~~JJH~~: ~~JCL~~: ~~TGG~~: RF
XF: None

TO: Dan Plummer

FROM: Tom Grumbles
DATE: September 18, 1984

Interoffice Communication

SUBJ: EDC/VCM MANUAL

VISTA

The following text should be used for EDC Product Safety Section. Changes in the Vinyl Chloride Safety Section are on the original text (enclosed).

1. Ethylene Dichloride

EDC exposure may produce irritation to the eyes, nose and throat. Overexposure can result in headache, mental confusion, fatigue, loss of appetite and possibly damage to kidneys, lungs, digestive, and nervous systems. EDC is an experimental animal carcinogen and mutagen.

The 1984-85 ACGIH TLV recommended exposure limits for EDC are 15 ppm as an eight-hour time-weighted average and 15 ppm time-weighted average for 15 minutes.

EDC should be handled in a closed system and only in well ventilated areas. Local exhaust is recommended.

EDC reacts slowly with water, producing a corrosive action. It will react violently with ammonia and NHx containing compounds.

Tom Grumbles /ajo
Thomas G. Grumbles

ajo

Enclosure

cc Jan Dopper

Dan Plummer

CONOCO

RECEIVED

SEP 17 '84

Route: TCC

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To Jim J Hall
Jan Dopper

Date 9/14

Any changes to recommen
in the EDC/VCM Manual
before final printing?
If so, let me know.

looks a little out of date

Thanks,
Dan

VVV 000016269

ETHYLENE DICHLORIDE/VINYL CHLORIDE MONOMER

EDC/VCM

VVV 000016270

A. GENERAL INFORMATION

Ethylene dichloride and vinyl chloride monomer are intimately linked in the chemical industry. In any given year, 80 to 90 percent of ethylene dichloride production goes to make vinyl chloride monomer.

Ethylene dichloride is a colorless liquid that boils at 83°C. It is also known as 1,2-dichloroethane or glycol dichloride. In the chemical industry, it is abbreviated as EDC.

Vinyl chloride is a gas at room temperature. It is also known as chloroethylene and ethylene chloride. In the chemical industry, it is known as VCM for vinyl chloride monomer.

It is interesting that although they are linked by the large usage of EDC to make VCM, these two chemicals can exhibit different growth demands on a year-to-year basis. Apparently, when VCM production is down due to lower demand, producers continue to make EDC as a convenient way to store future VCM. In the following year, although VCM use is increasing, EDC production does not keep pace due to the use of inventoried product.

B. CHEMISTRY

EDC is prepared by the direct chlorination of ethylene and by the oxychlorination of ethylene. It is common practice to link these two processes with the production of VCM. The three reactions together make up the so-called "balanced oxychlorination process." Vista uses this process at its facility in Lake Charles, Louisiana.

The first step in the process is the direct chlorination of ethylene with chlorine gas to produce EDC.

$$CH_2{=}CH_2 + Cl_2 \longrightarrow \underset{\text{ethylene dichloride}}{Cl{-}CH_2{-}CH_2{-}Cl}$$

The reaction is catalyzed by $FeCl_3$ and is run in the liquid state at ~70°C. The reaction produces heat. Temperatures up to 135°C have been reported.

The second step is the pyrolysis of EDC to produce VCM and by-product HCl.

$$Cl - CH_2 - CH_2 - Cl \xrightarrow[\text{catalyst}]{\text{heat}} \underset{\text{vinyl chloride}}{CH_2{=}CH - Cl} + HCl$$

EDC is passed through a tube containing a catalyst at 450°-500°C. The catalyst is usually pumice or charcoal. The EDC is cracked and splits out hydrogen chloride to produce VCM. Although the selectivity approaches 95 percent, a 50 to 60 percent conversion is usually realized. The three products then are separated. EDC is recycled back to cracking, vinyl chloride is sent to storage, and the hydrogen chloride is sent to the third step in the process.

The third step is the oxychlorination of ethylene. Ethylene, oxygen, and hydrogen chloride (from EDC cracking) are reacted in a reactor over a special catalyst to produce EDC.

$$2\ CH_2{=}CH_2 + 4\ HCl + O_2 \longrightarrow 2\ Cl - CH_2 - CH_2 - Cl + 2\ H_2O$$

The reaction is run at 350°-450°C and can be run in a fluidized or fixed bed reactor. Although oxygen could be supplied by air, it is general practice to use pure oxygen. This step is the heart of the whole process. It allows the producer to use all of the chlorines available and not lose one of them as hydrogen chloride. Vista's process now uses oxygen.

The overall reaction of the "balanced oxychlorination process" is:

$$4\ CH_2{=}CH_2 + 2\ Cl_2 + O_2 \longrightarrow 4\ CH_2{=}CH{-}Cl + 2\ H_2O$$

C. PROCESS

The process is diagrammed below. The EDC/VCM process can be run to maximize yields of any of the three products: VCM, EDC, or HCl. EDC is prepared in reactors by direct chlorination and oxychlorination. It is purified by washing with acid and then base. The EDC is drawn off and sent to a light ends column where a light ends distillate is removed. These light ends have commercial value and have been sold in the past to Vulcan Chemical. The bottoms from the light ends column are distilled to give EDC. The tar bottoms have been sold to PPG.

The purified EDC is sent to furnaces to be cracked. Quench columns cool the products and remove tarry products .

The products are refrigerated and hydrogen chloride is removed by distillation. The hydrogen chloride is either sent back to the oxychlorination unit or used at the Lake Charles Chemical Plant to produce methyl chloride from methanol. In general, about 10 percent of the hydrogen chloride is sent to the methyl chloride unit. After HCl removal, VCM is distilled from the remaining mixture. The VCM product is sent to storage while the unreacted EDC is sent back for recracking.

D. PRODUCT SAFETY

1. Ethylene Dichloride

EDC exposure may produce irritation to eyes, nose, and throat. Overexposure can result in headache; mental confusion; fatigue; loss of appetite; and possible bodily damage to kidneys, lungs, and digestive and nervous systems. EDC is ~~[illegible]~~ a carcinogen and mutagen in animal tests.

~~EDC has a rather pleasant odor so that overexposure due to its anesthetic action must be avoided.~~

~~[illegible]~~ The 1984-85 ACGIH TLV recommendation for EDC is 10 ppm, 8-hour TWA ~~Threshold limit value is 50 ppm per 8-hour day~~ and 15 ppm for a 15 minute TWA.

EDC should be handled in a closed system in a well-ventilated area. Local exhaust is recommended wherever possible.

EDC reacts slowly with water, producing a corrosive action. It will react violently with ammonia and NHx-containing compounds.

2. Vinyl Chloride

Vinyl chloride is a gaseous, flammable material which can form an explosive mixture with air. It should be kept away from ignition sources, and all equipment should be grounded to avoid static electricity.

Vinyl chloride should not be transferred or stored in vessels or fittings containing copper, aluminum, or their alloys.

Vinyl chloride has been found to be carcinogenic. It's use is strictly regulated by an OSHA Standard which sets permissible ~~There are strict OSHA~~ exposure limits of 1 ppm average for 8 hours with a ceiling of 5 ppm for any 15-minute period ~~placed on it~~. ~~There is a possibility of these being lowered even further by OSHA in the future.~~

E. THE VCM INDUSTRY

1. Background

Tracking and anticipating the growth of PVC, the largest VCM end use, the U.S. VCM industry saw a strong increase in both demand and capacity during the 1970's. U.S. VCM production rose from 4.0 billion pounds in 1970 to 7.5 billion pounds by 1979, an average of 7 percent annually. Capacity increased by 7.5 percent annually, from 4.3 to 8.2 billion pounds, over the same period.

Selling prices increased along with raw material prices. Since prices in Europe and the Far East rose more rapidly than domestic prices, U.S. VCM exports gained importance over the period. They went from 600 million pounds to 1.2 billion pounds and varied between 10 to 15 percent of total U.S. production.

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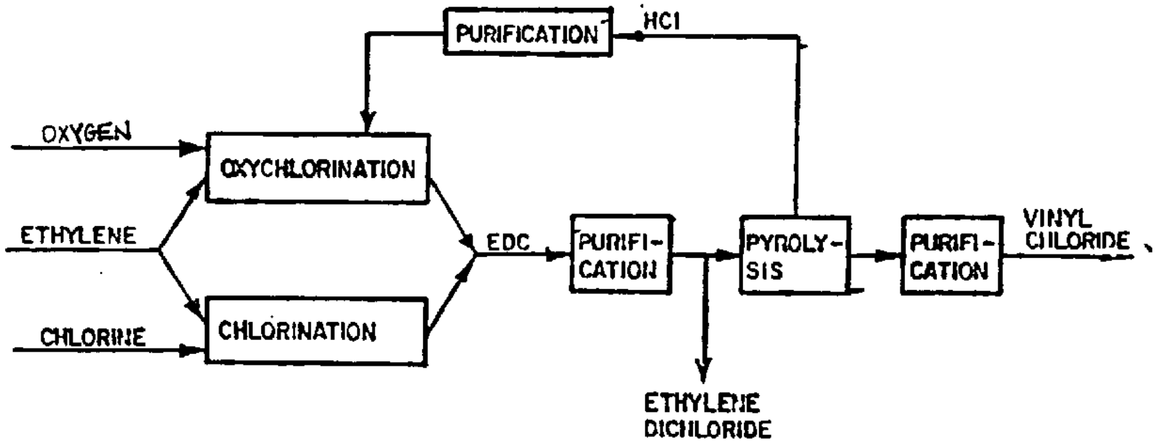
VCM - EDC PROCESS SCHEME



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Two and one-half years of recession in the United States, from 1980 to 1982, led to decreased demand for PVC building products and, consequently, vinyl chloride monomer. Because of lowered domestic prices due to over-capacity and lowered U.S. demand, VCM exports remained competitive and ran at levels between 800 to 900 MM pounds.

With an upturn in the U.S. economy in 1983 and 1984, both PVC and VCM domestic demand have increased some 10 to 12 percent over low 1982 levels. There are signs, however, that U.S. exports of VCM are on the downturn due to higher U.S. prices and increasing competition from Canada, Europe, and the Middle East in traditional U.S. Far East markets. Some minor permanent shutdown of older, inefficient VCM capacity (5 percent) occurred in 1982/83, along with a 700-MM-pound-per-year Shell plant at Norco, Louisiana, which could be brought back into production by 1986.

2. Industry Conditions

U.S. production of VCM hit a record 7.54 billion pounds in 1979, but was followed by a 14 percent decrease to 6.46 billion pounds in 1980, where it remained over the 1980-1982 recessionary period. By 1983, VCM production had recovered to 6.95 billion pounds, a 7.5 percent increase over 1982 but still 8 percent under the 1979 banner year.

The production of PVC resins continues to be the major end use market for vinyl chloride monomer. It accounts for 85 to 90 percent of all U.S.-produced VCM. Exports have fluctuated between 800 to 920 million pounds over the past three years, for another 8 to 10 percent of the market. Chlorinated products involve a minor 2 to 3 percent of the marketplace and are growing only with the economy.

PVC growth is concentrated in the building products area, with pipe and fittings accounting for over 40 percent of all PVC pounds sold. Siding, window profiles, and food grade packaging and bottles are other areas of strong PVC growth.

3. Outlook

VCM/PVC has enjoyed a long growth period, but there are signs that U.S. growth rates are slowing in the 1980's due to some maturing of markets and worldwide overcapacity and competition. Imports of VCM/PVC are also being targeted toward the U.S., especially from North American neighbors such as Canada.

From 1950 to 1974, growth averaged 12 percent per year. Over the 1970's when large volumes of U.S. and foreign capacity were added, U.S. VCM/PVC demand still grew at a healthy 7 to 8 percent per year. During the 1980's, U.S. growth in demand for VCM/PVC is expected to average under 4 percent annually. However, this is from a 5-to-6-billion-pound-per-year base. Thus the United States will continue to be the largest domestic market for VCM/PVC in the world.

Building and construction end use markets for PVC will continue to drive U.S. demand for VCM/PVC. PVC pipe and fittings, a 2.0-billion-pound-per-year market, will continue to grow at rates above GNP. PVC siding, window profiles, and other building extrusions are relatively young markets which will show strong growth over the decade, reaching 1.0 billion pounds by 1987. PVC rigid and flexible packaging and bottles, especially food grade, will increase in usage from the mid-to-late 1980's. The potential exists for development of better PVC extrusion and molding products and the use of blended and alloyed PVC to penetrate new market areas.

The significant rise in the cost of crude oil over the 1970's, especially in 1979, has led to a worldwide search for cheaper feedstocks. The start up and expansion of VCM/PVC capacity in areas of inexpensive feedstocks such as Canada, Mexico and the Middle East will mean increased worldwide competition for markets.

World overcapacity and slowly rising demand, dependent as it is on the increasing health of world economies, may have a dampening effect on prices short term. However, other than Saudi Arabian and some minor Middle Eastern and Far Eastern projects, no large new volumes are expected over the rest of the decade. This should lead to a gradually improving world VCM/PVC supply and demand situation.

In the United States, 1981 saw the last year for large increases in VCM capacity. A Georgia-Pacific grassroots plant (1.0 MMM lb) and a PPG expansion (500 MM lb) brought U.S. capacity to 10.7 billion pounds per year.

In 1982/83, shutdowns of older, inefficient plants occurred as producers either exited the business (Stauffer-175 MM; Ethyl-300 MM) or streamlined (Dow-200 MM). Shell temporarily shutdown a 700-MM-pound plant at Norco, Louisiana, in May 1983 to bring present U.S. VCM capacity to 9.0 billion pounds. This plant could be restarted over the next year or two.

Other than a Formosa Plastics grassroots plant which started up in late 1982 (530 MM pound), no new U.S. capacity is planned.

4. Manufacturers

a. Ethylene Dichloride

PRODUCERS—ETHYLENE DICHLORIDE—1984

Producer	MM lb Capacity
Dow	4,800
B. F. Goodrich	3,380
PPG	2,700
Georgia-Pacific	1,595
Shell[1]	1,400
Formosa Plastics	1,390
~~Conoco~~ VISTA	1,185
Borden	510
Arco	450
Vulcan	350
Union Carbide	300
Total	18,060

VISTA

[1]One plant only; Norco plant on temporary shutdown since May 1983.

b. Vinyl Chloride

PRODUCERS—VINYL CHLORIDE—1984

Producer	MM lb Capacity
Dow	2,200
B. F. Goodrich	2,000
Georgia-Pacific	1,000
PPG	900
Shell[1]	840
Formosa Plastics	830
~~Conoco~~ VISTA	700
Borden	600
Total	9,070[2]

[1]One plant only; Norco plant on temporary shutdown since May 1983.

[2]This amount of VCM consumes roughly 15 MMM pounds of EDC in its manufacture.

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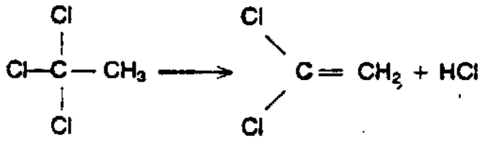
F. DEMAND—END USES

1. Ethylene Dichloride

The largest end use for EDC is the production of VCM. In recent years, from 80 to 90 percent of EDC production has been used for this purpose. VCM will be discussed in a following section.

The second largest end use for EDC is as a chemical intermediate for chlorinated organics such as 1,1,1-trichloroethane, trichloroethylene, and perchloroethylene.

1,1,1-trichloroethane is used to prepare vinylidene dichloride (VDC). VDC accounts for 3 percent of EDC demand. VDC is used as a monomer or comonomer in halogenated polymers.



vinylidene dichloride

Many of the chlorinated solvent uses for EDC and its derivatives have been curtailed due to health effects and pollution controls.

EDC finds widespread use as a solvent in the textile industry. It also has application as a solvent for metal cleaning and in adhesives. It can also be used as a fumigant in grain, upholstery, and carpets. Grain fumigants in the United States generally contain 20 percent EDC and 80 carbon tetrachloride.

Ethylenediamine is prepared by reacting ethylene dichloride with ammonia.

$$Cl - CH_2 - CH_2 - Cl + 2\,NH_3 \longrightarrow H_2N - CH_2CH_2 - NH_2 + 2\,HCl$$

It is used to produce chelating agents and carbamate fungicide. Ethylenediamine accounts for 3 percent of EDC demand.

EDC has been used as a lead scavenger in gasoline, but its use here has declined as the use of unleaded gasoline has increased. Only a negligible amount of EDC is now used for this purpose. The attached figure depicts EDC end uses graphically.

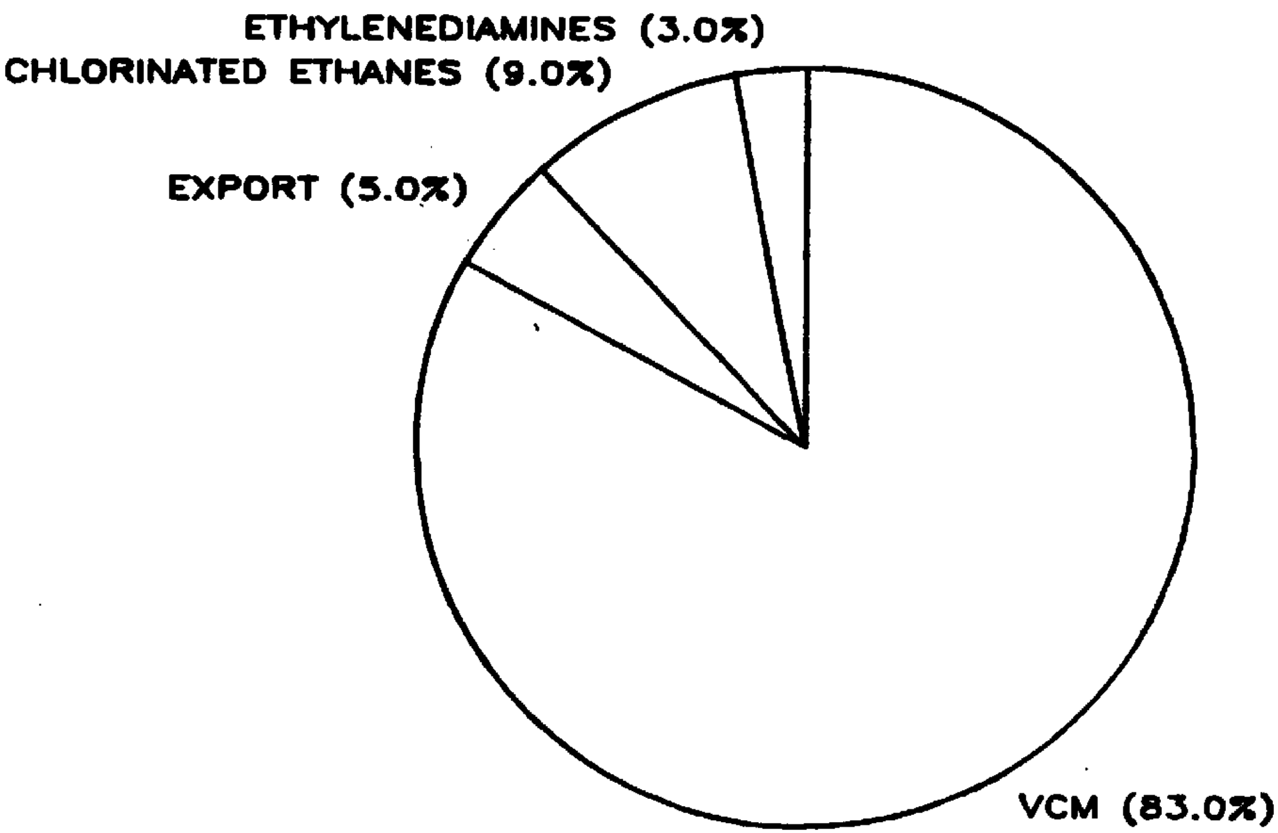
1983 ESTIMATE OF EDC END USES

Derivative	Percent
Vinyl Chloride	83
Poly-Chlorinated C2's	9
Ethylenediamine	3
Lead Scavenger	nil
Export	5
Miscellaneous	Nil

2. Vinyl Chloride Monomer (VCM)

Vinyl chloride monomer is used almost exclusively to produce polyvinyl chloride resins (PVC). These can be homopolymers or copolymers. VCM is compatible with a variety of vinyl monomers such as vinyl acetate, ethylene, propylene, vinylidene chloride, or acrylates in making the manufacture of copolymers. Polymer processes are so refined that variables such as molecular weight, particle size, and surface characteristics can be controlled to produce a particular resin with specific physical and chemical properties.

1983 EDC END USES



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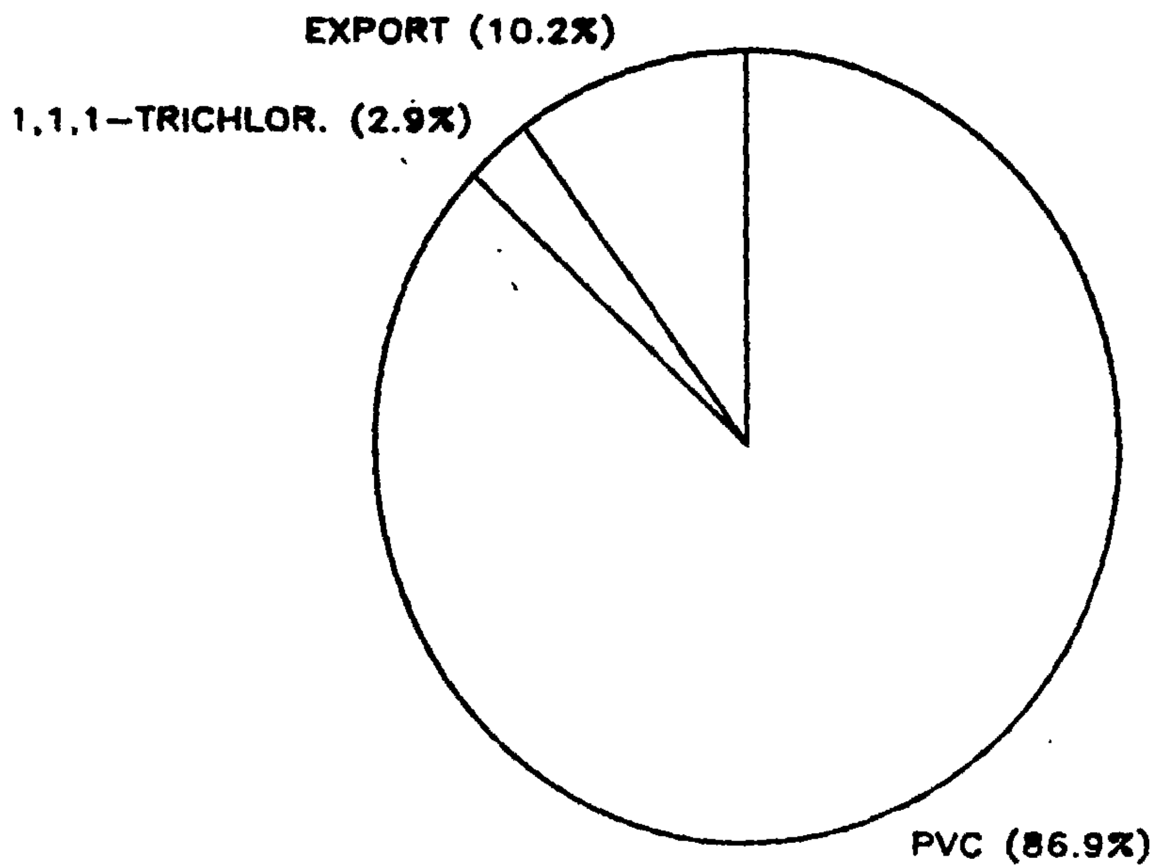
8

1984 VCM END USES



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PVC resins are particularly compatible with a wide range of plasticizers and modifiers. All proportions of plasticizers, from low (5 to 10 percent) to high (near 100 percent) can be used, and this gives finished products a wide range of properties. PVC can be made hard and stiff or soft and flexible with varying degrees of each. Additionally, with expertise in the area, PVC resins can develop good resistance to weather, water, and chemicals.

The ease of working with PVC resins has also helped its growth. It can be used in all types of normal plastics processes.

PVC can be extruded to produce rigid forms such as pipe or siding or flexible forms such as garden hose or wire insulation. PVC resins are calendered to produce film and sheet products which can be rigid or flexible. These can be laminated to give wall coverings. Blow molding produces a wide range of containers, while injection molding produces automotive parts, toys, machine covers, and pipe fittings.

The PVC end use pattern, which shows percentages of PVC used in construction, electrical/electronics, consumer products, home furnishings, packaging, transportation, and in exports and miscellaneous, is shown in the following figure.

G. VISTA POSITION

1. History

In 1966, Conoco entered into an agreement with the Stauffer Chemical Company concerning use of Stauffer-developed VCM technology. Conoco and Stauffer were to enter into a 5050 joint venture to construct a 600-MM-pound-per-year plant in Lake Charles, Louisiana. The plant was to be engineered and operated by Stauffer. Plant construction began in late 1966.

A court ruling in 1966 stated that the agreement was in violation of federal antitrust laws, and the court ordered Stauffer to divest itself of its interest in the Lake Charles plant to Conoco. Conoco was required to sell its PVC interests in Massachusetts. Conoco was allowed to continue operating the PVC facility at Aberdeen, Mississippi.

The plant was officially Conoco's when start-up began in early 1968. At its start-up, it was the largest VCM plant in the world.

This VCM plant was the first to use large reactor technology developed by Conoco. Several design flaws had to be remedied before it finally operated at design capacity in 1971.

Minor debottlenecking and operational improvements have brought the plant to its present capacity of 670 MM pounds per year. A VCM plant turnaround in the spring of 1983 was combined with the conversion from air to oxygen technology at Lake Charles. This conversion brings Vista into compliance with Louisiana EPA regulations and provides potential production efficiencies from the more modern process.

2. Business Strategy

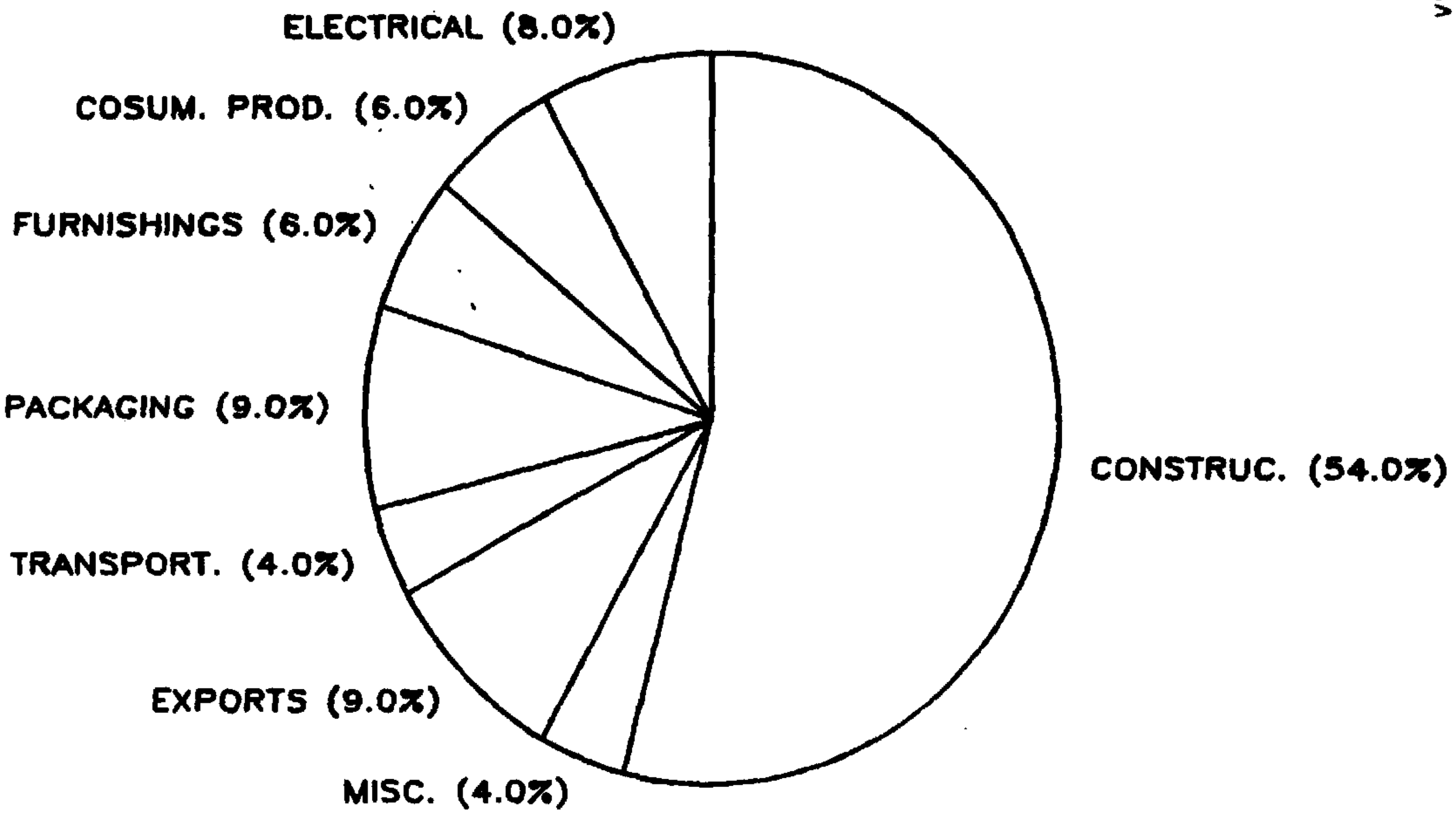
Vista's basic strategy is to combine the best available manufacturing technology with high-capacity utilization to achieve above average earnings in the VCM industry. Our VCM output is directed primarily at the Vista PVC plants with the goal being to supply all of their requirements in a reliable and economic fashion. Purchases and sales of VCM are utilized to fine tune our supply/demand balance and optimize profits.

3. Strength and Weaknesses

a. Vista has a well-integrated feedstock position. Current requirements can be supplied out of the Lake Charles ethylene plant, which has excellent reliability and production economics. All the chlorine requirements will be supplied by pipeline from PPG.

b. Our manufacturing facility is very reliable and efficient and has had a better operating history than our competitors.

1983 PVC END USES



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c. A large, and still increasing, captive requirement provides a strong baseload to our business, leading to higher capacity utilization.

d. Our very well-developed international network for VCM logistics and marketing provides flexibility and enables Vista to react to changes in market conditions.

e. Our 100 percent dependability on chlorine is a weakness under market conditions as prevailing in 1980, 1981, and 1982 (chlorine/caustic imbalance). Chlorine-driven competition (approximately 50 percent of U.S. nameplate capacity) can be aggressive in their pricing based on lower value of chlorine while we can take little advantage of such low-priced chlorine values. Additional flexibility will be considered in future contracts.

4. Product Volume

The VCM plant is scheduled to operate at capacity in 1984 with one scheduled turnaround and should produce 670 MM pounds. Domestic supplies will be supplemented with total purchases of 100 MM pounds from PPG and B.F. Goodrich. 690 MM pounds of the VCM will be shipped to Conoco PVC plants, 50 MM pounds will be sold domestically, and 50 MM pounds will be exported, primarily to Brazil.

5. Feedstocks

The production of 670 MM pounds of VCM requires 320 MM pounds of ethylene (50 percent of the Lake Charles ethylene unit's production) and 216 M tons of chlorine. This amount of ethylene is readily supplied by Lake Charles producing the required ethylene, while the chlorine supply is covered by contracts with two major suppliers, PPG and Diamond Shamrock. All chlorine arrives at Vista via the PPG pipeline. Additional chlorine for incremental EDC production can come from spot purchases. Spot purchases of EDC may also be used to supplement EDC production.

6. Pricing Strategy

In the domestic VCM market, Vista does not have a strong enough position to be a price setter. Our strategy is to keep aware of market trends and increase our prices where possible. Vista must constantly be aware of the effects of irresponsible VCM pricing upon PVC prices; our stake in the latter is much greater.

7. Marketing Strategy

Since Vista's capacity to consume VCM in our PVC plants exceeds capacity to produce VCM, our position in the merchant market is limited. Because of cycles in Vista's production and consumption of VCM, we maintain both purchase and sales contracts to balance the swings in our system. For example, we purchase more VCM when our production is down or sell more VCM when internal demand is depressed.

Merchant sales are divided between the export and domestic markets. The export market operates primarily on a spot basis and is thus well suited to handle swings in our supply/demand balance. In the domestic market, we direct our sales efforts to those accounts where we can complement rather than compete with our PVC marketing program.

8. Manufacturing Strategy

We are now forecasting only one turnaround in 1984 (February/March) depending on our experience with the new oxygen-based oxy technology and a new catalyst. Besides turnarounds, we are projecting to run at full operating rates in the three years ahead.

9. Customers

In 1984, Vista will purchase about 100 MM pounds of VCM from PPG and B. F. Goodrich.

Major Vista customers and approximate volumes are:

Customer	MM Pounds
Aberdeen PVC Plant	425
Oklahoma City PVC Plant	265
CertainTeed	25
General Tire	15
Uniroyal	10
Export	50

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