

Petrochemical guide—20

Vinyl chloride: how, where, who—future

*Here is how manufacturing methods,
markets, buyers and sellers and
economics affect the future of
vinyl chloride*

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VINYL CHLORIDE has a single important end use as monomer in production of polyvinyl chloride (PVC) and vinyl copolymers. The U.S. production of vinyl chloride expanded at an annual rate of 14 percent during the 1960s, reaching a level of 4 billion pounds in 1970 and 1971. This increase has been accompanied by a steady fall in average F.O.B. selling price from 10 cents/pound to about 4.5 cents per pound in 1970 and 1971. As a result, the imputed value of production has expanded for the decade at a 6 percent rate to \$180 million in 1970.

Polyvinyl chloride and other vinyl copolymers are being substituted for older materials on several fronts. Through replacement of steel and iron in piping, wood in construction and packaging, glass and paper in packaging, and leather in clothing, polyvinyl chloride consumption will continue to expand at a rate of about 10 percent through 1975 and beyond. We expect 1975 to see U.S. production of 5.6 billion pounds of vinyl chloride (VCM). This monomer will be sold at an average price of 4.5 cents/pound, and production will therefore be valued at about \$280 million (1971 dollars). Production of PVC in Europe is even larger, with 1970 production approximating 5.3 billion pounds. European growth rates have also been somewhat higher, with one enthusiastic source predicting a 1975 PVC production of 9.5 billion pounds.¹ In all likelihood, European PVC consumption will grow less rapidly than in the United States because of the higher per capita consumption prevalent in some major markets in Europe, which makes growth more difficult.

Manufacturing processes for VCM have changed rapidly since 1965. Several new ethylene oxychlorination processes have been employed to shut down older acetylene-based production. These large, new processes now account for over 80 percent of U.S. capacity, and the same process should continue to be employed in expansions through 1975. Recent announcement of an ethane-based process (TRANSCAT)[®] has raised the yet-unproved possibility of bypassing ethylene cracking entirely, but even a viable TRANSCAT cannot greatly influence the pre-1975 VCM business.

This process switch has also resulted in large changes in the cast of players. In general, some users of VCM have ceased to produce their own monomer, with production undertaken by large, integrated producers of ethylene and chlorine. Dow and B. F. Goodrich are the largest producers and have produced VCM for quite a few years. However, PPG, Shell and Conoco have become the third, fourth and fifth largest VCM producers despite not having been in the business in 1965. We expect this trend toward concentration of large VCM plants among feedstock producers to continue through the next several plants.

The PVC business has also grown at a rapid rate elsewhere in the world. Because of difficulty and expense of shipping, export of VCM has usually constituted a limited

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major; the processes should be roughly competitive based upon published data.³

3. Stauffer Chemical oxychlorination. This is again very similar to the earlier oxychlorination processes. Minor changes in the routing of streams, small differences in catalyst performance, and features of the mechanical design are all that differentiate between the published information for this process and the previous two. It is noteworthy that Stauffer published an estimate of 3.7 billion pounds/year of vinyl chloride capacity in 17 plants utilizing this process.⁴

4. Monsanto oxychlorination. There are several licensees for this similar process.⁵

5. Dow oxychlorination. Only Dow and foreign subsidiaries have used the Dow VCM process, and no indication of a willingness by Dow to license to others has been published.

6. Union Carbide (Lummus) balanced acetylene/ethylene process. No recent examples of this process have been constructed in the United States, but a Union Carbide venture using a Wulff process acetylene/ethylene plant in Brazil is employing this process to consume part of the production. Complete startup of this plant is planned for 1972.

The basic flow scheme is shown in Fig. 6-4. Ethylene and chlorine produce EDC, which is cracked to yield HCl and VCM; the process is very similar in this area to the above processes. However, instead of using oxygen and ethylene to convert the byproduct HCl to EDC, the balanced process then involves the older acetylene route. The reaction is a vapor phase reaction over HgCl_2 /carbon catalyst with a slight HCl excess. A circulating coolant removes reaction heat to control the reaction temperature to about 400° F. Conversion is less than complete in some plants, requiring recycle of acetylene and HCl, but the reaction yields are 95 percent or greater. Therefore, the removal of light and heavy byproducts is simple. This results in low capital and operating costs for the process, but the use of acetylene at current or projected U.S. prices makes this process less than competitive with balanced oxychlorination (see "Economics").

7. Others. Pechiney-Saint-Gobain offers combined production of chlorinated solvents and vinyl chloride in flexible proportions. A single plant at Saint Auban, France, has operated since the spring of 1970 to produce about 120,000 metric tons/year of VCM with this process.⁶

Diamond Shamrock/deNora offer "Dianor," a process to produce and crack EDC which is aimed at developing countries with no ethylene complexes.⁷ The process operates on ethylene as low as 60 percent concentration and produces HCl byproduct, which would leave the process uncompetitive under any but the special circumstances of small, developing chemical markets with tariff protection.

Feedstock availability. The importance of feedstock cost to VCM producers has resulted in the entry to the VCM market of large, integrated chlorine and ethylene producers (see "Individual Companies" and "Economics"). Future manufacturing efforts will be largely influ-

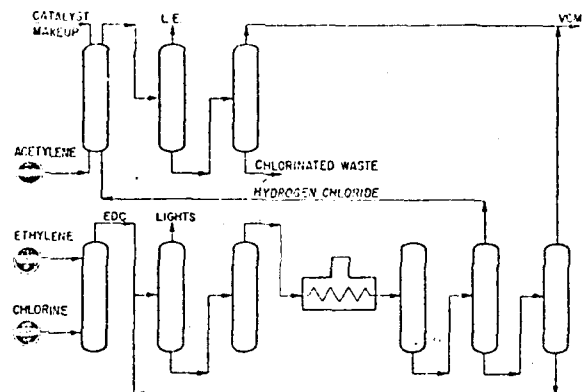


Fig. 6-4—Author's interpretation of the balanced VCM process as announced by Union Carbide (Lummus).

TABLE 6-1—Properties of VCM^a

Mol. wt.	62.50	
Specific gravity	0.9834	20°/20 °C
Melting point	-153.8° C	(-244.6 °F)
Boiling point	-13.81° C	(7.1 °F)
Flash point	-103° F	
Maximum allowable concentration (ppm by volume)	500	
Explosive limits % by volume in air	Lower 4	Upper 22

enced by trends in both of these related fields. A brief review of trends follows:

Ethylene production in the United States has been drifting away from the traditional patterns. Until recently more than 80 percent has been manufactured from ethane and propane cracking and about the same proportion located in the U.S. Gulf Coast.⁸ Some recent plants have involved movement toward the north and Puerto Rico and cracking of heavy feedstocks. With developing shortages of natural gas, a continuing erosion of the competitive advantage of cracking Gulf Coast ethane and propane is likely, and cracking of heavier feedstocks will probably result in higher ethylene prices. With ethylene much more difficult to ship large distances than either vinyl chloride or chlorine, a tendency to locate vinyl chloride production near ethylene plants should continue.

Chlorine is the other major feedstock, with VCM accounting for about 15 percent of U.S. chlorine production in recent years. Largely as a result of slumping VCM demand (which declined slightly in the first half of 1971), chlorine demand has been slack in the 1969-1971 period. However, as various chlorinated products resume their growth trends between 1971 and 1975, chlorine demand should once again require expanded capacity. Given the considerable economies of scale in chlorine/caustic production, the largest and most integrated producers will retain their competitive advantage in VCM.

Very substantial electrical energy requirements for chlorine production will force locations to sources of low-cost power. While nuclear fuel and coal are in the running as long-term suppliers of low cost power, petroleum and natural gas remain necessary until at least 1980. Therefore, availability of petroleum and natural gas fuels will help determine chlorine plant locations until at least 1975.

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These trends indicate that manufacturing locations for VCM are likely to be heavily influenced by availability of inexpensive hydrocarbon feedstocks and fuels, with relative labor and construction costs, water and transportation facilities acting as less important constraints.

Physical properties. See Table 6-1.

MARKETS

U.S. consumption of VCM was about 3.3 billion pounds in 1970, with 664 million pounds being exported. Con-

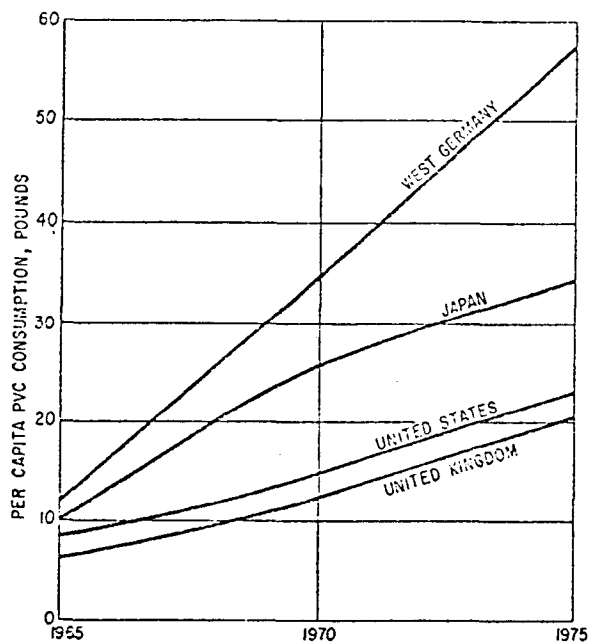


Fig. 6-5—Per capita consumption of polyvinyl chloride.¹⁰

APPAREL	9	6	5
CONSTRUCTION	5	6	10
FLOORING	17	12	9
HOME FURNISHINGS	16	15	12
PACKAGING	4	8	11
PIPE & FITTINGS	5	12	14
RECORDS	5	4	3
TRANSPORTATION	9	7	6
WIRE & CABLE	12	13	10
ALL OTHER	18	17	20
	1965	1970	1975

Fig. 6-6—End use markets for PVC.¹⁰

sumption of VCM is almost entirely for production of polyvinyl chloride resins and copolymer resins (propylene, ethylene and vinyl acetate are commonly copolymerized with VCM). Domestic consumption is projected to grow about 10 percent annually from the 1970 level of 3.3 billion pounds to 5.3 billion pounds in 1975. Export markets will decline from the 16 percent of U.S. production experienced in 1970 to the more usual level of 5-6 percent of production, or 300 million pounds, by 1975.

End uses of PVC are characterized by more variety than most other commodity resins. Physical properties of PVC vary from the soft and flexible plasticized varieties used in dolls to the strong and rigid PVC pipe invading the construction markets. Fig. 6-5 demonstrates the rapid growth in per capita consumption which has resulted from this variety of properties.¹⁰ As a result, PVC consumption is also less vulnerable to the loss of any single end use market.

The more rapidly growing markets for PVC are construction products, packaging, pipe and fittings. These areas should exceed the 10 percent growth rate of the overall PVC market. Segments which are more mature and will grow at less than 10 percent include apparel, flooring, home furnishings, phonograph records, transportation equipment, and wire and cable coatings. An estimate of the 1965, 1970 and 1975 market share of each category is given in Fig. 6-6. While some categories will have declined relative to all PVC consumption, actual volume sold in 1975 is projected to increase in all categories.¹⁰

Construction uses for PVC include vinyl-coated wall coverings, and strips of PVC sheet to serve as water stops in walls and weatherstripping. The largest potential, however, probably belongs to PVC siding and window frames, which are rapidly growing competitors of older wooden and aluminum products. The construction market should grow in excess of 20 percent annually for the next five years.

The packaging application of PVC has been growing very rapidly in recent years. There are environmental pressures to restrict PVC content of packaging because of HCl released when packaging is incinerated, but such restrictions will act to slow this growth area before 1975, not to reverse the trend. Packaging consumption of PVC grew at above 25 percent annually in the last five years, and should grow at 15-20 percent for the next five years. After 1975, however, look for growth to slow considerably as effective control of HCl emissions causes other materials to replace PVC in some applications.

Use of PVC pipe and fittings has benefitted from the accelerating change of U.S. building codes to allow plastic drain, waste and vent piping. A.D. Little has projected a 1975 consumption of 1 billion pounds of plastic piping, with PVC representing a large share.¹¹ The PVC in this application is often blended with chlorinated polyethylene resin. Competition with acrylonitrile-butadiene-styrene (ABS) resins and styrene-acrylonitrile (SAN) resins will be important in determining the actual growth of this PVC application, but 15 percent is a likely growth rate if PVC prices remain below those of ABS and SAN resins.

Among the more mature PVC markets, use of PVC in transportation equipment should continue at a relatively high growth rate. Further penetration of the automobile market is not a major hope for PVC, since seat

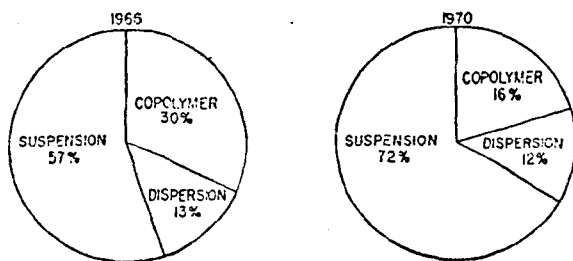


Fig. 6-7—PVC production by type according to the U.S. Tariff Commission.

covers, headliners and dashboards have all been heavily penetrated. As a result, this end use will grow at about the rate automobile production grows. While other transportation uses will increase, look for this segment to grow at 8-9 percent over-all.

Uses of PVC in apparel, flooring, home furnishings and wire coating are mature segments. Growth of these segments should keep pace with real GNP growth at about 5 percent annually through 1975.

Another possible categorization of PVC uses is by the processing methods being used to meet the above markets. Table 6-2 presents a breakdown by processing methods, again reflecting the diversity of PVC markets.

Polymer producers. One reason for the varied properties of PVC resin is the diversity of polymerization methods employed and another is the large number of PVC producers, each with a slightly different product line. While 65 percent of VCM was polymerized captively in 1960, this percentage declined rapidly as older acetylene-based plants were replaced with larger ethylene-based plants. Today companies such as Dow and Shell are exclusively merchant sellers of VCM, while PVC producers such as Monsanto and Union Carbide have discontinued VCM manufacture. As a result, only about 40 percent of VCM was captively consumed in 1970, and the percentage will probably be closer to 30 percent in 1975. The 21 companies currently producing PVC are listed in Table 6-3, together with capacity by region. Of these 21 companies, 7 also produce VCM (see Table 6-5).

A final characterization of PVC production is the type of polymerization employed. Suspension homopolymer resins have been an increasing fraction of PVC production in recent years, mostly at the expense of copolymer resins, while dispersion resins have maintained a relatively constant share. Fig. 6-7 presents a breakdown of PVC by method of polymerization.

World markets. During the 1960s, exports of VCM averaged less than 5 percent of domestic production. VCM must be shipped and stored either under pressure or in a refrigerated tank. The relative difficulty of shipping, low selling price in relation to freight cost, and ready availability of VCM technology has created a strong tendency to produce VCM locally rather than import for an extended period. In 1969, 1970 and 1971, however, rapid expansion of European VCM demand and lagging production capacity led to abnormally large imports from the U.S. Exports accounted for a high of 16 percent of domestic VCM production in 1970. As added capacity

TABLE 6-2—Processing methods for PVC^a

	Share of market, %
Extrusion (wire, film, sheet and general extrusion).....	40
Calendering (film, sheet and coating).....	35
Molding (blow, injection, roto, compression).....	10
Coating (dip, knife, roll, spray, lamination).....	10
Other.....	5

TABLE 6-3—PVC producers in the United States,¹⁹ Jan. 1, 1971

Region	Company	Capacity
Northeast	Borden.....	12 companies
	Diamond.....	
	Shamrock.....	13 plants
	Firestone.....	1,300 MM lbs. capacity
	B. F. Goodrich Chemical.....	
	Goodyear Tire & Rubber.....	
	Great American Plastics.....	
	Hooker.....	
	Monsanto.....	
	Olin.....	
Southeast	Panasote.....	5 companies
	Air Products.....	5 plants
	Continental Oil.....	450 MM lbs. capacity
	Firestone.....	
	Panasote.....	
	Union Carbide.....	
	Midwest Air Products.....	6 companies
	Allied Chemical.....	3 plants
	Borden.....	1,000 MM lbs. capacity
	General Tire.....	
Southwest	B. F. Goodrich Chemical.....	
	Uniroyal.....	
	Diamond.....	
	Shamrock.....	4 companies
	Ethyl.....	4 plants
	Goodyear Tire & Rubber.....	600 MM lbs. capacity
	Union Carbide.....	
	Far West American Chemical.....	3 companies
	B. F. Goodrich Chemical.....	3 plants
	Keysor.....	200 MM lbs. capacity
		21 total companies
		33 total plants
		3,550 MM lbs. total capacity

TABLE 6-4—Western European PVC consumption (thousands of metric tons)

Year	EEC	EFTA	Spain	Other	Total Western Europe
1972.....	506	227	17	40	795
1963.....	610	255	26	52	943
1964.....	709	308	29	72	1,118
1965.....	833	339	33	56	1,261
1966.....	950	359	46	53	1,410
1967.....	1,061	401	59	141	1,661
1968.....	1,227	472	71	155	1,925
1969.....	1,505	525	91	140	2,261
1970*.....	1,598	557	97	148	2,400
Growth rate (1962-1970).....	15%	12%	24%	18%	15%
1975 Consumption*.....	2,575	820	220	285	3,900*
Projected growth Rate (to 1975)*.....	10%	8%	18%	14%	10%

Source: European Chemical News and Oil, Paint and Drug Reporter, Oct. 26, 1970, plus authors' estimates.*

comes onstream in Western Europe and developing countries rush to build VCM plants, U.S. exports of VCM will decrease again to 5-6 percent of production or lower.

U.S. exports of PVC resin are also minimal; in 1969 and 1970, about 5.5 percent and 6 percent of the U.S. PVC sold was exported. Two reasons for this are the

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rapidly expanding domestic markets for PVC and the high relative freight costs. Furthermore, tariff barriers are high—20 percent or more—between European countries, as well as between Europe and the United States.¹² Despite this, the specific properties required by resin users remain the most difficult barrier to a large world trade in PVC. In a recent report of the Standard Research Institute¹³ projections of the world output of PVC for 1970 and 1980 are compared. The percentages accounted for by each producing area are as follows:

	1970	1980
North America	26.5%	26.5%
Western Europe	41.3	39.7
Japan	16.5	17.9
Others	15.7	15.9
	100.0%	100.0%

While special purpose resins sales to developing markets will continue to be an attractive market, PVC resin exports will remain a small market at 5 percent or less of production.

The European PVC market is considerably larger than the U.S. market (see Table 6-4), based upon Europe's large population and greater per capita consumption. This will allow European producers to build large, competitive VCM facilities to serve their own markets. As U.S. producers encounter higher ethylene costs based upon cracking heavier feedstocks and higher chlorine costs from more expensive electric power, exporting to the European VCM market should cease to be attractive to U.S. producers.¹⁴

Japanese PVC producers also represent a sizable market for VCM, but domestic Japanese production is ample to provide the estimated 2.4 billion pounds which will be required in 1972. Estimated VCM capacity is in the neighborhood of 3 to 3.3 billion pounds/year (see Table 6-6), indicating either sizable exports or low operating rates for Japanese VCM producers.

A partial listing of foreign VCM producers is given in Table 6-6. Since this is not an exhaustive listing, total capacity figures are not available. However, the per capita consumption of VCM is even higher in Europe than in the United States and trends toward oxychlorination are evident.

INDIVIDUAL COMPANIES

Table 6-5 lists U.S. producers of VCM as of 1972. Of the total capacity shown, 10 percent is based on acetylene and 8 percent on ethylene without oxychlorination capability. These plants must be considered vulnerable to continued construction of large oxychlorination facilities. The remaining 5 billion pounds (82 percent) consists of modern, apparently competitive oxychlorination plants. Also noteworthy is the concentration of over 70 percent of VCM capacity on the U.S. Gulf Coast. With the exception of PPG's Puerto Rican plant, all recent capacity additions have been in Texas and Louisiana.

The expansion of VCM capacity from 2.4 billion pounds/year in 1965 to about 6 billion pounds/year by 1971 was at an annual rate of 18 percent. The actual rate of new capacity construction has been even more

TABLE 6-5—U.S. producers of VCM

Producer	Location	Nameplate capacity (million lbs./yr.)	Process
Allied.....	Baton Rouge, La.	300	Oxychlorination
American Chemical.....	Watson, Calif.	170	Stauffer oxychlorination
(ARCO-Stauffer)			Acetylene
Monoschem.....	Geismar, La.	300	
(Lorden-Uniroyal)			
Conoco.....	Lake Charles, La.	600	Stauffer oxychlorination
Dow.....	Plaquemine, La.	340	Dow oxychlorination
	Freeport, Texas	180	Dow oxychlorination
	Oyster Creek, Texas	700	Dow oxychlorination
Ethyl.....	Baton Rouge, La.	270	Ethylene/EDC cracking
	Houston	150	Ethylene/EDC cracking
Goodrich.....	Calvert City, Ky.	1,000	Goodrich oxychlorination (multiple train)
PPG.....	Lake Charles, La.	300	Oxychlorination
	Puerto Rico	500	Oxychlorination
Shell.....	Houston	800	Stauffer oxychlorination
	Norco, La.	(Expanding) 800	Stauffer oxychlorination
	Houston	(1974) 255	Stauffer oxychlorination
Tenneco.....			Acetylene
1972 Total		5,865	

Source: Many published estimates as interpreted by the authors. Note that effective capacity probably does not equal nameplate capacity. A reasonable capacity figure would probably be 90% of the above rates. *Oil, Paint and Drug Reporter*, Oct. 11, 1971, has the most complete listing.

rapid, with fully half of the 1965 capacity being shut down in the same period. Eighty percent of 1971 capacity is less than 6 years old.

Among individual companies, Dow has about 19 percent of VCM capacity, and about 23 percent of oxychlorination capacity. Dow's position as a capacity leader among ethylene, chlorine and chlorinated solvents producers leaves no doubt of Dow's long-term position as a VCM producer. Raw materials costs are crucial to VCM economics, being roughly equally split between chlorine and ethylene (see "Economics"). In addition, byproduct chlorinated hydrocarbons from oxychlorination are routinely absorbed into Dow's production of perchloroethylene and carbon tetrachloride. At the present time, this VCM is largely sold in the merchant market. While Dow has extensive experience in production of bulk polymers, Dow has chosen to remain a merchant supplier and has discontinued production of PVC.

The second largest VCM capacity belongs to B. F. Goodrich at Calvert City, Ky. Two or three trains at this site employ Goodrich's oxychlorination process (see "Manufacture"), and are notable in being the only sizeable plants located in the northern or eastern United States. Goodrich has captive use for most or all of this VCM, but has made no recent move to expand beyond their existing 17 percent capacity share. Both ethylene and chlorine for this plant are produced by Goodrich at Calvert City.

PPG has moved into second place with a 14 percent capacity share. Plants in Lake Charles, La., and Puerto Rico benefit from large internal chlorine sources and chlorinated solvents business to absorb byproducts, but ethylene is purchased in both cases. As is the case with most recent expansions, the majority of VCM produced moves in the merchant market.

The fourth and fifth largest producers are oil companies with large ethylene capacity but insufficient chlorine for VCM production. Shell has recently completed and started up 12-14 percent of U.S. industry

Data collection

A TCA, Inc. team will photograph all relevant personnel records at each plant. Involvement of plant personnel during the course of the study will be minimal, unless desired by local management. The data collection team will require a contact person at each plant through whom arrangements can be made and information channeled to local management. The only physical equipment required at the plant is a worktable with a nearby electrical outlet. Our practice is to record data for active employees first and return the records to the files immediately, and then to examine the records for retirees, terminations and deceased employees.

Data analysis

Depending on the actual population size and the duration of follow-up activities, it appears probable that about 800 to 1,000 deaths will occur in the study group.

The basic mortality analysis will begin with a calculation of the number of person years of observation contributed by the study group at each year of age and at each point in time during the study period, using a computer program prepared specifically for this purpose. These data will be used together with the observed deaths at each age and each point in time to calculate mortality rates, which will be compared with the mortality to be expected in the comparable U. S. population, as obtained from national statistics. Techniques of this kind are well developed and have been used for some time in chronic disease studies. (See California Tumor Registry, Cancer Registration and Survival in California, California State Department of Public Health, 1963.)

The above analysis will be repeated for specific causes of death, paying particular attention to competing risks, or interaction among different causes of death.

In addition, analysis of general and cause-specific mortality will be repeated for subgroups of the study population identified as having high, medium and low exposure. The resulting mortality figures will be interpreted not only in light of their statistical significance, but for their relevance to known and suspected mechanisms of action of vinyl chloride, and for their implications with respect to future studies of special areas and groups.

The validity of the conclusions reached from a study of this kind depend crucially on the competence with which data are collected and processed, and the appropriateness of the comparative mortality analysis. TCA, Inc. is uniquely qualified in both areas. The

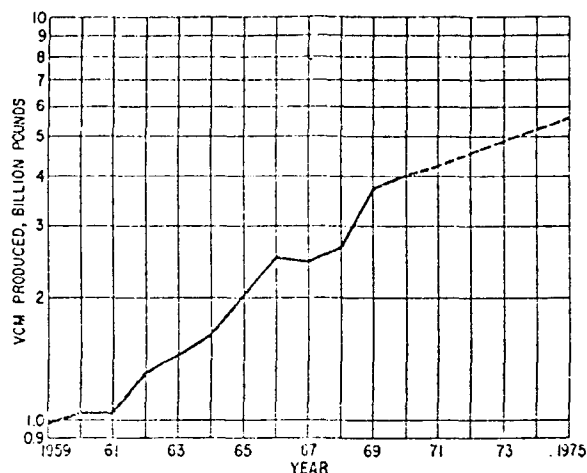


Fig. 6-8—VCM production in the United States, U.S. Tariff Commission and authors' estimates.

trends, the total value of production has increased only 6 percent per year since 1964. However, it is believed that the average sales price (real dollars) will hold steady through 1975 because of rising ethylene and chlorine costs and that the growth rate of VCM production will be closer to seven percent per year from 1970 to 1975.

The future of VCM is directly tied to the future of PVC, and PVC consumption in the United States is expected to show an annual growth rate of 10 percent from 1970 to 1975. The trends of VCM production, price and value are shown in Figs. 6-8, 6-9 and 6-10.

ECONOMICS

The price of VCM has exhibited the typical downward

trend of maturing petrochemical monomers. The major reasons for this trend have been the consistently improving technology, the much larger scale of existing production facilities, and the considerable decrease in the price of major feedstocks—ethylene, acetylene, chlorine and hydrochloric acid.

As with other petrochemicals such as acrylonitrile, vinyl acetate, and neoprene rubber, the 1960s saw the introduction of new processes which replaced acetylene as a raw material with a less expensive feedstock. Even though the new balanced oxychlorination processes (such as Goodrich, Stauffer and Monsanto processes) have a higher capital cost (see Fig. 6-11) than balanced ethylene/acetylene units of the same size, the raw material advantage of ethylene has been sufficient to more than justify the added capital. At ethylene and acetylene prices of 3 and 8 cents/pound, the switch in feedstocks reduces raw material cost by about 1.1 cents/pound at normal yield ratios. For a 500-million-pound/year plant, the raw material savings for balanced oxychlorination amounts to \$5 million/year (90 percent capacity). This in turn is more than enough justification for the approximate \$3-\$4 million increase in capital cost. While two U.S. vinyl chloride producers (Tenneco and Monocem) have been able to continue operation of highly integrated acetylene complexes, the operation of these units can almost certainly only be justified with an out-of-pocket analysis of cost. No new acetylene-based plants will be built in the United States.

The economics of a 600-million-pound/year balanced oxychlorination producer are shown in Table 6-8. This analysis presents a single year of the life of the plant at 90 percent of capacity, which can be justified as equally accurate with some of the component cost data. In any case, the economics indicate several notable characteristics of the VCM business. First, the two raw materials comprise two-thirds of the 8 percent profited manufacturing cost of VCM. With the large economies of scale in chlorine and the evident trend to oil company domina-

TABLE 6-8—Estimated cost of VCM production by ethylene chlorination and oxychlorination

Component	Usage rate (per lb. VCM)	Input price (\$/unit)	Manufacturing cost	
			(Thousand \$/yr.)	(\$/lb. VCM)
Chlorine.....	0.63 lb.	2.25	\$ 7,650	1.42
Ethylene.....	0.47 lb.	3.00	7,600	1.41
Catalyst & chemicals.....	.....	.....	550	0.10
Steam (net of credit).....	1.5 lb.	.05	450	0.08
Fuel.....	.0015 MM Btu.	25	200	.04
Cooling water.....	31 gal.	.003	550	.10
Electricity.....	0.1 KWH	.5	300	.06
2% royalty.....	.....	.....	500	.09
Total variable costs.....			\$17,800	3.29
Operating labor & supervision.....			\$ 300	.....
Maintenance (5% of BL capital).....			1,000	.....
General overhead (50% of operating & maintenance).....			450	.....
Taxes insurance and rentals (15% of fixed capital).....			350	.....
15% capital charge to earn 8% on fixed investment.....			3,600	.....
8% working capital interest.....			200	.....
Total fixed charges.....			\$ 5,900	1.09
8% profited manufacturing cost (F. O. B., plant).....			\$23,700	4.38

Basis: Usage rates and capital costs are derived from published claims. See especially Spits, Peter, "Vinyl Chloride Economics," *Chemical Engineering Progress*, 64(3):26, March 1968.
600-million-pound/year Gulf Coast plant (F. O. B.)
Working capital = one month of VCM sales value.
Capital cost = 16 on-site (million dollars)
8 off-sites

24 Total

11 year taxable life
15 year estimated useful life

Note: This is a steady-state calculation for one year at 90% of capacity; a more accurate discounted cash flow might produce a noticeably different price. No by-product credits or disposal costs are included; credits for chlorinated solvents feedstocks are assumed to balance heavy and light ends disposal costs.