	39	83	903
1961	238	424	100	72	36	95	965
1962	272	490	105	78	45	130	1,120
1963	317	559	144	97	-	206	1,323
1964	399	652	178	99	-	249	1,577
1965	483	686	203	121	-	295	1,788
1966	574	736	287	179	54	228	2,058
1967	596	660	231	177	72	305	2,041
1968	739	650	272	200	83	491	2,435
1969	1,000	793	279	248	84	350	2,754
1970	1,095	705	281	254	85	376	2,796
1971 ^p	1,295	835	415	309	90	281	3,225
1972	2,052	963	457 ^c	410 ^d	118 ^e	180	4,180

See MANUAL OF CURRENT INDICATORS for additional data.

- a. Terminology used by the Tariff Commission for these categories and their subcategories has been inconsistent over the years. Reported data were regrouped to permit this comparative organization.
 b. Data are reported under "Protective Coatings and Adhesives" and "All Other Coating Uses," although not all resin reported here is processed in solution applications.
 c. Components are: Coating-Flooring, and Textile and Paper Coating; Paste Processes-Plastisol Formulation, and All Other
 d. Components are: Bottles (blow molding), 77 million pounds; Sound Records (compression molding), 148 million pounds; All Other Molding (believed to be substantially all injection molding), 185 million pounds.
 e. Reported as "Protective Coatings" (59 million pounds) and "Adhesives and All Other Coating Uses" (also 59 million pounds). Believed to include mostly solutions but also some dispersion and powder coatings.

SOURCES: (A) SYNTHETIC ORGANIC CHEMICALS, U.S. PRODUCTION AND SALES, U.S. Tariff Commission (data for Total Domestic Consumption, designated as "Sales" or "Sales and Use" by the source, for 1960 through 1970).
 (B) SYNTHETIC ORGANIC CHEMICALS, U.S. PRODUCTION AND SALES OF PLASTICS AND RESIN MATERIALS, 1971 Preliminary, U.S. Tariff Commission (preliminary data for 1971).
 (C) ANNUAL STATISTICAL REPORT, PLASTICS & RESINS MATERIALS, 1972, The Society of the Plastics Industry, Inc., April 1973 (data for 1972).
 (D) CEM estimates (components of some data for 1960 and 1961 as detailed in subsequent tables).

* Detailed information on PVC compounding and processing may be found in the following sources: Brighton, C. A., "Vinyl Chloride Polymers, Compounding and Fabricating," Encyclopedia of Polymer Science and Technology, Volume 14, Interscience Publishers, New York, 1971, pp. 394-452; and McKelvey, J. M., Polymer Processing, John Wiley & Sons, Inc., New York, 1962.



POLYVINYL CHLORIDE RESINS - CONTINUED

PLASTICS AND RESINS

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The small difference between the sum of the reported domestic consumption and exports of PVC resins in 1972 and the reported U.S. production of these resins is believed to be largely due to year-to-year stock changes (imports were only 4.4 million pounds in 1972).

1. Extrusion Processes

Domestic PVC resin consumption in extrusion processes in recent years is given in the following table.

U.S. Consumption of PVC Resins in Extrusion Processes

	Millions of Pounds			Total	Total as a Percent of All PVC Consumption
	Wire and Cable	Film and Sheet	All Other ^a		
1960	--	--		(230)	26%
1961	--	--		(238)	25
1962	170	102		272	24
1963	184	133		317	24
1964	195	204		399	25
1965	217	206		483	27
1966	226	66	282	574	28
1967	196	103	297	596	29
1968	289	134	316	739	30
1969	376	161	463	1,000	36
1970	409	194	492	1,095	36
1971p	343	179	773 ^b	1,295	40
1972	439	220	1,392 ^c	2,052 ^d	49

a. Includes all PVC resins consumed for pipe, conduit, tubing and rod, and all other rigid, semirigid, and flexible profile extrusions, such as garden hose. Consumption of PVC resins in garden hose was reported as follows (millions of pounds):

1962	6	1964	14
1963	8	1965	11

b. Includes 497 million pounds consumed for pipe and conduit and 276 million pounds for other extrusions.

c. Includes 1,008 million pounds for rigid pipe and tubing, and 384 million pounds for all other extrusions.

d. Add total is lower than the sums of the individual categories because of rounding.

(continued)

POLYVINYL CHLORIDE RESINS - CONTINUED

- Sources: (A) CEH estimates (estimates for 1960 and 1961 in the table).
 (B) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission (data for 1962-1970).
 (C) Synthetic Organic Chemicals, U.S. Production and Sales of Plastics and Resin Materials, 1971 Preliminary, U.S. Tariff Commission (preliminary data for 1971).
 (D) Annual Statistical Report, Plastics & Resins Materials, 1972, The Society of the Plastics Industry, Inc., April 1973 (data for 1972).

Extrusion processes differ depending on the types of end products; from a process standpoint, it is significant whether these end products are rigid or flexible. Therefore, the following discussion is divided correspondingly.

Rigid Extrusions. The PVC resins most used in rigid extrusions are suspension homopolymers blended with vinyl chloride-vinyl acetate copolymers (of low vinyl acetate content) or propylene copolymers. Post-chlorinated homopolymers are also used. The resins are blended to balance the required physical properties of the end product with ease and speed of processing. In 1971, 717 million pounds or 55% of all PVC resins used in extrusion processes went into rigid extrusions. The following is an estimated breakdown of PVC resin consumption in rigid extrusions in 1971.

Estimated U.S. Consumption of PVC Resins in Rigid Extrusions--1971

	<u>Millions of Pounds</u>
Pipe and Conduit	497
Siding and Other Rigid Profiles	130
Film and Sheet	90
Architectural and engineering	55
Packaging	35
Total	<u>717</u>

Source: CEH estimates.



The bulk of the sensational 58% increase of PVC resin consumption in extrusion in the year 1972 alone went into rigid extrusions, as detailed later in the section of this report on Consumption by End Use. All products in the field of rigid PVC extrusion have shown particularly rapid growth in the past ten years and are expected to remain the principal growth areas for PVC resins between 1972 and 1980 (CEH estimate).

An emerging field of importance is that of foamed rigid profiles (extruded molding).

Pipe and conduit constitutes the largest and the fastest growth segment of extruded PVC plastics. Pipe extrusion constitutes a sizable captive market for two PVC resin producers--Ethyl Corporation and Olin Corporation.

Usage of vinyl chloride-vinyl acetate copolymers is heavy in the production of extruded rigid film and sheet,* also a growth area of above-average potential (CEH estimate).

Flexible Extrusions. General-purpose homopolymer resins are used in flexible extrusions where 578 million pounds (or 45% of all PVC resins used in extrusion) were consumed in 1971. An estimated breakdown of PVC resin consumption in flexible extrusions in 1971 follows:

Estimated U.S. Consumption of PVC Resins in Flexible Extrusions--1971

	<u>Millions of Pounds</u>
Wire and Cables	343
Profile Extrusions	150
Medical tubing	37
Garden hose	35
Gaskets and weather stripping	30
Waterstop sheetrib	27
Cove base	21
Packaging Film	85
Total	<u>578</u>

Source: CEH estimates.

* The term "film" is usually used for thicknesses under 6 mils (0.006 inches), whereas the term "sheet" applies to greater thicknesses. A good portion of so-called rigid PVC film and sheet is not strictly plasticizer-free but may contain up to 10% plasticizer, depending on the exact physical requirements in the end application.

POLYVINYL CHLORIDE RESINS - CONTINUED

In the wire and cable markets, PVC is used as a jacketing material for telephone station wire, but its largest wire and cable use is in so-called construction wire. Most flexible, extruded PVC film is highly plasticized and is used largely for food packaging.

Of the varied flexible PVC profile extrusions, medical tubing and so-called water-stop sheatrib (which is embedded in concrete slabs and aquaducts) have shown remarkable growth in recent years. Although numerous types of profile gaskets (primarily weather stripping) are extruded from PVC, other materials have replaced PVC in many of these applications.

2. Calendering Processes

A breakdown of domestic PVC resin consumption in calendering processes in recent years is given in the following table.

U.S. Consumption of PVC Resins in Calendering Processes

	Millions of Pounds			Total	Total as a Percent of All PVC Consumption
	Film and Sheeting ^a	Flooring ^b	Textile ^d		
1960	231	(182) ^c	(40)	392	43%
1961	237	(145) ^c	(42)	424	44
1962	244	186	(60)	490	44
1963	284	205	(70)	559	42
1964	328	244	(80)	652	41
1965	334	262	(90)	686	39
1966	(359) ^b	297	(80)	736	36
1967	(320) ^b	265	(75)	660 ^e	32
1968	(321) ^b	244	(85)	650 ^e	27
1969	(433) ^b	270	(90)	793 ^e	29
1970	(382) ^b	247	(76)	705 ^e	25
1971p	474	274	87	835	26
1972	556	333	74	963	23

a. Designated by the sources as "All Other Calendering."

b. Data for 1966-1970 are estimates of the calendered film and sheeting portion of the reported consumption in all calendering except flooring.

c. Data for 1960 and 1961 are estimates of the calendered portion of the total reported consumption for flooring, which was 156 million pounds for 1960 and 185 million pounds for 1961.

(continued)



- d. Data for 1960-1965 are estimates of the calender-coated portion of the total reported consumption for all paper and textile coating uses. Data for 1966-1970 are estimates of the calender-coated textiles portion of the reported consumption in all calendering except flooring.
- e. Total consumption in 1967-1970 is believed to have actually been higher by 100 million pounds or more in each year. This consumption is believed to be included in the Tariff Commission data on "All Other Uses."

- Sources: (A) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission (Film and Sheetting data for 1960-1965, Flooring data for 1962-1970, Total data for 1966-1970, and data in footnote c).
- (B) Synthetic Organic Chemicals, U.S. Production and Sales of Plastics and Resin Materials, 1971 Preliminary, U.S. Tariff Commission (preliminary data for 1971).
- (C) Annual Statistical Report, Plastics & Resins Materials, 1972, The Society of the Plastics Industry, Inc., April 1973 (data for 1972).
- (D) CEH estimates (all data in parentheses and estimate in footnote e).

Most PVC resins consumed in calendering are general-purpose homopolymers. The use of copolymers (with relatively high molecular weights and low vinyl acetate contents) has declined as cheaper homopolymers with comparable ease of processing were developed. Recently, bulk-polymerized homopolymers with even better calendering characteristics were introduced and these are expected to eliminate the usage of conventional calendering copolymer resins with low vinyl acetate content and to gradually reduce the use of higher vinyl acetate content resins in rigid sheet and in floor tile.

As the preceding table indicates, overall PVC consumption in calendering increased sharply in the early 1960's as a result of rapid growth in all three major consumption areas. More recently, growth has been more moderate except in some specific end uses for film and sheeting that have shown strong growth, e.g., rigid packaging films, specialty films for tapes, swimming pool liners, and printed overlay film for wood. (Individual end uses in all applications of calendered PVC products are discussed in the section of this report on Consumption by End Use.)

Calendered film and sheeting is used in a wide variety of applications; the major outlets are household uses, consumer goods, transportation, and packaging.

The choice of the type of resin used in the production of rigid and semirigid sheeting depends not only on its calendering characteristics (permitting high speeds), but also on required end-use properties, e.g., formability. Rapid thermofforming with or without vacuum is an important requirement in many packaging applications, and copolymers are favored where fast deep-draw formability is needed.

POLYVINYL CHLORIDE RESINS - CONTINUED

An estimated 154 PVC calenders were believed to be operating in the United States in 1968-1969 (MP, December 1969, p. 10). Reportedly, in 1970 about 60% of all calendered PVC film and sheeting (corresponding to over 400 million pounds of PVC resin and believed to include flooring and coated textiles) were produced captively by about 10 PVC producers. There is a similar number of calender operators who do not produce PVC resins. Some of the largest of these are Fields Plastics and Chemicals, Inc., Plymouth Rubber Company, Chrysler Corporation, and Ford Motor Company--each with four or more calenders (CEH estimate based on communication with industry).

Leading producers of rigid calendered film and sheeting from PVC homopolymers and copolymers are the Nixon-Baldwin Division of Tenneco Chemicals, Inc., Hoechst Polymer Corporation, subsidiary of American Hoechst Corporation (100% owned by Farbwerke Hoechst AG of West Germany), and Phillips Products Co., Inc. (MP, August 1969, p. 19; May 1970, p. 20; and September 1970, p. 18).

The largest single outlet for calendered PVC is vinyl asbestos flooring; the resins used are mostly vinyl chloride-vinyl acetate copolymers with 8 to 18% vinyl acetate content; these can bind particularly large amounts of mineral fillers.

Calender-coated fabrics are used mostly for furniture upholstery, for seating, interior trim and vinyl roofs for automobiles (Landau tops), and for a variety of smaller end uses. Hence PVC resin consumption in calender-coated textiles is always strongly dependent on business conditions in furniture and in automobiles.

3. Dispersion Processes

Reported domestic PVC resin consumption in dispersion is shown in the following table.

U.S. Consumption of PVC Resins in Dispersion Processes ^a					
Millions of Pounds					
	Plastisol Formulating and Molding	Textile and Paper Coating	Flooring	Total	Total as a Percent of All PVC Consumption
1960	(30)	(24)	(35)	(89)	10%
1961	(30)	(30)	(40)	(100)	10
1962	28 ^b	(30)	47	(105)	9
1963	34 ^b	(58)	52	(144)	11
1964	39 ^b	(76)	63	(178)	11
1965	43 ^b	(91)	69	(203)	11
1966	92	133 ^c	62	287	14
1967	78	101	52	231	11
1968	107	108	57	272	11
1969	112	101	66	279	10
1970	113	93	75	281	10
1971 ^p	156 ^d	142	117	415 ^c	13
1972	150	173	134	457	11

(continued)



- a. Includes predominantly the PVC resin content of plastisols, and also that of organosols (solvent-modified plastisols), and latexes.
- b. Reported as used in slush molding (rotational molding or rotocasting).
- c. Includes 117 million pounds of PVC resins reported for "coating" and 16 million pounds for unspecified "other" textile and paper applications.
- d. Includes 106 million pounds of PVC resins used in "plastisol formulation" and 50 million pounds for "other paste processes."
- e. Of this total, an estimated 35 million pounds are believed to have been used in latex form.

- Sources:
- (A) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission (Flooding and Plastisol Formulating and Molding data for 1962-1970 and Textile and Paper Coating data for 1966-1970).
 - (B) Synthetic Organic Chemicals, U.S. Production and Sales of Plastics and Resin Materials, 1971 Preliminary, U.S. Tariff Commission (preliminary data for 1971).
 - (C) Annual Statistical Report, Plastics & Resins Materials, 1972, The Society of the Plastics Industry, Inc., April 1973 (data for 1972).
 - (D) CEH estimates (all estimates for 1960 and 1961, Textile and Paper Coating estimates for 1962-1965, and estimate in footnote e).

Most PVC dispersion resins are homopolymers, although some copolymers do find use (all are prepared by the emulsion process). Blending resins (used in conjunction with dispersion resins to lower the cost) are also mostly homopolymers (but usually prepared by the suspension process [MP, October 1970, pp. 132-136]).

Fluid dispersions of vinyl resins include predominantly plastisols, which sometimes may contain minor amounts of solvents. (Classic organosols, which contain a carefully formulated balance of solvents, are no longer in widespread use.) Plastisols are processed as fluid compounds so their flow behavior over a range of shear stresses is important. The individual processes include knife coating, roller coating, casting (used for coated fabrics), rotational molding (to make hollow objects such as beach balls), dipping (for gloves and tool handles), and hot spraying (thick protective coatings on metal objects like tool housings). Rotational molding is believed to be the largest application under the category Plastisol Formulating and Molding.

POLYVINYL CHLORIDE RESINS - CONTINUED

It is estimated that less than 10% of total dispersion resin consumption (e.g., an estimated 40 million pounds in 1972) is used in latex form (CEH estimate). Some of these latex resins are copolymers with minor amounts of vinyl acetate; ethyl-, n-butyl-, or 2-ethylhexyl acrylate; or vinylidene chloride. The usage of PVC latices is restricted to a number of specialized applications which include the following: (1) the saturation and coating of paper and paperboard, (2) the impregnation of nonwovens used in the dielectric assembly of automotive trim parts (such as door panels), (3) the production of vinyl wall coverings, and (4) as a component in one type of house paint (see the CEH report on Vinyl Surface Coatings for details on this house paint).

As the preceding table indicates, dispersion resin consumption grew at an average annual rate of 15.3% between 1961 and 1971. The 48% increase in the reported consumption of dispersion resins from 1970 to 1971 and the large increase from 1965 to 1966 were accompanied by a marked reduction in the reported consumption of PVC resins in "Miscellaneous" applications, so it appears possible that actual gains in dispersion resin consumption may not have been as great as these data suggest. However, it is known that the coated-type PVC flooring took up significant quantities of dispersion resins in 1971. In addition, carpet backing consumed much more dispersion resin in 1971 than in 1970. A trend that continued in 1972 and 1973.

The term "plastisol formulation" as used by the Tariff Commission is believed to refer to commercial plastisols which are prepared and sold by a large number of small compounders to an equally large number of small users. In 1971, approximately 70 million pounds of PVC resins are estimated to have been used for such commercial plastisols. The remaining 36 million pounds that were reported under "Plastisol Formulation" in 1971, plus the 50 million pounds reported under "Other Paste Processes," are all believed to have been used in rotational molding (CEH estimate).

The consumption of dispersion resins in rotational molding, as it was estimated for the year 1970, is shown in the following table.

U.S. Consumption of PVC Dispersion Resins in Rotational Molding--1970

	<u>Millions of Pounds</u>
Toys and Novelties	30
Miscellaneous Consumer Articles	30
Automotive (arm rests, head rests, crash pad skins, gear box covers)	12.5
Recreational (bicycle saddles, beach balls, basketballs)	12.5
Total	85.0

Source: Modern Plastics, March 1971, pp. 52-56.



The production of plastisol-coated fabrics and papers for use in automobiles, furniture, garments, luggage, wall coverings, outer apparel, shoes, and a multitude of other uses has shown consistent growth despite competition from calender-coated textiles. Most large coaters operate both calender and dispersion processes because technical factors usually dictate the use of one process or the other for a particular product.

A particularly fast growing and relatively new market for vinyl dispersion resins in the textile-coating field is in foamed carpet backings. Such PVC backings not only provide cushioning for tufted carpets and, at the same time, lock the tufting yarns in place, but also help the carpet meet current flammability requirements. The widespread use of relatively low-melting polypropylene tufting backings prompted the development of new paste-forming PVC copolymers which allow fusion of the vinyl foam backing at or below 300°F.

The consumption of vinyl dispersion resins in cast flooring (such as that produced by Congoleum Industries, Inc., a subsidiary of Bath Industries, Inc.) has increased remarkably in the last three years, mostly at the expense of calendered vinyl flooring.

Additional information on PVC dispersion resin consumption may be found in Bucsko, R. J., "Future Markets for Vinyl Dispersion Resins," a paper presented before the 15th Film, Sheet and Coated Fabrics Conference, The Society of the Plastics Industry, Inc., New York, November 1971.

4. Molding Processes

Reported domestic PVC resin consumption in the various molding processes is shown in the following table.

U.S. Consumption of PVC Resins in Molding Processes

	Millions of Pounds			Total	Total as a Percent of All PVC Consumption
	Compression Molding ^a	Injection Molding ^b	Blow Molding ^b		
1960	(58)	(12)	0	(70)	8%
1961	(58)	(14)	0	(72)	7
1962	61	(17)	0	78	7
1963	78	(19)	0	97	7
1964	75	(24)	0	99	6
1965	90	(26)	(5)	121	7
1966	114	(50)	(15)	179	9
1967	105	(52)	(20)	177	9
1968	122	(55)	(23)	200	8
1969	138	(64)	(46)	248	9
1970	141	(66)	(47) ^d	254	9
1971 ^p	138	135 ^c	36 ^d	309	10
1972 ^c	148	185	77	410	10

(continued)

POLYVINYL CHLORIDE RESINS - CONTINUED

- a. Designated by the Tariff Commission as "Sound Records."
- b. Data for 1960-1965 were reported as "All Other Molding" and for 1966-1970 as "Injection and Blow Molding" (combined).
- c. Designated by the Tariff Commission as "All Other Molding."
- d. It is widely believed that actual consumption in blow molding in 1970 and 1971 was considerably higher. Estimates for PVC resin consumption in blow-molded bottles are on the order of 70 million pounds in both years (see the section on Packaging on p. 580.1883P).
- e. Reported components are: Bottles (blow molding), Sound Records (compression molding), and All Other Molding (believed to be substantially all injection molding).

Sources: (A) CEH estimates (estimates for 1960 and 1961 and estimates for Injection Molding and Blow Molding for 1965-1970).

(B) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission (data for 1962-1970).

(C) Synthetic Organic Chemicals, U.S. Production and Sales of Plastics and Resin Materials, 1971 Preliminary, U.S. Tariff Commission (preliminary data for 1971).

(D) Annual Statistical Report, Plastics & Resins Materials, 1972, The Society of the Plastics Industry, Inc., April 1973 (data for 1972).

PVC resin consumption in the various (technically very different and unrelated) molding processes had a combined average annual growth of 15.7% from 1961 to 1971, and a rate of only 5.6% between 1966 and 1971. Then in 1972, a 33% increase occurred. As the data in the table show, however, the growth rate for resin consumption in the three different molding processes varied greatly.

Compression Molding. PVC consumption in compression molding, which includes essentially only sound records, grew at an average annual rate of slightly over 8% between 1960 and 1972.

To obtain adequate replicas of the sound vibrations in the grooves of records, particular flow properties of the compound (which consists of 98% PVC resins) are needed so that it can conform to the required surface pattern in microscopic detail. High vinyl acetate content (10-16%) copolymers, specially designed for this purpose, are used in the compression molding of phonograph records.

Injection Molding. The resins most frequently used in PVC injection molding are medium molecular weight homopolymers and some lower molecular weight vinyl chloride-vinyl acetate copolymers. An estimated 90% of all PVC resins consumed in injection molding is used for pipe fittings and the balance is mostly used for industrial parts, e.g., fan blades for chemically resistant exhaust systems.

PVC consumption in injection molding increased by an average of almost 26% per year from 1961 to 1971; between 1966 and 1971, an average growth rate of 22% prevailed--thus, this category is an outstanding growth field. The doubling of consumption in 1971 is believed to have been due to the following: (1) the operation of newly installed multiple-screw injection machines, (2) the general increase in PVC piping installations in many phases of construction, and (3) the strong resurgence of building activity in 1971. In 1972, resin consumption increased again by 37% in injection molding.

Blow Molding. The blow molding of PVC resin is a relatively recently developed, sophisticated, and highly capital-intensive technology used primarily for the mass production of PVC bottles and requires special resins, special compounds, and special equipment.

PVC resin consumption in blow molding grew steeply from 1965 to 1972 (see footnote d in the preceding table concerning data for 1970 and 1971). Data on the 1971 consumption are conflicting (see the section on Packaging in this report); it appears that some decline occurred in 1971 in connection with industry concern about the possibility of government-imposed limitations on the large scale use of PVC bottles in the future.

In mid-1971, an estimated 225 production machines (of which more than 95% were imported) and an estimated 100 proprietary machines (designed and built by some leading PVC bottle producers themselves) were in operation in the United States. The technical problems that have been successfully solved in recent years to develop efficient production technology for the blow molding of PVC bottles were formidable and are too complex for treatment in this report. (Technical details may be found in the following articles: "Plastic-Bottle Future: Grafted to Proliferating Molecules," Modern Packaging, May 1969, pp. 78-83; and Waechter, C. J. "What's Happening in PVC Blow Molding," SPE Journal, July 1971, pp. 43-47.)

Heat stability during processing was a major problem in the early stages of the development of the technology for blow molding of PVC bottles. To overcome this problem, vinyl chloride-olefin copolymers were developed (by Air Products and Chemicals, Inc. and Union Carbide Corporation) that proved very successful in blow molding. Special compounds based on bulk-polymerized homopolymers and on suspension homopolymers (the latter usually in admixture with such copolymers as a lauryl ether-vinyl chloride copolymer made by GAF Corporation) are offered to processors.

POLYVINYL CHLORIDE RESINS - CONTINUED

5. Solutions

Data on PVC resin consumption in solution applications in recent years are given in the following table. This consumption has been reported as "Protective Coatings and Adhesives," and recently together with a category called "All Other Coating Uses." It is believed that the bulk of this consumption has been in applications where the resin is put in solution, although some dispersion coating resins and powder coating resins are probably included.

U.S. Consumption of PVC Resins in Solutions^a

	Millions of Pounds	Total as a Percent of All PVC Consumption
1960	39	4%
1961	36	4
1962	45	4
1963	(50)	4
1964	(50)	3
1965	(50)	3
1966	54	3
1967	72	4
1968	83	3
1969	84	3
1970	85	3
1971 ^p	90 ^b	3
1972	118 ^c	3

- a. Reported in the source as "Protective Coatings and Adhesives" in 1960-1962 and 1966-1970. In 1971 also includes "All Other Coating Uses." Believed to include mostly solutions but also some dispersion and powder coatings.
- b. Includes 41 million pounds reported as used in "Protective Coatings and Adhesives" and 49 million pounds reported as used in "All Other Coating Uses."
- c. Reported as "Protective Coatings" (59 million pounds) and "Adhesives and All Other Coating Uses" (also 59 million pounds). Believed to include mostly solutions but also some dispersion and powder coatings.

Sources: (A) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission (data for 1960-1962 and 1966-1970).

(B) CEH estimates (estimates for 1963-1965).

(C) Synthetic Organic Chemicals, U.S. Production and Sales of Plastics and Resin Materials, 1971 Preliminary, U.S. Tariff Commission (preliminary data for 1971).

(D) Annual Statistical Report, Plastics & Resins Materials, 1972, The Society of the Plastics Industry, Inc., April 1973 (data for 1972).



All solution-grade resins are made by solution polymerization and most are vinyl chloride-vinyl acetate copolymers with vinyl acetate contents of 8 to 12%. One type often used in adhesives has a small amount of free carboxyl groups and another often used in protective coatings has a small amount of free hydroxyl groups. Typical solvents used in the solutions are cyclohexanone, tetrahydrofuran, methyl ethyl ketone, and diisobutyl ketone; however, some of the resins tolerate the presence of minor quantities of low-cost aromatic hydrocarbon diluents. (For more information on the use of PVC solution resins in coatings, see the CEH report on Vinyl Surface Coatings.)

PVC resin consumption in the form of solutions (including some other forms of coatings) had an average annual growth rate of 9.7% between 1960 and 1972, as indicated in the preceding table.

6. All Other Uses

The Tariff Commission has maintained this category largely to balance statistics (the great bulk reported under this heading actually belongs in the individual process categories previously discussed). The following table presents the reported data with pertinent commentary footnotes.

PVC resin consumption in some specialty uses may not have been covered by the main process categories. They may include, for example, the production of rigid vinyl foams.

U.S. Consumption of PVC Resins in All Other Uses

	<u>Millions of Pounds</u>
1960	(83) ^a
1961	(95) ^a
1962	(130) ^b
1963	206 ^c
1964	249 ^c
1965	295 ^c
1966	228
1967	305 ^d
1968	491 ^d
1969	350 ^d
1970	376 ^d
1971 ^p	281
1972	180

- a. The actual figures reported for 1960 and 1961 were 113 million pounds and 125 million pounds, respectively. An estimated 30 million pounds of resins used in commercial plastisols were subtracted in each year and added to the table on U.S. Consumption of PVC Resins in Dispersion Processes (p. 580.1882X).

(continued)

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- b. The 161 million pounds-actually reported by the source includes an estimated 40 million pounds of exports (included in the INTERNATIONAL section statistics on Exports).
- c. Believed to include about 50 million pounds used in protective coatings and adhesives in each of the years 1963, 1964, and 1965.
- d. It is generally believed that at least 100 million pounds of each of these amounts were actually consumed in calendaring.

Sources: (A) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission (data for 1960-1970).

(B) Synthetic Organic Chemicals, U.S. Production and Sales of Plastics and Resin Materials, 1971 Preliminary, U.S. Tariff Commission (preliminary datum for 1971).

(C) Annual Statistical Report, Plastics & Resins Materials, 1972, The Society of the Plastics Industry, Inc., April 1973 (datum for 1972).

(D) CEH estimates (data in notes b, c, and d).

B. Consumption by End Use

The breakdown of PVC consumption by end use given in the following section is based largely on the annual publication of end use data by Modern Plastics magazine. This total consumption by end use usually varies somewhat from PVC consumption by process data reported by the U.S. Tariff Commission. Considering the size and diversity of the markets for PVC resins, however, this difference is not believed to require analysis. Some relatively small end uses are not included in the Modern Plastics data; these are believed to include applications where soluble copolymers are consumed, e.g., industrial protective coatings and topcoatings, as well as printing inks applied by rotogravure printing on most of the vinyl-coated fabrics and film produced, and perhaps powder coatings (see the CEH report on Vinyl Surface Coatings for more information). Examples of other small-volume end uses for PVC resins that are not mentioned in the Modern Plastics data are rigid vinyl foams, foamed carpet underpadding, and coated fabrics for tarpaulins and inflatable structures. No effort has been made to establish the volume of these relatively small markets.



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The following breakdown of PVC resin consumption by major end-use category in recent years shows that the average annual growth rate of PVC consumption by end use was 9.9% between 1966 and 1971. Then total PVC consumption by end use increased over 27% in 1972 alone.

U.S. Consumption of PVC Resins for Major End-Use Categories
(Millions of Pounds)

	Building and Construction	Household Uses	Consumer Goods	Electrical Uses	Packaging	Transportation	Miscellaneous Uses	Total
1966	(615)	(440)	(350)	226	(90)	(175)	(161)	(2,057)
1967	596	410	320	223	107	160	(181)	(2,007)
1968	668	443	375	301	161	199	123	2,269
1969	617	513	374	405	228	234	141	2,712
1970	1,006	513	424	425	272	225	162	3,027
1971	1,165	564	437	385	246	254	193	3,286
1972	1,739	630	504	439	277	255	256	4,180

Sources: (A) CEH estimates (estimates for 1966 and 1967).

(B) CEH estimates based on data from Modern Plastics, January 1973, p. 58, and Annual Statistical Report, Plastics Resins Materials, 1972, The Society of the Plastics Industry, Inc., April 1973 (data for 1972).

(C) Modern Plastics, January issues (all other data).

The major end uses shown in this table are discussed and further breakdowns are given in the following sections.

1. Building and Construction

A breakdown of PVC resin consumption in building and construction in recent years is given in the following table.

The data in the table indicate that PVC resin consumption in building and construction has grown at an average annual rate of 13.7% between 1966 and 1971. In 1972 alone, a 49% increase in PVC resin usage in construction took place. As a percent of total PVC resin consumption by end use, it grew from 20% in 1966 to 42% in 1972.

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U.S. Consumption of PVC Resins in Building and Construction

(Millions of Pounds)

	Pipe and Conduit	Pipe Fittings	Flooring	Siding	Windows and Other Rigid Profiles	Swimming Pool Liners	Weather Stripping	Water Stops	Lighting Fixtures	Rain Gutters	Total
1966	123	12	370	(22)	(16)	--	--	--	--	--	(615)
1967	(155)	(20)	303	25	20	20	25	18	7	4	596
1968	186	34	302	35	25	30	26	18	8	4	668
1969	238	52	347	50	35	32	28	20	9	8	817
1970		(480)	325	(53)	45	35	30	20	9	7	1,006
1971		(810)	325	(60)	55	40	32	27	9	7	1,165
1972	1,008	86	343 ^a	70	108 ^b	44	40	31 ^c	11	--	1,739

a. The SPI reported 333 million pounds of PVC used for calendered flooring plus 123 million pounds for coated flooring. Modern Plastics listed a total of 344 million pounds only.

b. Includes 31 million pounds of extruded foam molding.

c. Includes rain gutters.

Sources: (A) CEH estimates (all data in parentheses).

(B) CEH estimates based on Annual Statistical Report, Plastics & Resins Materials, 1972, The Society of the Plastics Industry, Inc., and Modern Plastics, January 1973, p. 58 (data for 1972).

(C) Modern Plastics, January 1973 (all other data).

Pipe, Conduit, and Pipe Fittings. Between 1966 and 1971, PVC resin consumption in pipe, conduit, and pipe fittings grew at an average annual rate of 34%, and in 1972 alone, almost 80%.

ABS, other styrene copolymers, and polyethylene compete with PVC in the plastic pipe and conduit markets. Overall, CEH estimates that PVC had well over half of the total plastic pipe and conduit business in 1972; a breakdown by segment of the PVC pipe and conduit markets, and fittings, for 1973 follows:

Estimated PVC Consumption in Pipe and Conduit--1973

	Millions of Pounds
Pipe and Conduit	
Communications duct	114
Electrical conduit	75
Pressure pipe ^a	792
Drain, waste, and vent pipe	99
Sewer pipe ^b	55
Other ^c	31
Total	1,166
Fittings	264
Total	1,430

a. Includes water supply and distribution, and gas distribution lines.

b. Includes home sewer piping and sewer mains.

c. Includes oil and gas production lines, and chemical processing pipe.

Source: Modern Plastics, March 1973, p. 59.



The share that each type of plastic holds of each market is determined to a great extent by each material's particular ability to competitively match the cost and performance requirements in the individual applications. For example, PVC is leading in water supply pipe and conduit but has smaller--although not insignificant--shares in (a) gas distribution pipe (where polyethylene leads), (b) DWV pipe (where ABS is dominant), and (c) sewer pipe (where PVC has just begun to move in strongly).

About 75% of the PVC resin used in pipe production was compounded into powder blends by the pipe producer in recent years. However, new blending techniques developed by some resin producers indicated a change in this pattern as some resin producers prepared to become major sources for ready-to-extrude pipe compounds (MP, July 1971, pp. 72 and 76, and September 1971, p. 14).

Plastic pipe is cheaper and much less costly to install than conventional cast iron piping, but its acceptance reportedly is strongly resisted by plumbers' unions and cast iron pipe interests (CE, July 28, 1969, pp. 76, 78, and 80). However, market fundamentals (demand, lower cost, satisfactory performance) favor continued strong expansion of plastic pipe. In 1969, plastic pipe sales amounted to a mere 3% of the total U.S. pipe sales (industrial and residential).

According to industry observers, leading in the expected continued expansion of PVC pipe and conduit applications will be low pressure pipe, particularly large diameter water pipe (12 inches and larger), and sewer pipe. Other end uses also expected to grow vigorously include telephone conduit and residential hot-water pipe made from post-chlorinated PVC. In DWV pipe, PVC's market share is believed to be about 30% as of mid-1973, and PVC is expected to gradually increase its market share (CEH estimate based on communication with industry).

PVC consumption in pipe, conduit, and pipe fittings is expected to rise at an average annual rate of 22-24% between 1972 and 1975 and at a slightly lower rate thereafter, so that PVC resin usage in this field will be slightly over 2 billion pounds by 1975 and at least 4.1 billion pounds by 1980 (CEH estimates).

Flooring. Of total PVC resin consumption in building and construction, flooring's share declined from 60% in 1966 to 28% in 1971 when only 325 million pounds of PVC resins were used in flooring. A slight upturn occurred in 1972.

Until 1970, flooring was the largest single end use for PVC. PVC tile and sheet for floor covering is produced in a variety of types. In 1969, 67% of all PVC flooring produced was of the vinyl-asbestos type (these compounds are based on vinyl chloride-vinyl acetate copolymers and contain only 15% resin), 30% were roll goods, and 3% were of the solid, homogeneous type (MP, December 1969, p. 16). In recent years, coated vinyl flooring (plastisol-coated felts) have moved into the lower-cost markets at the expense of calendered vinyl-asbestos tile.

Because of the persisting trend toward increased usage of carpeting, the market for PVC flooring has declined from about 30% of all basic floor coverings in 1961 to about 30% in 1971 (CEH estimates). SPI data for 1972 show 333 million pounds of PVC used for calendered and 134 million pounds for coated flooring, but Modern Plastics showed only 313 million pounds for all PVC flooring in 1972. The latter figure is believed to be more accurate. By 1973, PVC consumption in flooring is estimated to reach 400 million pounds per year--an average growth rate of about 5% annually from the 343 million pounds believed consumed in 1972 (CEH estimates). However, this does not include a possible requirement of, according to one source, as much as 250 million pounds of PVC resins (half of them dispersion resins and the other half blending resins) which has been estimated for consumption in foamed vinyl carpet backing by 1975. Vinyl foam is expected to compete strongly with styrene-butadiene copolymer backcoatings because it effectively imparts the flame retardance properties now required by U.S. government regulations (MP, April 1971, p. 86).

Siding, Windows, and Other Rigid Profiles. The average annual growth rate between 1966 and 1971 was 22% for siding and 20% for windows and other rigid profiles. In 1972, siding advanced further, and a new category of rigid profile extrusion, foamed molding, was reported. This technology has developed over the last several years.

Most PVC siding is sold in the replacement market and in mobile homes, where it competes with aluminum siding. Some new types of vinyl siding, produced by the thermoforming of rigid sheet, simulate stone and wood shingles. Recently, PVC siding has also been more widely used in new residential construction (major producers are Nastec Corp., South Bend, Indiana, Bird & Son, Walpole, Massachusetts, and Certain-teed Products Corp., Valley Forge, Pennsylvania). PVC siding is expected to grow at an average annual rate of about 25% from 1972 to 1975 (CEH estimates).

PVC consumption in window frames is mostly in vinyl-clad wood at the present time; vinyl is extruded directly over a wood core of the sash, while corner joints are given a welded seal after assembly. In another method, rigid PVC extrusions are attached to wooden frames with adhesives. All-PVC window frames have been in the development stage for some time, but their commercial future is still uncertain.

Rigid profiles other than window frames are spline for storm windows and doors, rigid weather stripping, and rigid molding. An expandable PVC extrusion compound introduced by The Goodyear Tire & Rubber Company in 1971 lends itself to the production of a rigid foam molding with an integral skin, on which a woodgrain pattern can be printed. The product is distributed by Champion International Corporation (formerly U.S. Plywood-Champion Papers, Inc.). Other major producers are B. F. Goodrich and Georgia-Pacific. It has been estimated that 50% of this rigid, cellular PVC molding goes into mobile homes, and that it has captured about 8% of the prefinished wood molding market; by 1975, as much as 200 million pounds of PVC have been estimated to be required for extruded PVC foam molding (PW, June 1973, pp. 42-45).



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These rigid extrusions (siding, windows, and other rigid profiles) are expected to grow at an average annual rate of 25% between 1972 and 1975, and probably to 1980. Particularly strong growth is expected in window frames. Rigid foam profile extrusions are estimated to grow about 20% per year in the same period (CEH estimates).

Other Uses in Building and Construction. Other end uses in this market are led by swimming pool liners (calendered sheet 8 to 30 mils thick), which became popular in the late 1960's and had an average annual growth rate of 19% between 1967 and 1971. Foremost among producers of pool liners are the PVC resin producers (MP, June 1969, p. 12).

Combined PVC usage in swimming pool liners, weather stripping, water stops, lighting fixtures, and rain gutters amounted to roughly 10% of PVC resin consumption in all building and construction uses in 1971. All of these applications are expected to show moderate growth—an average rate of approximately 10% per year—between 1972 and 1975 (CEH estimates).

2. Household Uses

PVC resin consumption in household uses is shown in the following table. PVC resin consumption in household uses grew at an average annual rate of 5% between 1966 and 1971, but 1972 saw an almost 12% increase. As a percentage of total PVC resin consumption by end use, it was 21% in 1966 and 15% in 1972.

U.S. Consumption of PVC Resins in Household Uses^a

(Millions of Pounds)

	<u>Furniture Upholstery</u>	<u>Wall Coverings</u>	<u>Garden Hose</u>	<u>Tablecloths and Placemats</u>	<u>Shower Curtains</u>	<u>Closet Accessories</u>	<u>Appliances</u>	<u>Wood-Surface Films</u>	<u>Other</u>	<u>Total</u>
1966	(200)	(80)	(27)	(30)	(25)	(20)	(18)	--	(40)	(440)
1967	188	81	29	25	20	20	16	--	31	410
1968	218	60	30	26	21	22	17	12	37	443
1969	260	70	33	29	23	24	19	13	40	513
1970	247	80	35	30	25	25	24	17	30	513
1971	260	85	35		85 ^b		29	20	50	564
1972	319	128 ^c	44		104		35	--	--	630

a. Believed to include institutions and restaurants, other businesses, and public buildings as well as homes.

b. Includes closet accessories, shower curtains, tablecloths, and placemats.

c. Includes wood-surface films.

Sources: (A) CEH estimates (estimates for 1966).

(B) Modern Plastics, January issues (all other data).

POLYVINYL CHLORIDE RESINS - CONTINUED

Furniture Upholstery. About 46 to 50% of PVC resins consumed for all household uses is in furniture upholstery; this percentage remained substantially the same between 1966 and 1972. Vinyl-coated fabrics established themselves firmly in furniture in the early 1960's, particularly in low-priced lines. Backing fabrics changed from mostly cotton to mostly rayon in recent years for reasons of material economics. Today, almost all furniture upholstery containing PVC is in the form of coated fabrics. Over 90% of these fabrics are believed to be calendered sheet. Only a relatively small quantity of high-style expanded vinyls cast from plastisol is used (mostly in high-priced furniture).

After an apparently strong advance in 1972, the vinyl furniture upholstery market is expected to show only slight growth (about 4% per year between 1972 and 1975); however, it will always mirror fluctuations in the furniture business (CEH estimate).

All Other Household Uses. Wall coverings is the second largest household use and accounts for about 16% of PVC resin consumption in this category. PVC wall coverings are in most cases coated fabrics (predominantly sheetings and sateens) with a film thickness of 5 to 20 mils. Even though classified under household uses, most of the vinyl wall coverings produced are believed to go into institutions such as hospitals, nursing homes, and schools and into public buildings, business places, and restaurants. Vinyl's durability and toughness make it appropriate for use in institutions. Vinyl is also fairly fire resistant (depending on the type and amount of plasticizer in the compound), scuff resistant, and washable. Embossing and printing provide a large variety of styled products.

PVC consumption is expected to increase more in wall coverings than in any other household use--at an average rate of 12% per year in the 1972-75 period (CEH estimate).

Other household uses of PVC resins also include garden hose, tablecloths and placemats, shower curtains, unsupported film and coated papers with pressure-sensitive adhesive backings (for what are called closet accessories), and some unspecified uses such as window shades. These are established markets that are expected to show marginal growth--4 to 5% per year on the average--between 1972 and 1975. The relatively small market for PVC resins (mostly in the form of gaskets) in appliances is expected to grow about 7% per year, and PVC consumption in wood-surfacing films, an often publicized and rather new application of semirigid film, is expected to increase between 1972 and 1975 at an average annual rate of about 12% (CEH estimates).



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3. Consumer Goods

PVC resin consumption in consumer goods is shown in the following table.

U.S. Consumption of PVC Resins in Consumer Goods
(Millions of Pounds)

	<u>Sound Records</u>	<u>Footwear</u>	<u>Toys</u>	<u>Outerwear</u>	<u>Sporting Goods</u>	<u>Baby Pants</u>	<u>Other</u>	<u>Total</u>
1966	114	60 ^a	--	--	--	--	--	(350)
1967	104	83 ^b	57 ^c	45	--	19	12 ^d	320
1968	122	90	64	46	26	19	8	375
1969	116	100	58	40	30	21	9	374
1970	140	110	60	47	35	23	9	424
1971	125	115	62	53	40	20	22	437
1972	148	141	75	66	48	24	--	504

a. Reported as "Soles and Heels."

b. Includes 23 million pounds designated as rainwear (slipovers) and 60 million pounds for shoes.

c. Includes 13 million pounds for playballs, 18 million pounds for dolls, 19 million pounds for inflatable toys, and 7 million pounds for other toys.

d. Designated as "Other Clothing."

Sources: (A) CEH estimate (Total estimate for 1966).

(B) Annual Statistical Report, Plastics & Resins Materials, 1972, The Society of the Plastics Industry, Inc., April 1973 (1972 datum for Sound Records).

(C) Modern Plastics, January issues (all other data).

PVC resin consumption in consumer goods grew at an average annual rate of only 4.5% between 1966 and 1971, indicating near-saturation of the markets. Renewed strength was apparent in 1972, however.

The largest single consumer goods application is in sound records but, as the data in the preceding table indicate, growth in this area was quite marginal from 1966 to 1972. Average annual growth between 1972 and 1975 is expected to be about 5% (CEH estimate).

The second largest application of PVC in the field of consumer goods is in footwear. Most of this is for lower priced children's shoes, and a lesser portion is used for innersoles, socklining, and soling. This PVC market is expected to grow about 10% annually from 1972 to 1975 (CEH estimate).

POLYVINYL CHLORIDE RESINS - CONTINUED

- Most other applications of PVC resins in consumer goods (including toys, outerwear, sporting goods, baby pants, and various unspecified other uses such as home movie screens) are expected to continue in their established patterns and are expected to grow at rates between 5 and 8% per year. However, there are two exceptions: wigs and plastic Christmas trees. Both are relatively small and recent consumer applications which are expected to show above average growth in the next several years (see the CEH report on Vinyon Fibers for more information on PVC consumption in wigs).

4. Electrical Uses

PVC resin consumption in electrical uses, as shown in the following table, has grown at an average annual rate of 11% between 1966 and 1971, and almost 19% in 1972. As a percentage of total PVC consumption by end use, it was 11% in 1966 and slightly less in 1972.

U.S. Consumption of PVC Resins in Electrical Uses

(Millions of Pounds)			
	<u>Wire and Cable</u>	<u>Other</u>	<u>Total</u>
1966	226	--	226
1967	213 ^a	10	223
1968	289	12	301
1969	390	15	405
1970	410	15	425
1971	479	15	485
1972	438	--	439

- a. Includes 143 million pounds for construction cable, 48 million pounds for communications wire and cable, and 22 million pounds for automotive electrical wire and cable.

Sources: (A) Annual Statistical Report, Plastics & Resins Materials, 1972, The Society of the Plastics Industry, Inc., April 1973 (datum for 1972).

(B) Modern Plastics, January issues (all other data).



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Wire and Cable. PVC consumption in the wire and cable field breaks down as shown in the following table.

U.S. Consumption of PVC Resins in Wire and Cable--1971

Building Wire	47%
Communication Wire	18
Flexible Cord (for Household Lamps, Extension Cords)	16
Automotive Electrical Wire and Other Auto Uses	12
Appliance Wire	7
Total	100%

Source: Communication with industry.

The particularly strong advance of PVC consumption in wire and cable in 1969 reflected an ongoing trend from copper to aluminum conductors; the latter are larger in diameter (because a greater volume of aluminum is needed for the same load capacity) and thus require more insulation material around them.

PVC competes with several other plastics and elastomers in wire and cable insulation. Polyolefins are better electrical insulators, but PVC is a better jacketing material where resistance to flexing is required in a wire or cable. PVC's dominance in building wire suggests increasing consumption in this field in the next several years because of the anticipated continuing strength of the construction business. PVC's inroads into communication wire (PW, May 1969, pp. 31-32) are also expected to deepen. Thus, in the fields of building and communications wire (which together accounted for 65% of all PVC usage in wire and cable in 1971), the average annual growth between 1972 and 1975 is expected to be between 10 and 12% but in the remaining wire applications, growth is expected to be marginal--on the order of 5% per year. Total PVC consumption in wire and cable is expected to grow at an average annual rate of about 8% between 1972 and 1975 (CEH estimates).

Other Electrical Uses. The main "other" use for PVC in the electrical field is in electrical insulating tape where PVC competes with several other materials. Nevertheless, consumption for electrical tape is expected to increase gradually (CEH estimate).

POLYVINYL CHLORIDE RESINS - CONTINUED

5. Packaging

PVC resin consumption in packaging, as shown in the following table, grew at an average annual rate of 26% between 1966 and 1971. As a percentage of total PVC consumption by end use, it was 4% in 1966 and almost 9% in 1971.

U.S. Consumption of PVC Resins in Packaging

(Millions of Pounds)

	Film	Sheet ^a	Bottles	Coatings	Bottle Cap Liners and Gaskets	Total
1966	55	11	9	--	--	(90)
1967	55 ^b	15 ^c	22	15 ^c	--	107
1968	90	20	29	22 ^d	--	161
1969	105	50	46	15	12	228
1970	115	60	70	15	12	272
1971	110	75	70 ^e	16	15	286
1972	135	107	77	20	18	357

- a. Believed to be all rigid sheet (i.e., containing less than 10% plasticizer).
 b. Reported as "Used for Food Packaging."
 c. The estimated sheet portion of the 30 million pounds reported for "Non-Food Packaging."
 d. Believed to include bottle cap linings.
 e. The revised figure (of January 1973) is only 50 million pounds, which was also reported by the SPI.

Sources: (A) CEH estimates (Total estimate for 1966 in the table and estimates in footnotes a and c).

(B) Annual Statistical Report, Plastics & Resins Materials, 1972, The Society of the Plastics Industry, Inc., April 1973 (1972 datum for Bottles).

(C) Modern Plastics, January issues (all other data).

Film and Sheet. Of the estimated 185 million pounds of PVC film and sheeting used for packaging applications in 1971, 65 million pounds are believed to have been calendered rigid sheet (about half homopolymer and half copolymer), 35 million pounds extruded rigid film and sheet, and 85 million pounds highly plasticized extruded film* (CEH estimates).

* A relatively small quantity of PVC packaging film is cast from solution by The Goodyear Tire & Rubber Company (MP, November 1969, p. 18).



Of the 65 million pounds of calendered rigid sheet, about 40 million pounds are believed to have been used in blister packaging (illustrative are packages for hardware and pharmaceuticals) and the remaining 25 million pounds probably went into other packaging applications involving thermoforming, such as lids for greeting card boxes. Most of the 35 million pounds of extruded rigid material is believed to have been film, of which 15 million pounds were used in food packaging. The remaining 20 million pounds of extruded rigid film and sheet went in nonfood packaging uses. For many packaging applications, PVC film is laminated to polyethylene film that has been coated with polyvinylidene chloride to meet all performance requirements of the package.

The 85 million pounds of highly plasticized extruded film were used in meat packaging and have captured a large part of produce packaging (CEH estimates based on communication with industry). At present, 5-mil food-grade film is used for packaging meat, cheese, and crackers; 10-mil film is used for single portions of jam and syrup; and 20-mil film is used for processed meats.

The growth potential for PVC resins in film and sheet packaging applications is believed to be very good for the 1972-1975 period in spite of concern about the possible harmful effects of PVC products on the environment (PVC liberates hydrogen chloride when incinerated. It has been asserted that hydrogen chloride is not only a serious pollutant but that it can also damage conventional incinerators, and that without incineration, PVC packaging materials represent a solid waste problem after use). An average growth rate of about 17% annually appears likely for PVC film and sheet (mostly rigid and semirigid) in this market between 1972 and 1975 (CEH estimate).

Bottles. According to reported data, PVC consumption in bottles grew from 11 million pounds in 1966 to 70 million pounds in 1970--an average annual growth rate of 8%. However, 1971 consumption was first reported to have been 70 million pounds, which was later revised to only slightly over 50 million pounds. PVC competes with polyethylene and, to a lesser extent, with polypropylene in the plastic bottles market (Modern Packaging, March 1971, pp. 30-34). Typical uses include liquor, cooking oil, salad dressing, liquid detergent, and cosmetic and toiletry bottles.

The blow molding of PVC bottles has been a field of much excitement and speculation in recent years because of its large potential. The high expectations (250 million pounds of PVC bottles in 1975 and 500 million pounds in 1980, according to MP, October 1971, p. 96) were mixed with uncertainty in 1971 as a result of concern over the previously mentioned environmental considerations concerning PVC as a packaging material in general. But since that time, developments have given rise to a more optimistic view (MP, May 1972, pp. 16 and 18) and a minimum growth rate of 21% per year between 1972 and 1975 is expected (CEH estimate).

POLYVINYL CHLORIDE RESINS - CONTINUED

6. Transportation

As shown in the following table, PVC resin consumption in transportation grew at an average annual rate of 6.5% between 1966 and 1972. As a percentage of total PVC consumption by end use, it was 8.5% in 1966 and 6.1% in 1972.

U.S. Consumption of PVC Resins in Transportation
(Millions of Pounds)

	Upholstery and Seat Covers ^a	Auto Tops	Auto Floor Mats	Other Trim	Total
1966	(130)	(15)	(30)	--	(175)
1967	130	--	30	--	160
1968	140	25	34	--	199
1969	160	27	37	10	234
1970	150	30	35	10	225
1971	170	32	37	15	254
1972	180	35	40	--	255

a. Believed to include seat covers and trim for trucks, aircraft, boats, and recreational vehicles as well as passenger cars, and to include other interior trim in those years (1966-1968) where this is not separately reported.

Sources: (A) CEH estimates (estimates for 1966).

(B) Modern Plastics, January issues (all other data).

The bulk of PVC usage in transportation is in automotive upholstery and seat covers, mostly in the form of coated fabrics, and vinyl auto tops (Landau roofs), which have been a contributor to increased overall PVC consumption in this field. Seating material knitted from slit PVC film wrapped around a core of nylon filament has appeared in some cars (Daily News Record, September 8, 1971, p. 17).

Accompanied by the fluctuations in the automotive market, PVC resin consumption in transportation is expected to continue to show an average annual growth rate on the order of 6% from 1972 to 1975 (CEH estimate).

7. Miscellaneous Uses

The miscellaneous category encompasses diverse end uses that are in no way inter-related; therefore, their combined PVC resin consumption is of no analytical value except as a component of the total consumption in all uses. As the table below indicates, the largest of these miscellaneous end uses is in laminates. These laminates are believed to include vinyl clad metal, which is used predominantly in luggage, and in some appliances and automotive applications, e.g., gear box enclosures, plywood covered with printed film, and wallboard.



POLYVINYL CHLORIDE RESINS - CONTINUED

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U.S. Consumption of PVC Resins in Miscellaneous Uses

(Millions of Pounds)

	Laminates	Medical Tubing	Stationery Supplies	Agri- culture	Credit Cards	Tools and Hardware	Novelties	Other	Total
1966	--	--	--	--	--	--	--	--	(161)
1967	--	--	--	--	--	--	--	--	(191)
1968	33	23	22	20	6	9	9	--	122
1969	36	28	25	23	9	10	10	--	141
1970	38	32	27	24	11	10	10	10	162
1971	39	37	28	24	12	11	10	34	195
1972	48	46	35	29	15	13	13	57	256

Sources (A) CEH estimates (estimates for Total for 1966 and 1967; and estimate for Other in 1972).

(B) Modern Plastics, January issues (all other data).

The use of PVC resins in medical tubing increased at an average annual rate of 19% between 1968 and 1972. Included in this market in 1971 were an estimated 10 million pounds used in biomedical applications in or on the human body or in contact with human blood. The total plastics use in the medical field, of which PVC had about 67% in 1971, is expected to double by 1976 (CW, June 16, 1971, p. 24).

Stationery supply uses for PVC include ring binders, sheet separators, and many other items. Clear rigid and semirigid film and sheet is usually made from copolymer resins, as are most credit cards. Credit cards is a relatively small specialty application but it had an average annual growth rate of 26% between 1968 and 1972.

Other miscellaneous applications of PVC resins not specifically covered in the preceding table include carpet underpadding, vinyon fibers (see the CEH report on Vinyon Fibers for additional information on this end use), rigid PVC foams, and traffic cones (the latter alone accounting for perhaps 3 to 5 million pounds of PVC resins). One industry source believes that future consumption of PVC resins in rigid foams could become substantial.

POLYVINYL CHLORIDE RESINS - CONTINUED

PRICE AND UNIT SALES VALUEVinyl Chloride

A history of vinyl chloride prices and unit sales values is given in the following table and graph.

Price and Unit Sales Value--Vinyl Chloride
(Cents per Pound)

	<u>Price^{a,b}</u>	<u>Unit Sales Value</u>
1952	--	13
1953	--	--
1954	13.25	--
1955	10.50	10
1956	11.00	11
1957	11.00	11
1958	11.00	11
1959	12.50	11
1960	12.50	10
1961	7.50	8
1962	8.00	7
1963	8.00	7
1964	8.00	6
1965	8.00	6
1966	8.00	6
1967	8.00	5
1968	8.00	5
1969	4.75	4
1970	4.75	4
1971	4.75	4p
1972	4.75	--
1973	5.00	--

a. List prices taken on or near July 1 of each year. Whenever a range of prices was given in the source, the lowest was used.

b. Price bases are:

1954-1955	Tanks, freight equalized
1956-1960	Tanks, works
1961-1968	Tanks, works, minimum freight allowed East
1969-1972	Polymer grade, tanks, works, freight equalized East
1973	Polymer grade, tanks, f.o.b. works

(continued)



- Sources: (A) CMR (Price data).
- (B) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission (Unit Sales Value data for 1952-1970).
- (C) Synthetic Organic Chemicals, U.S. Production and Sales of Miscellaneous Chemicals, 1971 Preliminary, U.S. Tariff Commission (preliminary 1971 Unit Sales Value datum).

In early 1971, actual selling prices of vinyl chloride reportedly moved up somewhat from the level of as low as 4.5 cents per pound which had prevailed prior to that time. It is believed that rising costs made these firmer prices mandatory. Part of the picture was the prospect of rising chlorine costs and the probability of tighter ethylene supply in the future (MP, March 1971, pp. 61 and 62). In early 1972, actual selling prices are believed to have been close to the list price of 4.75 cents per pound. In December 1972, vinyl chloride prices climbed to 5 cents per pound, and in early 1973 they climbed further. Vinyl chloride monomer prices do not fluctuate nearly as much as do polyvinyl chloride resin prices because most of the monomer is sold on long-term contracts.

Polyvinyl Chloride Resins

Actual selling prices are generally lower than list prices, e.g., general-purpose resins in late 1971 are believed to have sold for 10.0-10.5 cents per pound when the list price was 12.5 cents per pound. However, in mid-1972, industry prices were very close to list prices. As of April 1973, general-purpose PVC moved at 13 cents per pound, and dispersion resins at 22 cents per pound (communication with industry).

Although the new plants employing very large reactors and more efficient catalyst systems are believed to be more economical, the savings so achieved are believed to be substantially offset, if not exceeded, by rising costs in labor, packaging and warehousing, fuel and other supplies, and taxes. Thus, profit levels were generally recognized as so poor in the 1971-72 period that capacity increases needed for 1973-74 were not set in motion in time to prevent a general resin shortage during the second half of 1973.

POLYVINYL CHLORIDE RESINS - CONTINUED

PRICE AND UNIT SALES VALUE-POLYVINYL CHLORIDE RESINS
(Cents per Pound)

	Price ^{a,b}				
	General Purpose	Dispersion (Emulsion) Grade	Acetate Copolymer	Vinylidene Chloride Copolymer	Unit Sales Value
1950	38	41	↓	-	37
1951	38	41		35	39
1952	38	41		31	-
1953	38	41		31	38
1954	38	41		30	38
1955	31	34	-	30	34
1956	27	30	32	26	31
1957	27	30	32	26	29
1958	23.5	26.5	28.5	26	-
1959	23.5	26.5	28.0	26	25
1960	18.5	24.0	23.0	26	23
1961	16.0	24.0	20.5	26	19 ^c
1962	16.0	24.0	20.5	26	18
1963	16.0	24.0	20.5	26	18
1964	16.0	24.0	16.5	26	17
1965	16.0	24.0	16.5	26	17
1966	14.0	24.0	16.5	26	17
1967	13.5	24.0	16.5	26	16
1968	10.0	24.0	-	26	14
1969	11.0	24.0	-	26	14
1970	11.5	24.0	20.5	27	13
1971	12.5	24.0	20.5	28	13 ^p

- a. Price histories are shown for those resins believed to be types commonly used. Although the prices may be for an individual company's products, it should neither be inferred that this company is necessarily the predominant one in the field, nor that there are no similar products available with slightly different specifications available. Descriptions of each product appear in the following notes.
- b. Prices are those in effect at the end of each year and (except for VINYLIDENE CHLORIDE COPOLYMER) are for truck-load quantities of material packed in 50-pound bags, minimum transportation allowed or prepaid.
- (1) GENERAL PURPOSE: Uniroyal Chemical's Marvinol® VR-22, VR-23, VR-24, VR-25, VR-26, VR-31, VR-33, for standard calendar and extrusion processing.
 - (2) DISPERSION (EMULSION) GRADE: Uniroyal Chemical's Marvinol® VR-50 and VR-51, for plastisols.
 - (3) ACETATE COPOLYMER: Data for 1956-1967 are for Uniroyal Chemical's Marvinol® VR-60, 15% vinyl acetate, for record molding. Data for 1970-1971 are for B. F. Goodrich Chemical's Geon® Resin 428, for record molding.
 - (4) VINYLIDENE CHLORIDE COPOLYMER: Dow Chemical Company U.S.A.'s Latex 874 (prior to 1965, this product was known as Latex 7448). This material averages 50% solids, and prices quoted are for each pound of dry solids, tank car quantities, f.o.b. shipping point, minimum transportation paid, in all states east of the eastern boundary of Idaho, Utah, and Arizona.
- c. The UNIT SALES VALUE for PVC homopolymer was 18 cents per pound and the average for all PVC copolymers was 23 cents per pound.
- SOURCES: (A) SYNTHETIC ORGANIC CHEMICALS, U.S. PRODUCTION AND SALES, U.S. Tariff Commission (UNIT SALES VALUE data for 1950-1970).
- (B) SYNTHETIC ORGANIC CHEMICALS, U.S. PRODUCTION AND SALES OF PLASTICS AND RESIN MATERIALS, 1971 Preliminary, U.S. Tariff Commission (preliminary UNIT SALES VALUE datum for 1971).
- (C) Communication with industry (all other data).

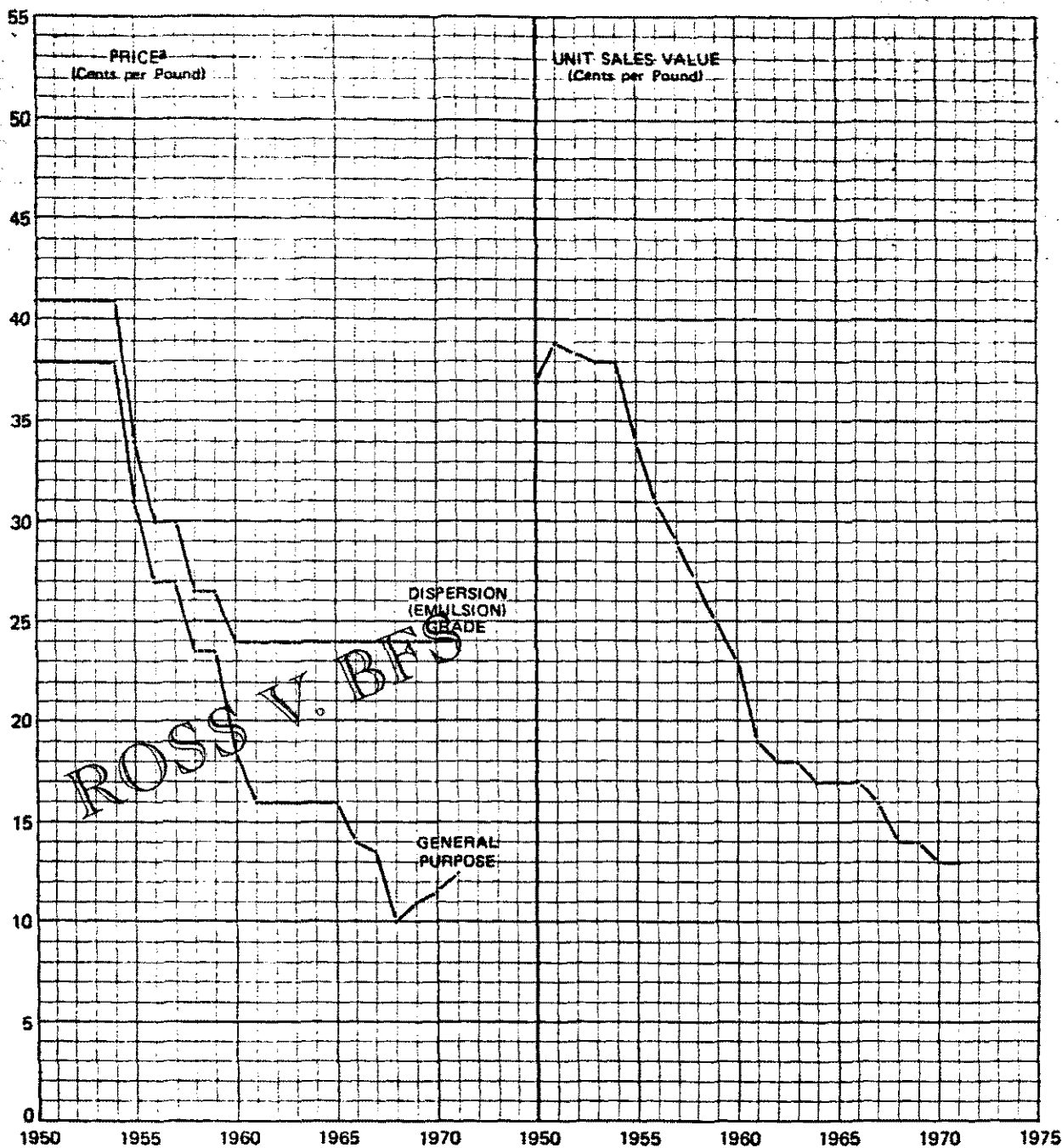


POLYVINYL CHLORIDE RESINS - CONTINUED

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a. Price data on ACETATE COPOLYMER and VINYLIDENE CHLORIDE COPOLYMER are included in the table.

POLYVINYL CHLORIDE RESINS - CONTINUED

INTERNATIONALTradeA. Exports1. Vinyl Chloride

Separate data on U.S. exports of vinyl chloride were not reported until 1970. A breakdown of exports by country of destination is given in the following table.

U.S. Exports of Vinyl Chloride
(Millions of Pounds)

	<u>1970</u>	<u>1971</u>	<u>1972</u>
Mexico	42.0	49.7	84.8
Brazil	--	18.7	80.7
United Kingdom	40.5	212.2	29.2
Belgium	294.8	159.3	111.4
France	73.2	46.7	33.2
Norway	--	--	129.4
Spain	97.3	103.5	111.1
Other	118.8	29.4	41.1
Total ^a	664.1	619.5	620.9

See MANUAL OF CURRENT INDICATORS for additional data.

- a. Total export values were 34.3 million dollars in 1970, 30.9 million dollars in 1971, and 31.0 million dollars in 1972.

Source: U.S. Exports, FT 410, U.S. Department of Commerce, Bureau of the Census.

Vinyl chloride exports in the first two months of 1973 were 12% above those of the comparable 1972 period (U.S. Exports, FT 410, U.S. Department of Commerce, Bureau of the Census).

2. Polyvinyl Chloride Resins

U.S. exports of PVC resins since 1960 are shown in the following table. Both the data reported by the Bureau of the Census and those reported by the Tariff Commission are presented for comparison.



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U.S. Exports of Polyvinyl Chloride Resins^a
(Millions of Pounds)

Bureau of the Census					
	Uncompounded	Compounded		Estimated Total	Tariff
		Reported	Estimated		Commission
			Resin Content ^b		
1960	--	--	--	(35)	--
1961	--	--	--	(30)	--
1962	--	--	--	(40)	--
1963	--	--	--	--	42
1964	--	--	--	--	70
1965	48	31	(25)	(73)	68
1966	50	37	(30)	(80)	69
1967	42	34	(27)	(69)	71
1968	74	38	(30)	(104)	114
1969	129	38	(30)	(159)	162
1970	132	35	(28)	(160)	188
1971	118	34	(27)	(145)	169p
1972	119	40	(32)	(151)	--

See MANUAL OF CURRENT INDICATORS for additional data.

a. Included are all homopolymer and copolymer resins containing 50% or more vinyl chloride.

b. Based on an estimated average PVC resin content of approximately 80%.

Sources: (A) U.S. Exports, FT 410, U.S. Department of Commerce, Bureau of the Census (Uncompounded and Reported Compounded data in the table).

(B) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission (Tariff Commission data in the table for 1963-1970).

(C) Synthetic Organic Chemicals, U.S. Production and Sales of Plastics and Resin Materials, 1971 Preliminary, U.S. Tariff Commission (preliminary Tariff Commission datum for 1971).

(D) CEH estimates (all other data in the table and estimate in footnote b).

Total exports of PVC resins in the January through March 1973 period were 36.0 million pounds (Monthly Statistical Report, The Society of the Plastics Industry, Inc., March 1973). If continued at the same rate, total 1973 PVC resin exports would amount to about 145 million pounds.

B. Imports

U.S. imports of vinyl chloride were negligible from 1964 through March 1973. Since 1968, they have been less than one million pounds per year (U.S. Imports, FT 246, U.S. Department of Commerce, Bureau of the Census [data for 1964-1971] and U.S. Imports for Consumption, IM 146, Schedule 4, Parts 1-3, U.S. Department of Commerce, Bureau of the Census [data for 1972 and 1973]).

POLYVINYL CHLORIDE RESINS - CONTINUED

U.S. imports of polyvinyl chloride resins also were small in 1964-1972 as shown in the following table:

U.S. Imports of Polyvinyl Chloride Resins	
	Millions of Pounds
1964	5
1965	7
1966	9
1967	14
1968	17
1969	6
1970	6
1971	4
1972	4

Sources: (A) U.S. Imports, FT 246, U.S. Department of Commerce, Bureau of the Census (data for 1964-1971).

(B) U.S. Imports for Consumption, IM 146, Schedule 4, Parts 4-13, U.S. Department of Commerce, Bureau of the Census (datum for 1972).

Polyvinyl chloride resin imports for January through March 1973 (a total of 9 million pounds) have already more than doubled the total annual 1972 imports (U.S. Imports for Consumption, IM 146, Schedule 4, Parts 4-13, U.S. Department of Commerce, Bureau of the Census).

World Production and Capacity

The following table gives a regional breakdown of estimated 1972 production and annual production capacities for PVC resins.

World Production and Production Capacity For PVC Resins--1972 (Millions of Pounds)		
	Production	Annual Capacity ^a
Western Europe	6,500	7,900
United States	4,300	4,400
Japan	2,400	3,500
Eastern Europe	1,900	1,800
Other Areas	1,200	1,800
Total	16,300	19,400

a. Estimated capacities as of mid-1972.

Source: CEH estimates based on information in trade publications.



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The leading producer of PVC resins in Western Europe is West Germany with a capacity of about 2.4 billion pounds per year in 1972, followed by France, Italy, and the United Kingdom, each with an annual capacity of roughly 1.3 billion pounds in 1972. Of the PVC capacity of Eastern Europe, the U.S.S.R. is estimated to have about 700 million pounds per year and East Germany 400-500 million pounds per year in 1972 (CEH estimates).

Japan has had a substantial overcapacity in PVC for several years, and in 1972 had to take steps to restrict PVC production.

Producing Companies

The following list of foreign polyvinyl chloride producers has been compiled from various trade publications. The list may not be complete nor up to date; no attempt has been made to verify the accuracy of the reported information with the companies listed.

Vinyl chloride capacity has been included when obtainable from the same articles used for polyvinyl chloride information. (See the CEH Acetylene and Ethylene Dichloride reports and the Ethylene and Major Ethylene Derivatives-International Plant Survey for further information on foreign vinyl chloride producers.)*

When salient statistics information on polyvinyl chloride for a specific country was available in trade publications, the information has been included before the list of individual producing companies for that country.

NORTH AMERICACanada

Available statistics are as follows:-

Polyvinyl Chloride Resins - Canada
(Millions of Pounds)

	<u>Production</u>	<u>Imports</u>	<u>Exports</u>	<u>Consumption</u>	<u>Annual Capacity</u>
1970	158 ^a	47 ^a	17	205 ^a	190
1971	161 ^a	52 ^a	20	213 ^a	190
1972	205	60	20	245	200

- a. The source not only reported raw resin but also some compounded resins (on a gross weight basis). To convert the compounded resins to raw resin, it was assumed that the average resin content of the compounded material was 70%.

Source: Canadian Plastics, February issues.

- * Worldwide listings of ethylene dichloride and vinyl chloride monomer plants and capacities are available in the Chemical Economics Handbook International World Hydrocarbons reports.

B. F. Goodrich Canada Limited (owned 100% by The B. F. Goodrich Company)

1. Niagara, Ontario. In 1972, capacity was 50 million pounds per year. Vinyl chloride is supplied by Dow Chemical of Canada, Limited; Gulf Oil Canada Limited; or from the United States (CCP, August 1971, p. 15).
2. Shawinigan, Quebec. Capacity is 45 million pounds per year. A 20 million pounds-per-year expansion is under consideration (Canadian Plastics, February 1973, p. 26).

Imperial Oil Limited (owned 70% by Exxon Corporation), Esso Chemical Canada Division, Sarnia, Ontario. In 1972, capacity was 60 million pounds per year. The vinyl chloride is supplied by Dow Chemical of Canada, Limited; Gulf Oil Canada Limited; or from U.S. producers (CCP, August 1971, p. 15).

Monsanto Canada, Limited (owned 100% by Monsanto Company), La Salle, Quebec. In 1972, capacity was 40 million pounds per year (Canadian Plastics, February 1973, p. 26).

Mexico

Polyvinyl chloride resins production was 83 million pounds in 1970, imports were estimated at 5 million pounds, consumption was estimated at 88 million pounds, and annual capacity was estimated at 86 million pounds. In 1971, annual capacity was estimated at 130 million pounds (CA, September 3, 1971, p. 10, and CFI estimates).

Geon de Mexico, SA (owned 40% by The B. F. Goodrich Company and 60% by Celulosa y Derivados, SA [CYDSA], Mexico City, D.F. In 1969, the combined capacity of this plant and the Industrias Resistol SA plant at Lecheria was estimated at 53 million pounds per year (CII, 1/1969, p. 16). Geon's total capacity for polyvinyl chloride resins and compounds was estimated at 322 million pounds per year in 1968 (Bullard, Fredda Jean, "Mexico's Natural Gas," Studies in Latin-American Business No. 5, Bureau of Business Research, The University of Texas at Austin, 1968, p. 230). In May 1972, plans to expand polyvinyl chloride resins capacity were under consideration (CW, May 17, 1972, p. 33).

Industrias Resistol SA (IRSA) (owned 37% by Monsanto Company and 63% by Resistol SA and Desarrollo Economico SC), Lecheria, Mexico, D.F. In 1969, the combined capacity of this plant and the Geon de Mexico, SA, plant at Mexico City, D.F., was estimated at 53 million pounds per year. Plans for a large expansion in capacity were being considered in 1969 (CII, 1/1969, p. 16).

Petroleos Mexicanos (PENEX), Pajaritos. In 1969, the vinyl chloride capacity of this plant was 44 million pounds per year and an expansion of 121 million pounds per year was under construction (MP, January 1969, p. 119).

Plasticos Omega, SA, Mexico D.F. In 1967, capacity was 7 million pounds per year (CII, 1/1969, p. 16).

Polimeros de Mexico (owned 60% by Banco de Comercio SA and Banco del Atlantico SA; 20% by Farbwerke Hoechst AG [West Germany]; and 20% by Rhone-Progil [France]), San Martin Texmelucan, Puebla. In 1970, the capacity of this plant, which uses Pechiney-Saint-Gobain's two-step bulk polymerization process, was 44 million pounds per year (IC, July-August 1970, p. 94).



Promociones Industriales Mexicanas SA, Puebla, Puebla. In 1969, capacity was 20 million pounds per year (CII, 1/1969, p. 16).

Nicaragua

Polimeros Centroamericanos, SA (POLICASA), Managua. In 1969, Adela Investment Company, SA, was reported to have made an investment of \$167,000 in a polyvinyl chloride resins plant which was to use imported monomer (Abrahams, A. E., and D. Gerumsky, "Financing Petrochemical Ventures in Latin America," ID/WG.34/12, Interregional Petrochemical Symposium on the Development of the Petrochemical Industries in Developing Countries, Baku, U.S.S.R., October 20-31, 1969, United Nations Industrial Development Organization, p. 43).

SOUTH AMERICA

Argentina

Polyvinyl chloride resins production in 1970 was 48 million pounds and consumption was 57 million pounds (Department of State Airgram, DIB 71 10 041, August 30, 1971). Annual capacity in 1972 was estimated at 77 million pounds per year (CEH estimate based on trade publications).

In 1972, polyvinyl chloride resins demand for 1976 was estimated to reach 172 million pounds (CW, October 4, 1972, p. 38).

Company information for the following Argentine producers is based on information in the Department of State Airgram, DIB 72 10 336, September 25, 1972.

Electroclor SA Industrial y Comercial (owned 40% by public interests, 30% by Duperial S.A.I.C., and 30% by Celulosa Argentina SA), Capitan Bermudez, Santa Fe. In 1972, the capacity of this plant (based on ICI technology) was 40 million pounds per year. Plans to expand capacity to 141 million pounds per year in 1975, or to build a new plant jointly owned by Indupa SA, are being considered.

Indupa SA (owned 43% by Rhone-Progil [France]), Cinco Saltos, Rio Negro. In 1972, capacity was 26 million pounds per year.

Viplastic SA (wholly owned subsidiary of Monsanto Company), Chacras de Coria, Mendoza. In 1972, capacity was 11 million pounds per year.

POLYVINYL CHLORIDE RESINS - CONTINUED

Brazil

Available statistics are as follows:

Polyvinyl Chloride Resins - Brazil				
(Millions of Pounds)				
	<u>Production</u>	<u>Imports</u>	<u>Consumption</u>	<u>Annual Capacity</u>
1970	--	48	165	--
1971	103	(102)	205	192
1972	108	163	269	295

- Sources: (A) The Chemical Industry, South America, Chemical Data Services, 1973, p. 96 (1970 Imports datum).
 (B) ECN, April 13, 1973, p. 10 (all Production and Consumption data for 1970 and 1971).
 (C) CW, March 14, 1973, p. 29 (1972 Imports and Consumption data).
 (D) CEH estimates based on trade literature (all other data).

Brasivil-Resinas Vinilicas Ltda. (owned 33% by Chemische Werke Hüls AG [West Germany], 17% by Bayer AG [West Germany], and 50% by Uniao de Industrias Petroquimicas SA [UNIPAR]), Riberao Pires, Sao Paulo. In 1972, capacity was 88 million pounds per year. Plans are under consideration to double the present capacity (CA, July 7, 1972, p. 20). Feedstock is supplied by Consortio Paulista de Monomero Ltda. (Copamo)'s monomer plant at Santo Andre.

Carbocloro SA Industrias Quimicas (a joint venture of Diamond Shamrock Corporation and Unias de Industrias Petroquimicas SA [UNIPAR]), at an unspecified location. Polyvinyl chloride resins and copolymers capacity is 20 million pounds per year (The Chemical Industry, South America, Chemical Data Services, 1973, p. 96).

Geon do Brasil Industria e Comercio, SA (owned 25% by The B. F. Goodrich Company and 75% by S/A Industrias Reunidas F. Matarazzo), Vila Bela, Sao Paulo. In 1972, capacity was 33 million pounds per year. Capacity is being expanded to 55 million pounds per year (CW, December 20, 1972, p. 24).

Hulsbrasil-Resinas Vinilicas Ltda. (owned 33% by Chemische Werke Hüls AG [West Germany], 17% by Bayer AG [West Germany], and 50% by Uniao de Industrias Petroquimicas SA [UNIPAR]), Piassaquera, Sao Paulo. Hulsbrasil started to build a 110 million pounds-per-year polyvinyl chloride resins plant in 1971. The feedstock reportedly will be supplied from the monomer plant of Consortio Paulista de Monomero Ltda. (Copamo) at Santo Andre (CII, 2/1971, p. 60).

Industrias Quimicas Eletro-Cloro SA (a subsidiary of Solvay & Cie [Belgium] and Imperial Chemical Industries Limited [United Kingdom]), Sao Andre, Sao Paulo. Polyvinyl chloride resins capacity was 154 million pounds per year in 1972 (Chemical Age International, November 3, 1972, p. 18).



Petrobras Quimica SA (a subsidiary of Petroleo Brasileiro SA), Mitsubishi Chemical Industries Limited (Japan), Nissho-Iwai Co., Ltd. (Japan) (each with 30% ownership), and Comargo Correa SA (10% ownership), Cumacari, Bahia. Approval from the Brazilian government to establish a new firm and to construct a 331 million pounds-per-year vinyl chloride plant and a 309 million pounds-per-year polyvinyl chloride resins plant is pending (JCW, January 18, 1973, p. 1).

Chile

Chilean Government (formerly Petroquimica-Dow SA [owned 60% by The Dow Chemical Company, 20% by Petroquimica Chilena SA, 10% by Empresa Nacional del Petroleo, and 10% by Dow Quimica Chilena SA]), Concepcion. Plans to expand the present 33 million pounds-per-year plant to 66 million pounds per year have been included in the Chilean five-year plan (OGJ, September 20, 1971, p. 80).

Colombia

In 1971, annual capacity was estimated at 45 million pounds (CEH estimate based on trade publications).

Colombiana de Carburo y Derivados SA (COLCARBURO), Medellin, Antioquia. Capacity is 17 million pounds per year. Monomer is produced locally (Chemicals, U.S. Department of Commerce, Bureau of Domestic Commerce, March 1971, p. 24).

Petroquimica Colombiana SA, Mamonal, Bolivar. Polyvinyl chloride resins capacity is 35 million pounds per year. Vinyl chloride is presently imported, but a 35 million pounds-per-year plant is under construction at Cartagena (HP, May 1972, p. 44-CC).

Plasticas y Productos Industriales, Zipaquira, Tolima. Polyvinyl chloride resins capacity is 7-13 million pounds per year (The Chemical Industry, South America, Chemical Data Services, 1973, p. 175).

Peru

Petroleos del Peru (Petroperu) (a state-owned enterprise), near Lima. A 55 million pounds-per-year vinyl chloride plant, a 44 million pounds-per-year suspension-grade plant and a 22 million pounds-per-year emulsion-grade polyvinyl chloride plant are planned for completion in 1976 (CA, March 31, 1972, p. 4).

Sociedad Paramonga Ltda., Paramonga. Plant capacity data are not available.

Venezuela

Venezolana Industria de Plasticos (25% owned by The B. F. Goodrich Company and 75% by Instituto Venezolano de Petroquimica and private investors), El Tablazo. A plant is scheduled to be built by late 1973 with a 100 million pounds-per-year capacity using B. F. Goodrich technology (RA, October 1971, p. 30).

WESTERN EUROPEAustria

Production of polyvinyl chloride resins was 79 million pounds in 1970 (The Chemical Industry, 1970/1971, OECD, p. 153).

Halvic Kunststoffwerke GmbH (81.9% owned by Solvay & Cie. [Belgium] and 18.1% by the Austrian State), Halle. The plant has a capacity of 141 million pounds per year and is based on Solvay technology (ECN Austria Survey, July 2, 1971, p. 50).

Belgium

Polyvinyl chloride resins consumption was 143 million pounds in 1970 and 165 million pounds in 1971 (Chemical Age International, December 15, 1972, p. 25). Annual capacity for 1970 and 1971 is estimated to have been 357 million pounds per year (CEH estimates based on trade publications).

Badische-Phillips Petroleum NV (Badiphil) (owned 50% by Phillips Petroleum Company and 50% by BASF AG [West Germany]), Antwerp. Capacity of the plant is 170 million pounds per year. The vinyl chloride is supplied by BASF (CA, November 27, 1970, p. 7, and communication with industry).

Solvic, SA pour l'Industrie des Matieres Plastiques (owned 75% by Solvay & Cie and 25% by Imperial Chemical Industries Limited [United Kingdom]), Jemeppe-sur-Sambre. Capacity in 1970 was 198 million pounds per year. Plans to increase capacity to 253 million pounds per year are expected to be completed in 1975. The vinyl chloride is supplied on site by a 440 million pounds-per-year plant (ECN, June 9, 1972, p. 14).

Denmark

Polyvinyl chloride resins are not yet produced in Denmark, although one source estimated in 1970 that Danish consumption would be 75 million pounds in 1970 and 110 million pounds in 1975 (ECN Polymer Intermediates, October 30, 1970, pp. 5 and 12).

KemaNord AB (Sweden), Lonza AG (Switzerland), and Rhone-Progil (France) (owned 93% by Rhone-Poulenc SA and 7% by Pechiney Ugine Kuhlmann) were planning to build a medium-sized plant at Skaelskor, Sjalland. The plant, which was to use Pechiney-Saint-Gobain's mass polymerization process, has been delayed until the polyvinyl chloride resins market improved sufficiently (ECN, May 19, 1972, p. 34).

Finland

One source estimated in 1970 that consumption would be 62 million pounds in 1970 and 90 million pounds in 1975 (ECN Polymer Intermediates, October 30, 1970, pp. 5 and 12).



POLYVINYL CHLORIDE RESINS - CONTINUED

PLASTICS AND RESINS

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SEPTEMBER 1973

Pekema Oy (owned 44% by Neste Oy, 6% by Enso-Gutzeit AB, 20% by Kymmene Aktiebolag, 5% by Nokia Oy, 15% by Pargas Kalkbergs AB, 5% by Sateri Oy, 2.5% by Stromberg AB, and 2.5% by Upo Oy), Porvoo. Vinyl chloride capacity is 110 million pounds per year and polyvinyl chloride resins capacity is 66 million pounds per year. Expansion of the polyvinyl chloride resins plant to 110 million pounds per year within two to three years is under consideration (ECN, February 16, 1973, p. 16).

France

Available statistics are as follows:

	Polyvinyl Chloride Resins - France				
	(Millions of Pounds)				
	Production	Imports	Exports	Consumption	Annual Capacity ^a
1970	1,003	223	198	1,031	(1,030)
1971	1,009	--	--	--	(1,100)
1972	1,187	--	--	--	(1,188)

- a. By 1973-1975, total capacity is expected to reach nearly 2 billion pounds per year if all the presently planned expansions and new plants come on stream.

Sources: (A) Chimie Actualités, February 10, 1972, p. 18 (all data for 1970 except Annual Capacity).

(B) CEH estimates based on trade publications (Annual Capacity estimates).

(C) CMR, March 27, 1972, pp. 5 and 51 (1971 Production datum).

(D) Chemical Age International, April 6, 1973, p. 5 (1972 Production datum).

Aquitaine Total Organico (a subsidiary of ATO), Balan, Ain. Capacity is 154 million pounds per year. Plans to increase capacity by 220 million pounds per year by 1976 with a new plant are being considered (ECN, December 10, 1971, p. 20). The vinyl chloride is purchased from Rhone-Progil at Saint Fons and Societe Dauphinoise de Fabrications Chimiques (DAUFAC) at Jarrie (ECN, January 23, 1970, p. 14).

CDF Chimie (a subsidiary of Charbonnages de France). Plans are being discussed to build a 220 million pounds-per-year plant by the end of 1974 at Douvrin (near Douai) or Carling (Lorraine). Limburgse Vinyl Maatschappij-NV (The Netherlands) has agreed to supply vinyl chloride monomer (ECN, July 7, 1972, p. 16).

POLYVINYL CHLORIDE RESINS - CONTINUED

Societe Dauphinoise de Fabrications Chimiques (DAUFAC) (owned 25% by Rhone-Progil, 50% by Rhone-Poulenc SA, and 25% by Pechiney Ugine Kuhlmann), Jarrie, Isere. The company has a vinyl chloride plant based on The B. F. Goodrich Company/Farbwerke Hoechst AG technology: capacity is 440 million pounds per year. The vinyl chloride is sold to the polyvinyl chloride resins plants of Rhone-Poulenc SA, Rhone-Progil, and Plastimer SA (ECN New Plants 1972, February 23, 1973, p. 58). Some vinyl chloride is produced from ethylene supplied by Societe Nationale des Petroles d'Aquitaine (SNPA) and then used by Aquitaine Total Organico.

Plastimer SA (owned 50% by Pechiney Ugine Kuhlmann and 50% by Rhone-Progil), Brignoud, Isere. Capacity was 154 million pounds per year in 1970. Capacity is being expanded to 264 million pounds per year with completion expected in 1973. DAUFAC supplies the vinyl chloride (ECN French Survey, November 26, 1971, p. 80, and ECN New Plants 1972, February 23, 1973, p. 46).

Rhone-Progil (owned 93% by Rhone-Poulenc SA and 7% by Pechiney Ugine Kuhlmann).

A. Vinyl Chloride

1. Lavera. Vinyl chloride capacity is 440 million pounds per year (ECN New Plants 1972, February 23, 1973, p. 58).
2. Saint Auban, Basses Alpes. Capacity is estimated to be 264 million pounds per year. Further expansion to 331 million pounds per year is planned (OPD, July 19, 1971, p. 47, and ECN, August 8, 1969, p. 10).
3. Saint Fons, Rhone. Capacity is 132 million pounds per year (ECN, January 23, 1970, p. 14).

B. Polyvinyl Chloride

1. Montlucon, Allier. In 1968, capacity was 33 million pounds per year (ECN, January 3, 1969, p. 18).
2. Saint Auban, Basses Alpes. Polyvinyl chloride resins capacity was 230 million pounds per year in 1970 (ECN, January 3, 1969, p. 18, and C&EN, August 3, 1970, p. 31).
3. Saint Fons, Rhone. In 1969, capacity was 132 million pounds per year (ECN, January 3, 1969, p. 18).

Rhone-Poulenc SA (owned 7% by Pechiney Ugine Kuhlmann), Peage de Roussillon, Isere. Capacity was 88 million pounds per year in 1970 (C&EN, August 3, 1970, p. 31).

Solvic SA (owned 75% by Solvay & Cie [Belgium] and 25% by Imperial Chemical Industries Limited [United Kingdom]), Tavaux, Jura. Capacity for vinyl chloride (from ethylene feedstock) was 440 million pounds per year in 1969. About 50% was consumed on site for polyvinyl chloride resins production (OPD, March 31, 1969, p. 40). Polyvinyl chloride resins capacity is 397 million pounds per year (ECN, August 28, 1970, p. 12, and ECN New Plants 1971, February 25, 1972, p. 58).

POLYVINYL CHLORIDE RESINS - CONTINUED

Lenza-Werke GmbH (100% owned by Lenza AG [Switzerland]), Waldshut. In 1969, capacity was 55 million pounds per year (OPD, September 1, 1969, pp. 5 and 47).

Wacker-Chemie GmbH (50% owned by Farbwerke Hoechst AG and 50% by the Wacker Family Corp.), Burghausen and Cologne. Total capacity at both sites is 683 million pounds per year. Vinyl chloride is produced at Burghausen and some is shipped to Cologne as needed (ECN, December 22/29, 1972, p. 7).

Greece

Nicos Vardinoyannis and CdF Chimie (France), Korinth. Plans are under consideration to build a 110 million pounds-per-year polyvinyl chloride resins plant which will use imported monomer (ECN, June 15, 1973, p. 16).

Esso-Pappas Chemical AE (a subsidiary of Exxon Corporation), Diavata, Thessaloniki. Polyvinyl chloride resins capacity is 61 million pounds per year. Capacity is being expanded to 99 million pounds per year with completion of the plant expected early in 1974 (CW, May 23, 1973, p. 46). Vinyl chloride is supplied by Esso Hellas Chemical Company (also a part of the Esso-Pappas group), also at Diavata (ECN, May 30, 1969, p. 10).

Italy

Available statistics are as follows:

Polyvinyl Chloride Resins - Italy
(Millions of Pounds)

	Production	Imports	Exports	Consumption ^a	Annual Capacity
1970	1,168	77	495	749	(1,190)
1971	1,168	--	551	--	(1,190)
1972	1,360	--	--	--	(1,454)

a. Calculated: Equals Production + Imports - Exports.

Sources: (A) Chimie Actualités, February 10, 1972, p. 18 (all data for 1970 except Annual Capacity).

(B) Chemical Age International, October 6, 1972, p. 22 (1971 Production and Exports data).

(C) CEH estimates based on information in trade publications (Annual Capacity estimates).

(D) ECN, June 29, 1973, p. 8 (1972 Production datum).

Italy's total capacity for polyvinyl chloride resins is expected to reach nearly 1.8 billion pounds per year when all of the presently planned expansions and new plants have come on stream (CEH estimate based on information in trade publications).



POLYVINYL CHLORIDE RESINS - CONTINUED

PLASTICS AND RESINS

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Societa Chimica Ravenna SpA (owned 51% by ANIC SpA and 49% by Wacker-Chemie GmbH [West Germany]), Ravenna. Capacity is 154 million pounds per year (based on Pechiney-Saint-Gobain technology), of which 66 million pounds is suspension grade and 88 million pounds is emulsion grade. Vinyl chloride capacity is 165 million pounds per year (Chemical Age Survey, Italian Projects, April 28, 1972, p. S13).

Societa Italiana Serie Acetica Sintetica SpA (SISAS), Pioltello Limito (near Milan). In late 1970, a 99 million pounds-per-year PVC plant was under construction (CII, 4/1970, p. 115).

Montecatini Edison SpA

1. Brindisi. In late 1970, capacity was 276 million pounds per year (CII, 4/1970, p. 115). Vinyl chloride is also produced at this location.
2. Porto Marghera. Polyvinyl chloride resins capacity is 529 million pounds per year (Chemical Age International Survey, Italian Projects, April 27, 1973, p. S21). Vinyl chloride is also produced at this location.

Polisarda (a subsidiary of Societa Italiana Resine SpA), Porto Torres. Capacity is 220 million pounds per year (ECN, January 15, 1973, p. 18). An additional 154 million pounds-per-year plant is under construction (Chemical Age Survey, Italian Projects, April 28, 1972, p. S22). Viclosar (also a Societa Italiana Resine SpA subsidiary) has a vinyl chloride plant at this location.

Pozzi Ferrandina SpA, Ferrandina, Matera. In late 1970, capacity was 99 million pounds per year with a future expansion of 22 million pounds per year planned (CII, 4/1970, p. 115). A vinyl chloride plant is also located at this site.

Quirinia SpA (a subsidiary of Rumianca, SpA), Assemini. In late 1969, capacity was 66 million pounds per year (CII, 4/1969, p. 115). Capacity is being expanded by 220 million pounds per year with completion planned for 1973 (Chemical Age International Survey, Italian Projects, April 27, 1973, p. S22). Sodio SpA (also owned by Rumianca, SpA) has a vinyl chloride plant at the same site.

SARP (owned 65% by Ente Minerario Siciliano and 35% by Societa Italiana Resine SpA), between Palma di Montechiaro and Licata. In May 1972, plans for a polyvinyl chloride resins plant had been approved (ECN, May 26, 1972, p. 10).

Solvic, Industria Delle Materie Plastiche SpA (a subsidiary of Solvay & Cie [Belgium]), Ferrara. In late 1970, capacity was 110 million pounds per year (CII, 4/1970, p. 115). Plans to expand by 110 million pounds per year by 1972 were being considered in 1970 (C&EN, August 3, 1970, p. 31).

POLYVINYL CHLORIDE RESINS - CONTINUED

The Netherlands

NV Nederlandse Staatsmijnen (DSM), Beek. The plant, based on Sumitomo technology, has a capacity of 165 million pounds per year. Capacity is being expanded to 220 million pounds per year with completion expected in 1975 (ECN, May 11, 1973, p. 16). Vinyl chloride is presently supplied domestically and by imports from Germany (ECN, February 18, 1972, p. 4). Vinyl chloride is also being supplied via pipeline by Limburgse Vinyl Maatschappij NV from its Tessenderloo, Belgium, plant. The pipeline capacity is 441 million pounds per year which allows for future polyvinyl chloride expansion (CE, October 19, 1970, p. 73).

Shell Nederland Chemie NV (a subsidiary of Shell Petroleum NV), Pernis. Capacity is 352 million pounds per year (CA, August 7, 1970, p. 16, and HP, Section 2, June 1973, p. 22). Vinyl chloride is supplied by AKZO Chemie Verkoopkantoor NV, Salt Chemical Division, at Botlek (ECN, July 23, 1971, p. 4).

Norway

Production of polyvinyl chloride resins was 104 million pounds in 1970 (The Chemical Industry, 1970/1971, OECD, 1972, p. 153). Nearly one-third of the polyvinyl chloride resins produced are exported to the United Kingdom (CMR, May 1, 1972, pp. 7 and 12).

Norsk Hydro AS, Heroya. In early 1971, capacity was 132 million pounds per year. Both Continental Oil Company and BP Chemicals International Limited (a subsidiary of The British Petroleum Company Limited) were supplying the vinyl chloride (ECN, May 14, 1971, p. 10). In April 1972, plans were announced to increase polyvinyl chloride resins production by an unspecified quantity (PCN, April 24, 1972, p. 2).

Portugal

Production of polyvinyl chloride resins was 26 million pounds in 1970 (The Chemical Industry, 1970/1971, OECD, 1972, p. 153).

Companhia Industrial de Resinas Sinteticas SARL (CIRES) (a joint Portuguese-Japanese enterprise with 25% owned by Shinetsu Chemical Industry Co., Ltd.), Aveiro. In mid-1970, capacity was 22 million pounds per year (ECN, July 24, 1970, p. 10). Plans to increase the capacity to 58 million pounds per year have been approved (ECN, January 14, 1972, p. 18).

Companhia Uniao Fabril SARL, Sines. The firm has obtained government permission to build a 95 million pounds-per-year polyvinyl chloride resins plant (CA, August 18, 1972, p. 17).

Spain

Production of polyvinyl chloride resins was 207 million pounds in 1970, and consumption was estimated at 249 million pounds. In 1970, consumption was projected to reach 617 million pounds by 1975 (The Chemical Industry, 1970/1971, OECD, 1972, p. 153, and ECN Polymer Intermediates, October 30, 1970, p. 12).

Compania Aragonesa de Industrias Quimicas, SA, Sabinanigo, Huesca. In 1969, capacity was 4 million pounds per year (Oilgas, October 1969, p. 11).



Hispanic Industrial SA (owned 75% by Solvay & Cie [Belgium] and 25% by Imperial Chemical Industries Limited [United Kingdom])

1. Martorell, Barcelona. A 55 million pounds-per-year plant came on stream in 1969 (ECN, August 15, 1969, p. 2). Viniclor SA has a 264 million pounds-per-year vinyl chloride plant at this site (ECN, January 12, 1973, p. 8).
2. Torrelavega, Santander. In 1969, capacity was 99 million pounds per year (Oilgas, October 1969, p. 11). Viniclor SA has a vinyl chloride plant at the same location.

Monsanto Iberica SA (wholly owned by Aiscondel SA which is a joint venture of Monsanto Company and Desarrollos Industriales) Monzon, Huesca. In early 1971, capacity was 95 million pounds per year and the capacity was being expanded to 132 million pounds per year. Vinyl chloride is supplied from Monsanto Iberica's new plant at Vilaseca, Tarragona (ECN, February 5, 1971, p. 4).

In 1974, the company hopes to have a polyvinyl chloride plant at Tarragona with a capacity of 330 million pounds per year (Chemical Age International, December 8, 1972, p. 9).

Resinas Poliesteres, SA (Reposa) (owned 40% by Rhone-Progil, 30% by The Dow Chemical Company, and 30% by Union Explosivos Rio Tinto, SA)

1. Hernani (near Guipuzcoa). Capacity is 110 million pounds per year (ECN New Plants 1970, February 26, 1971, p. 60).
2. Mirando de Ebro, Burgos. Polyvinyl chloride resins capacity is 66 million pounds per year (ECN New Plants 1970, February 26, 1971, p. 60).

Sweden

Consumption of polyvinyl chloride resins ranged between 152 and 176 million pounds in 1970 (Brighton, C. A., "Vinyl Chloride Polymers (Introduction)," Encyclopedia of Polymer Science and Technology, Volume 14, Interscience Publishers, New York, 1971, pp. 306 and 307, and ECN, July 23, 1971, p. 16).

KemaNord AB

1. Stenungsund. In late 1970, capacity of the plant (which is based on a self-developed process) was 55 million pounds per year. Vinyl chloride is produced on site (ECN, December 18/25, 1970, pp. 44 and 46).
2. Stockviksverken. Capacity of the plant (which is based on the Lonza AG emulsion process) is 53 million pounds per year. Capacity is being expanded by 44 million pounds per year and is expected on stream in 1974 (ECN, March 23, 1973, p. 14). Vinyl chloride is supplied by the company's plant at Stenungsund.

Switzerland

Estimated consumption of polyvinyl chloride resins in 1970 was 62 million pounds (Encyclopedia of Polymer Science and Technology, Volume 14, Interscience Publishers, New York, 1971, pp. 306 and 307).

Lonza AG, Lalden. In 1970, capacity was 44 million pounds per year (ECN Polymer Intermediates, October 30, 1970, p. 9).

POLYVINYL CHLORIDE RESINS - CONTINUED

United Kingdom

Available statistics are as follows:

Polyvinyl Chloride Resins - United Kingdom
(Millions of Pounds)

	<u>Production</u>	<u>Imports</u>	<u>Consumption</u>	<u>Annual Capacity</u>
1970	>727	172	760	(736)
1971	738	--	--	(1,192)
1972	--	--	782	(1,309)

Sources: (A) PCN, Volume 8, Number 44, November 2, 1970, p. 1
(Production datum for 1970).

(B) ECN, February 19, 1971, p. 10 (Imports datum for 1970), and January 5, 1973, p. 4 (Consumption datum for 1972).

(C) Brighton, C. A., "Vinyl Chloride Polymers (Introduction)," Encyclopedia of Polymer Science and Technology, Volume 11, Interscience Publishers, New York, 1971, pp. 306 and 307 (Consumption datum for 1970).

(D) Chemical Age International, March 23, 1973, p. 9
(Production datum for 1971).

(E) CEH estimates based on information in trade publications (Annual Capacity estimates).

BP Chemicals International Limited (a subsidiary of The British Petroleum Company Limited)

1. Baglan Bay, England. Capacity is 99 million pounds per year and an additional 99 million pounds per year is due on stream in 1973. Both plants are based on Pechiney-Saint-Gobain's two-step bulk polymerization process (CW, October 6, 1971, p. 38, and February 14, 1973, p. 31). Vinyl chloride is produced on site.
2. Barry, South Wales. In early 1971, capacity was 440 million pounds per year (ECN, January 8, 1971, p. 10). Some vinyl chloride is supplied by the Baglan Bay facility.

Bakelite Xylonite Limited (a subsidiary of Turner & Newall Ltd.), Aycliffe, Durham, England. Capacity is 66 million pounds per year (ECN, January 12, 1973, p. 4). Vinyl chloride has been purchased from BP Chemicals International Limited (ECN, October 23, 1970, p. 18).

Imperial Chemical Industries Limited (ICI)

1. Hillhouse, Lancashire, England. Capacity is 440 million pounds per year (ECN, November 5, 1971, p. 17). Vinyl chloride is produced on site.
2. Runcorn, Cheshire, England. Capacity is 154 million pounds per year (ECN, November 5, 1971, p. 17). Vinyl chloride is produced on site.



Vinatex Limited (a joint venture of Continental Oil Company and Stavely Chemicals Ltd.), Stavely, Chesterfield, England. In 1969, capacity was 110 million pounds per year (99 million pounds per year were suspension grade and 11 million pounds per year were emulsion grade). Vinyl chloride was purchased from ICI (ECN, June 20, 1969, p. 12). Only about 70% of the product was expected to be marketed with the remainder being used captively for polyvinyl chloride products (CA, October 30, 1970, p. 24).

EASTERN EUROPE

Bulgaria

A 220 million pounds-per-year polyvinyl chloride resins plant is planned (ECN, April 20, 1973, p. 20).

Karl Marx Chemical Plant, Reka Devnya. Capacity was 66 million pounds per year in 1969 (Chemische Industrie, XXI/November 1969, p. 762). A 331 million pounds-per-year vinyl chloride plant is to be built here by 1975 (ECN, April 20, 1973, p. 20).

Czechoslovakia

Total polyvinyl chloride resins capacity at year-end 1970 was estimated at 88 million pounds per year ("Petrochemicals and Their Raw Materials in Europe," Proceedings of the Fourth International Conference of the European Chemical Marketing Research Association, Budapest, Hungary, October 13-15, 1970, p. 109).

Novaky. Polyvinyl chloride resins capacity is 101 million pounds per year. Capacity is to be expanded by 220 million pounds per year in 1975 (Chimie Actualités, July 13, 1972, p. 25).

Spolana complex, Neratovice. A 110 million pounds-per-year polyvinyl chloride resins plant is scheduled for 1973 with an expansion to 264 million pounds per year planned for 1975 (Chimie Actualités, July 13, 1972, p. 25).

Polyvinyl chloride resin plants are also located near Bratislava and/or Sala (CII, 4/1970, p. 113).

POLYVINYL CHLORIDE RESINS - CONTINUED

East Germany

Total polyvinyl chloride resins capacity at year-end 1969 was 397 million pounds ("Petrochemicals and Their Raw Materials in Europe," Proceedings of the Fourth International Conference of the European Chemical Marketing Research Association, Budapest, Hungary, October 13-15, 1970, p. 103). In 1969, it was reported that all polyvinyl chloride resins production was to be concentrated at the VEB Chemische Werke Buna factory at Schkopau by 1975-1980 (CII, 2/1969, p. 55). Exports of polyvinyl chloride resins in 1970 and 1971 were 3 million pounds and 12 million pounds, respectively (Chemical Age International, October 13, 1972, p. 16).

In March 1972, it was announced that a vinyl chloride plant and a 132 million pounds-per-year polyvinyl chloride resins plant were to be built at Schkopau (ECN, March 31, 1972, p. 14).

Hungary

Consumption of polyvinyl chloride resins in 1970 amounted to an estimated 88 million pounds (ECN, June 4, 1971, p. 16).

Borsodi Vegyi Kombinat, Borsod. Capacity is 55 million pounds per year. A second plant with a capacity of 264 million pounds per year is to be built by 1980 (CII, 1/1973, p. 11).

Poland

In 1970, production of polyvinyl chloride resins was 187 million pounds, imports were 11 million pounds, exports were 39 million pounds, and annual capacity was 298 million pounds per year (ECN, June 4, 1971, p. 8; September 10, 1971, p. 6; and July 3, 1970, p. 8).

Felix Dzierzynski Nitrogen Factory, Tarnow. Capacity of this plant (which is based on the Montecatini suspension process) is 88 million pounds per year (CII, 4/1968, p. 101).

Oswiecim. Capacity is 115 million pounds per year (C&EN, August 14, 1972, p. 14).

Wloclawek Nitrogen Works, Wloclawek. A 264 million pounds-per-year polyvinyl chloride resins plant is to be completed by 1977 (C&EN, August 14, 1972, p. 14).

Rumania

Polyvinyl chloride resins production was about 176 million pounds in 1970, and is expected to reach 529 million pounds by 1975 (ECN, June 15, 1973, p. 22).

Borzesti Chemical Combine, Borzesti. Capacity of this plant, which is based on suspension polymerization technology, is 79 million pounds per year (ECN, June 25, 1971, p. 18).



Rimnicu-Vilcea Chemical Combine, Rimnicu Vilcea. Capacity of this plant, which is based on suspension polymerization technology, is 88 million pounds per year, with another 309 million pounds-per-year plant under construction at this site, to be completed in 1974 (ECN, June 15, 1973, pp. 22 and 24).

Polyvinyl chloride resins are reportedly also produced at Tirnaveni and possibly at Iasi and Turda (ECN, June 25, 1971, p. 18). In June 1972, plans were announced for a polyvinyl chloride resins plant of unknown capacity to be built at Constanta during the next five-year plan (ECN, June 23, 1972, p. 16).

U.S.S.R.

Production of polyvinyl chloride resins for 1970 was reported at 353 million pounds. The government is planning to increase production to 961 million pounds by 1975 (CA, June 2, 1972, p. 16). In 1970, an estimated 55 million pounds of polyvinyl chloride resins were supplied by Japan (OPD, October 26, 1970, p. 4). Capacity has been estimated at 661 million pounds per year for year-end 1970 ("Petrochemicals and Their Raw Materials in Europe," Proceedings of the Fourth International Conference of the European Chemical Marketing Research Association, Budapest, Hungary, October 13-15, 1970, p. 103).

Kalush. A 132 million pounds-per-year polyvinyl chloride resins plant will be constructed in conjunction with a 440-550 million pounds-per-year vinyl chloride plant which is also planned for this site. Two other 132 million pounds-per-year polyvinyl chloride resins plants are also to be built nearby (ECN, October 8, 1971, p. 16).

Navoi. A polyvinyl chloride resins plant is planned for this site (ECN, January 5, 1973, p. 12).

Novomoskovsk. Capacity of the plant is unknown, but reportedly is to be expanded by 128 million pounds per year (ECN, August 6, 1971, p. 14).

Sterlitamak. A 132 million pounds-per-year polyvinyl chloride resins plant is planned along with a vinyl chloride plant (ECN, August 27, 1971, p. 10).

Yugoslavia

Estimated demand for polyvinyl chloride resins was projected at 66 million pounds for 1971 and 220-264 million pounds for 1975 (CII, 2/1972, p. 58).

Hemijska Industrija Pancevo (HIP), Pancevo (near Belgrade). An 88 million pounds-per-year plant is under construction, based on Stauffer Chemical Company technology. Completion of the plant is expected in early 1975. A 220 million pounds-per-year vinyl chloride plant is also planned for this site (ECN, September 10, 1971, p. 14).

INA Consortium, Organsko Hemijska Industrija Skopje, and Jugovinil, Rijeka. In 1971, plans for a 220 million pounds-per-year plant were under consideration (CW, November 17, 1971, p. 35).

POLYVINYL CHLORIDE RESINS - CONTINUED

Jugovinil, near Split. Capacity is 55 million pounds per year. The vinyl chloride used for the polymer is made from acetylene feedstock (CE, July 27, 1970, p. 94).

Jugovinil (55%) and Montecatini Edison SpA [Italy] (45%), Kastel Sucarac (near Split). In late 1971, a 176 million pounds-per-year plant was planned for late 1973. Plans include exporting 30% of the polyvinyl chloride resins to Italy (CW, November 17, 1971, p. 38).

Organsko Hemijska Industrija Skopje (OHIS), Skopje. Capacity is 26 million pounds per year (ECN, April 7, 1972, p. 18).

Organsko Hemijska Industrija Skopje (OHIS) [87.5%] and Rhone-Poulenc SA (France) [12.5%], Skopje. A 106 million pounds-per-year plant is planned which will use Pechiney-Saint-Gobain technology (CW, November 17, 1971, p. 35).

Vinilplastika, Zadar. In June 1973, a 44 million pounds-per-year plant, using Pechiney-Saint-Gobain technology and imported vinyl chloride, was nearly completed (HP, Section 2, June 1973, p. 26).

ASIA

China (Mainland)

Total PVC capacity is estimated at 165 million pounds per year, distributed among four plants (Apte, G. S., "Development of the Petrochemical Industry in the ESCAPE Region," ID/WG.34/5, Interregional Petrochemical Symposium on the Development of the Petrochemical Industries in Developing Countries, Baku, U.S.S.R., October 20-31, 1969, United Nations Industrial Development Organization, p. 49).

India

Available statistics are as follows:

Polyvinyl Chloride Resins - India
(Millions of Pounds)

	Production	Consumption	Annual Capacity
1970	85	110	96
1971	95	--	99
1972	103	--	--

Sources: (A) Indian Petroleum & Chemicals Statistics, Jan-Dec 1972, Government of India (Production data).
(B) CA, October 1, 1971, p. 20 (Consumption datum for 1970).
(C) Chemical Industry News-India, December 1972, p. 688 (Annual Capacity data).



The Ahmedabad Manufacturing & Calico Printing Co., Limited, Bombay, Maharashtra. In 1970, capacity was 15 million pounds per year and was to be expanded to 44 million pounds per year using a Pechiney-Saint-Gobain license (Chemicals, U.S. Department of Commerce, Business and Defense Services Administration, March 1970, p. 33, and Petrochemical Directory 1971, The Petroleum Publishing Company, Tulsa, Oklahoma, 1970, p. 18).

Chemicals & Plastics India Limited (Chemplast) (jointly owned by The B. F. Goodrich Company and Indian investors), Madras, Tamil Nadu. In 1969, capacity was 13 million pounds per year. The capacity was to have been expanded to 30 million pounds per year in 1970 using Kureha Chemical Industry Company Ltd. technology. A further expansion to 44 million pounds per year was planned (Chemical Industry News-India, October 1969, p. 441).

The Delhi Cloth & General Mills Co., Ltd., Shriram Vinyl and Chemical Industries Division, Kota, Rajasthan. In 1970, capacity was 24 million pounds per year (Chemicals, U.S. Department of Commerce, Business and Defense Services Administration, March 1970, p. 33). In 1971, the capacity was being expanded to 44 million pounds per year (Petrochemical Directory 1971, The Petroleum Publishing Company, Tulsa, Oklahoma, 1970, p. 19).

National Organic Chemical Industries Limited (NOCIL) (owned 33.3% by the Royal Dutch/Shell Group [The Netherlands], 28.3% by Indian Mafatlal Group, and 38.3% by the public), Thana, Bombay. Capacity is 44 million pounds per year and plans are under consideration for increasing capacity by another 44 million pounds per year (CII, 2/1972, p. 44).

Indonesia

Nusantour Duta Development and Hong Kong Industries Co., Ltd., near Djakarta. A 33 million pounds-per-year PVC plant is scheduled to be built and completed by the end of 1973 (CW, January 10, 1973, p. 46).

Iran

Abadan Petrochemical Company, Ltd. (owned 74% by National Iranian Oil Company and 26% by The B. F. Goodrich Company), Tehran. In 1970, capacity was only 44 million pounds per year, although the plant does have expansion capability up to 88 million pounds per year. Capacity is to be tripled by multi-phase expansions. Feedstocks for the vinyl chloride are based on natural gas (IC, May-June 1970, p. 38, and Adhesives Age, April 1973, p. 58).

Israel

Electrochemical Industries (Frutarom) Ltd., Acre (near Haifa). This plant, which is based on Monsanto Company technology, has a capacity of 26 million pounds per year. In late 1971, an additional 29-35 million pounds per year was expected on stream (CW, November 24, 1971, p. 21).

POLYVINYL CHLORIDE RESINS - CONTINUED

Japan

Salient statistics are as follows:

Polyvinyl Chloride Resins - Japan				
(Millions of Pounds)				
	<u>Production</u>	<u>Consumption</u>	<u>Exports</u>	<u>Annual Capacity</u>
1970	2,561	2,213	294	(3,636)
1971	2,246	2,023	321	(3,636)
1972	2,379	2,164	316	(3,526) ^a

- a. Some of the older plants were scrapped because of depressed market conditions and modernization of other plants during this year. It is not known which plants were shut down.

Sources: (A) JCW, February 11, 1971, p. 1 (Production, Consumption, and Exports data for 1970), and February 24, 1972, p. 8 (Production, Consumption, and Exports data for 1971).

(B) CEH estimates based on information in trade publications (Annual Capacity estimates for 1970 and 1971).

(C) PIN, March 1973, pp. 40 and 41, and April 1973, p. 54 (all data for 1972, and information in footnote a).

Most of the company information in this section is based on the following reference (unless otherwise noted), Oikawa, Yoshiyuki, Yasuhiro Uchida, and Susumu Imaizumi, "Growing Petrochemical Industry and Polyvinyl Chloride Industry," CEER, May 1971, pp. 11-22.

Asahi Glass Company, Ltd. All of the polyvinyl chloride resins produced by Asahi Glass are used for a special fiber glass-reinforced PVC plastic product (PIN, October 1969, pp. 122-124).

1. Goi, Chiba Prefecture. In 1969, capacity was 9 million pounds per year. The vinyl chloride was supplied by Asahi-Penn Chemical Company, Ltd. (owned by Asahi Glass Company, Ltd. and PPG Industries, Inc.) (PIN, October 1969, pp. 122-124).
2. Kashima, Ibarki Prefecture. In 1971, capacity was 5 million pounds per year. The vinyl chloride is supplied by pipeline from the Kashima Vinyl Chloride Monomer Co., plant at Kashima, Ibarki Prefecture.

Central Chemical Company, Ltd. (joint venture of Central Glass Co., Ltd. and Toa Nenryo Kogyo KK), Kawasaki, Kanagawa. Plans to build a 53 million pounds-per-year plant by early 1974 have received government approval (JCW, July 19, 1973, p. 3).

Chisso Corporation

1. Goi, Chiba Prefecture. In 1970, capacity was 70 million pounds per year (PIN, September 1970, pp. 121-123). Vinyl chloride is supplied by pipeline from Asahi-Penn Chemical Company, Ltd., Goi, Chiba Prefecture (capacity is 110 million pounds per year).
2. Minamata, Kumamoto Prefecture. In 1970, capacity was 122 million pounds per year (PIN, September 1970, pp. 121-123). Vinyl chloride is produced on site by a 132 million pounds-per-year plant owned by Chisso Corporation.
3. Mizushima, Okayama Prefecture. In 1970, one source estimated capacity at 66 million pounds per year (PIN, September 1970, pp. 121-123). In 1971, another source estimated capacity at 79 million pounds per year. Vinyl chloride is supplied by pipeline from the Sanyo Monomer Company, Ltd., which has a vinyl chloride plant at Mizushima with a capacity of 264 million pounds per year.

Denki Kagaku Kogyo KK (DENKA)

1. Goi, Chiba Prefecture. In 1971, capacity was 77 million pounds per year. Vinyl chloride is supplied by pipeline from the 353 million pounds-per-year vinyl chloride plant of Chiba VCM Company, Limited, Anegasaki, Chiba Prefecture.
2. Omi, Niigata Prefecture. Capacity was 110 million pounds per year in 1970. Some of this capacity may have been scrapped to meet government restrictions when the plant at Goi came on stream in late 1970 or early 1971. Vinyl chloride is supplied by lorry transport from Nissan Petrochemicals Ltd., Goi, Chiba Prefecture (capacity is 110 million pounds per year).

Gunma Kagaku KK, subsidiary, Shibukawa, Gunma Prefecture. Capacity was 119 million pounds per year in 1970. Some of this capacity may have been scrapped to meet government restrictions when the plant of Denki at Goi came on stream in late 1970 or early 1971. The vinyl chloride is supplied by lorry transport by the companies that supply the parent company at Omi.

Kanegafuchi Chemical Industry Company Limited

1. Kashima, Ibaraki Prefecture. In 1971, capacity of this plant, which is based on a self-developed process, was 110 million pounds per year. Vinyl chloride is supplied by Kashima Vinyl Chloride Monomer Co., which has a 485 million pounds-per-year vinyl chloride plant at Kashima.
2. Osaka, Osaka Prefecture and Takasago, Hyogo Prefecture. In 1971, combined capacity of these plants, which are based on Stauffer technology, was 253 million pounds per year. Some of the capacity at Osaka may have been scrapped when the plant at Kashima came on stream. Vinyl chloride is supplied by pipeline from Kanegafuchi Chemical's monomer plant at Takasago which has a capacity of 264 million pounds per year.

Kureha Chemical Industry Co., Ltd., Nishiki, Fukushima Prefecture. In 1971, capacity was 272 million pounds per year. Vinyl chloride is supplied by a plant at the same location which has a capacity of 309 million pounds per year.

POLYVINYL CHLORIDE RESINS - CONTINUED

Mitsubishi-Monsanto Chemical Company (a joint venture of Mitsubishi Chemical Industries Limited and Monsanto Company), Yokkaichi, Mie Prefecture. In 1970, capacity was 238 million pounds per year. All of the vinyl chloride produced on site by Mitsubishi-Monsanto from a 132 million pounds-per-year plant is used. Additional quantities are purchased from Ryo-Nichi Co., Ltd., at Mizushima (PIN, September 1970, pp. 121-123).

Mitsui Toatsu Chemicals, Incorporated (merger of Mitsui Chemical Industry Co., Ltd., and Toyo Koatsu Industries, Inc.), Nagoya, Aichi Prefecture. In 1971, capacity was 185 million pounds per year. Plans to decrease capacity at this plant and to increase capacity at Mitsui Senboku Petrochemicals, Inc., were under consideration. Vinyl chloride is supplied by sea transport from Mitsui Senboku Petrochemicals, Inc., Senboku, Osaka Prefecture.

Mitsui Senboku Petrochemicals, Inc., subsidiary, Senboku, Osaka Prefecture. In 1971, capacity was 66 million pounds per year. Plans to increase capacity at this plant and to decrease capacity at the parent company's Nagoya plant were under consideration. Vinyl chloride is supplied by a 264 million pounds-per-year plant on site.

Nippon Carbide Industries Company, Inc.

1. Uozu, Toyama Prefecture. In 1971, capacity was 147 million pounds per year. Vinyl chloride is supplied by sea transport from Ryo-Nichi Co., Ltd., Mizushima, Okayama Prefecture (capacity is 440 million pounds per year).
2. Hayatsuki, Toyama Prefecture. Asahi Glass Company has invested in the existing plant which has a capacity of 13 million pounds per year for specialty polyvinyl chloride copolymer resins (JCW, April 5, 1974, p. 7).

Ryo-Nichi Co., Ltd., (jointly owned by Nippon Carbide Industries Company, Inc., and Mitsubishi Chemical Industries Limited), Mizushima, Okayama Prefecture. In 1971, capacity was 127 million pounds per year. The vinyl chloride is supplied by pipeline from Ryo-Nichi Co., Ltd., Mizushima, Okayama Prefecture (capacity is 440 million pounds per year).

Nippon Zeon Co., Ltd. (partly owned by Asahi Chemical Industry Co., Ltd.)

1. Mizushima, Okayama Prefecture. In 1971, capacity was 128 million pounds per year. Vinyl chloride is supplied by pipeline from the Sanyo Monomer Company, Ltd., which has a vinyl chloride plant with a capacity of 264 million pounds per year.
2. Takaoka, Toyama Prefecture. In 1971, the capacity of this plant, which uses B. F. Goodrich technology, was 242 million pounds per year. Vinyl chloride is supplied by pipeline from Nippon Zeon's 286 million pounds-per-year plant at Takaoka.

Shin-Etsu Chemical Industry Co., Ltd.

1. Kashima, Ibaraki Prefecture. In 1971, capacity of this plant, which is based on the company's own new technology, was 331 million pounds per year. Vinyl chloride is supplied by pipeline from the Kashima Vinyl Chloride Monomer Co., Ltd., vinyl chloride plant at Kashima, which had a capacity of 485 million pounds per year.
2. Nanyo, Yamaguchi Prefecture. In 1970, capacity was 66 million pounds per year (PIN, September 1970, pp. 121-123). Vinyl chloride is supplied by pipeline from the Toyo Soda Manufacturing Co., Ltd., plant at Tokuyama, Yamaguchi Prefecture.



3. Naoetsu, Niigata Prefecture. In 1970, capacity was 132 million pounds per year. However, after the Kashima plant was built, the capacity of the Naoetsu plant was to be reduced substantially (PIN, September 1970, pp. 121-123).

Nissin Chemical Industry Co., Ltd., subsidiary, Takefu, Fukui Prefecture. Capacity in 1970 was 127 million pounds per year. The Japanese government has approved an expansion by 56 million pounds per year of capacity, but this had not yet been utilized in 1971 (Japan Chemical Review 1971, p. 98).

Sumitomo Chemical Co., Ltd.

1. Anegasaki, Chiba Prefecture. In 1970, capacity was 53 million pounds per year (PIN, September 1970, pp. 121-123).
2. Niihama, Ehime Prefecture. In 1971, capacity was 110 million pounds per year. Vinyl chloride is supplied by pipeline from the Chiba VCM Company, Limited, at Sodegaura, Chiba Prefecture, which has a vinyl chloride capacity of 110 million pounds per year.

An additional 61 million pounds per year of polyvinyl chloride resins capacity had been approved by the Japanese government but had not yet been utilized in 1971 (Japan Chemical Review 1971, p. 98).

Sun Arrow Chemical Company, Ltd. (owned by Tokuyama Soda Co., Ltd., Tekkosha Co., Ltd., and Daicel Ltd.), Tokuyama, Yamaguchi Prefecture. In 1971, capacity was 132 million pounds per year. Vinyl chloride was supplied by a 242 million pounds-per-year plant on site.

Toagosei Chemical Industry Co., Ltd., Tokushima, Tokushima Prefecture. In 1971, capacity was 126 million pounds per year. Of this total, 29 million pounds per year is based on Pechiney-Saint-Gobain technology. Approval has been given by the Japanese government for an additional 44 million pounds per year, but this had not yet been realized in 1971. Vinyl chloride was supplied by a 106 million pounds-per-year vinyl chloride plant on site and was supplemented by purchases from outside (ECN, April 3, 1970, p. 14; Japan Chemical Review 1971, p. 98; and PIN, September 1970, pp. 121-123).

Kawasaki Organic Chemical Co., Ltd., subsidiary, Kawasaki, Kanagawa Prefecture. In 1971, capacity was 66 million pounds per year. Vinyl chloride is supplied by pipeline from Central Chemical Company, Ltd., at Kawasaki.

Tokuyama Sekisui Industry Company, Ltd. (a subsidiary of Sekisui Chemical Co., Ltd.), Nanyo, Yamaguchi Prefecture. In 1971, capacity was 68 million pounds per year. An additional 27 million pounds per year has been approved by the Japanese government but had not yet been realized in 1971 (Japan Chemical Review 1971, p. 98). Vinyl chloride is supplied by pipeline from the Toyo Soda Manufacturing Co., Ltd., vinyl chloride plant at Tokuyama, Yamaguchi Prefecture, which has a capacity of 331 million pounds per year.

Toyo Soda Manufacturing Co., Ltd., Shin-Nanyo, Yamaguchi Prefecture. Plans to build a 53 million pounds-per-year plant by early 1974 have received government approval (JCW, July 19, 1973, p. 3).

POLYVINYL CHLORIDE RESINS - CONTINUED

Yokkaichi Tekkosha Co., Ltd. (a wholly owned subsidiary of Tekkosha Company, Ltd.), Yokkaichi, Mie Prefecture. In 1971, capacity of this plant, which is based on a Tekkosha process, was 79 million pounds per year. Vinyl chloride is supplied by the Toyo Soda Manufacturing Co., Ltd., plant at Yokkaichi which has a capacity of 200 million pounds per year. In late 1971, it was reported that Toyo Soda Manufacturing Co., Ltd., was planning to take an equity interest in Yokkaichi Tekkosha (OPD, December 6, 1971, p. 7).

Korea, North

A 4 million pounds-per-year polyvinyl chloride plant is operational (JCW, January 18, 1973, p. 3).

Korea, Republic of

Daehan Plastics Ltd., location unspecified. In 1971, capacity was 15 million pounds per year (Japan Chemical Review 1971, p. 8).

Kongyong Chemical Co., Ulsan. In 1967, capacity was 15 million pounds per year (Soo Suh, Jin, Editor, Review of Korean Economy in 1967, The Bank of Korea, Seoul, Korea, July 20, 1968, p. 104).

Korea Chemical Industry Co., location unspecified. In 1968, capacity was 33 million pounds per year (Shik Chuh, Eun, Editor, Review of Korean Economy 1968, The Bank of Korea, Seoul, Korea, August 15, 1969, p. 100).

Upung Chemical Co., Ulsan. In 1969, capacity was 22 million pounds per year (Shik Chuh, Eun, Editor, Review of Korean Economy 1969, The Bank of Korea, Seoul, Korea, August 31, 1970, p. 100).

Malaysia

Petrochemicals Malaysia Sdn. Bhd. (owned by Sumitomo Shoji Kaisha, Ltd. [Japan] [a member of the Sumitomo group] and 49% by Idemitsu Petrochemical Co., Ltd. [Japan]), location unspecified. A 13 million pounds-per-year plant is under construction which will use Sumitomo technology. Completion is expected in October 1973 (JCW, November 16, 1972, p. 1).

Pakistan

Arokey Chemicals, location unspecified. Polyvinyl chloride resins capacity is 12 million pounds per year (JCW, February 8, 1973, p. 15).

Fauji Foundation (government pension fund for officers), near Karachi. In early 1971, plans were in progress to build a 48 million pounds-per-year plant using ICI technology. The plant was expected to be completed by 1974 (ECN, February 12, 1971, p. 12).

Philippines

Mabuhay Vinyl Corporation, Iligan. Capacity is 22 million pounds per year (U.S. Department of State Airgram, January 24, 1973, DIB 73 03 133).

Philippine Vinyl Consortium, Inc. (The B. F. Goodrich Company is a minor shareholder), near Manila. In May 1972, plans to build a 44 million pounds-per-year plant using B. F. Goodrich Company technology were under consideration. The plant is expected to be completed in 1974 and will use imported vinyl chloride (CMR, May 22, 1972, p. 5).

Singapore

Camel Chemical, Singapore. In 1969, a 22 million pounds-per-year plant was under construction, and was to have come on stream in the fall of 1970 (CW, July 5, 1969, p. 34).

Taiwan

Total polyvinyl chloride resins capacity in Taiwan was 210 million pounds per year in 1970 and 298 million pounds per year in 1971 (CER estimates based on information in trade publications).

Cathay Plastic Industry Co., Ltd., location unspecified. In 1969, capacity of this plant, which is based on Sumitomo technology, was 26 million pounds per year (CII, 1/1969, p. 7).

China-Gulf Plastics Corporation (owned 63% by Gulf Oil Corporation and 37% by the Chinese Petroleum Corporation [which is government-owned]), location unspecified. In 1969, capacity was 89 million pounds per year (CII, 1/1969, p. 7).

Formosa Plastics Corporation, location unspecified. In early 1970, capacity was estimated at approximately 77 million pounds per year (C&EN, April 13, 1970, pp. 16-19). Another plant is under construction with 7 million pounds per year of capacity already on stream and an additional 7 million pounds per year scheduled for June 1973 and December 1974 (CW, October 18, 1972, p. 17).

I Fan Plastics Corporation, location unspecified. In 1969, capacity was 18 million pounds per year (CII, 1/1969, p. 7).

Taiwan VCM Corporation (a joint venture of all four of the above polyvinyl chloride producers, Chinese Petroleum Corporation (which is government-owned), and Taiwan Alkali Company (also government-owned))

1. Kaohsiung. In early 1970, a new 88 million pounds-per-year vinyl chloride plant was scheduled to start up at the end of 1971 and an additional 88 million pounds per year was already planned (C&EN, April 13, 1970, pp. 16-19).
2. Tufen. In early 1970, a 132 million pounds-per-year vinyl chloride plant was planned (C&EN, April 13, 1970, pp. 16-19).

POLYVINYL CHLORIDE RESINS - CONTINUED

Thailand

Mitsui Toatsu Chemicals, Inc. [Japan], and Thai investors, location unspecified. In 1971, it was reported that there were plans to build a polyvinyl chloride resins plant in July 1976, using Mitsui Toatsu technology (ECN, September 24, 1971, p. 4).

Thai Plastic and Chemical Company (owned 33% by Mitsui & Co., Ltd. [Japan] and Mitsui Toatsu Chemicals, Incorporated [Japan]; and 33% by Thai Asahi Caustic Soda Company), near Bangkok. Capacity is 22 million pounds per year and may be expanded to 44-66 million pounds per year (CMR, November 6, 1972, p. 32). Vinyl chloride was to be supplied from Japan.

Turkey

Petkim Petrokimya AS (a subsidiary of Turkish Petroleum Corporation)

1. Aliaga. A 57 million pounds-per-year polyvinyl chloride resins plant is under construction (CII, 4/1972, p. 122).
2. Yarmca. In late 1971, the capacity of this plant, which is based on ICI and Solvay & Cie technology, was 57 million pounds per year (OPD, November 15, 1971, p. 9). Vinyl chloride was supplied by a 60 million pounds-per-year plant on site (OPD, September 15, 1969, pp. 7 and 35). It was expected that the vinyl chloride and polyvinyl chloride resin capacities would be doubled (ECN, July 4, 1969, p. 10).

AUSTRALIA

In 1970, total Australian consumption of polyvinyl chloride resins was estimated to reach 88 million pounds by 1970 and 154 million pounds by 1975 (CII, 2/1970, p. 56). Total polyvinyl chloride resins capacity in 1969-1971 is estimated to have been 92 million pounds per year (CEH estimate based on information in trade publications).

B. F. Goodrich Chemical Limited (owned 80% by The B. F. Goodrich Company), Altona (near Melbourne), Victoria. In 1969, capacity was estimated at 15 million pounds per year (McKern, R. B., "Recent Development in the Australian Petrochemical Industry," ID/WG.34/69, Interregional Petrochemical Symposium on the Development of the Petrochemical Industries in Developing Countries, Baku, U.S.S.R., October 20-31, 1969, United Nations Industrial Development Organization, p. 12).

ICI Australia Limited (owned 62.5% by Imperial Chemical Industries Limited [United Kingdom]), Botany (near Sydney). Capacity in 1969 is estimated to have been 77 million pounds per year (CEH estimate based on McKern, R. B., "Recent Development in the Australian Petrochemical Industry," ID/WG.34/69, Interregional Petrochemical Symposium on the Development of the Petrochemical Industries in Developing Countries, Baku, U.S.S.R., October 20-31, 1969, United Nations Industrial Development Organization, p. 13).

AFRICAAlgeria

SONATRACH (Societe Nationale pour la Recherche, la Production, le Transport, la Transformation et la Commercialization des Hydrocarbures), Skikda. In May 1972, plans were under consideration to build an 88 million pounds-per-year vinyl chloride plant and a 77 million pounds-per-year polyvinyl chloride resins plant based on Mitsui Toatsu technology. The plants are expected to come on stream in 1975 (CMR, May 22, 1972, p. 5).

Nigeria

In early 1971, plans were under consideration to build a 66 million pounds-per-year polyvinyl chloride resins plant in conjunction with a new petrochemical complex at a site not yet determined (CII, 1/1971, p. 25).

South Africa, Republic of

Consumption of polyvinyl chloride resins in 1970 amounted to an estimated 110 million pounds (ECN, October 1, 1971, p. 16). In 1971, consumption was above 110 million pounds with large amounts of polyvinyl chloride resins having been imported to meet demand (CII, 1/1972, pp. 13 and 14).

AA Plastics and Chemicals, Benoni. Construction of a polyvinyl chloride resins plant of unspecified capacity was started in 1969. The plant was to have come on stream in 1970 (ECN, October 31, 1969, p. 14).

AELCI Ltd. (owned 42.5% by Imperial Chemical Industries Limited [United Kingdom]).

1. Midland, Orange Free State. Polyvinyl chloride capacity is 64 million pounds per year (ECN, September 22, 1972, p. 10).
2. Umbogintwini (near Durban). Capacity is 20 million pounds per year. Plans are under consideration to build a second plant (CII, 1/1972, pp. 13 and 14).

Sentrachem Limited (owned by Federale Volks Beleggings, Industrial Development Corporation of South Africa, and BP Chemicals International Limited), unknown location. A polyvinyl chloride resins plant is being considered (ECN, January 19, 1973, p. 12).

BIBLIOGRAPHY

The following is a listing of pertinent references for supplemental reading.

Allen, Dr. G. D., Dr. P. A. Arias-Soto, and Dr. T. M. Gallub, "The Plastics Industry: Some International Comparisons-USA V EEC V Japan," paper presented at the Chemical Marketing Research Association meeting, New Orleans, Louisiana, February 1973.

Brighton, C. A., "Vinyl Chloride Polymers, Compounding and Fabricating," Encyclopedia of Polymer Science and Technology, Volume 14, Interscience Publishers, New York, 1971, pp. 394-452.

_____, "Vinyl Chloride Polymers, Polymerization and Copolymers," Encyclopedia of Polymer Science and Technology, Volume 14, Interscience Publishers, New York, 1971, pp. 320-358.

Bucsko, R. T., "Future Markets for Vinyl Dispersion Resins," paper presented before the 13th Film, Sheetting and Coated Fabrics Conference, The Society of the Plastics Industry, Inc., New York, November 1971.

"CHLOrine + Ethylene = CHLOE," Informations Chimie, May-June 1971, pp. 37-47.

"Crosslinked PVC Foams Aim for High Performance Jobs," Modern Plastics, September 1968, p. 53.

"Europe offers viable technology for chlorinated hydrocarbon waste recovery processes," Chemical Age International, March 23, 1973, pp. 9-11.

"Huels PVC Batch Process Goes Well Under Computer Control," Oil and Gas Journal, December 16, 1968, pp. 78-81.

Hurard, Henry, "The European Market of PVC," Proceedings of the 4th International Conference of the European Chemical Marketing Research Association, Budapest, Hungary, October 1970.

Mazzolini, C., L. Patron, A. Moretti and M. Campanelli, I&EC Product Research and Development, December 1970, pp. 504-511.

McKelvey, J. M., "Polymer Processing," John Wiley & Sons, Inc., New York, 1962.

"New Route to Vinyl Chloride," Oil and Gas Journal, November 8, 1971, pp. 64 and 65.

"Plastic-Bottle Future: Grafted to Proliferating Molecules," Modern Packaging, May 1969, pp. 78-83.

"Polyvinyl Chloride," ECN Process Survey, European Chemical News, January 29, 1971.

Sarvetnick, Harold A., Polyvinyl Chloride, Van Nostrand Reinhold Company, New York, 1969.



Schroeter, G., Kunststoffe, June 1970, pp. 363-366.

Shelley, P. G., and E. J. Sills, "Monomer Storage and Protection," Chemical Engineering Progress, April 1969, pp. 29-36.

Skiest, E. N., "Blending/Dispersion Resin Interactions," Modern Plastics, October 1970, pp. 132, 133, and 136.

Stinson, Stephen C., "Developments Are Breaking Fast on the Red-Hot Foams Front," Plastics Technology, September 1972, pp. 33-36.

Thomas, J. C., "New Improved Bulk PVC Process," Hydrocarbon Processing, November 1968, pp. 192-196.

Waechter, C. J., "What's Happening in PVC Blow Molding," SPE Journal, July 1971, pp. 43-47.

ROSS V. BFS

LEGEND - PERIODICALS ABBREVIATIONS

AC	Agricultural Chemicals	I&EC	Industrial and Engineering Chemistry
APJ	American Paint Journal	JCA	Japan Chemical Annual
CA	Chemical Age	JCW	Japan Chemical Week
CCP	Canadian Chemical Processing	ME	Materials Engineering
CE	Chemical Engineering	MP	Modern Plastics
C&EN	Chemical & Engineering News	NI	Nitrogen
CEER	Chemical Economy & Engineering Review	O&GJ	Oil and Gas Journal
CEH	Chemical Economics Handbook	PCN	Petrochemical News
CEP	Chemical Engineering Progress	PIN	Plastics Industry News
CII	Chemische Industrie International	P&P	Phosphorus & Potassium
CMR (OPD)	Chemical Marketing Reporter	PVP	Paint and Varnish Production
CPE	Chemical & Process Engineering	PW	Plastics World
CW	Chemical Week	RA	Rubber Age
DS	Detergents and Specialties	RW	Rubber World
ECN	European Chemical News	SCCS (S&CS)	Soap/Cosmetics/Chemical Specialties
FC	Farm Chemicals	SU	Sulphur
HP	Hydrocarbon Processing	TO	Textile Organon
IC	Informations Chimie International		