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CEH Marketing Research Report

POLYVINYL CHLORIDE RESINS

By H. E. Frey
with Robert L. Maffly

This is the

CEH Marketing Research Reports are comprehensive studies prepared from information in the CEH Data Center and from extensive personal interviews with sources in the chemical industry. A distinctive feature of these reports is the analysis of future supply/demand relationships.

Chemical Economics Handbook - SRI International

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SUMMARY

Current Supply/Demand

A. Vinyl Chloride Monomer (VCM)

Key data describing supply and demand for vinyl chloride in 1978 are given below.

VINYL CHLORIDE MONOMER SUPPLY/DEMAND - 1978

	Millions of Pounds	Thousands of Metric Tons
Production	6,955	3,155
Annual Production Capacity (year-end, nameplate)	8,695[a]	3,944[a]
Domestic Consumption	6,065	2,751
Exports	899	408

a. Includes 500 million pounds (227 thousand metric tons) of capacity that was operated by PPG in Puerto Rico until the end of 1978.

SOURCE: U.S. government publications, trade literature, and CEH estimates.

In 1979, total VCM demand for domestic use is estimated to be 6.4 billion pounds (2.9 million metric tons); U.S. exports are expected to be about 1 billion pounds (454 thousand metric tons). Capacity to meet this demand level is sufficient in spite of the loss of PPG's Puerto Rican capacity.

B. Polyvinyl Chloride (PVC) Resins

The 1978 PVC supply/demand balance is characterized by the following figures.

PVC RESIN SUPPLY/DEMAND - 1978

	Millions of Pounds	Thousands of Metric Tons
Production	5,724	2,596
Annual Production Capacity (mid-1978, nameplate)	6,890	3,125
Domestic Consumption	5,570	2,527
Exports	252	114

SOURCE: U.S. government publications, trade literature, and CEH estimates.

Effective U.S. PVC capacity in 1978 was, overall, 12-15% less than nameplate because of operating deficiencies and also as a result of regulatory compliance with VCM control standards. On that basis, U.S. production capacity, overall, operated at nearly full utilization in 1978.

The incremental capacity increases that became operational in the second half of 1978 and the first half of 1979 were comparatively minor; total mid-1979 U.S. PVC production

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capacity (nameplate) amounted to 7,115 million pounds (3,227 thousand metric tons). Since more stringent EPA control requirements took effect in October 1978, however, copolymer and dispersion resin capacities were further reduced in their effectiveness. The overall (predominantly suspension homopolymer) capacity effectiveness is believed to have improved to about 90% of nameplate, however. With domestic PVC demand for 1979 estimated at 5,890 million pounds (2,672 thousand metric tons) and PVC exports at 260 million pounds (118 thousand metric tons), capacity utilization again was about 96%, overall, but copolymers and dispersion resins were actually in short supply.

Projected Demand

A. Vinyl Chloride Monomer (VCM)

Monomer demand for domestic use will parallel PVC demand growth, and on that basis is estimated to increase an average of 6% annually between 1979 and 1983, leading to a projected domestic monomer demand of 8.07 billion pounds (3.66 million metric tons) by 1983 (non-PVC uses are projected to grow at about the same rate). Monomer exports are expected to run at the 800 million pound-per-year (363 thousand metric tons) level through 1981 and then drop to about 600 million pounds (272 thousand metric tons) per year. Thus, total VCM requirements are estimated to be 8.6-8.7 billion pounds (3.9 million metric tons) in 1983.

B. Polyvinyl Chloride (PVC) Resins

Long-term demand for PVC in its major markets is expected to remain stable, since PVC plastics uses are firmly established and there is no competitive material that can readily replace PVC.

The following table summarizes demand projections for major PVC end-use markets.

ESTIMATED CONSUMPTION OF PVC RESINS - 1978 AND 1983

	1978		1983[a]		
	Millions of Pounds[a]	Thousands of Metric Tons	Millions of Pounds[a]	Thousands of Metric Tons	Average Annual Growth Rate, 1978-1983 (Percent)
Construction	3,000	1,361	4,410	2,000	8%
Consumer Goods	710	322	840	381	
Electrical Uses	510	231	610	277	
Packaging	460	209	550	249	
Transportation	280	127	330	150	3.5%
Home Furnishings	220	100	260	118	
Miscellaneous	390	177	460	209	
Exports	250	113	300	136	
Total	5,820	2,640	7,760	3,520	6%

a. Data have been rounded to the nearest 10 million pounds.

SOURCE: CEH estimates.

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The above projections assume an average annual GNP growth of 3.5-3.7%.

Construction is by far the largest market for PVC; in fact, one sector of this market, pipe and conduit, accounts for the bulk. PVC resin consumption for pipe has become the decisive factor in the determination of overall PVC demand. In 1978, 2.3 billion pounds (1.0 million metric tons), about 40% of the total consumption, were used in this market, which is expected to consume 3.3-3.4 billion pounds (1.5 million metric tons) by 1983. Any major deviation of PVC consumption for pipe from the projected figures would, therefore, cause significant change in the projected overall PVC consumption.

PVC pipe and conduit markets will continue to grow primarily as a result of the ongoing replacement of conventional pipe and tubing. The remaining potential for this growth is particularly large for sewer pipe (10-13% annually), although in terms of PVC requirements, municipal water pipe for urban areas continues to be an important growth market. By contrast, almost no growth is seen in the rural water pipe market in general, although this varies somewhat among geographic regions. In the conduit field, growth is expected to continue and will be the strongest for electrical conduit. Comparatively low growth rates are expected for drain, waste, and vent (DWV) pipe, and for irrigation pipe.

Demand for other rigid PVC building products is generally expected to increase at a combined average annual rate of at least 8% between 1978 and 1983, with siding as the leading product. Flooring, however, is not expected to grow at that high a rate.

The other PVC market categories represent generally mature or highly penetrated markets; some segments are not expected to grow at all and might even decline (e.g., shower curtains, garden hose, baby pants), while others will increase (e.g., wall coverings) resulting in modest overall growth. Electrical uses represent a market that is expected to parallel construction activity, resulting in somewhat better gains for PVC than more consumer-related markets.

PVC resin prices are firm as of mid-1979; they reflect added costs for controlling vinyl chloride monomer as well as the industry's need to continue expanding.

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Supply and Availability

The near-term supply of VCM and PVC compared to projected demand is tabulated below.

NEAR-TERM SUPPLY/DEMAND BALANCE FOR VCM AND PVC

	1980			1981		
	Millions of Pounds	Thousands of Metric Tons	Percent	Millions of Pounds	Thousands of Metric Tons	Percent
Estimated Mean Annual Effective VCM Capacity[a]	7,826	3,550		8,546[b]	3,876[b]	
Estimated Domestic VCM Demand[c]	6,575	2,982		6,905	3,132	
Estimated VCM Exports	800	363		800	363	
Capacity Utilization			94%			90%
Estimated Mean Annual Effective PVC Capacity[a]	6,850	3,107		7,435	3,372	
Estimated PVC Demand[d]	6,310	2,862		6,610	2,998	
Capacity Utilization			92%			89%

a. Estimated capacity is nameplate capacity reduced by 10%.

b. Includes 630 million pounds (286 thousand metric tons) as the estimated capacity of Georgia-Pacific, which will be effective in 1981.

c. Includes 100 million pounds (45 thousand metric tons) for non-PVC uses. Reduction (from total PVC demand) to allow for comonomer used in copolymers and increase to allow for VCM monomer losses were assumed to be equal.

d. Includes 260 million pounds (113 thousand metric tons) for exports.

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SOURCE: CEH estimates.

According to these estimates, domestic VCM supply will be barely adequate in 1980 if domestic demand continues to increase as projected and exports stay up. Relief will come in 1981 when new capacity by Georgia-Pacific and by PPG comes on stream.

PVC supply will be sufficient, overall, through 1980, but in early 1981 supply could become tight until new capacity by Tenneco and by Shintec becomes operational. (Late in 1981, additional new capacity by BFGoodrich and Conoco is expected to come on stream).

Of the eleven U.S. producers of vinyl chloride monomer, Dow Chemical is the largest, followed by Shell, Diamond Shamrock, BFGoodrich, and Conoco (78% of the total U.S. capacity). Georgia-Pacific is scheduled to start up a one billion pound-per-year VCM plant in late 1980.

Of the 21 PVC resin producers, BFGoodrich remains the largest by far, followed by Tenneco, Firestone, Diamond Shamrock, Conoco, Borden, and Stauffer (67% of total U.S. capacity). Georgia-Pacific will have sufficient capacity in early 1980 to become one of the four largest U.S. PVC producers.

DESCRIPTION

Vinyl Chloride

Vinyl chloride, the monomer for polyvinyl chloride homopolymer and copolymer resins, is a gaseous, reactive intermediate derived from ethylene or acetylene. Generally, 1.025 pounds of vinyl chloride are needed to manufacture 1.0 pound of PVC homopolymer. (A factor of 1.03 is sometimes used).

Polyvinyl Chloride Resins

The term polyvinyl chloride (PVC) resins includes vinyl chloride homopolymers with the repeating unit-CH_2CHCl-, and copolymers of vinyl chloride with varying amounts of vinyl acetate, ethylene, propylene, vinylidene chloride, or acrylates. Generally, these resins are in the form of white powders or granules that, after compounding with auxiliary ingredients, are converted into a large variety of plastic end products through several types of processes. Because PVC resins are thermoplastic, these processes employ heat (except in the case of coating resins, which are processed by dissolving them and applying them from solution).

The general performance characteristics of PVC plastics include mechanical toughness, fairly good 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. PVC plastics that contain little or no plasticizer, therefore, tend to be sensitive to impact at low temperatures. All of these properties depend entirely on the exact composition of the compounds used.

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. Molecular weight distribution, particle size, and particle surface characteristics are other variables that are controlled in resin production and that vary among the different grades of PVC resins.

Of particular importance to the characteristics of PVC plastics is the presence or absence of plasticizer. Most PVC plastics produced in past decades have been flexible types containing plasticizer. The processing of plasticized PVC is relatively easy to carry out, compared to that for PVC compounds containing essentially no plasticizer. Processing of the latter, which are used 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.

Although the great majority of PVC resins used 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 used for phonograph records and those for vinyl asbestos floor tile; these have an average vinyl acetate content of about 13%. Other PVC-vinyl acetate copolymers are used in calendering and extrusion formulations; these have an average vinyl acetate content of 4%. Special, soluble PVC-acetate copolymers with an average vinyl acetate content of 12%, as well as some dispersion and blending resins with a lower vinyl acetate content, are used for coatings and adhesives.

Other vinyl chloride copolymers are specialty resins of comparatively small commercial volume. Copolymers with vinylidene chloride are used in coating applications because of their enhanced solubility, and as extender resins in plastisols where rapid fusion is required. Copolymers with maleate and fumarate esters are used for special applications in coatings and adhesives. Specialty terpolymers that are used in the form of emulsions are based on vinyl acetate, ethylene, and vinyl chloride.

Post-chlorinated PVC homopolymer resins are also a small-volume specialty. Products made from them have better heat resistance than products made from ordinary PVC resins. The main application is in residential hot water pipe.

Minor amounts of PVC are produced and consumed in latex form (usually containing 50% solids and characterized by small particle size and low viscosity in the uncompounded state); most are homopolymers, but some are copolymers, e.g., with acrylates.

MANUFACTURING PROCESSES

Vinyl Chloride

The bulk of the vinyl chloride produced in the United States is made from ethylene - about half by oxychlorination and half by chlorination. In both processes, ethylene dichloride is first obtained, then cracked to vinyl chloride monomer and hydrogen chloride (HCl). (In the oxychlorination process, HCl is recycled to the oxychlorination reactor).

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 paragraphs.

A. Polymerization Processes*

In all processes, the polymerization is initiated by free radicals (produced by the thermal decomposition of such initiators as peroxides or 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 and type of initiators used. The molecular weight distribution of the final product, which is of key importance to the processing characteristics of the resin, is also influenced substantially by these parameters.

The trend in these batch processes has been toward larger and larger reactors that typically have a capacity in the range of 2,000 to 7,500 gallons, although recently reactors with capacities of 26,000 and even 35,000 gallons have been installed. In the Federal Republic of Germany, the polymerization of vinyl chloride is carried out continuously in tall reaction towers by some producers.

* Comprehensive descriptions and analyses of PVC manufacturing processes are provided by the Process Economics Program, SRI International.

For a useful summary of PVC resin manufacturing processes and related aspects, see "Chemistry and Technology of Polyvinyl Chloride," by Roy T. Gottesman, a paper presented at the symposium of The American Chemical Society, Division of Organic Coatings and Plastics Chemistry, Atlantic City, NJ, September 11, 1974.

The control of vinyl chloride monomer escaping into the atmosphere during its handling in the production of PVC resins and the protection of workers from exposure to vinyl chloride, e.g., during the cleaning of reactors, became an issue of great impact when, in early 1974, cases of angiosarcoma, a rare type of cancer of the liver, were first reported to have occurred among workers exposed to the monomer. Since that time, manufacturing processes have been modified to comply with stringent standards set by various government agencies to ensure uniform controls on vinyl chloride monomer, e.g., its emission, the exposure of workers, and residual content in PVC resins.

1. Suspension Polymerization. The majority of all PVC resins (both homopolymers and copolymers) produced in the United States in recent years have been made 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., hydroxypropyl methylcellulose).

   Generally, suspension polymerization is operated as a batch process employing glass-lined or stainless steel reactors. The reactor is first charged with deionized water; then a protective colloid (0.05-2% of the weight of the monomer), a buffer (e.g., sodium acetate), and an initiator (e.g., lauryl peroxide, azobisisobutyronitrile, or diisopropyl 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 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, polymerization is substantially complete after a period of about 16 hours; with diisopropyl peroxydicarbonate, typical reaction periods are on the order of 8 hours. In the last several years the use of so-called co-initiator systems, which permit better control of the molecular weight distribution and faster reaction rates resulting in higher output, has come into prominence in PVC resin production by the suspension process. Residence times of about six hours are achieved with such systems (e.g., diisopropyl peroxydicarbonate combined with acetyl cyclohexyl sulfonylperoxide).

   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 flash dried in an air stream at about 80°C. The dry polymer is screened, generally through a 40-mesh screen, and shipped in bulk or packed in multiwall paper bags.

   A typical cost breakdown for suspension-polymerized PVC is as follows.

	CENTS PER POUND
Vinyl Chloride Monomer (1.025 pounds per 1.0 pound of resin)	17.6[a]
Conversion and Overhead	4.7
Depreciation	2.7
Distribution	1.5
Corporate Overhead	2.9
Total Cost	29.4

a. At a vinyl chloride monomer cost of 17.2 cents per pound.

SOURCE: CEH estimates.

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2. Emulsion Polymerization. Roughly 10% of the PVC resins produced in the United States in recent years was made by emulsion polymerization; this process is basically similar to the suspension process except that relatively large amounts of emulsifying agents are used, usually in pairs; one of the pair is soluble in the monomer and the other in water. Such systems effectively prevent the coalescence of polymer particles and result in resins of a very small particle size. The initiator systems used are also different from those described for suspension polymerization; typically they are redox-type systems employing persulfates. The drying methods are also designed to maintain a small particle size; spray dryers are frequently used. Because complete removal of emulsifiers is never achieved, articles of high clarity (as needed in packaging film) or of very low water absorption (as needed in wire insulation) cannot be produced from these 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). In the United States, most resins produced by emulsion polymerization are used for plastisols (and are to a minor extent in latex form). In Europe, general-purpose resins (useful for calendering and extrusion) are also produced by variations of the emulsion process.

3. Bulk Polymerization. In this process, used to a small extent in the United States, vinyl chloride is polymerized without the addition of other liquids. A two-stage version of the process, which was developed by Pechiney-Saint-Gobain of France, has been widely licensed. U.S. licensees are Occidental Petroleum Corporation, Hooker Chemical Corporation, subsidiary; The Goodyear Tire & Rubber Company, Chemical Division; The BFGoodrich Company, BFGoodrich Chemical Division; and Certain-Teed Corporation.

   In the two-stage bulk polymerization process, a suitably shaped reactor is provided for the initial liquid phase of the reaction. A differently designed autoclave is used for the second phase to agitate the then-dry powdery mass effectively until the conversion from monomer to polymer reaches a level of about 80%. Heat exchange is provided by the distillation of monomer and its recondensation within the reactor and in external condensers. The rate of output in two-stage bulk polymerization plants is said to be considerably higher than that in typical suspension process plants of comparable size (i.e., with a comparable number and size of reactors).

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

4. Solution Polymerization. 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 specialty copolymers of vinyl chloride with vinyl acetate (usually those containing 10-25% acetate). These solution-polymerized copolymers are very pure and uniform, and their chief value lies in their unique solubility and film-forming characteristics.

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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). Polyester plasticizers (e.g., adipic acid-glycol polyesters) and epoxy plasticizers (e.g., epoxidized soybean oil) are resistant to leaching and are therefore used in biomedical products. (See the CEH Marketing Research Report on Plasticizers for detailed 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) or organotin compounds; about 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. When flexibility and toughness are needed in an end product, vinyl compounds tolerate only relatively light filler loadings.

PVC compounding in general begins with premixing followed by very intense mixing, because uniform distribution (especially of stabilizers) is mandatory for trouble-free processing and uniform product quality. Of the many types of PVC compounds in use, most (plasticized as well as unplasticized) are relatively dry in the premix stage and have a free-flowing, sandy consistency. To achieve intimate mixing, they are subjected to a hot mixing step at fusing temperature, usually in a Banbury mixer. Modern twin-screw extruders perform these steps successively. 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** is used to produce both rigid items (e.g., pipe and conduit, siding, window sash) and flexible items (e.g., electrical wire insulation, garden hose, packaging film).

Extruder trains naturally vary greatly in their particular engineering features and are designed for the production of one particular type of extrusion. Typically, extruders are continuously fed with compound, which is either purchased or prepared in an on-site compounding plant.

Calendering is used for the manufacture of some types of vinyl flooring and for most of the great variety of PVC film and sheeting produced - flexible and rigid. The sheet may be combined with a fabric as it leaves the calender, or this may be done subsequently in a separate laminating step.

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

Modern PVC calenders run widths usually to 72 inches and some as broad as 92 inches. 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).

Dispersions or plastisols are used mostly for fabric coating (either on knife machines, roll coaters, or casting machines) and in the production of coated types of vinyl flooring where plastisol is cast on a felt base. Plastisols are also used in rotational molding, and in dipping and hot-spraying.

Compression molding of PVC resins is restricted to the production of phonograph records, although modified compression molding is used in the production of certain plasticized PVC products, e.g., automobile floor mats.

Injection molding of rigid (as well as plasticized) PVC compounds was developed largely in the 1960s and is mostly employed in the production of pipe fittings. Other uses include the production of parts for automobiles, communications equipment, business machines, and toys.

Blow molding requires special equipment and is used in the production of PVC bottles.

PRODUCING COMPANIES, PLANT LOCATIONS, AND CAPACITIES

Vinyl Chloride

U.S producers of vinyl chloride monomer and the annual capacities of their plants are listed in the following table.

U.S. PRODUCERS OF VINYL CHLORIDE MONOMER

Company and Plant Location	Annual Vinyl Chloride Capacity As of October 1979[a]: Millions of Pounds		Thousands of Metric Tons	
Borden Inc.				
Borden Chemical Division				
Geismar, LA		380		172
Conoco Inc.				
Conoco Chemicals Co. Division				
Lake Charles, LA		700		318
Diamond Shamrock Corporation				
Industrial Chemicals and Plastics Unit				
La Porte, TX		1,000		454
Dow Chemical U.S.A.				
Freeport, TX	150	2,150	68	975
Oyster Creek, TX	750		340	
Plaquemine, LA	1,250		567	

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U.S. PRODUCERS OF VINYL CHLORIDE MONOMER (continued)

Company and Plant Location		Annual Vinyl Chloride Capacity As of October 1979[a] Millions of Pounds		Thousands of Metric Tons
Ethyl Corporation				
Industrial Chemicals Division				
Baton Rouge, LA		300		136
The BFGoodrich Company				
BFGoodrich Chemical Division				
Calvert City, KY		1,000		454
ICI Americas Inc.				
Petrochemicals Division				
Baton Rouge, LA		300		136
Monochem, Inc. (jointly owned by Borden Inc. and Uniroyal, Inc.)				
Geismar, LA[b]		300		136
PPG Industries, Inc.[c]				
Chemical Group				
Chemical Division-U.S.				
Lake Charles, LA		400		181
Shell Chemical Company				
Deer Park, TX	840	1,540	381	699
Norco, LA	700		318	
Stauffer Chemical Company				
Long Beach, CA		175		79
Total		8,245		3,740

a. Actual operating capacities are usually somewhat lower than these nameplate capacities. The new emission standards for vinyl chloride have caused some reduction of these operating capacities according to industry sources.

b. Vinyl chloride production based on acetylene.

c. Company discontinued production of VCM at Guayanilla, Puerto Rico at the end of 1978.

SOURCE: CEH estimates based on trade announcements and communication with industry.

The following companies plan to add vinyl chloride capacity: Dow, 400 million pounds (181 thousand metric tons) at Plaquemine (already in place; start-up date will depend on demand); Georgia-Pacific, one billion pounds (454 thousand metric tons) at Plaquemine (late 1980);

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PPG, 500 million pounds (227 thousand metric tons) at Lake Charles (late 1980); Shell, 800 million pounds (363 thousand metric tons) at Edgard, Louisiana (construction not expected to begin until 1981).

Polyvinyl Chloride Resins

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

U.S. PRODUCERS OF PVC RESINS

Company and Plant Location	Estimated Annual Polyvinyl Chloride Resins Capacity As of October 1979: Millions of Pounds		Thousands of Metric Tons	
Air Products and Chemicals, Inc.				
Plastics Division				
Calvert City, KY	(220)[a]	300[a]	(100)[a]	136[a]
Pensacola, FL	200		91	
Borden Inc.[b]				
Borden Chemical Division				
Illiopolis, IL	340	525	154	238
Leominster, MA	185		84	
Certain-Teed Corporation				
Lake Charles, LA		190		86
Conoco Inc.				
Conoco Chemicals Co. Division				
Aberdeen, MS	335	550[c]	152	250[c]
Oklahoma City, OK	215		98	
Diamond Shamrock Corporation				
Industrial Chemicals and Plastics Unit				
Plastics Division				
Deer Park, TX	470	590	213	268
Delaware City, DE	120		55	
Ethyl Corporation				
Industrial Chemicals Division				
Baton Rouge, LA		180		82
The Firestone Tire & Rubber Company				
Firestone Plastics Company, division				
Baton Rouge, LA[d]	200	700	91	318
Perryville, MD	260		118	
Pottstown, PA	240		109	

(continued)

U.S. PRODUCERS OF PVC RESINS (continued)

Company and Plant Location	Estimated Annual Polyvinyl Chloride Resins Capacity As of October 1979: Millions of Pounds		Thousands of Metric Tons	
The General Tire & Rubber Company				
Chemical/Plastics Division				
GTR Chemical Company				
Ashtabula, OH	125	185	57	84
Point Pleasant, WV	60		27	
Georgia-Pacific Corporation				
Plaquemine, LA		350[e]		159[e]
The BFGoodrich Company				
BFGoodrich Chemical Division				
Avon Lake, OH	300	1,365[f]	136	619[f]
Henry, IL	200		91	
Long Beach, CA	150		68	
Louisville, KY	375		170	
Pedricktown, NJ	150[g]		68[g]	
Plaquemine, LA	190		86	
The Goodyear Tire & Rubber Company				
Chemical Division				
Niagara Falls, NY		70		32
Great American Chemical Corporation				
Fitchburg, MA		75		34
International Materials Corporation				
IMEX Polymers, Inc., subsidiary				
New Bedford, MA		50		23
Keysor Corporation				
Saugus, CA		50		23
Occidental Petroleum Corporation				
Hooker Chemical Corporation, subsidiary				
RUCO, subsidiary				
Burlington, NJ		190		86

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U.S. PRODUCERS OF PVC RESINS (continued)

Company and Plant Location	Estimated Annual Polyvinyl Chloride Resins Capacity As of October, 1979: Millions of Pounds		Thousands of Metric Tons	
Pantasote Inc.				
Eleonora Chemical Division				
Passaic, NJ	55	140	25	64
Point Pleasant, WV	85		39	
Rico Chemicals Corporation				
Guayanilla, Puerto Rico		160		73
Shintech Incorporated (owned by Shin-Etsu Chemical Industry Company Ltd. (Tokyo))				
Freeport, TX		330[h]		150[h]
Stauffer Chemical Company				
Plastics Division				
Delaware City, DE	280	420	127	191
Long Beach, CA	140		64	
Tenneco Inc.				
Tenneco Chemicals, Inc.				
Organic and Polymers Division				
Burlington, NJ	160	720	73	327
Flemington, NJ	80[i]		36[i]	
Pasadena, TX	480[i]		218[i]	
Union Carbide Corporation				
Chemicals and Plastics, division				
South Charleston, WV	50	175	23	80
Texas City, TX	125		57	
Total		7,315[j]		3,318[j,k]

a. The capacity at the Calvert City plant represents designed output; the effective capacity of this plant in most of 1979 is believed to have been in the 100 million pound (45 thousand metric ton) per year range. Company's total PVC capacity during 1979 is estimated to have been about 300 million pounds (136 thousand metric tons) per year, nameplate.

b. Company has announced plans to build a new 240 million pound (109 thousand metric ton) per year PVC plant at Geismar, LA. The first production from the plant is scheduled to come on stream in early 1982.

c. Company plans to expand total PVC capacity of these two plants to 700 million pounds (318 thousand metric tons) per year by late 1981.

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(continued)

d. Came on stream during October 1979.

e. Company is expanding PVC capacity to 700 million pounds (318 thousand metric tons) per year, to be complete by late 1979.

f. Company has announced plans to approximately double its PVC production in North America by year-end 1985. Specific plant expansions or new plant constructions have not been announced.

g. Company plans to expand PVC capacity at this location by 200 million pounds (91 thousand metric tons) per year by late 1981.

h. Company plans to expand capacity to 660 million pounds (299 thousand metric tons) per year by mid-1981.

i. Company has announced plans to expand plant capacity to a total of 750 million pounds (340 thousand metric tons) per year by mid-1981.

j. The capacity distribution for PVC dispersion resins as of mid-1979 was approximately as follows.

	Millions of Pounds per Year	Thousands of Metric Tons per Year
Firestone	170	77
BFGoodrich	160	73
Stauffer	100	45
Diamond Shamrock	80	36
Goodyear	52	24
Tenneco	45	20
Borden	30	14
Ethyl	20	9
Total	657	298

As a result of operating procedures designed to meet EPA requirements, actual effective U.S. dispersion resin capacity was only 70-75% of nameplate, i.e., 460-490 million pounds (209-222 thousand metric tons) per year, for much of 1979.

k. Total does not equal the sum of the categories due to rounding.

SOURCE: CEH estimates based on communication with industry.

Most large resin manufacturers also produce PVC compounds for sale or for feeding their own manufacturing operations of fabricated end-products. For example, Conoco Chemicals has a PVC compound production capacity of 135 million pounds (61 thousand metric tons) per year at Aberdeen, MS. The Plastics Division of Diamond Shamrock has two compound plants with a combined capacity of 175 million pounds (79 thousand metric tons) per year. BFGoodrich Chemical has long operated several large compound facilities. Other large

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producers of compounded resins are Tenneco Chemicals, Inc., Firestone Plastics Company, and the Pantasote Company.

PRODUCTION AND SALES

Vinyl Chloride

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

U.S. PRODUCTION OF VINYL CHLORIDE

	Millions of Pounds	Thousands of Metric Tons
1955	529	240
1956	597	271
1957	627	284
1958	691	313
1959	977	443
1960	1,037	470
1961	1,044	474
1962	1,312	595
1963	1,435	651
1964	1,615	733
1965	2,000	907
1966	2,500	1,134
1967	2,424	1,100
1968	2,969	1,347
1969	3,736	1,695
1970	4,040	1,833
1971	4,336	1,967
1972	5,089	2,308
1973	5,351	2,427
1974	5,621	2,550
1975	4,196	1,903
1976	5,677	2,575
1977	5,986	2,715
1978p	6,955	3,155

See MANUAL OF CURRENT INDICATORS - SUPPLEMENTAL DATA for additional information.

SOURCES: (A) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. International Trade Commission (formerly U.S. Tariff Commission) (data for 1955-1977).

(B) Preliminary Report on U.S. Production of Selected Synthetic Organic Chemicals, SOC Series C/P-79-1, U.S. International Trade Commission (preliminary data for 1978).

Polyvinyl Chloride Resins

The following table presents data on U.S. production of polyvinyl chloride resins as reported by the U.S. International Trade Commission (formerly the U.S. Tariff Commission) and, in recent years, by The Society of the Plastics Industry, Inc.

U.S. PRODUCTION OF PVC RESINS
(millions of pounds)

	Suspension Homopolymers[a]	Suspension Copolymers[b]	Dispersion Resins[c]	Total[d]
1955	—	—	—	527
1956				637
1957				690
1958				657
1959				905
1960				936
1961				977[e]
1962				1,215
1963				1,386
1964				1,637
1965	—	—	—	1,838
1966	1,224	658	282	2,164
1967	1,303	550	289	2,142
1968	1,713	578	344	2,635
1969	2,052	592	388	3,032
1970	2,232	519	364	3,115
1971	2,475	504	458	3,437
1972	3,149	559	550	4,259
1973	3,433	540	589	4,562
1974	3,772	608	471	4,850
1975	2,861	402	385	3,648
1976	3,738	489	489	4,716
1977	4,200	559	494	5,253
1978	4,690	578	456	5,723

(continued)

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U.S. PRODUCTION OF PVC RESINS (continued)
(thousands of metric tons)

	Suspension Homopolymers[a]	Suspension Copolymers[b]	Dispersion Resins[c]	Total[d]
1955	—	—	—	239
1956				289
1957				313
1958				298
1959				411
1960				424
1961				443[e]
1962				551
1963				629
1964				743
1965	—	—	—	834
1966	555	298	128	982
1967	591	249	131	972
1968	777	262	156	1,195
1969	931	269	176	1,375
1970	1,012	235	165	1,413
1971	1,123	229	208	1,559
1972	1,428	254	249	1,932
1973	1,557	245	267	2,069
1974	1,711	276	213	2,200
1975	1,298	182	175	1,655
1976	1,696	222	222	2,139
1977	1,905	254	224	2,383
1978	2,127	262	207	2,596

See MANUAL OF CURRENT INDICATORS - SUPPLEMENTAL DATA for additional information.

a. Included in recent years are an estimated 400-500 million pounds (181-227 thousand metric tons) per year of homopolymers produced by bulk polymerization. Beginning in 1974, blending resins and latexes are included in this category.

b. Included are copolymers produced by solution polymerization.

c. According to the source, latexes and suspension homopolymers used as blending resins are included up to 1973. Not all blending resin produced is believed included due to erroneous reporting.

d. Totals may not equal sums of categories due to rounding.

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e. Includes 678 million pounds (308 thousand metric tons) of PVC homopolymer, 283 million pounds (128 thousand metric tons) of vinyl chloride-acetate copolymer, and 16 million pounds (7 thousand metric tons) of other PVC copolymers.

SOURCES: (A) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission (data for 1955-1971 in the table, and data in footnote e).

(B) Year-end Monthly or Annual Statistical Reports, Plastic and Resin Materials, The Committee on Resin Statistics of The Society of the Plastics Industry, Inc., as compiled by Ernst & Ernst (all other data in the table).

(C) CEH estimates (estimate in footnote a).

Data in the table on pp. 580.1882 M-N indicate that, historically, growth in PVC resin production has been cyclic. The years 1962, 1968, and 1977 were years of peak production, or catch-up years.

Captive PVC resin consumption by producers, e.g., Borden, Diamond Shamrock, Firestone, BFGoodrich, Stauffer, and Tenneco, is estimated to be close to 2 billion pounds per year.

Producers typically manufacture a line of resin grades for various markets. Most producers manufacture general-purpose type suspension resins for the calendering and/or extrusion of plasticized PVC products. There is some specialization in the production of other resin grades. The following table gives a breakdown of estimated 1978 PVC resin production by resin type.

U.S. PRODUCTION OF PVC HOMOPOLYMER
AND COPOLYMER RESINS
BY TYPE OF RESIN AND MAJOR PRODUCERS - 1978

Type of Resin	Millions of Pounds	Thousands of Metric Tons	Major Producers
Pipe Extrusion	2,300	1,043	Conoco Georgia-Pacific[a] Diamond Shamrock BFGoodrich Shintech Tenneco
General-Purpose	1,900	862	BFGoodrich Firestone Diamond Shamrock Borden Tenneco
Dispersion	490	222	Firestone BFGoodrich Stauffer Diamond Shamrock Tenneco Goodyear
Copolymer	430	195	Tenneco Borden Air Products Stauffer
Solution (copolymer)	150	68	Union Carbide
Other	480	218	(various)
Total	5,750	2,608	

a. Increased capacity due on stream by late 1979 or early 1980 will make Georgia-Pacific the largest domestic producer of PVC pipe extrusion resin.

SOURCE: CEH estimates based on communication with industry.

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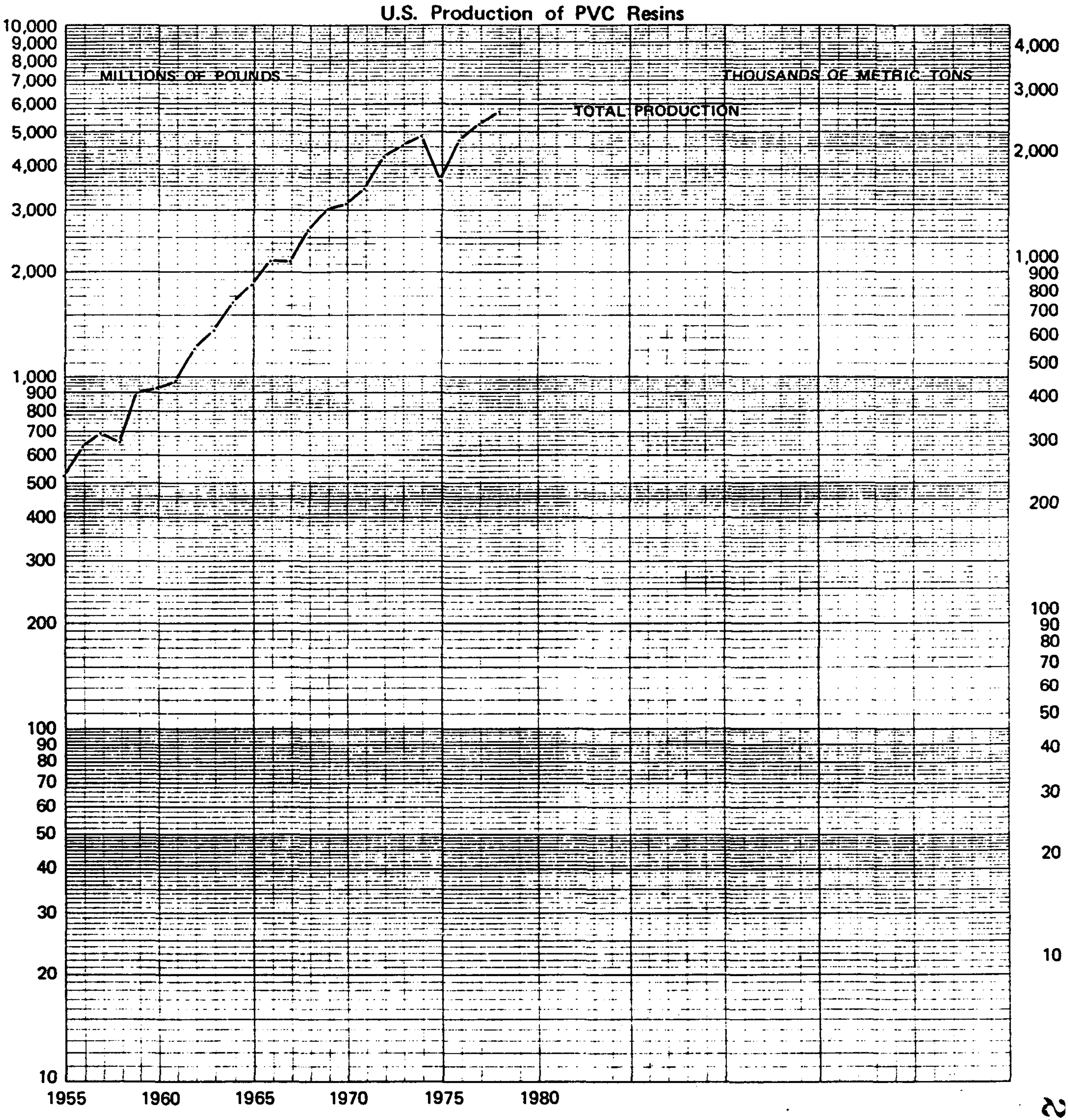

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CONSUMPTION

Vinyl Chloride

Vinyl chloride monomer is used almost entirely for the production of polyvinyl chloride homopolymer and copolymer resins. Industry sources variously apply a factor of 1.025 or 1.03 to pounds of PVC homopolymer resin produced to determine pounds of vinyl chloride monomer consumed. Using a factor of 1.025, the 1978 consumption of VCM breaks down as follows.

	Millions of Pounds	Thousands of Metric Tons
PVC Resins	5,965	2,706
Exports	899	408
Other Uses	100	45
Total	6,964	3,159

SOURCE: CEH estimates.

The 100 million pounds for "Other Uses" represent a rough estimate of VCM used for vinylidene chloride copolymer containing less than 50% vinyl chloride, and other uses as a comonomer.

Polyvinyl Chloride Resins

Total consumption of PVC resins (exports included) in 1978 was 5.8 billion pounds, and it is expected to reach 6.1-6.2 billion pounds in 1979.

All PVC resins are used in the production of plastic products and, to a relatively minor extent, in coatings. These PVC products are produced by a large number of fabricators, either from purchased PVC compounds (most merchant compounds are produced by PVC resin manufacturers in large, automated plants) or from compounds that the fabricators prepare themselves.

In most cases, processing of the PVC compounds to the end products requires specially designed and capital-intensive operations.* This fact, and the very competitive nature of the PVC plastics business in most of its segments, explain the specialization by process of most PVC plastic producers.

Rigid and semirigid (substantially unplasticized) PVC resin consumption is estimated to have totaled 3,050 million pounds (55%) in 1978, versus 2,520 million pounds (45%) for flexible (plasticized) products.

Resin consumption for rigid applications has increased steadily over the last decade, primarily as a result of the continuous rise in PVC pipe production, the predominant rigid

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

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PVC product. Other rigid extrusion has consumed much smaller, although increasing, amounts of PVC. Rigid calendering, the rigid portion of injection molding, compression-molded sound records, blow molding, and solution coatings are the remaining rigid PVC categories.

Flexible (plasticized) PVC consumption is mostly for calendered as well as dispersion coated fabrics, film and sheeting, and for extruded and injection-molded products.

Per capita PVC consumption in some Western European countries, particularly in the Federal Republic of Germany, is considerably greater than in the United States. A major portion of this higher PVC usage is in rigid building products. European PVC consumption in transportation is also proportionately greater than in the United States. Total PVC consumption in Western Europe in 1978 is estimated to have been approximately 3.5 million metric tons (7.7 billion pounds), and Japanese PVC consumption was approximately one-third as large. For additional information on world PVC supply and demand and a breakdown of PVC production capacities by country, see the **INTERNATIONAL** section of this report.

In the following subsections of this report, domestic PVC consumption is first analyzed by conversion process, and then is discussed by major end-use market.

A. PVC Resin Consumption by Process of Conversion

Estimated domestic PVC resin consumption by process of conversion is shown in the following table.

ESTIMATED DOMESTIC CONSUMPTION OF PVC RESINS BY PROCESS OF CONVERSION - 1978

	Millions of Pounds	Thousands of Metric Tons
Rigid Extrusion	2,390	1,084
Flexible Extrusion	850	386
Calendered Film and Sheet (flexible)	805	365
Rigid Calendering	85	39
Dispersion Processes	615	279
Injection Molding	330	150
Compression Molding	210	95
Blow Molding	90	41
Solution Coatings and Latex	195	88
Total	5,570	2,527

SOURCE: CEH estimates.

Resin producers reporting sales cannot always determine the ultimate application of the resin in advance, however. Therefore, published statistics on PVC resin consumption by process of conversion always include the use of resin under such headings as "All Other Uses," although no conversion processes other than those listed in the preceding table exist. Nevertheless, the reported data are listed in the following paragraphs because they are useful for tracing historical trends in PVC resin consumption.

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Published historical data on PVC resin consumption by major process of conversion are given below.

DOMESTIC CONSUMPTION OF PVC RESINS BY PROCESS
(millions of pounds)

	Extrusion	Calendering	Dispersions[a]	Molding[a]	Solutions[b]	All Other Uses	Total[c]
1960	230	392	89	70	39	83	903
1961	238	424	100	72	36	95	965
1962	272	490	105	78	45	121	1,111
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	1,295	835	415	309	90	281	3,225
1972	2,052	963	457[d]	410[e]	118	180	4,181
1973	2,298	913	497[d]	511[e]	142	224	4,586
1974	2,214	809	504[d]	454[e]	150	283	4,414
1975	1,777	591	411[d]	334[e]	123	216	3,452
1976	2,380	700	453[d]	416[e]	171	247	4,366
1977	2,883	664	474[d]	468[e]	177	327	4,993
1978	3,254	667	491[d]	535[e]	209	411	5,567

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DOMESTIC CONSUMPTION OF PVC RESINS BY PROCESS (continued)
(thousands of metric tons)

	Extrusion	Calendering	Dispersions[a]	Molding[a]	Solutions[b]	All Other Uses	Total[c]
1960	104	178	40	32	18	38	410
1961	108	192	45	33	16	43	438
1962	123	222	48	35	20	55	504
1963	144	254	65	44	—	93	600
1964	181	296	81	45	—	113	715
1965	219	311	92	55	—	134	811
1966	260	334	130	81	24	103	934
1967	270	299	105	80	33	138	926
1968	335	295	123	91	38	223	1,105
1969	454	360	127	112	38	159	1,249
1970	497	320	127	115	39	171	1,268
1971	587	379	188	140	41	127	1,463
1972	930	437	207[d]	186[e]	54	82	1,896
1973	1,042	414	225[d]	232[e]	64	102	2,080
1974	1,004	367	229[d]	206[e]	68	128	2,002
1975	806	268	186[d]	152[e]	56	98	1,566
1976	1,080	318	205[d]	189[e]	78	112	1,980
1977	1,308	301	215[d]	212[e]	80	148	2,265
1978	1,476	303	223[d]	243[e]	95	186	2,525

See MANUAL OF CURRENT INDICATORS - SUPPLEMENTAL DATA for additional information.

a. Terminology used by the U.S. International Trade Commission for these categories and their subcategories has been inconsistent over the years. Reported data were regrouped to permit this comparative organization.

b. Reported as "Protective Coatings" and "Adhesives and All Other Coating Uses." Believed to include mostly resins for solutions but also some for dispersion coatings and powder coatings.

c. Totals may not equal the sums of the categories due to rounding.

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

e. Components: Bottles (blow molding), Sound Records (compression molding), Fittings (for rigid pipe and tubing), and All Other Molding.

SOURCES: (A) CEH estimates (components of some data for 1960, 1961, and 1962 as detailed in subsequent tables).

(B) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission (data for 1960 through 1971).

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(C) Year-End Monthly or Annual Statistical Reports, Plastic and Resin Materials, The Committee on Resin Statistics of The Society of the Plastics Industry, Inc., as compiled by Ernst & Ernst (data for 1972-1978).

Further breakdowns of these major process categories are given in the following paragraphs.

1. Extrusion. Domestic PVC resin consumption in extrusion is shown in the following table.

U.S. CONSUMPTION OF PVC RESINS IN EXTRUSION
(millions of pounds)

	Rigid Pipe and Tubing	Wire and Cable	Film and Sheet	All Other[a]	Total[b]	Total as a Percent of All PVC Consumption
1960	—	—	—	—	230	26%
1961		—	—	—	238	25
1962		170	102		272	24
1963		184	133		317	24
1964		195	204		399	25
1965		217	266		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
1971	497	343	179	276	1,295	40
1972	1,008	439	220	384	2,052	49
1973	1,255	414	204	425	2,298	50
1974	1,245	348	220	401	2,214	50
1975	1,016	273	175	312	1,777	52
1976	1,418	330	254	378	2,380	55
1977	1,818	384	238	442	2,883	58
1978	2,099	400	255	500	3,254	58

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U.S. CONSUMPTION OF PVC RESINS IN EXTRUSION (continued)
(thousands of metric tons)

	Rigid Pipe and Tubing	Wire and Cable	Film and Sheet	All Other[a]	Total[b]	Total as a Percent of All PVC Consumption
1960	—	—	—	—	104	26%
1961		—	—	—	108	25
1962		77	46		123	24
1963		83	60		144	24
1964		88	93		181	25
1965		98	121		219	27
1966		103	30	128	260	28
1967		89	47	135	270	29
1968		131	61	143	335	30
1969		171	73	210	454	36
1970	—	186	88	223	497	36
1971	225	156	81	125	587	40
1972	457	199	100	174	930	49
1973	569	188	93	193	1,042	50
1974	565	158	100	182	1,004	50
1975	461	124	79	142	806	52
1976	643	150	115	171	1,080	55
1977	825	174	108	200	1,308	58
1978	952	181	116	227	1,476	58

a. Includes all PVC resins consumed for pipe, conduit, tubing, and rod from 1966 to 1970, and all other rigid, semirigid, and flexible profile extrusions in all years.

b. Totals may not equal the sums of the categories due to rounding.

SOURCES: (A) CEH estimates (data for 1960 and 1961).

(B) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission (data for 1962-1971).

(C) Year-End Monthly or Annual Statistical Reports, Plastic and Resin Materials, The Committee on Resin Statistics of The Society of the Plastics Industry, Inc., as compiled by Ernst & Ernst (data for 1972-1978).

The data show that the principal factor that drove PVC resin consumption in extrusion to current levels was pipe extrusion.

a. Rigid Extrusions. The PVC resins most commonly used in rigid extrusions are suspension homopolymers of high bulk density, compounded in the form of so-called powder blends. (Postchlorinated homopolymers are also used in relatively small quantities). The resins and additives are blended to balance the required physical properties of the end product with ease and speed of processing. Aside from heat stabilizers, light stabilizers (for such products as siding), lubricants, and relatively small amounts of pigments,* impact modifiers (special acrylic and ABS polymers) are important. The bulk of PVC resin consumption in rigid extrusion is for pipe.

Leading suppliers of PVC resins for pipe extrusion are listed in the table on p. 580.1882 Q. Most of these suppliers also offer powder blend compounds for pipe production.

Extruded rigid PVC film and sheet** (using an estimated 35 million pounds of resin in 1978) were mostly for packaging (shrink and blister), for signs and display uses, and stationery supplies. Other rigid extrusions (using about 200 million pounds of resin in 1978) include mostly siding and window hardware. More information about each of these markets can be found in the appropriate end-use sections of this report.

b. Flexible Extrusions. Approximately one-half of an estimated 850 million pounds of PVC resins consumed in flexible extrusions in 1978 (almost all general-purpose homopolymer resins) was used for wire and cable insulation (420 million pounds). The largest single product after wire and cable is clear film for meat packaging and stretch film (using about 240 million pounds of resin in 1978); other flexible extrusions include biomedical products, garden hose and other tubing, gaskets, some products used in construction, e.g., cove base, and a variety of specialty products that consume comparatively small amounts of resin. (See the **Consumption By End Use** section of this report for more information.)

* See the CEH Marketing Research Report on TITANIUM DIOXIDE PIGMENTS for the consumption of that major pigment in rigid PVC extrusions.

** The term "film" is usually used for thicknesses under 6 mils (0.006 inch), whereas the term "sheet" applies to thicknesses greater than 6 mils. 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.

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U.S. CONSUMPTION OF PVC RESINS
IN CALENDERING (continued)
(thousands of metric tons)

	Film and Sheeting[a]	Flooring	Textile[b]	Total[c]	Total as a Percent of All PVC Consumption
1960	105	55[d]	18	178	43%
1961	108	66[d]	19	192	44
1962	111	84	27	222	44
1963	129	93	32	254	42
1964	149	111	36	296	41
1965	152	119	41	311	39
1966	163[e]	135	36	334	36
1967	145[e]	120	34	299	32
1968	146[e]	111	39	295	27
1969	196[e]	122	41	360	29
1970	173[e]	112	34	320	25
1971	215	124	39	379	26
1972	252	151	34	437	23
1973	249	132	33	414	20
1974	244	84	39	367	18
1975	171	67	29	268	17
1976	201	75	41	318	16
1977	155	78	69	301	13
1978	167	69	66	302	12

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

b. 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.

c. Totals may not equal the sums of the categories due to rounding.

d. Data for 1960 and 1961 are estimates of the calendered portion of the total reported consumption for flooring, which was 156 million pounds (71 thousand metric tons) in 1960 and 185 million pounds (84 thousand metric tons) in 1961.

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

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2. Calendering. Domestic PVC resin consumption in calendering is given in the following table.

U.S. CONSUMPTION OF PVC RESINS IN CALENDERING
(millions of pounds)

	Film and Sheeting[a]	Flooring	Textile[b]	Total[c]	Total as a Percent of All PVC Consumption
1960	231	121[d]	40	392	43%
1961	237	145[d]	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[e]	297	80	736	36
1967	320[e]	265	75	660	32
1968	321[e]	244	85	650	27
1969	433[e]	270	90	793	29
1970	382[e]	247	76	705	25
1971	474	274	87	835	26
1972	556	333	74	963	23
1973	548	292	73	913	20
1974	537	186	86	809	18
1975	378	148	65	591	17
1976	444	165	91	700	16
1977	341	171	152	664	13
1978	367	153	146	667	12

(continued)

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SOURCES: (A) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission (FILM AND SHEETING data for 1960-1965 and 1971, FLOORING data for 1962-1971, TEXTILE datum for 1971, TOTAL data for 1960-1971, and data in footnote d).

(B) Year-End Monthly or Annual Statistical Reports, Plastic and Resin Materials, The Committee on Resin Statistics of The Society of the Plastics Industry, Inc., as compiled by Ernst & Ernst (data for 1972-1978).

(C) CEH estimates (all other data in the table).

Most PVC calendering (using an estimated total of 890 million pounds of resin in 1978) involves flexible film and sheeting of a great variety but substantially all based on general-purpose homopolymers. The use of general-purpose copolymers (with relatively high molecular weight and low vinyl acetate content) has declined since less expensive homopolymers with comparable ease of processing have been available for a number of years.

Flexible calendered film and sheeting is used in many applications; the major markets are seating for furniture and for motor vehicles; in this use, the film is combined with a backing textile, either directly at the calender or in a separate laminating step. Most of the flexible calendered film and sheeting produced is combined with textiles to produce vinyl coated fabrics; the rest is used as so-called unsupported film and sheeting. PVC coated fabrics and film and sheeting are used in many other markets, mostly for home furnishings and consumer goods.

Production of calendered film, sheet, and coated fabrics recovered in 1978 after a decline in 1977 when a flood of imported calendered goods from the Far East appeared on the U.S. market (for such uses as outerwear, footwear, handbags, inflatable toys, and other consumer goods).

PVC resin consumption in calendered flooring in 1978 was about 170 million pounds. Of this amount, an estimated 70 million pounds were for vinyl-asbestos floor tile, and the balance was for plasticized roll goods.

Rigid calendering consumed an estimated 90 million pounds of specialty resins, some of them copolymers. The principal end uses for calendered rigid PVC sheet are in packaging.

There are probably about 130 PVC calenders in operation in the United States, most of them producing flexible film and sheeting, and flooring. The largest calender operators for general PVC film and sheet production include the following companies (listed in order of estimated production capacity and output).

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The General Tire & Rubber Company
Kalex Chemical Products, Inc.
Uniroyal, Inc.
Tenneco Chemicals, Inc.
Borden Inc.
Stauffer Chemical Company
The Goodyear Tire & Rubber Company
Diamond Shamrock Corporation
The Pantasote Company of New York, Inc.
Ford Motor Company
Chrysler Corporation
Intex Corporation
Atlantic Tubing & Rubber Company
Plymouth Rubber Company
Firestone Plastics Company
Hooker Chemical Corporation

These companies account for about 100 calenders. General Tire is by far the largest, with at least 16 calenders.

On the order of ten calenders are believed to be used for rigid products. Major producers of calendered rigid sheet include American Hoechst, Tenneco, Reneer (Division of Goodyear), Firestone, Pantasote, and Plicoflex.

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3. Dispersion. Dispersions of PVC resins in plasticizer are fluid compounds called plastisols. (In a solvent-modified version, used infrequently, they are called organosols.) Dispersion resin consumption in the reported use categories is presented in the following table.

U.S. CONSUMPTION OF PVC DISPERSION RESINS[a]
(millions of pounds)

	Plastisol Formulating and Molding	Textile and Paper Coating	Flooring	Total[b]	Total as a Percent of All PVC Consumption
1960	30	24	35	89	10%
1961	30	30	40	100	10
1962	28[c]	30	47	105	9
1963	34[c]	58	52	144	11
1964	39[c]	76	63	178	11
1965	43[c]	91	69	203	11
1966	92	133[d]	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	156[e]	142	117	415	13
1972	150[e]	173	134	457	11
1973	155[e]	191	150	497	11
1974	157[e]	200	147	504	11
1975	117[e]	162	132	411	12
1976	147[e]	150	155	453	10
1977	164[e]	153	158	474	10
1978	169[e]	141	181	491	9

(continued)

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U.S. CONSUMPTION OF PVC DISPERSION RESINS[a] (continued)
(thousands of metric tons)

	Plastisol Formulating and Molding	Textile and Paper Coating	Flooring	Total[b]	Total as a Percent of All PVC Consumption
1960	14	11	16	40	10%
1961	14	14	18	45	10
1962	13[c]	14	21	48	9
1963	15[c]	26	24	65	11
1964	18[c]	34	29	81	11
1965	20[c]	41	31	92	11
1966	42	60[d]	28	130	14
1967	35	46	26	123	11
1968	49	49	26	123	11
1969	51	46	30	127	10
1970	51	42	34	127	10
1971	71[e]	64	53	188	13
1972	68[e]	78	61	207	11
1973	70[e]	87	68	225	11
1974	71[e]	91	67	228	11
1975	53[e]	73	60	186	12
1976	67[e]	68	70	205	10
1977	74[e]	69	72	215	10
1978	77[e]	64	82	223	9

a. Includes predominantly the PVC dispersion resin content of plastisols, and also that of organosols (solvent-modified plastisols). To obtain estimates for the total PVC resin consumption in dispersions that include the use of blending resins, a factor of 1.15 should be applied. Latexes have not been included since 1974. An estimated 70 million pounds (32 thousand metric tons) of latexes, resin content, were consumed annually in recent years.

b. Totals may not equal the sums of the categories due to rounding.

c. Reported as used in slush molding (rotational molding or rotocasting).

d. Includes 117 million pounds (53 thousand metric tons) of PVC resins reported for "Coating" and 16 million pounds (7 thousand metric tons) for unspecified "Other" textile and paper applications.

e. Includes resins reported as used in "Plastisol Formulation," and those reported as used in "All Other Paste Processes."

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SOURCES: (A) CEH estimates (all data for 1960 and 1961; TEXTILE AND PAPER COATING data for 1962-1965).

(B) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission (FLOORING and PLASTISOL FORMULATING AND MOLDING data for 1962-1971; TEXTILE AND PAPER COATING data for 1966-1971).

(C) Year-End Monthly or Annual Statistical Reports, Plastic and Resin Materials, The Committee on Resin Statistics of The Society of the Plastics Industry, Inc., as compiled by Ernst & Ernst (all data for 1972-1978).

An additional amount of so-called blending resin is consumed in these dispersions; typically, 80 parts of dispersion resin are blended with 20 parts of the (less expensive) blending resin. However, blending resins are not used in all applications of dispersion resins. Overall, a factor of 1.15 applied to dispersion resin consumption provides a useful approximation for the total resin consumption that includes blending resins.

A large part of the growth of dispersion resin consumption in the 1970s is attributable to the commercial success of coated types of vinyl flooring. (Major producers are listed on p. 580.1883 P).

Also, the production of plastisol-coated fabrics* for use in automobiles, furniture, garments, luggage, wall coverings, and a multitude of other items 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.

Processes include knife coating, reverse roll coating, casting (used for coated fabrics), rotational or slush molding (to make hollow objects such as beach balls), dipping (for gloves and tool handles), and hot spraying (thick protective coatings on metal objects such as tool housings).

Casting ovens came into widespread use in the 1960s. Typically, a PVC dispersion is cast on release paper that may be embossed; it is fused, separated from the substrate, and in most cases, combined with a textile. Sometimes chemical blowing agents are employed to produce a cellular structure.

Major producers of dispersion-coated fabrics include Borden Inc., The General Tire & Rubber Company, Pervel Industries (division of Bemis Company, Inc.), the Bandel-Bradford Company, and Uniroyal, Inc.

Most PVC dispersion resins are homopolymers, but some copolymers are used (most are prepared by the emulsion process). Blending resins (used in conjunction with dispersion resins to lower the cost and to adjust flow properties) are also mostly homopolymers, but they are produced by the suspension process.

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* Nonwoven webs, papers, and saturated felts are used as a substrate for specialty products.

In 1978, approximately 530 million pounds of dispersion resins are estimated to have been used in conjunction with about 85 million pounds of blending resins. In addition, a major portion of an estimated 70 million pounds of PVC latexes (resin content) consumed were used in conjunction with dispersion coating operations. This total consumption can be broken down as follows.

CONSUMPTION OF PVC IN DISPERSIONS AND LATEX - 1978

Application	Millions of Pounds, PVC Resin	Thousands of Metric Tons, PVC Resin
Coated Fabrics	220	100
Coated Flooring	210	95
Molding, Dipping, and Other	160	73
Carpet Backing, Synthetic Turf Backing, Gymnasium Floors	25	11
Closures	30	14
Protective Coatings	25	11
Total	670	304

SOURCE: CEH estimates.

A major portion of the resin used for molding, dipping, for protective coatings, and smaller portions of some of the other categories went through formulator/compounders.

Included in the coated fabrics category is the use of plastisols as tie-coats for laminating film to fabrics or other substrates; also included are nonwoven fabrics, in which some latex may be involved. Some of this consumption may be reported by the SPI under "Adhesives and All Other Coating Uses." (See p. 580.1883 T of this report).

Molding is mostly rotational molding and slush molding of hollow articles that include toys and novelties, recreational articles (such as beach balls, bicycle saddles, basketballs), a few automotive interior trim items (some headrests, armrests, and crash pad skins), and other specialty products.

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

U.S. CONSUMPTION OF PVC RESINS IN MOLDING
(millions of pounds)

	Sound Records (compression molding)	Injection and Other Molding[a]	Blow Molding	Total[b]	Total as a Percent of All PVC Consumption
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[c]	254	9
1971	138	135	36[c]	309	10
1972	148	185	77	410	10
1973	144	280	87	511	11
1974	153	227	74	454	11
1975	129	145	60	334	10
1976	150	187	78	416	10
1977	175	219	75	468	9
1978	211	230	94	535	10

(continued)

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U.S. CONSUMPTION OF PVC RESINS IN MOLDING (continued)
(thousands of metric tons)

	Sound Records (compression molding)	Injection and Other Molding[a]	Blow Molding	Total[b]	Total as a Percent of All PVC Consumption
1960	26	5	0	32	8%
1961	26	6	0	33	7
1962	28	8	0	35	7
1963	35	9	0	44	7
1964	34	11	0	45	6
1965	41	12	2	55	7
1966	52	23	7	81	9
1967	48	24	9	80	9
1968	55	25	10	91	8
1969	63	29	21	112	9
1970	64	30	21[c]	115	9
1971	63	61	16[c]	140	10
1972	67	84	35	186	10
1973	65	127	39	232	11
1974	69	103	34	206	11
1975	59	66	27	152	10
1976	68	85	35	189	10
1977	79	99	34	212	9
1978	96	104	43	243	10

a. Includes injection-molded fittings for rigid pipe and tubing, reported to have consumed 117 million pounds (53 thousand metric tons) of resin in 1978, and "All Other Moldings," 113 million pounds (51 thousand metric tons) in 1978.

b. Totals may not equal the sums of the categories due to rounding.

c. 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 (32 thousand metric tons) in both years.

SOURCES: (A) CEH estimates (all data for 1960 and 1961; data for INJECTION AND OTHER MOLDING, 1962-1970; data for BLOW MOLDING, 1965-1970; and estimate in footnote c).

(B) Synthetic Organic Chemicals, U.S. Production and Sales, U.S Tariff Commission (all other data for 1962-1971).

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(C) Year-End Monthly or Annual Statistical Reports, Plastic and Resin Materials, The Committee on Resin Statistics of The Society of the Plastics Industry, Inc., as compiled by Ernst & Ernst (data for 1972-1978 and data in footnote a).

a. Compression Molding. The principal component is the reported consumption of resins for phonograph records, which require special acetate copolymer resins. This resin consumption for phonograph records has always been a separate reporting category, but other compression molding is believed reported together with other consumption under "All Other Molding." Strictly speaking, there is no compression molding of PVC other than sound records, but there is resin consumption for some press-molded articles that are plasticized. Although very low pressure is involved in the molding of, for example, automobile vinyl floor mats, or kitchen drainboards (in most cases the compound is injected into the mold), some of this production can be called compression molding.

b. Injection Molding. The principal component is consumption for pipe fittings. Injection molding of PVC resin for rigid and plasticized products other than pipe fittings is estimated to have consumed 210 million pounds of resin in 1978. Typical products (in addition to those mentioned under Compression Molding) include electrical outlet boxes (rigid), electrical outlet plugs, filler strips and other parts for automobile bumpers, automobile rearview mirror housings, window winder knobs, bicycle grips, toys, shoe soles and heels (unit soles), and a variety of parts for business machines and electrical and electronic uses.

Typically, injection molders buy pelletized compound. PVC compounds for injection molding are made and sold by such companies as BFGoodrich, Schulman Manufacturing, and Firestone Plastics.

c. Blow Molding. This sophisticated technology was developed in the 1960s and is used for the production of containers. The bulk of the polymer used is high-density polyethylene; PVC consumption is relatively small and is mostly for bottles of chemicals and pharmaceuticals.

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5. Coatings and Adhesives. Data on PVC resin consumption in coatings and adhesives in recent years are given in the following table.

U.S. CONSUMPTION OF PVC RESINS
IN COATINGS AND ADHESIVES[a]

	Millions of Pounds	Thousands of Metric Tons	Total as a Percent of All PVC Consumption
1960	39	18	4%
1961	36	16	4
1962	45	20	4
1963	50	23	4
1964	50	23	3
1965	50	23	3
1966	54	24	3
1967	72	33	4
1968	83	38	3
1969	84	38	3
1970	85	39	3
1971	90	41	3
1972	118	54	3
1973	142	64	3
1974	150	68	3
1975	123	56	4
1976	171	78	4
1977	177	80	4
1978	209	95	4

a. Reported by the sources as "Protective Coatings and Adhesives" in 1960-1962 and 1966-1971 and as "Protective Coatings" (123 million pounds (58 thousand metric tons) in 1978) and "Adhesives and All Other Coating Uses" (86 million pounds (39 thousand metric tons) in 1978) since 1972.

SOURCES: (A) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission (data for 1960-1962 and 1966-1971).

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

(C) Year-End Monthly or Annual Statistical Reports, Plastic and Resin Materials, The Committee on Resin Statistics of The Society of the Plastics Industry, Inc., as compiled by Ernst & Ernst (data for 1972-1978).

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This consumption has been reported as "Protective Coatings and Adhesives" and recently was in a category called "Adhesives and All Other Coating Uses." A major portion of this consumption has been in applications in which the resin is dissolved (about 90 million pounds in 1978); dispersion resins, powder coating resins, and latex probably account for most of the balance.

Solution-grade resins are produced mostly by solution polymerization (Union Carbide), and most are vinyl chloride-vinyl acetate copolymers with vinyl acetate content of 8-12%. One type often used in adhesives is modified to contain a certain amount of free carboxyl groups, and another type frequently used in protective coatings contains free hydroxyl groups. Other acetate copolymers are used, often in admixture with acrylic resins, for rotogravure printing inks and topcoatings on vinyl film and sheeting. Can coatings and other packaging applications are also important markets.

Adhesives based on or containing PVC copolymer resins are used in a variety of specialized industrial applications. 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 aromatic hydrocarbon diluents. (For more information on the use of PVC resins in coatings, see the CEH Marketing Research Report on VINYL SURFACE COATINGS).

Resin consumption for PVC powder coatings does not amount to more than 5 million pounds per year.

6. All Other Uses. This category accounts mostly for resins sold to distributors and to compounders with an end use undetermined when the resin is sold. The category serves largely to balance statistics (i.e., the bulk reported under this heading actually belongs in the individual process category previously discussed). The following table presents the reported data with pertinent commentary in the footnotes.

U.S. CONSUMPTION OF PVC RESINS
IN ALL OTHER USES

	Millions of Pounds	Thousands of Metric Tons
1960	83[a]	38[a]
1961	95[a]	43[a]
1962	121[b]	55[b]
1963	206[c]	93[c]
1964	249[c]	113[c]
1965	295[c]	134[c]
1966	228	103
1967	305	138
1968	491	223
1969	350	159
1970	376	171
1971	281	127
1972	180	82
1973	224	102
1974	283	128
1975	216	98
1976	247	112
1977	327	148
1978	411[d]	186[d]

a. The actual figures reported for 1960 and 1961 were 113 million pounds (51 thousand metric tons) and 125 million pounds (57 thousand metric tons), respectively. An estimated 30 million pounds (14 thousand metric tons) of resins used in commercial plastisols were subtracted in each year and added to the table on U.S. consumption of PVC dispersion resins (pp. 580.1883 C-D).

b. The 161 million pounds (73 thousand metric tons) reported by the source include an estimated 40 million pounds (18 thousand metric tons) of exports (included in the U.S. TRADE section of this report).

c. Believed to include about 50 million pounds (23 thousand metric tons) per year used in protective coatings and adhesives in 1963, 1964, and 1965).

d. Consists of 89 million pounds (40 thousand metric tons) reported under "Resellers" and 322 million pounds (146 thousand metric tons) reported as "All Other Uses."

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SOURCES: (A) CEH estimates (data for 1960-1962 and estimates in the footnotes).

(B) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission (data for 1963-1971).

(C) Year-End Monthly or Annual Statistical Reports, Plastic and Resin Materials, The Committee on Resin Statistics of The Society of the Plastics Industry, Inc., as compiled by Ernst & Ernst (data for 1972-1978).

PVC resin consumption in some specialty uses may not have been covered by the main process categories.

B. Consumption by End Use

A breakdown of domestic PVC resin consumption by major market category is given in the following table.

ESTIMATED DOMESTIC CONSUMPTION OF PVC RESINS - 1978

	Millions of Pounds	Thousands of Metric Tons
Construction	3,000	1,361
Consumer Goods	710	322
Electrical Uses	510	231
Packaging	460	209
Transportation	280	127
Home Furnishings	220	100
Miscellaneous Uses	390	177
Total	5,570	2,527

SOURCE: CEH estimates.

The individual categories are discussed in the following paragraphs.

1. Construction. Estimated PVC resin consumption in construction is listed below.

ESTIMATED CONSUMPTION OF PVC IN CONSTRUCTION - 1978

	Millions of Pounds	Thousands of Metric Tons
Pipe and Conduit	2,160	980
Pipe Fittings	120	54
Siding, Window Hardware, and Other Rigid Profiles	200	91
Flooring	375	170
Wall Coverings and Paneling	80	36
Pool and Pond Lining	30	14
Other	35	16
Total	3,000	1,361

SOURCE: CEH estimates.

a. Pipe, Conduit, and Pipe Fittings. The data in the preceding table indicate that 39% of the total PVC resin consumption is for pipe, conduit, and pipe fittings. The data represent PVC resin shipped to pipe producers, not actual pipe shipped or installed.

Massive federal funding of rural water projects and HUD support of plastic pipe use in the early 1970s were principal factors in the phenomenal growth of PVC pipe markets in the last decade.

It is estimated that PVC has 70-80% of the current total plastic pipe and conduit business on a poundage basis. A breakdown of the PVC pipe and conduit market is as follows.

ESTIMATED PVC CONSUMPTION IN PIPE AND CONDUIT - 1978

	Millions of Pounds	Thousands of Metric Tons
Water-Supply Pipe	740	336
Sewer and Drain Pipe	350	159
Electrical and Telephone Conduit	310	141
Drain, Waste, and Vent Pipe	250	113
Agricultural and Turf Irrigation	200	91
Other Pipe	120	54
Total	1,970	894

SOURCE: CEH estimates.

These data represent the PVC content of (salable) pipe shipped. The PVC resin content of pipe and conduit varies from about 80% for some types of conduit to 95% or more for most pressure pipe, overall, the resin content can be considered to be about 90% by weight.

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The penetration of pipe markets by plastic pipe (on the basis of economics and performance properties) varies greatly. For water-supply pipe the penetration is estimated to be less than 50% overall, and considerable growth potential for PVC is seen in the municipal water pipe market. However, the fastest growing segment for PVC pipe in the last three years has been sewer pipe, which is expected to lead future demand growth for PVC pipe. Resin consumption for conduit (which includes conduit for power cables and electrical wiring, and for communication wiring) also has increased markedly in the last few years.

The drain, waste, and vent (DWV) segment, which PVC shares with ABS at a roughly 50:50 ratio, is more than 50% penetrated and has shown relatively little demand increase for PVC in the recent past. Similarly, at least 50% of the agricultural and turf irrigation pipe is believed to be plastic (with PVC the predominant plastic pipe used).

Other pipe markets of commercial significance include natural gas distribution pipe (predominantly polyethylene), with an estimated penetration by plastic of 40-50%, water distribution (inside the house, with minimal penetration by plastic), oil production pipe, and chemical process pipe (for which plastics are heavily used).

The leading multiplant producers of PVC pipe and conduit include the following companies (listed by estimated pipe extrusion capacity and output).

Robintech Incorporated
Johns-Manville Corporation
Certain-Teed Corporation
Indian Head, Inc., Carlon Division
Harsco Corporation, Cantex Division

Robintech is believed to process 300-400 million pounds of PVC pipe resin annually. Other smaller extruders of PVC pipe include Gifford-Hill & Company, Inc., Western Plastics Corporation (Tacoma), Celanese Piping Systems Division of Celanese Corporation, and Clow Corporation. There is also a large number of smaller single-plant producers.* R. & G. Sloane Manufacturing Company, Inc., is the leading producer of fittings for PVC pipe and conduit.

b. Siding, Window Hardware, and Other Rigid Profiles. The major portion of this consumption, an estimated 150 million pounds in 1978, is for siding. PVC siding is now cost-competitive with aluminum siding. That, as well as quality improvements, have resulted in strong demand for PVC siding in 1978 and 1979. Distributors of aluminum siding now typically carry a complete line of PVC siding as well; Alcoa has become a producer of PVC siding (major producers of PVC siding are Bird & Son, Inc., Certain-Teed Corporation, and Mastic Corporation). In the past, most PVC siding was sold in the replacement (remodeling) market and for mobile homes, but recently its use in new residential construction has become more widespread.

An estimated 45 million pounds of PVC were used for windows and window hardware in 1978.

PVC consumption in window frames is still mostly for vinyl-clad wood; vinyl is extruded directly over a wood core of the sash, while corner joints are given a welded

* Listings of all producers of approved PVC and other pipe are in the directory of the National Sanitation Foundation Testing Laboratory, Inc., Ann Arbor, Michigan.

seal after assembly. In another method, rigid PVC extrusions are attached to wooden frames with adhesives. All-vinyl windows are still at the infancy stage.

Rigid profiles other than window frames are spline for storm windows and doors, rigid weather stripping, and molding. Some gutter and rigid profile sheet are also included in this market segment, as are shutters thermoformed from extruded sheet.

c. Flooring. Coated PVC flooring (typically with a saturated felt base and intermediate layers that are sometimes cellular in structure) is still the leading product category and is estimated to have consumed 210 million pounds of dispersion and blending resins in 1978. Calendered vinyl flooring has been holding its position (these products are typically calendered with copolymer resins that are highly filled); the 1978 resin use is estimated at about 170 million pounds.

Leading producers of vinyl flooring include the following companies.

Armstrong Cork Company
Congoleum Industries Inc.
GAF Corporation
Kentile Floors Inc.
Mannington Mills Inc.
National Floor Products Company, Inc.
Vinyl Plastics Inc.

In contrast to the declining vinyl flooring market of the 1960s, the industry has been characterized by growth since that time as a result of attractive new products. The large replacement market is believed to be growing more than the new construction market as the remolding of older homes gains importance in the face of soaring building costs.

d. Other Uses in Building and Construction. PVC wall coverings (actually a consumer product in the sense that they are in the replacement market as much as in new construction) are mostly coated fabrics (predominantly sheetings and sateens) with film thickness of 5-20 mils; some constructions use nonwoven webs as a substrate. An estimated 55 million pounds of PVC were used for these products in 1978. About two-thirds are calendered, the balance dispersion coated. In addition, there is paneling, consisting of particle board or gypsum board to which a rigid or flexible vinyl film (typically painted with a wood-grain pattern) is laminated. In 1978, an estimated 25 million pounds of PVC went into these products, which are not all used for wall paneling but are also used for furniture and other case goods such as speaker cabinets and for the interiors of recreational vehicles.

Also included in this category is PVC sheet for swimming pool liners and for the lining of water settling ponds and reservoirs. Other inclusions are resins used for some extruded products such as cove base and for some rigid PVC products used in industrial ducting and fan impellers and housings.

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2. Consumer Goods. This large market is highly diversified. An attempted breakdown is given in the table below.

ESTIMATED CONSUMPTION OF PVC RESIN IN CONSUMER GOODS - 1978

	Millions of Pounds	Thousands of Metric Tons
Sound Records	210	95
Footwear, Handbags, Purses, and Similar Articles; Bookbinding; Toys and Recreational Articles; Kitchenware and Appliances; Consumer Electronics; Luggage; Garden Hose	400	181
Other (e.g., beauty supplies, novelties, stationery articles, window shades, waterbeds, tool handles, bicycle grips, wigs, plastic Christmas trees)	100	45
Total	710	322[a]

a. Total does not equal sum of categories due to rounding.

SOURCES: CEH estimates.

The largest single segment, sound records, requires special polyvinyl chloride-acetate copolymers for compression molding. This market was rather static for a long time, but it surged in 1978 as a result of several events (among them the death of singer Elvis Presley and also as a result of several highly successful new releases). While the level of resin use for records dropped in 1979, industry observers expect a pattern of fluctuating demand around the 200 million pound-per-year level in the next few years. In spite of skyrocketing costs for recordings, new pressing facilities are in the installation and planning stage.

The next largest single market of this category is probably footwear, which includes coated fabrics (for uppers and linings), calendered or extruded soling, and injection-molded soles and heels for sneakers and other shoewear. Also included are injection-molded boots. PVC resin use for this market is believed to total somewhat over 100 million pounds, but it fluctuates from year to year depending on fashion trends.

Also included are coated fabrics and film and sheeting for such diverse uses as handbags and purses, toys and recreational articles (mostly cases or bags, e.g., for golf clubs, rifles, backpacks, and camping gear), for luggage, kitchenware and appliances (gaskets), and garden hose.

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3. Electrical Uses. Total PVC consumption in 1978 for electrical uses is estimated to have been 510 million pounds. Wire and cable insulation, the predominant use, consumed 420 million pounds. This market can be subdivided roughly as follows.

ESTIMATED BREAKDOWN OF PVC CONSUMPTION IN WIRE AND CABLE - 1978

Building Wire and Power Cables	50%
Communication and Signal Wire	20
Flexible Cord (for household lamps, extension cords)	12
Automotive Electrical Wire and Other Auto Uses	10
Appliance Wire	8
Total	100%

SOURCE: Communication with industry.

PVC shares the wire and cable market with several other plastics and elastomers. Polyolefins are better electrical insulators, but PVC is a better jacketing material when resistance to flexing is required in a wire or cable.

The largest use of PVC in wire and cable is in the low-voltage field (500V and below), in which building wire accounts for a large portion. PVC jacketing, usually black, is common on 1-5 kV unshielded distribution cable for industrial use and in low-voltage city networks, as well as on cables for the 10-35 kV range that are used by utilities in underground power distribution.

PVC resins used for wire and cable are of slightly higher molecular weight than calender-grade resins but are sold as general-purpose resins. Wire and cable extruders use large amounts of compound (pelletized) as well as resin (for their own compounding). The largest suppliers of PVC compounds for wire and cable are BFGoodrich, Firestone, and Tenneco.

The largest wire and cable extruders are listed below.

COMPANY	PLANT LOCATION
Aluminum Company of America	Marshall, Texas Massena, New York
The Anaconda Company Anaconda Wire & Cable Co., subsidiary	Marion, Indiana Orange, California Sycamore, Illinois Watkinsville, Georgia
Belden Corporation	Richmond, Indiana
Essex International Inc. (subsidiary of United Technologies Corporation)	Marion, Indiana Paducah, Kentucky

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(continued)

General Cable Corporation	Elkton, Maryland Pownal, Virginia
Kaiser Aluminum & Chemical Corporation Electrical Products Division	Pawtucket, Rhode Island San Leandro, California
Reynolds Metals Company	Chester, Pennsylvania
Western Electric Company	Atlanta, Georgia Baltimore, Maryland Buffalo, New York Omaha, Nebraska Phoenix, Arizona

Of these, Essex International and Western Electric alone are believed to consume as much as half of all PVC resins used for wire and cable extrusion.

Other large consumers in this field include Packard Electric Division of General Motors Corporation (Warren, Ohio) and Prestolite Division of Eltra Corporation (Port Huron, Michigan, and Hazelton, Pennsylvania), both producers of automotive wire and cable products.

Outside of wire and cable insulation, about 20 million pounds of PVC were used in rigid injection molding for electical outlet boxes and, to a minor extent, for some other items in the electronics field. An estimated 70 million pounds were used for outlet plugs and for wire connectors. PVC consumption for electrical tape is not included here.

4. Packaging. A breakdown of PVC resin consumption in packaging is given in the following table.

ESTIMATED PVC RESIN CONSUMPTION IN PACKAGING - 1978

	Millions of Pounds	Thousands of Metric Tons
Plasticized Clear Film	235	107
Bottles	90	41
Rigid Sheet (blister and trays)	90	41
Coatings	15	7
Closures	30	14
Total	460	209[a]

a. Total does not equal sum of categories due to rounding.

SOURCE: CEH estimates.

Of the extrusion-blown plasticized clear film, about 150 million pounds were for meat wrap, and the balance was mostly for stretch film. The Resinite Division of Borden Inc.

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is the largest producer, followed by The Goodyear Tire & Rubber Company. Rigid sheet (of which about 60 million pounds were calendered and the balance extruded) is mostly for blister-packaging and shrink-packaging of hardware; lesser quantities are used for processed meats and for pharmaceuticals, for trays or boxes for candy, and for greeting cards. An example of a food packaging film composite employing PVC is a laminate of Saran®-coated polyethylene film and PVC. Also, laminates of PVC and Saran® films are used. Such combinations provide both the barrier properties and processing characteristics (e.g., for heat sealing) needed.

Closures involve plasticized bottle cap and jar lid linings based on dispersion resins. Resin consumption for coatings is for can coatings.

5. Transportation. An estimated breakdown for 1978 consumption in the transportation market is given below.

ESTIMATED PVC RESIN CONSUMPTION IN TRANSPORTATION - 1978

	Millions of Pounds	Thousands of Metric Tons
Passenger Car Seating and Interior Trim (including trunk lining)	135	61
Seating and Accessories for Trucks, Buses, and Other Vehicles (e.g., campers, mass transit, snowmobiles)	30	14
Auto Floormats	25	11
Auto Tops and Exterior Trim	25	11
Bumper Strips, Bumper Guards, Window Winder Knobs, and Other Items	20	9
Other	45	20
Total	280	127[a]

a. Total does not equal sum of categories due to rounding.

SOURCE: CEH estimates.

Most of this consumption is in the form of coated fabrics (about three-fourths of these are calender-coated, and the balance is dispersion coated). Floor mats are molded from extruded sheet or injection molded; such items as bumper guards, window winder knobs, and rearview mirror housings are typically injection molded. The resin consumption listed under "Other" is for such items as air filter incaps, battery separators, and other items.

This market has not grown for PVC, overall, in the last two years. Principal factors are the trend toward smaller cars, the increasing use of fabrics instead of vinyl for seating, and the loss of the vinyl headliner to the rigid molded snap-in headliner on most GM cars.

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6. Home Furnishings. An estimated breakdown of this market is given in the following table.

ESTIMATED CONSUMPTION OF PVC IN HOME FURNISHINGS - 1978

	Millions of Pounds	Thousands of Metric Tons
Furniture Upholstery	150	68
Shower Curtains	10	5
Adhesive-Backed Film	10	5
Tablecloths and Placemats	50	23
Total	220	100[a]

a. Total does not equal sum of categories due to rounding.

SOURCE: CEH estimates.

Most of the products listed are made from calender-coated fabrics and, to a lesser extent, dispersion-coated fabrics and unsupported film.

Vinyl furniture upholstery, the largest single end use of this category, has declined somewhat in the last two years as upholstery fabrics have become less expensive relative to vinyl. Also, polypropylene upholstery fabrics have taken an increasing share of this market.

7. Miscellaneous Uses. A total of 390 million pounds of PVC is estimated to have been used in miscellaneous applications in 1978. About 180 million pounds of this were for coatings and adhesives. Included are an estimated 75 million pounds of resin for high-performance protective coatings (based on special copolymers) for ships, and for industrial, military, and farm equipment; and topcoatings and inks (often in admixture with acrylic resins) for coated fabrics and sheeting. Solvent-based adhesives containing these PVC copolymers in conjunction with other resins are used in the manufacture of leather goods and simulated leather goods including luggage, shoes, handbags, and purses; and in the assembly of toys, novelties, and swimming pool liners. About 35 million pounds of noncoating specialty applications of these same types of soluble resins are also included, as are resins for powder coatings (less than 5 million pounds). Some plastisols and an estimated 70 million pounds (dry basis) of latex are also included, the main use of which is for coated fabrics; some dipped products are also included.

Other uses for PVC in this category are for medical tubing, blood bags, and for other hospital and health care uses; credit card stock (rigid sheet); and flooring applications such as carpet and synthetic turf backing.

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PRICE AND UNIT SALES VALUE

Vinyl Chloride

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

U.S VINYL CHLORIDE MONOMER PRICE AND UNIT SALES VALUE

	Price[a]		Unit Sales Value	
	Cents per Pound	Cents per Kilogram	Cents per Pound	Cents per Kilogram
1955	10.5	23	10	22
1956	11	24	11	24
1957	11	24	11	24
1958	11	24	11	24
1959	12.5	28	11	24
1960	12.5	28	10	22
1961	7.5	17	8	18
1962	8	18	7	15
1963	8	18	7	15
1964	8	18	6	13
1965	8	18	6	13
1966	8	18	6	13
1967	8	18	5	11
1968	8	18	5	11
1969	4.75	11	4	9
1970	4.75	11	4	9
1971	4.75	11	4	9
1972	4.75	11	4	9
1973	5	11	4	9
1974	7-10	15-22	8	18
1975	9-12	20-26	10	22
1976	12-13	26-29	10	22
1977	14.5-15	32-33	12	26
1978	13.4-14.5	30-32	—	—
1979	15.2	34	—	—

a. Midyear list prices. Price bases are:

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
1973-1979	Polymer grade, tanks, f.o.b. works.

SOURCES: (A) Chemical Marketing Reporter (PRICE data).

(B) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. International Trade Commission (formerly U.S. Tariff Commission) (UNIT SALES VALUE data).

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. As of September 14, 1979, the list price for vinyl chloride was 17.2 cents per pound (tanks, f.o.b. works).

Polyvinyl Chloride Resins

As of October 1, 1979, PVC resin prices were generally as follows.

RESIN TYPE	PRICE Cents per Pound	Cents per Kilogram
General-Purpose Suspension Homopolymer:		
Calender and Extrusion Grades	35[a]	77[a]
Pipe Resin	34[a]	75[a]
Specialty Homopolymers	41[a]	90[a]
Suspension Copolymers (flooring and record grades)	39-40[a]	86-88[a]
Dispersion Resins	50[b]	110[b]
Blending Resins	41[b]	90[b]

a. Bulk price (bulk hopper rail cars), f.o.b. producing location, freight allowed.

b. Bagged, truckload, carload, f.o.b. producing location, freight allowed.

SOURCE: Communication with industry.

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A history of domestic PVC resin prices and reported unit sales value is given in the following table.

U.S. POLYVINYL CHLORIDE RESINS PRICE AND UNIT SALES VALUE

	Price[a]					
	General Purpose		Dispersion		Unit Sales Value	
	Cents per Pound	Cents per Kilogram	Cents per Pound	Cents per Kilogram	Cents per Pound	Cents per Kilogram
1955	31	68	34	75	34	75
1956	27	60	30	66	31	68
1957	27	60	30	66	29	64
1958	23.5	52	26.5	58	—	—
1959	23.5	52	26.5	58	25	55
1960	18.5	41	24	53	23	51
1961	16	35	24	53	19	42
1962	16	35	24	53	18	40
1963	16	35	24	53	18	40
1964	16	35	24	53	17	37
1965	16	35	24	53	17	37
1966	14	31	20-22	44-49	17	37
1967	13.5	30	20-22	44-49	16	35
1968	10	22	18-19	40-42	14	31
1969	11	24	18-19	40-42	14	31
1970	11.5	25	18-19	40-42	13	29
1971	14.5	32	19-20	42-44	13	29
1972	14	31	19-20	42-44	13	29
1973	15.5	34	24-26	53-57	15	33
1974	20	44	34	75	23	51
1975	24	53	35	77	24	53
1976	27.5	61	39	86	26	57
1977	28.5	63	39	86	26	57
1978	29	64	41	95	—	—

a. Prices are those in effect at the end of each year and are for truckload quantities of material packed in 50-pound bags, minimum transportation allowed or prepaid.

SOURCES: (A) Communication with industry (PRICE data).

(B) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. International Trade Commission (formerly U.S. Tariff Commission) (UNIT SALES VALUE data).

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U.S. TRADE

Vinyl Chloride

A. Imports

Data on U.S. imports of vinyl chloride are reported by the U.S. Department of Commerce, Bureau of the Census under import code # 429.4400. U.S. imports of vinyl chloride were negligible from 1964 through 1967. Since 1968, they have been less than 5 million pounds per year.

The import rate of duty on vinyl chloride prior to 1968 was 2.5 cents per pound (5.5 cents per kilogram) plus 12.5% ad valorem. As a result of the Kennedy Round Agreements, the duty was decreased in stages to 1.25 cents per pound (2.8 cents per kilogram) plus 6% ad valorem as of January 1, 1972 (Tariff Schedules of the United States Annotated (1976), USITC Publication 749, U.S. International Trade Commission).

B. Exports

Data on U.S. exports of vinyl chloride as reported by the U.S. Depatment of Commerce are presented in the following table.

U.S. EXPORTS OF VINYL CHLORIDE[a]

	Millions of Pounds	Thousands of Metric Tons
1970	664	301
1971	620	281
1972	621	282
1973	420	191
1974	412	187
1975	415	188
1976	641	291
1977	423	192
1978	899	408

See MANUAL OF CURRENT INDICATORS - SUPPLEMENTAL DATA for additional information.

a. Data were reported in the source under export code # 512.0978 though 1977, and under export code # 511.3100 in 1978.

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

According to industry sources, VCM exports in 1977 actually are believed to have been 466 million pounds. Exports of VCM through July 31, 1979, were 633 million pounds (287 thousand metric tons).

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Data on U.S. exports by country of destination in 1978 are shown in the following table.

U.S. EXPORTS OF VINYL CHLORIDE - 1978[a]

Country of Destination	Quantity: Millions of Pounds	Quantity: Thousands of Metric Tons	Value (millions of of dollars)	Unit Value: Cents per Pound	Unit Value: Cents per Kilogram
Taiwan	153.8	69.8	16.0	10.4	23.0
Yugoslavia	121.9	55.3	13.6	11.2	24.6
Mexico	110.9	50.3	15.5	14.0	30.8
Canada	104.4	47.4	14.2	13.6	29.9
Brazil	99.7	45.2	13.6	13.7	30.2
Korea	97.6	44.3	11.1	11.4	25.0
Australia	68.7	31.2	7.7	11.2	24.7
Colombia	59.5	27.0	7.6	12.8	28.2
Nicaragua	39.1	17.7	5.1	13.1	28.9
Other	43.3	19.6	5.8	13.4	29.5
Total[b]	898.9	407.7	110.2	12.3	27.0

a. Data are reported in the source under export code # 511.3100.

b. Totals may not equal sums of categories due to rounding.

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

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Polyvinyl Chloride Resins

A. Imports

Data on U.S. imports of polyvinyl chloride resins as reported by the U.S. Department of Commerce are presented in the following table.

U.S. IMPORTS OF
POLYVINYL CHLORIDE RESINS[a]

	Millions of Pounds	Thousands of Metric Tons
1964	5	2
1965	7	3
1966	9	4
1967	14	6
1968	17	8
1969	6	3
1970	6	3
1971	4	2
1972	4	2
1973	65	29
1974	124	56
1975	27	12
1976	52	24
1977	37	17
1978p	45	20

See MANUAL OF CURRENT INDICATORS - SUPPLEMENTAL DATA for additional information.

a. Data are reported in the source under import code # 445.4520.

SOURCES: (A) U.S. Imports, FT 246, U.S. Department of Commerce, Bureau of the Census (data for 1964-1977).

(B) U.S. Imports for Consumption, IM 146, U.S. Department of Commerce, Bureau of the Census (data for 1978).

Polyvinyl chloride imports for the first seven months of 1979 totaled just over 25 million pounds (11 thousand metric tons).

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Data on U.S. imports by country of origin in 1978 are given in the following table.

U.S. IMPORTS OF POLYVINYL CHLORIDE RESINS - 1978[a]

Country of Origin	Quantity: Millions of Pounds	Quantity: Thousands of Metric Tons	Value (millions of dollars)	Unit Value: Cents per Pound	Unit Value: Cents per Kilogram
Canada	12.7	5.8	3.6	28.6	63.1
Mexico	9.2	4.2	2.0	21.6	47.5
Federal Republic of Germany	5.6	2.5	1.4	25.8	56.9
Japan	5.3	2.4	2.2	40.7	89.7
Italy	5.2	2.4	1.2	23.8	52.6
Other	6.7	3.0	1.6	24.0	52.9
Total[b]	44.7	20.3	12.1	27.0	59.5

a. Data are reported in the source under import code # 445.4520.

b. Totals may not equal sums of categories due to rounding.

SOURCE: U.S. Imports for Consumption, IM 146, U.S. Department of Commerce, Bureau of the Census.

The import rate of duty on polyvinyl chloride resins prior to 1968 was 2.5 cents per pound (5.5 cents per kilogram) plus 12.5% ad valorem. As a result of the Kennedy Round Agreements, the duty was decreased in stages to 1.25 cents per pound (2.8 cents per kilogram) plus 6% ad valorem as of January 1, 1972 (Tariff Schedules of the United States Annotated (1976), USITC Publication 749, U.S. International Trade Commission).

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B. Exports

Data on U.S. exports of polyvinyl chloride resins as reported by the U.S. Department of Commerce (exports by all shippers) and The Society of the Plastics Industry, Inc. (SPI) (exports by resin producers only) are presented in the following table.

U.S. EXPORTS OF POLYVINYL CHLORIDE RESINS
(millions of pounds)

	Department of Commerce				
		Compounded			
	Uncompounded[a]	Reported[b]	Estimated Resin Content[c]	Estimated Total	SPI
1965	48	31	25	73	—
1966	50	37	30	80	
1967	42	34	27	69	
1968	74	38	30	104	
1969	129	38	30	159	
1970	132	35	28	160	—
1971	118	34	27	145	165
1972	119	40	32	151	156
1973	110	54	43	153	146
1974	212	105	84	296	297
1975	121	55	44	165	164
1976	225	141	113	338	272
1977	187	127	102	289	239
1978	177	94	75	252	243

See MANUAL OF CURRENT INDICATORS - SUPPLEMENTAL DATA for additional information.

a. Data reported in the source under export code # 581.2022 through 1977, and under export code # 588.1350 in 1978.

b. Data reported in the source under export code # 581.2024 through 1977, and under export code # 588.1355 in 1978.

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

SOURCES: (A) U.S. Exports, FT 410, U.S. Department of Commerce, Bureau of the Census (UNCOMPOUNDED and REPORTED COMPOUNDED data).

(B) Year-End Monthly or Annual Statistical Reports, Plastic and Resin Materials, The Committee on Resin Statistics of The Society of the Plastics Industry, Inc., as compiled by Ernst & Ernst (SPI data).

(C) CEH estimates (all other data, and estimate in footnote c).

Exports of uncompounded PVC resins totaled 136 million pounds (62 thousand metric tons) through July 1979. Reported exports of compounded PVC resins totaled 51 million pounds (23 thousand metric tons) for the same period.

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Data on U.S. exports by country of destination in 1978 are given in the following tables.

U.S. EXPORTS OF UNCOMPOUNDED POLYVINYL CHLORIDE RESINS - 1978[a]

Country of Destination	Quantity: Millions of Pounds	Quantity: Thousands of Metric Tons	Value (millions of dollars)	Unit Value: Cents per Pound	Unit Value: Cents per Kilogram
Canada	39.1	17.7	11.8	30.2	66.6
Belgium	22.6	10.3	7.2	31.8	70.1
New Zealand	18.5	8.4	5.2	28.3	62.4
Brazil	17.7	8.0	4.5	25.5	56.3
Venezuela	14.7	6.7	4.1	27.7	61.0
Australia	7.5	3.4	2.9	38.6	85.0
Japan	6.4	2.9	4.2	66.3	146.1
Republic of South Africa	5.6	2.5	2.3	40.5	89.4
Other	44.7	20.3	17.3	38.6	85.1
Total[b]	176.8	80.2	59.5	33.6	74.2

a. Data are reported in the source under export code # 558.1350.

b. Totals may not equal the sums of the categories due to rounding.

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

U.S. EXPORTS OF COMPOUNDED POLYVINYL CHLORIDE RESINS - 1978[a]

Country of Destination	Quantity: Millions of Pounds	Quantity: Thousands of Metric Tons	Value (millions of dollars)	Unit Value: Cents per Pound	Unit Value: Cents per Kilogram
Canada	28.9	13.1	9.9	34.2	75.5
Brazil	10.9	5.0	2.1	19.5	43.0
Venezuela	8.4	3.8	2.2	26.9	59.3
Dominican Republic	7.6	3.5	2.3	30.7	67.6
Peru	5.7	2.6	1.1	19.3	42.3
Jamaica	3.8	1.7	1.3	35.1	77.3
Other	29.2	13.2	11.7	40.0	88.3
Total[b]	94.4	42.8	30.7	32.5	71.7

a. Data are reported in the source under export code # 588.1355.

b. Totals may not equal the sums of the categories due to rounding.

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

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INTERNATIONAL*

Producers and Capacities

A. Vinyl Chloride

The following table summarizes world vinyl chloride monomer capacity by region and country. Data are obtained from the **PRODUCING COMPANIES, PLANT LOCATIONS, AND CAPACITIES** section of this report and from the World Petrochemicals (WP) Program. Detailed information by company is contained in the WP study.

ANNUAL WORLD VINYL CHLORIDE CAPACITY
(thousands of metric tons)

	As of August 1, 1979	Future[a]
North America	**3,900**	**5,305**
Canada	90	408
Mexico	70	270
United States and Puerto Rico	3,740	4,627
South America	**456**	**760**
Argentina	55	155
Brazil	296	496
Chile	18	18
Colombia	29	29
Peru	8	12
Venezuela	50	50
Western Europe	**6,234**	**7,144**
Belgium	820	820
Finland	57	57
France	930	1,130
Germany, Federal Republic of	1,255	1,275
Greece	30	30
Italy	1,018	1,058
The Netherlands	500	500
Norway	300	300
Portugal	32	182
Spain	497	847
Sweden	100	100
Switzerland	35	35
United Kingdom	660	810

(continued)

* Data and information in this section were developed by the World Petrochemicals Program, SRI International.

ANNUAL WORLD VINYL CHLORIDE CAPACITY (continued)
(thousands of metric tons)

	As of August 1, 1979	Future[a]
Eastern Europe	**1,231**	**2,356**
Bulgaria	35	185
Czechoslovakia	220	220
German Democratic Republic	0	200
Hungary	223	223
Poland	188	393
Rumania	233	233
U.S.S.R.	332	602
Yugoslavia	0	300
Middle East	**216**	**549**
Iran	62	212
Iraq	0	66
Israel	100	100
Turkey	54	171
Asia	**3,059**	**4,026**
China	80	680
India	100	147
Japan	2,394	2,244
Korea, Republic of (South)	60	410
Pakistan	5	5
Philippines	10	10
Taiwan	410	530
Oceania	**81**	**81**
Australia	81	81
Africa	**223**	**409**
Algeria	40	40
Libya	0	65
Morocco	0	27
Nigeria	0	42
Senegal	0	52
South Africa, Republic of	183	183
World Total	**15,400**	**20,630**

a. Includes capacity already on stream and announced expansions, closures, and new plant construction scheduled for year-end 1984.

SOURCE: World Petrochemicals Program, SRI International.

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Vinyl chloride monomer producers outside the United States with annual capacities of 250 thousand metric tons or more in any one country are listed below. For information about producers in the United States and Puerto Rico, see the **PRODUCING COMPANIES, PLANT LOCATIONS, AND CAPACITIES** section of this report.

MAJOR VINYL CHLORIDE PRODUCERS OUTSIDE THE UNITED STATES, ANNUAL CAPACITY AS OF JANUARY 1979
(thousands of metric tons)

Western Europe	
Montedison SpA (Italy)	580
Akzo Zout Chemie Nederland BV (owned 100% by Akzo NV) (The Netherlands)	500
Limburgse Vinyl Maatschappij NV (owned 50% by DSM, by Tessenderlo Chemie sa, and 5% by Compagnie Financiere de Tessenderlo) (Belgium)	450
Chemische Werke Huels AG (owned 50% by VEBA AG and 50% by Chemie-Verwaltungs-AG) (Federal Republic of Germany)	415
Imperial Chemical Industries Limited (United Kingdom)	400
Rhone-Poulenc Industries SA (owned by Rhone-Poulenc SA) (France)	400
Norsk Hydro a.s (owned 51% by the Norwegian government) (Norway)	300
BP Chemicals Ltd. (unit of BP Chemicals International Limited) (United Kingdom)	260
Hoechst AG (Federal Republic of Germany)	260
Japan	
Toyo Soda Manufacturing Co., Ltd.	319
Kashima Vinyl Chloride Monomer Company Ltd. (owned 50% by Shin-Etsu Chemical Co., Ltd.; 25% by Mitsubishi Petrochemical Co., Ltd; 10% by Asahi Glass Company, Ltd.; 10% by Kanegafuchi Chemical Industry Company Limited; and 5% by Asahi Denka Kogyo K.K.)	270

SOURCE: World Petrochemicals Program, SRI International

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B. Polyvinyl Chloride Resins

The following table summarizes world polyvinyl chloride resin capacity by region and country. Data are obtained from the **PRODUCING COMANIES, PLANT LOCATIONS, AND CAPACITIES** section of this report and from the World Petrochemicals (WP) Program. Detailed information by company is contained in the WP study.

ANNUAL WORLD POLYVINYL CHLORIDE RESINS CAPACITY
(thousands of metric tons)

	As of August 1, 1979	Future[a]
North America	**3,527**	**4,310**
Canada	166	266
Mexico	134	208
United States	3,227	3,836
Central America	**30**	**30**
Nicaragua	30	30
South America	**462**	**783**
Argentina	53	152
Brazil	297	497
Chile	15	15
Colombia	43	43
Peru	8	30
Venezuela	46	46
Western Europe	**5,187**	**5,955**
Austria	60	60
Belgium	240	240
Finland	55	55
France	975	1,145
Germany, Federal Republic of	1,325	1,385
Greece	45	88
Italy	1,012	1,032
The Netherlands	330	330
Norway	75	75
Portugal	35	85
Spain	260	490
Sweden	135	135
Switzerland	30	30
United Kingdom	610	805
Eastern Europe	**1,162**	**2,068**
Bulgaria	35	155
Czechoslovakia	205	205
German Democratic Republic	—	100
Hungary	207	207
Poland	180	380
Rumania	225	225
U.S.S.R.	238	488
Yugoslavia	72	308

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ANNUAL WORLD POLYVINYL CHLORIDE RESINS CAPACITY (continued)
(thousands of metric tons)

	As of August 1, 1979	Future[a]
Middle East	212	372
Iran	60	60
Iraq	—	60
Israel	100	100
Turkey	52	152
Asia	2,806	4,024
China		600
India	100	200
Indonesia	56	66
Japan	1,863	1,863
Korea, Democratic People's Republic of (North)	24	24
Korea, Republic of (South)	184	384
Malaysia	24	24
Pakistan	5	5
Philippines	47	47
Singapore	15	15
Taiwan	470	754
Thailand	18	42
Oceania	116	166
Australia	116	166
Africa	177	432
Algeria	35	35
Egypt	—	80
Libya	—	60
Morocco	—	25
Nigeria	—	40
Senegal	—	50
South Africa, Republic of	142	142
World Total	13,679	18,140

a. Includes capacity already on stream and announced expansions, closures, and new plant construction scheduled for year-end 1984.

SOURCE: World Petrochemicals Program, SRI International.

Polyvinyl chloride resin producers outside the United States with annual capacities of 200 thousand metric tons or more in any one country are listed below. For information about producers in the United States and Puerto Rico, see the **PRODUCING COMPANIES, PLANT LOCATIONS, AND CAPACITIES** section of this report.

MAJOR POLYVINYL CHLORIDE RESIN PRODUCERS OUTSIDE THE UNITED STATES, ANNUAL CAPACITY AS OF JANUARY 1979
(thousands of metric tons)

Western Europe	
Montedison SpA (Italy)	510
Chemische Werke Huels AG (owned 50% by VEBA AG and 50% by Chemie-Verwaltungs-AG) (Federal Republic of Germany)	410
Rhone-Poulenc Industries SA (owned by Rhone-Poulenc SA)(France)	375
Wacker-Chemie GmbH (Federal Republic of Germany)	310
Imperial Chemical Industries Limited (United Kingdom)	280
Solvic SA (owned 75% by Solvay & Cie SA and 25% by Imperial Chemical Industries Limited) (France)	250
Hoechst AG (Federal Republic of Germany)	240
BP Chemicals Ltd. (unit of BP Chemicals International Limited) (United Kingdom)	230
Asia, Far East	
Formosa Plastics Corporation (Taiwan)	342
Shin-Etsu Chemical Co., Ltd. (Japan)	218
Kanegafuchi Chemical Industry Company Limited (Japan)	216

SOURCE: World Petrochemicals Program, SRI International.

Production and Demand

A. Vinyl Chloride

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The following table shows world production of vinyl chloride monomer in 1977 by geographic region.

WORLD PRODUCTION OF VINYL CHLORIDE - 1977

Region	Thousands of Metric Tons	Percent of Total
United States	2,715	31%
Canada	90	1
Mexico	56	1
South America	170	2
Western Europe	3,899	45
Japan	1,338	15
Other	468	5
Total	8,736	100%

SOURCE: World Petrochemicals Program, SRI International.

The table below shows world consumption of vinyl chloride monomer in 1977 by geographic region, with a forecast for 1983.

WORLD CONSUMPTION OF VINYL CHLORIDE - 1977 AND 1983

	1977		1983	
Region	Thousands of Metric Tons	Percent of Total	Thousands of Metric Tons	Percent of Total
United States	2,492	29%	3,600	29%
Canada	109	1	290	2
Mexico	79	1	170	1
South America	257	3	659	5
Western Europe	3,875	44	5,051	40
Japan	1,191	14	1,422	11
Other	697	8	1,486	12
Total	8,700	100%	12,678	100%

SOURCE: World Petrochemicals Program, SRI International.

B. Polyvinyl Chloride Resins

The following table shows world production of polyvinyl chloride resins in 1977 by geographic region.

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WORLD PRODUCTION OF POLYVINYL CHLORIDE RESINS - 1977

Region	Thousands of Metric Tons	Percent of Total
United States	2,383	29%
Canada	100	1
Mexico	71	1
South America	250	3
Western Europe	3,754	46
Japan	1,031	12
Other	677	8
Total	8,266	100%

SOURCE: World Petrochemicals Program, SRI International.

The table below shows world consumption of polyvinyl chloride resins in 1977 by geographic region, with a forecast for 1983.

WORLD CONSUMPTION OF POLYVINYL CHLORIDE RESINS - 1977 and 1983

	1977		1983	
Region	Thousands of Metric Tons	Percent of Total	Thousands of Metric Tons	Percent of Total
United States	2,265	28%	3,360	29%
Canada	137	2	250	2
Mexico	70	1	160	1
South America	336	4	640	6
Western Europe	3,396	43	4,469	39
Japan	1,030	13	1,270	11
Other	691	9	1,392	12
Total	7,925	100%	11,541	100%

SOURCE: World Petrochemicals Program, SRI International.

In 1977, consumption of polyvinyl chloride resins by major category in Western Europe was as follows: rigid PVC, 60%, and flexible PVC, 40%.

In major Western European countries, the polyvinyl chloride consumption patterns varied, as shown below.

CONSUMPTION OF POLYVINYL CHLORIDE RESINS IN WESTERN EUROPE (percent)

	Benelux	France	Federal Republic of Germany	Italy	United Kingdom
Rigid PVC	68%	65%	62%	55%	45%
Flexible PVC	32	35	38	45	55
Total	100%	100%	100%	100%	100%

SOURCE: World Petrochemicals Program, SRI International.

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Trade

A. Vinyl Chloride

The following table presents world imports and exports of vinyl chloride monomer in 1977 by region.

WORLD IMPORTS AND EXPORTS OF VINYL CHLORIDE - 1977
(thousands of metric tons)

Region	Imports	Exports
United States	0	192
Canada	17	0
Mexico	20	0
South America	87	0
Western Europe	476	536
Japan	0	166
Other	194	0
Total	794	894

SOURCE: World Petrochemicals Program, SRI International.

B. Polyvinyl Chloride Resins

The following table presents world imports and exports of polyvinyl chloride resins in 1977 by region.

WORLD IMPORTS AND EXPORTS OF
POLYVINYL CHLORIDE RESINS - 1977
(thousands of metric tons)

Region	Imports	Exports
United States	17	108
Canada	40	4
Mexico	6	7
South America	106	18
Western Europe	903	1,248
Japan	11	90
Other	101	43
Total	1,184	1,518

SOURCE: World Petrochemicals Program, SRI International.

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CHEMICAL ECONOMICS HANDBOOK - The following CEH Marketing Research Reports, Product Reviews, and Data Sheets contain additional information that is pertinent to the subject of this report.

Acetylene
Chlorine - Salient Statistics
Ethylene
Ethylene Dichloride
Hydrochloric Acid - Salient Statistics
Plasticizers
Vinyl Acetate, Polyvinyl Acetate, and Polyvinyl Alcohol
Vinyl Surface Coatings

PROCESS ECONOMICS PROGRAM - The following reports contain more detailed information on the manufacturing processes, process design, and process economics of the chemicals discussed in this report. Address inquiries concerning this information to the Process Economics Program, SRI International, Menlo Park, California, 94025.

Polyvinyl Chloride, Reports No. 13, 13A, 13B, and 13C1, June 1966, May 1970, November 1975, and April 1977.

Vinyl Chloride, Reports No. 5, 5A, 5B1, and 5B, May 1965, February 1967, October 1970, and September 1975.

Other References - Below is a list of recent articles suggested for supplemental reading.

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"Worldwide Activity in VCM and PVC Heats up," Chemical Week, April 11, 1979, p. 54.